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Expert knowledge-based co-development of scenarios for maritime spatial planning in the Northeast Atlantic

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ABSTRACT

Scenarios constitute narratives or storylines that reasonably describe how the future is likely to unfold. The usefulness of scenarios in Maritime Spatial Planning (MSP) is now recognised within policy and research, with many institutions urging the development of likely trajectories in the future state of the marine environment and space. However, little progress exists in the actual development and application of actual scenario building approaches. This paper presents the methodology and results of such an approach developed within the framework of the "Geographical and Political Scenarios in Maritime Spatial Planning for the Azores and North Atlantic (GPS Azores)" project. A scenario-building approach for MSP in the area is developed and future scenarios' storylines are formulated through the active engagement of regional experts. Outcomes from the analysis enable identifying the major risks and opportunities in the management and use of marine space and key maritime sectors, under different scenarios. Three storylines are developed representing distinct trajectories in the use and governance of marine space: (i) Nature at Work; (ii) Business-as-usual; and (iii) Blue Development. Final storylines are the outcome of intense experts' engagement throughout the scenario-building exercise,

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stressing the usefulness of such participative approaches. Results can assist policymakers in the context of an adaptive and participatory MSP approach. The methodology can be tailored to other regions, while results can be revisited and adapted as new information and knowledge emerge.

1. Introduction

Scenarios are imagined as descriptions of different versions of the future and are used to help decision-makers to deal with uncertainty and estimate the outcomes of their developments [9,16]. Scenario building promotes discussion, allows planners and other stakeholders to acquire a better understanding of the impact of uncertainty in decision-making and helps envision and create a desirable future. Importantly, one of the greatest benefits of scenario planning tools is to help break the habit of seeing familiar patterns (expecting the future to look much like the present) and being blind to the unexpected, especially in situations where data gaps make planning difficult or where strategic visions are required [12]. Consequently, planning can extend beyond defining and analysing existing conditions, or maintaining the status quo, and can reveal possible alternatives on how the management area could look like in the future [7].

Scenarios are relevant in Maritime Spatial Planning (MSP) as they offer an inclusive and comprehensive approach, comprising all the directly and indirectly interacting sectors in a given area. As different ocean users can function at the same time in the same place, conflicts over maritime space are becoming more and more common, with multisector integrated planning being required to reduce these conflicts and optimise marine management [14,31]. Indeed, there is a need to coordinate these human uses, and MSP through scenario approach seems to be the most appropriate choice [6].

Moreover, scenario planning contributes both to filling knowledge gaps on existing and potential ocean uses and activities [10], and increasing understanding of complex system processes by those involved in MSP [9]. These, therefore, provide policy-makers with an orientation on how measures may evolve and develop over the years, and how they may contribute (or not) to the established set of goals and values of a region. Whereas a single-sector management may determine a single solution that are efficient for a specific sector, scenario planning methodologies offer a wide range of solutions equally efficient and may be more feasible to implement, allowing decision-makers to compare many alternatives simultaneously [10].

In creating scenarios, analyses of data (e.g. demographic) is not sufficient and stakeholders' engagement in the process is crucial: to properly manage natural resources, it is essential to create a "shared environment" where the interests of all relevant stakeholders can be discussed, allowing for increased transparency, legitimacy of the negotiation process, trade-offs, and more efficient and effective implementation of measures [13]. Including decision-makers and experts in the scenario-building process, becomes a standard practice, improving the efficiency and the credibility of the developed scenarios [4,19,34]. To that end, storytelling is key in making scenario development work, as it does not imply that stakeholders must take a position against, or for a scenario [30]. Moreover, associating the story with quantitative assessments of data can fortify the persuasive power of the scenario and enhance internal consistency. As such, a combination of narrative and numbers is essential for an effective scenario approach [25].

In this regard, expert consultation (or expert involvement) can be integrated as part of the stakeholder engagement process, helping to create knowledge and information based on scientific backgrounds and reasoning, thus translating complex qualitative analysis into choice support. Adopting the definition of [8], experts can be understood as "*stakeholders who have gained domain specific expertise through their profession*. Because of their level of knowledge, experts' opinion plays an important role in decision-making and in the development of policies, and that, for such reason, many stakeholder's consultation processes focus on experts [8].

In the specific context of Maritime Spatial Planning (MSP), expert knowledge can unravel new management options, promote better understanding of the system complexity and respective human influences, and ensure reliability of conducted assessments [8,33]. It is acknowledged the careful integration of sound scientific knowledge supports the development and implementation of management instruments and compliance tools [23]. Several studies now rely extensively on experts' opinion for determining key pressures on the marine environment (e.g., [3,5,15,23,29]), others complement "traditional" data analyses with expert opinion (e.g., [21]).

The objective of the present study is to develop and apply a scenario-planning methodology to support the future development of MSP in the Azores Archipelago, Portugal. In a region where the roots of economy, tradition and leisure strongly rely on the marine ecosystem and its services, visualisation through storylines of how the future may unfold due to immediate actions (or the lack of them), helps to guide the decision-making process along the pathway towards a sustainable future. To that end, experts' engagement in the scenario-development process is a fundamental part of the analysis. The present study builds on previous works developed in the North Atlantic region and the Azores [4,17], going a step further and allowing for a more comprehensive analysis, by considering nuances among different use sectors and their consequences on the environment, society, and economy.

