



D9.2 Case Study 8 Report

Ecosystem-based solutions to solve sectoral conflicts on the path to sustainable development in the Azores



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About AQUACROSS

The project ‘Knowledge, Assessment, and Management for AQUAtic Biodiversity and Ecosystem Services aCROSS EU policies’ (AQUACROSS) aims to support EU efforts to protect aquatic biodiversity and ensure the provision of aquatic ecosystem services. Funded by Europe’s Horizon 2020 research programme, AQUACROSS seeks to advance knowledge and application of ecosystem-based management (EBM) for aquatic ecosystems to support the timely achievement of the EU 2020 Biodiversity Strategy targets.

Aquatic ecosystems are rich in biodiversity and home to a diverse array of species and habitats, providing numerous economic and societal benefits to Europe. Many of these valuable ecosystems are at risk of being irreversibly damaged by human activities and pressures, including pollution, contamination, invasive species, overfishing and climate change. These pressures threaten the sustainability of these ecosystems, their provision of ecosystem services and ultimately human well-being.

AQUACROSS responds to pressing societal and economic needs, tackling policy challenges from an integrated perspective and adding value to the use of available knowledge. Through advancing science and knowledge; connecting science, policy and business; and supporting the achievement of EU and international biodiversity targets, AQUACROSS aims to improve ecosystem-based management of aquatic ecosystems across Europe.

The project consortium is made up of sixteen partners from across Europe and led by Ecologic Institute in Berlin, Germany.

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1 Introduction and background

1.1 Introduction

Globally, marine biodiversity declined by 49% between 1970 and 2012 (Tanzer et al. 2015). This rapid decline threatens the resilience of marine ecosystems and their ability to sustainably produce ecosystem services that humans depend on to survive and thrive (Cardinale et al. 2012). The EU Biodiversity Strategy to 2020 seeks to halt and reverse this trend, establishing six targets, including to protect species and habitats (target 1), maintain and restore ecosystems (target 2), and make fishing more sustainable and seas healthier (target 4) (European Commission 2011). Policy makers have turned to Marine Protected Areas as a key tool to achieve these goals (Gill et al. 2017). Indeed, globally, the Convention of Biological Diversity's Aichi Target 11 and the UN Sustainable Development Goal 14 aim to “efficiently and equitably” protect 10% of coastal and marine areas within Marine Protected Areas (MPA) (UN 2016; Secretariat of the CBD 2011). However, the efficacy and equity of Marine Protected Areas is questioned and considered highly variable (Gill et al. 2017).

In this report, we apply the AQUACROSS Assessment Framework to the Faial–Pico Channel, a 240km² MPA in the Azores, Portugal, an EU Outermost Region. We aim to understand how ecosystem-based management can support existing MPAs to become more effective and equitable, and ultimately support the long-run sustainability of the Faial–Pico Channel social–ecological system. Ecosystem-based management (EBM) is a principle-based management approach that aims to protect, restore, or enhance the resilience and sustainability of an ecosystem to ensure sustainable flows of ecosystem services and conserve its biodiversity (see Gómez et al. 2017, Rouillard et al. 2017). Table 1 shows the six principles of EBM identified by Rouillard et al. (2017), which are central to the AQUACROSS Project. Of particular relevance to this case study are EBM principle 2, 4, 5, and 6.

Table 1 Principles of ecosystem-based management (Rouillard et al. 2017)

EBM principles:
1. EBM considers ecological integrity, biodiversity, resilience and ecosystem services
2. EBM is carried out at appropriate spatial scales
3. EBM develops and uses multi-disciplinary knowledge
4. EBM builds on social–ecological interactions, stakeholder participation and transparency
5. EBM supports policy coordination
6. EBM incorporates adaptive management

The Faial–Pico Channel is a richly biodiverse Marine Protected Area, which aims to protect biodiversity whilst also allowing economic activities in some areas, such as fishing and tourism. Despite a 30 year history of increasing international, Azorean, and local protection for the area (Abecasis et al. 2015), biodiversity in the MPA continues to be lost, as indicated by falling population indices of target coastal species in the channel (Afonso et al. 2014). Numerous human activities at place in the Channel place pressure on the ecosystem, especially fishing and pressures associated with swiftly increasing tourist numbers. Fishers and tourism operators (including diving operators), value the biodiversity hotspots within the Channel, but have different objectives for how they should be managed. Managing the Channel is complicated by multi-level and overlapping responsibilities, with policy development and enforcement split across the local–level Nature Park of Faial and Nature Park of Pico, both under

the mandate of the Regional Directorate for the Environment (Direcção Regional do Ambiente, DRA). Other competent authorities include the Azores-level Regional Directorate for Sea Affairs (DRAM) and the Regional Directorate for Fisheries (Direcção Regional das Pescas, DRP), all who must consider local (i.e. Faial and Pico Island), Azorean, Portuguese, and EU policy targets. Additionally, as evidenced by the policy process that lead in 2016 to three new, more highly regulated protected areas within the Channel (Ordinance no. 53/2016), stakeholders such as recreational fishers and tourism operators could be better integrated into policy development. Given this context, we aim to understand the threat to biodiversity in the Channel and collaborate with local stakeholders and policy-makers to identify measures that protect the long-run sustainability of the ecosystem whilst balancing the competing objectives of local commercial fishers, recreational fishers, tourism operators, and other stakeholders.