2. Methods

2.1. Study area

The study area of the present work pertains to the internal maritime waters, territorial waters, and Exclusive Economic Zone (EEZ) of the Azorean Archipelago (Fig. 1). The Azores is an autonomous region of Portugal and an outermost region of Europe, located in the North Atlantic Ocean, and consisting of nine volcanic islands (São Miguel, Santa Maria, Flores, Faial, Corvo, Terceira, São Jorge, Pico, and Graciosa). The area is home to several ports and maritime heritage sites. Several conservation and designation status areas of regional and national significance (NATURA 2000 network sites) are present in the study area, where numerous international, national, and regional conventions apply (e.g., OSPAR).

The development of scenarios has already been used in the Azores to support the local government during planning processes, both marine and terrestrial. For example, the European-funded MarSP project ("Macaronesian Maritime Spatial Planning" www.marsp.eu) made use of scenarios to support MSP and bring insights on how the development of the Azores region could unfold. The project developed three scenarios – namely, "Blue Society", "Blue Growth" and "Blue Development" – based on local, national, and international legislation and policies, where each storyline was presented, modified (when needed) and validated by local stakeholders [4]. Another example, by Lobo et al. [17], used a broader perspective and developed alternative scenarios to support the definition of local terrestrial sustainable development strategies in the Azores. Using a participatory and qualitative approach, the authors developed five scenarios that unfold differently based on the driving forces that were more crucial to each of them. Similarly, the Celtic Seas Partnership developed scenarios building on stakeholder consultation to support discussions regarding integrated marine management in the Celtic Sea [27]. Here, developed scenarios made use of experts' consultation on drivers and outlined key assumptions and distinctions between scenarios for each sector. But unlike the approach of

MarSP (where storylines developed a general overview of possible futures, not going into detail about the different maritime sectors), Celtic Sea scenarios developed an overview of maritime activities under each scenario, promoting a debate on potential future trade-offs and synergies among involved sectors [27].

2.2. Scenario-building process

The present study adopts a predictive approach to scenario building where hypothetical scenarios about how the future is likely to unfold are developed. Predictive approaches are increasingly being used within the framework of MSP-related projects [e.g., Celtic Seas Partnership Future trends work, ABPmer & ICF International [1]]. Here, the scenario-building process is structured in five stages (Fig. 2). First, key sectors of the study area and major driving forces in their development are identified, based on the assessment of the marine environment present state. Second, an agenda of future scenarios based on different trajectories is formulated. Third, future trajectories, in the form of pre-elaborated scenarios are developed. Fourth, scenarios are edited, evaluated, and validated. Fifth, the final framing of scenarios is established. It is worth noting that it was opted for a short-term timeframe for the scenarios to represent a not-so-distant future, namely 10 years. This timeframe was selected to align with the general key policies (e.g., Table 1) timeframe and was agreed upon with stakeholders.

Experts engaged in the current work have experience in maritime and marine-related topics in the Northeast (NE) Atlantic region and represent diverse disciplines and backgrounds. This is considered crucial in capturing a range of different opinions and ensuring an acceptable degree of subjectivity in the formulation of future trajectories [28]. The study seeks to develop detailed accounts of possible future states of the marine environment under different scenarios, allowing an overview of each sector and possible trade-offs, and how to manage them to ensure a sustainable development for the region. This approach differs from others that aim to predict future trajectories, or how to meet specific policy objectives. Details on the scenario-building and expert consultation processes are provided in the following sub-sections.

2.2.1. Expert consultation

Focusing on having a more robust and diverse consultation process, and also considering particular aspects of the Geographical and Political Scenarios in Maritime Spatial Planning for the Azores and North Atlantic (GPS-Azores) project, the expert selection was based on the three following criteria: (i) experience of the Azorean region; (ii) involvement in the GPS project; (iii) discipline - field of expertise (social, governance, environmental, and economic).

Being the experts' consultation the main core this study, fourteen experts were engaged in the scenario-building process considering the criteria previously established, along with the core research team. Experts had substantial experience in different disciplines and fields of expertise (e.g., biology, engineering, geography, hydrography), and the team was composed of representatives from academia (n = 11), government (n = 2) and consultancy (n = 1). The different disciplines and practices substantially added to the richness of narratives and to the subsequent quality of the developed scenarios.

In regard to information gathering, experts' inputs were methodically collected in each step of the scenario-building approach (Fig. 2) in a tabular form. Information was then collated by the core research team, and categorised according to scenario, sector, driver and other relevant categories and themes (e.g., blue growth sectors). For the subsequent analysis, the background and field of expertise was assigned to statements. This enabled elaborating and refining statements and forming storylines while ensuring that invaluable context and knowledge was included.

2.2.2. Key sectors and drivers in future development

This stage aimed to establish the major maritime sectors and activities in the area (e.g., tourism, maritime transport, fisheries), as well as the drivers that determine expected to their future development (e.g., demographic change, environmental change). Experts provided their input, with relevant information collected in a common tabular format to enable streamlining across experts and consistency of relevant information.

As listed below, sectors included both traditional (e.g., tourism, fisheries) and emerging sectors with potential for future development.

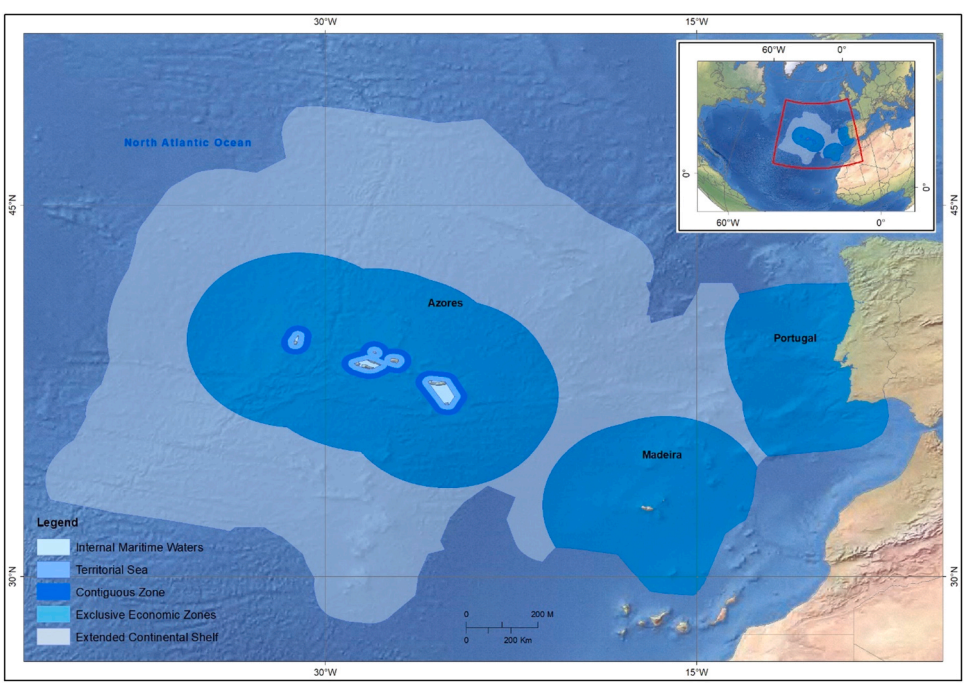

Fig. 1. Study area - Azores archipelago and Portuguese Maritime jurisdiction.

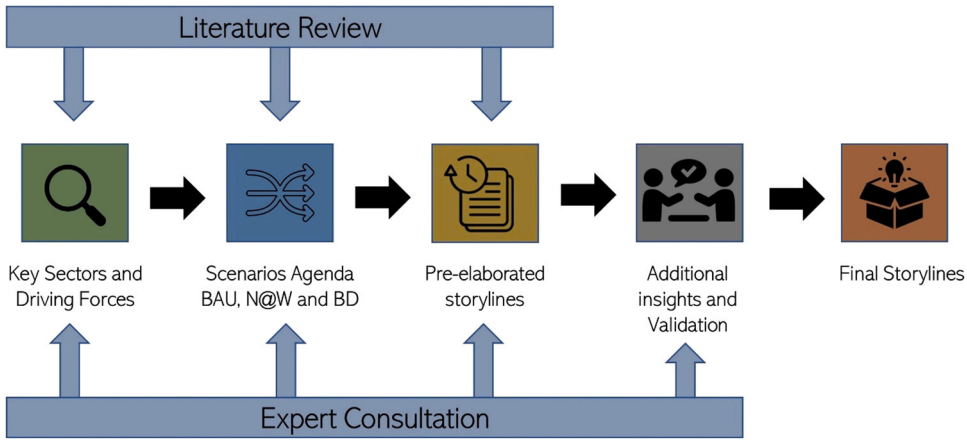

Fig. 2. Scenario-building approach. Where BAU means Business-as-usual, N@W means Nature at Work, and BD means Blue Development.

Table 1
Literature review. Indicative overview of sources assessed for developing the draft of scenario storylines.

Sector	Policy	Studies, Projects
Fisheries	North-East Atlantic Environment Strategy; International Council for the Exploration of the Sea; EU Common Fisheries Policy, Technical Measures Regulation, Control Regulation	Macaronesian Maritime Spatial Planning (MarSP) project [26]; Multi UseS (MUSES) project, Governo dos [11]
Aquaculture	Regional Legislative Decree 31/2012/A.	Governo dos [11]
Marine protection	United Nations Convention on Biological Diversity (CBD), EU Habitats and Birds Directives, EU Biodiversity Strategy; Azores Maritime Strategy	Ibid
Tourism, UCH	Marine Strategy Framework Directive	EU MUSES project [4, 26]
Maritime transport, ports and coastal infrastructure		[26], Governo dos [11]
Geological extraction	European Parliament on international ocean governance (2017/2055(INI))	[26], Governo dos [11]
Marine renewable energy (MRE)	Marine Strategy Framework Directive	Alves et al. [2], Governo dos [11]

- Fisheries
- Aquaculture
- Nature protection
- Tourism, Underwater Cultural Heritage (UCH)
- Maritime transport, ports, and coastal infrastructure
- Geological extraction
- Marine renewable energy (MRE)

Experts elaborated on the specificities of the sectors, what these would include in the future according to their knowledge, thus framing drivers for their further development. Regarding MRE, planning experts mentioned that this mostly includes wave energy, with other technologies having less potential for commercial development in the region. Experts with a conservation background noted that what was initially termed as "marine conservation" should change to "marine protection" to be more encompassing and include environmental management measures outside protected areas. The sector includes Marine Protected Areas (MPAs), such as NATURA 2000 network sites but also special conservation features such as Endangered, Threatened and Protected (ETPs) species.

2.2.3. *Scenarios building agenda*

A scenario-building agenda was developed, based on various potential future trajectories in marine space use and the future state of maritime sectors in the area, namely *Business as Usual (BAU)*, *Nature at Work (N@W)* and *Blue Development (BD)*. A brief overview of storylines and sectors development was compiled based on results from the previous stage (Section 2.2.2.), and on an in-depth literature and policy review. Storylines of scenarios were developed based on policy objectives [e.g., European Union (EU), regional, national and international]. Sources also included results from past studies and projects in the North Atlantic region – e.g., ABP Marine Environmental Research Report and SIMCELT (Celtic Seas), MarSP (Macaronesian Region) – together with key findings from other sea basins (e.g., Baltic Sea, www.meriskenaariot.info) that could be potentially transferable to the study area. The brief overview was subsequently provided to experts who reflected on, and refined its content.

2.2.4. *Pre-elaborated storylines*

After identifying key sectors and establishing the scenario agenda, key drivers and their specificities were contextualised for each of the scenario storylines, based on an extensive literature review of key policies and studies on MSP (Table 1). Key international, regional and EU policies were assessed to determine drivers in the future development of both MSP and maritime sectors. An extensive literature review on scenario-building processes for MSP was conducted (e.g., Supporting Implementation of Maritime Spatial Planning in the Celtic Seas (SIM CELT), Baltic [4]), including studies, profiles, and fiches relating with the development status of specific maritime sectors in the region [26]. Experts were also presented with a scenario agenda containing the scenario overview, and statements elaborating the development of each individual sector under each scenario.

2.2.5. *Validation of scenarios and final development*

This stage involved the scoping of scenarios by the experts. Being an important step for refining statements and providing additional insights, the experts reviewed and commented on the final scenarios. Through a critical review of experts' opinions, and the identification of commonalities and differences among them, a final storyline was developed.

3. Results

The interactive nature of the methodology enables the development of detailed storylines which integrated information from both literature review and experts. Results bellow present the final narratives of the scenario-building approach.

3.1. Scenarios agenda and drivers for future development

The assessment of the state of key sectors and drivers in future development enabled establishing the scenario agenda and the formulation of three (3) pre-elaborated scenario storylines, representing distinct future trajectories:

- Business as usual (BAU): A future largely resembling the current state of the marine environment and status of key maritime sectors and activities. The future is largely market-driven, and thus key drivers are demographic and short-term economic gain;
- Nature at Work (N@W): A future where environmental protection is key in future development, with conservation playing a leading role and maritime sectors developing in an environmentally-friendly, sustainable manner, at the community, local level;
- Blue Development (BD): A future where substantial Research and Development (R&D) funds are allocated for research in the development of emerging maritime activities and sectors ('blue growth') with the overarching aim of the technical and ultimately commercial development of sectors.

Experts provided their input on sectors, activities, and drivers fundamental to review under the various scenarios, especially helpful for framing the subsequent storylines. This was particularly helpful for framing the BD scenario, with several key experts suggesting that under this large-scale fisheries will display a marked growth.

3.2. Scenario development

Detailed storylines for each of the three scenarios, together with overviews for each maritime sector under each scenario, are presented in the following subsections. They are the result of experts' input integrated into pre-elaborated storylines, bringing more content and nuance in the outcome.

3.2.1. Business as usual (BAU)

3.2.1.1. General overview storyline overview. Under this scenario the **status quo** continues in the future. Central to the scenario are current **socio-economic** and **demographic** drivers. Tourism is the major growing sector under this narrative. No major changes take place in the planning and management framework for the marine environment. Different institutions continue having different jurisdictions, perpetuating policy fragmentation and a sectoral approach to the management and planning of maritime activities and space. Conflicts between sectors remain. No marked progress occurs with respect to achieving key policy targets under the Azorean Marine Strategy. Blue Growth (BG) priority sectors do not reach full potential as uncertainty regarding policy framework remains not attracting investments [32]. Key environmental problems continue (runoff, bycatch in fisheries, alien species introduction, impacts from touristic development).

3.2.1.2. Marine protection. Extent of MPAs remains at 2020 levels, approximately 4% of total marine waters, significantly lower than policy objectives of 10% (EU Biodiversity Strategy and Aichi Biodiversity Target 11). Moreover, no clear management plans for MPAs (e.g., NATURA 2000 sites) are established and no areas of strict protection are designated. For the protected areas where plans are developed, management measures for key sectors such as fisheries are not integrated sufficiently with conservation objectives. Conflicts between users continue, for instance, between fisheries and conservation, in low compliance with measures. Limited progress is achieved with respect to the reduction of the bycatch of sea turtles and marine mammals, as set by regional policy provisions (Azorean Marine Strategy). Status of alien species and birds' population below Good Environmental Status (GES) objectives set by regional government.

3.2.1.3. Fisheries. The sector exhibits an overall negative development under this scenario, with short-term revenues being the main goal. An increasing demand of seafood, and no change in consumer behaviour towards sustainable consumption patterns, lead to an increase in fishing effort, and a marked decrease in fish stocks. Major commercial target species come to the edge of collapse, with emergency fishing moratoria having pronounced impacts on the fishing industry and fishers livelihoods. Little or no investment is made in alternative gears or technical measures for more sustainable fishing practices. As such, fishing practices continue having negative impacts on ETP species, contrary to the provisions of the Habitats Directive, Birds Directive, and the Marine Strategic Framework Directive (MSFD), with minimal investment in strategies to minimise bycatch. Key objectives of environmental, fisheries and conservation policies objectives are not met [Common Fishery Policy, (CPF); Habitats and Birds Directives; MSFD]. Overfishing results in the decline of the profitability of fishing and income of fishers. There is a rise in unemployment in the sector, which in combination with the limited diversification options for unemployed professionals, leads to precariousness and consequent social implications. No major developments in monitoring take place (e.g., landing declaration), while there is an absence of efficient control and enforcement plans. Fishers are largely excluded from decision-making, which leads to low compliance with conservation goals.

3.2.1.4. Tourism. The sector's development continues as before the Covid-19 pandemic, largely involving mass tourism, driven by low-cost flights and cruise ships, due to a lack of a longer-term integrated strategy for the sector. Unsustainable practices relating with the consumption of endangered species continue in the future.

3.2.1.5. Maritime transport, ports, and coastal infrastructure. Shipping is market-driven and will continue to be vital in the future under this scenario. There is no marked progress in the development of environmentally friendly modes of maritime transport (e.g., LNG, cold-ironing, hybrid technologies). Anchorage continues taking place within UCH and natural heritage sites and remains largely unregulated within MPAs. Increased maritime traffic (cruise ships, cargos) has negative environmental impacts on cetaceans (noise pollution and strikes). There is an absence of proactive adaptation to climate-induced impacts which, coupled with an increased frequency and intensity of coastal hazards (storms, flooding, and erosion), leads to pressure on coastal infrastructure and higher cost for reparations.

3.2.1.6. Blue growth sectors. The potential of BG sectors is not fully reached, with cruise tourism being the only sector that shows marked growth. Aquaculture remains in its infancy, with negligible investment in R&D and few commercial applications. Although MRE mostly waves has considerable potential, no major developments take place, with renewable energy investments dominated by land-based resources (e.g., geothermal).

3.2.2. Nature at work (N@W)

3.2.2.1. General overview storyline overview. Central to this scenario are environmental drivers. The scenario prioritises nature protection based on key policy provisions (Convention on Biological Diversity (CBD); United Nations Sustainable Development Goals (UN SDGs); EU Birds and Habitats Directives; MSFD; EU Biodiversity Strategy; Azorean Marine Strategy). Marine activities develop in an environmentally friendly, sustainable manner. Marine protection is prioritised and sustainable practices for key sectors (i.e., fisheries, tourism) are promoted. GES is

actively sought, and additional, more ambitious conservation and sustainable use targets are set (EU Biodiversity Strategy). Monitoring and compliance systems are substantially strengthened through additional investment (remote monitoring systems and observers' programmes). Integrated planning results in conflict resolution between key sectors minimises negative environmental impacts from maritime activities. Central to MSP are climate change considerations, the precautionary approach, ecosystem-based management and multi-use of maritime sectors and activities. The dialogue, communication and exchanges between policy-makers, stakeholders and research institutions increases. Investment in R&D is promoted, namely on programmes aiming to identify and minimise environmental impacts from different activities that take place in the marine environment. The development of each sector is based on the best available science.

3.2.2.2. Marine protection. UN SDGs and CBD provisions are central to the development of marine protection provisions. Substantial increase in the maritime area covered by MPAs, amounting to 30%, of which 10% strict protection (EU Biodiversity Strategy), is envisaged. Designation of MPAs considers threatened species and high ecological sensitivity areas (e.g., vents, seeps, seamounts), climate change refugia and due regard to ecological corridors used by migratory species. Protection of essential habitats for ETP species (e.g., seabirds), such as nursery and feeding areas, with measures pertaining to fisheries closures well-grounded on science become a reality. The development of concrete and clear management measures for MPAs based on an adaptive approach, and the definition of conservation goals and compatible uses will be the rule to manage the marine environment. The latter include low impact activities such as research and certain forms of ecotourism like canoeing and coasteering. Bycatch reduction of marine mammals at levels below 1% of population, achieving policy provisions (Azorean Marine Strategy) becomes a reality. Regulation, policies, and operational measures are effectively in place to control and monitor non-indigenous species spreading. Use of observers (marine mammal and fisheries) and novel technologies for marine surveillance (e.g., drones), to complement remote monitoring systems (e.g., Automatic Identification System (AIS); Vessel monitoring system (VMS); video surveillance) is implemented. MPAs' management follows a bottom-up approach, with the participation and engagement of all stakeholders in all steps.

3.2.2.3. Fisheries. Fish resources and fisheries are managed according to an ecosystem-based approach. Only use of selective gear is permitted and there is a marked shift away from gillnets to longlines and hook-and-lines, along with bycatch reduction measures and schemes (pingers, LEDS, etc.). These result in the decrease in fishing mortality and improvement in the status of fish stocks, with several overfished stocks recovering and a considerable decrease in the bycatch of marine mammals and other non-target organisms. Fishing mortality and stock biomass are at levels that deliver Maximum Sustainable Yield (MSY) and meet GES policy objectives (Common Fishery Policy (CFP), MSFD). At first, relocation of fishing activity has negative impacts on fishermen, but eventually, the establishment of MPAs bring positive spill-over effects (e.g., Condor Seamount) with marked benefits for fishers (increase in quality of product, size, and abundance of species and diversity of target species). Distribution of final seafood products directly from fishermen to official selling points. The high environmental standards enable the certification of fisheries, with ecolabels generating higher profits (premium) for fishers. Fishermen are actively engaged in management and surveillance and their involvement is a critical factor for the effectiveness of relevant measures.

3.2.2.4. Tourism. The long-term strategy for the sector is based on the carrying capacity of the marine environment. Low-impact, sustainable forms of tourism, in particular Fishing-tourism and combinations of UCH and tourism, develop, with careful planning of activities within MPAs and UCH sites. Revenues from nature-based tourist taxes are used for MPA management. Communities are actively engaged in the process, with attention to the needs and aspirations of communities of relevant tourist activities.

3.2.2.5. Maritime transport, ports, and coastal infrastructure. Considerable research and development (R&D) and investment in cleaner and more efficient fuel sources (hybrid, cold ironing), ships, harbour operations and grids for fuelling equipment and machinery. Anchorage is limited in spots established in designated areas in all the islands. The scenario favours infrastructure improvement in existing harbours, instead of the construction of new ones, blue green certification, and the uptake of blue taxes. The number of docked cruise ships is limited to one at a time. There is an improvement in the conditions of Ponta Delgada wastewater treatment plant to receive and treat sewage from cruise ships. Actions are implemented to avoid or minimise the risk of introduction of alien species. The previous result in lengthy procedures and higher operational costs for licensing of relevant projects. Proactive and soft adaptation to climate change impacts enable lower costs in damages in the long run.

3.2.2.6. Blue growth sectors. Investments in R&D and an increase in the number of small-size pilot projects occur. Sound Environmental Impact Assessments (EIAs) and Strategic Environmental Assessments (SEAs) for projects and clear and timely engagement and involvement of stakeholders in the development process are in place. Potential commercial development of few small-size projects to cover energy demands of local communities become a reality.

3.2.3. Blue Development (BD)

3.2.3.1. General overview storyline overview. Main drivers for this scenario are the development of innovative technology and R&D. Under this scenario, the development of blue growth sectors is prioritised according to key policy (EU Blue Growth Strategy). Some of these BG sectors exhibit increased growth within the next 10 years, notably aquaculture and industrial fisheries, with marked infrastructure construction. For others, although commercial applications may be limited, there is significant investment in R&D, and the development of strong maritime clusters and links with mainland Portugal. Prioritisation of BG sectors results in conflicts with traditional activities such as tourism and coastal fisheries, while infrastructure development and extractive activities may result in adverse environmental impacts.

3.2.3.2. Aquaculture. There is an increase in aquaculture development, leading to conflicts with fisheries, as fisheries are not allowed in the direct vicinity of aquaculture sites (Regional Legislative Decree 31/2012/A). On several occasions, aquaculture also takes place within and in vicinity of UCH sites and MPAs, resulting in conflicts between the sectors. There are synergies with other BG sectors, with the co-location of activities (e.g., with MRE), the sharing of infrastructure, land-based installations, and vessels.

3.2.3.3. Marine renewable energy. Investment in R&D for the sector, aimed at exploring the combination and optimisation of areas with wave and wind energy potential. Although pilot and trial development of MRE with no commercial applications, marked progress in research and technology makes MRE more competitive in terms of market share. Land-based (e.g., geothermal) energy sources constitute the main renewable source. Investments to develop this sector come from international partnerships and cooperation and funds from relevant EU programmes and mechanisms. Azores become key in leading the energy transition path, implementing the EU Green deal and national policy.

3.2.3.4. Maritime transport, ports, and coastal infrastructure. Volume of

ship traffic increases, establishing more direct routes between islands and continental Europe and Azores acquires a Trans-regional status. Ports play a fundamental role in supporting BG development. Development of geographically dispersed shipyards of small capacity operating in a network is put in place. There is an investment in lower-carbon energy sources [e.g., liquefied natural gas (LNG)] and grids for fuelling equipment and machinery. There is an obligation to implement an Environmental Management System (ISO 14001:2015) at main harbours and marinas.

3.2.3.5. Geological (mineral) extraction. Extensive mapping of seabed takes place, with the identification of high-value rare elements. Data quality and availability aid the development of an economic exploration strategy. To better understand and mitigate the impact of such activities on the marine environment, considerable investments in R&D take place. Pilot projects develop, to gain expertise before industrial exploitation. Inactive hydrothermal vents are areas of high interest, with special attention for investments.

3.2.3.6. Fisheries. There is a marked shift from coastal fisheries towards large-scale offshore fishing, primarily for tuna. There is a development in high-tech fleets, oriented to the export of high-value final products. Investment is made to optimise technology of tracking and exploiting fish resources. There is a marked consolidation in the sector, impacting especially traditional, family-owned small-scale coastal fisheries. Impacts on the coastal fisheries are driven by competition for space with emerging sectors.

3.2.3.7. Marine protection. The large-scale, industrial development of BG sectors, causes adverse environmental impacts environmental impacts, mostly during the construction, but also associated with operation of activities. Aquaculture and extractive activities (mineral, fisheries) take place within MPAs, with conflicts with conservation objectives and impacting protected species, while noise pollution has adverse impacts on cetaceans.

3.2.3.8. Tourism. With the improved connections, and the promotion of cruise tourism, a key BG sector, there is a high increase in the number of visitors to the Azores. Limited synergies between BG sectors and tourism (visits to MRE and aquaculture sites) and limited development in recreational fishing and Fishing-tourism occur. Touristic development results in conflicts with UCH and MPAs.

3.3. Comparison between different scenarios

The multiple drivers and their different development under the scenarios result in distinct differences between scenarios. Table 2 summarises how the different sectors are likely to develop under each scenario, highlighting differences and similarities between scenarios.

Minimal investment in R&D takes place under BAU, differentiating it from the BD trajectory, which promotes R&D and targeted policy intervention and funding for the further development of blue growth sectors, most notably aquaculture, MRE and cruise tourism. Both BAU and BD differ distinctly from N@W, concerning environmental protection. While BD is characterised by small investment in environmental protection, BAU showed the least investment in marine protection resulting in environmental degradation and adverse impacts on resources and sectors (e.g., fisheries, coastal infrastructure). However, high investment in R&D under the BD scenario, ultimately promotes the development and uptake of MRE technologies with less greenhouse gas emissions. Another difference between BD and N@W concerns the development of key Blue Growth sectors within MPAs. Under BD sectors such as aquaculture and MRE can take place within MPAs, while under N@W MPAs are locations of strict protection, where no extractive, industrial maritime activities take place.

Table 2
Development of sectors under future scenarios. Where R&D means Research and Development.

	Business as usual (BAU)	Nature at work (N@W)	Blue Development (BD)
Marine protection	↓	↑	↓
Fisheries	↓	↓ (short term) / ↑ (after scenario timeline)	↑ (overall profitability) / ↓ (coastal fisheries)
Tourism	↑	↓ (overall, some forms increase)	↓
Maritime transport*	↑ (transport & ports) ↓ (coastal infrastructure)	↓ (overall, but R&D increase)	↑
Blue growth sectors	- (minor change)	- (minor change)	↑

Size of arrow represents the likelihood magnitude of change for the sector under each scenario where an up-arrow means a positive effect, a down-arrow a negative one and size the magnitude of such change. (*) Includes ports and coastal infrastructure.

For certain scenarios and sectors benefits become visible after the timeline set in the study (2020–2030). This is especially the case for the N@W and underlies the need for long-term planning for relevant scenario-building approaches. Synergies and benefits for the other sectors by conservation under N@W and spill over effects.

Experts noted that there is uncertainty regarding how blue growth sectors are likely to develop in the future. This was especially the case with aquaculture, with uncertainties relating to the location, size, and type of aquaculture development in the archipelago, affecting particularly the framing of the BAU and BD scenarios installations. For novel BD sectors, such as MRE uncertainties in development under all scenarios stem from the current technological and commercial readiness levels of the sector. However investments in the sector mainly to develop technologies that explore wave energy and offshore wind farms are under discussed for the region [11]. Experts also voiced concerns for the future development of mineral extraction, mentioning that the technology that makes such exploration possible is still largely lacking and far from being commercially ready. It should be noted however that the topic is currently in the spotlight, with ongoing discussions in the Portuguese Parliament [24]. These discussions support the development of international agreement taking a precautionary position to the exploration of mineral resources, thus conducting such exploration "until the effects of mining in the high seas on biodiversity and human activities at sea have been sufficiently studied and investigated and all possible risks are known" (European Parliament).[1] This political commitment may suggest that under the BD scenario, R&D on the sector is likely to take place.

4. Discussion

The scenarios represent three distinct trajectories in the future state of the marine environment and maritime sectors and activities. Different drivers shaped each scenario, largely accounting for the main dissimilarities between scenarios: the BAU scenario was market-driven, shaped by socio-economic and demographic drivers. Nature protection and conservation were the main drivers under the N@W scenario. In the BD scenario, drivers were mainly investments in emerging sectors, R&D and innovative technology.

A fundamental difference among scenarios also related to **the governance and management framework of the marine environment** and maritime activities. BD and BAU scenarios follow sectoral

[1] https://www.europarl.europa.eu/doceo/document/TA-8–2018–0004_EN.html

approaches, whereas nature at work adopts an ecosystem-based approach to the management of the marine environment. These also resulted in differences regarding the planning and response to environmental and climate risks. This is especially evident in the case of the BAU scenario, where it is envisaged that the absence of a coherent planning and management framework will result in risks and impacts on the ecosystem (e.g. overfishing, adverse impacts within MPAs, conflict of uses and space). Importantly, the EBA to management followed under the N@W scenario could aid a proactive adaptation of key sectors to the adverse impacts of climate change, while in BD, climate change mitigation could become key with investments and development in marine renewable energy. **Scales of development of the marine environment** and sectors also differed substantially between scenarios. The N@W scenario largely favoured a low-impact, community-based development, with soft sectors showing marked progress in development and economies of scale. Under BD, large-scale, in some cases of industrial extent, development of sectors is foreseen.

Consumers' behaviours and preferences were key in shaping the development and state of sectors under the three scenarios. For tourism, N@W is characterised by a shift to more sustainable, low-impact forms of tourist activities, as opposed to mass tourism based on low-cost flights followed under BAU, or a strong focus on cruise tourism, under BD. Such behaviours and preferences also largely shaped the future development of aquaculture and fisheries and led to the uptake of innovative solutions for instance the engagement in fishing-tourism, the eco-certification of practices.

Also, during the expert consultation process, a valuable element that came from their input had to do with commonalities or conflicting statements among them. This enabled establishing specific topics that deserved attention for further analysis, and most importantly what these differences meant in terms of knowledge and perceptions. For instance, there were different opinions among experts relating to the distribution of seafood products and MRE development under different scenarios. This highlighted the need to frame scenarios also with respect to a local versus a more export-oriented development, giving nuances to scenarios.

5. Conclusions

The scenarios set out above describe likely trajectories in the future state of the marine environment and maritime users in the Azores region. Scenarios do not constitute predictions; rather describe drivers and trends in the state of sectors [18]. They can thus provide valuable insights to the development of MSP in the Azores and assist in prioritising sectors and activities that deserve attention and targeted policy interventions. To better inform policy and assist in MSP decision-making, a number of key outcomes from this analysis, and respective suggestions, are identified:

(1) **Ecosystem-based approaches require long-term planning and management**: positive impacts from N@W are only realised after taking into account the full timeline of the exercise, spillover effects, and positive impacts on local communities and users. The considerable positive effects of the scenario are mostly evident after the 10-year timeline of the exercise (e.g. stock recovery, ecosystem components at GES). Likewise; and partly due to the previous, the potential negative implications of following the specific trajectory (e.g. conflicts between conservation and others users), are significantly minimised after the 10-year timeline of the exercise.

(2) **Integrating users, communities, and stakeholders is key:** Findings highlight the need to account for local communities when developing scenarios for key sectors. Results stress the aspect of 'consensus-driven' space availability when designating MPAs and accounting for impacts on other users, especially with respect to compliance with management measures. To that end, findings stress the need for integrative approaches to MSP, and experts' knowledge for scenarios storylines (co)development.

(3) **The need for a proactive adaptation to risks** including impacts from climate change, rather than a reactive, post-hoc approach. For example, many studies have shown that the maintenance of a healthy ocean and its ecosystem is important for carbon sequestration supporting climate regulation [20,22,35].

(4) **Attention to vulnerable sectors:** Findings from the study highlight the need for careful consideration to the future diversification of activities and sectors likely to show negative development in the future. These include fisheries, nature conservation and coastal infrastructure, sectors that appear especially vulnerable in the short-term, under all three scenarios.

(5) **The role of ocean literacy:** Consumption preferences were key in the development of sectors. This situation highlights the role of ocean literacy for informing consumers, among others on the added-value of sustainable seafood and the adverse impacts from uncontrolled tourism. It can also raise the visibility of innovative techniques and tools to producers and developers (e.g., ecolabeling for fishers, fishing-tourism, etc.).

(6) **No one-size-fits-all scenario building solutions:** Different scenario building methodologies are not mutually exclusive. Results from the present approach can inform the MarSP scenarios and vice versa. This can enable targeted policy interventions, highlighting the limitations and advantages for each sector under each potential. Similarities between the scenario building exercises GPS and MarSP can also be established.

The present scenario-development approach allowed the formulation of a detailed narrative for the future state of the Azores' marine space and maritime sectors. However, it is essential to highlight that there is no "right scenario", but a variety of possibilities which policymakers can consider and work on. Besides, scenarios are not static representations, and the authors thoroughly recommend revising and adapting them for a region and unforeseen situations, like the current Pandemic, drastically changing the structure of any narrative as new information, expertise and knowledge arises.

CRediT authorship contribution statement

H. Calado, C. Pegorelli and E. Papaioannou: Conceptualization, Methodology, Writing – original draft, Formal analysis. **M. Vergílio, C. Fonseca**: Conceptualization, Methodology, Writing – review & editing. **C. Hipólito, A. Campos, F. Moniz, A.C. Costa, C. Pereira da Silva, C. Frazão Santos, D. Gabriel, J. Guerreiro, A. Gil, D. Johnson, K. Ng, M.M. Monwar, M.A. Ventura, J.L. Suárez-de Vivero, M. Pinho, P. Borges and M. Caña-Varona**: Provided input to methods and results and reviewed manuscript.

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Conflict of interest

The authors have no conflict of interest to disclose. The views expressed are those of the authors and do not reflect official EU and national policy.

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