We apply the AQUACROSS Assessment Framework in five steps: we first identify policy objectives (section 2.1) and stakeholder objectives (section 2.2). We then apply the AQUACROSS linkage framework and selected indicators to semi-quantitatively characterise the drivers, pressures, biodiversity, ecosystem-functioning, and ecosystem-services that make up the ecological and socio-economic aspects of the Faial–Pico Channel social–ecological system (section 3). In section 4, we summarise this in a baseline scenario for 2018–2050, and identify gaps between the baseline and the stakeholder and policy objectives. In section 5, we select a set of ecosystem-based management measures to shrink this gap, and evaluate the difference between this future EBM scenario and the baseline in terms of effectiveness, equity, and efficiency. Local stakeholders have contributed at each step, co-creating the final EBM plan.

The resulting EBM plan for the Faial–Pico Channel consists of five key recommendations:

1. Increase monitoring – a current lack of Channel biodiversity data limits understanding and policymaker and stakeholders' ability to adaptively manage the Channel.
2. Increase stakeholder participation – to date, stakeholder participation in the Channel MPA management decisions has been limited. A representative Stakeholder Advisory Group would increase equity, transparency, reduce conflict between stakeholders, and support adaptive management of the Channel.
3. Integrate management of the Channel across policy and geographical boundaries – the current split of management across jurisdictional and geographical boundaries limits the achievement of multiple objectives. A management plan covering the entire Faial–Pico Channel MPA and a coordinating management unit of institutions would improve effectiveness and efficiency.
4. Increase enforcement – stakeholders believe existing biodiversity and fishing rules are poorly understood and under-enforced, limiting their positive impact. Easy wins could be achieved through better information and greater enforcement.
5. Finance EBM with a “sustainability tax” – to equitably meet the costs of the EBM management plan, we discuss the potential cost-sharing benefits of a per-night tourism tax and a diving fee.

We conclude that the Faial–Pico Channel case study provides evidence that EBM and the AQUACROSS Assessment Framework can support decision-makers to make the management of MPAs more effective, so that they equitably meet biodiversity goals. EBM's strong emphasis on stakeholder co-creation and trans-disciplinary research can ensure that diverse stakeholders – fishers, tourism operators, environmentalists, and others – participate in MPA management; the analysis of these processes and recommendations on how stakeholder

engagement can be improved in the Channel is a focus of this report. The other elements of EBM, especially its focus on interdisciplinary science and integrative management, are likely to support biodiversity in the Channel, however, data and methodological limitations in the case study limit our ability to assess environmental effectiveness. Practical challenges remain, including the appropriate scale of management, financing, and ensuring representative stakeholder participation.

Before beginning to apply the Assessment Framework in section 2, in section 1.2 we describe stakeholder co-creation in the case study, and in section 1.3 we briefly characterise the spatial, ecological, socio-economic, and stakeholder context of the Faial–Pico Channel.

1.2 Stakeholder co-creation in the AQUACROSS Azores case study

Stakeholder co-creation is central to EBM and has been central to this Azores case study. At every stage, this report is guided and framed by the discussions, guidance, and feedback we received from stakeholders. After an initial scoping visit and planning meetings with our cooperating institutional partner DRAM, and the stakeholder mapping exercise (see section 1.3 and Figure 2), we gathered context and scoped the project through one-on-one in-person and phone interviews, which we continued throughout the project. The most significant input came at two stakeholder workshops. The first was held in Horta, Faial Island, Azores, on the 3rd of October 2017. The workshop brought together 31 local stakeholders, including fishing, tourism, and civil society representatives, as well as scientists and policy-makers. In focus was the current and future management of the Faial–Pico Channel MPA. Other key topics discussed included how scientific research and local stakeholder knowledge have informed decision-making and the management of the MPA in the past – and how they should contribute in the future. We produced a proceedings summarising the key conclusions of this meeting, which we reference throughout the report (AQUACROSS 2017)¹. The second workshop took place in Horta on the 23rd of May, 2018. 18 local stakeholders, including tourism, fishing, and environmental representatives, as well as scientists and policy-makers, collaborated on a concrete plan for stakeholder-based management of the Faial–Pico Channel MPA and elaborated future management strategies for the Faial–Pico Channel MPA; we also reference the proceedings of this meeting throughout the report (AQUACROSS 2018). In addition to stakeholder input, DRAM and by local scientists at the University of Azores provided considerable support.

1.3 Context

Spatial characterisation

The case study centres on the Faial–Pico Channel MPA, a 240km² marine area situated between the Faial and Pico islands in the Azores (see Figure 1). At its widest point, the channel separates the islands by 8km. The channel features a shallow shelf: the average depth at the channel's middle is 45m, relative to depths of 500m at its edge (MarBEF Data System 2006).

The Faial–Pico Channel MPA is located in the middle of the Azores, an archipelago of nine volcanic islands located in the North–East Atlantic Ocean. The Azores islands are dispersed in three clusters over 600 km, positioned approximately 1500 km west of Portugal. Due to its

¹ Full details of the workshops, including a Proceedings (in Portuguese and English), agenda, and participants list, as well as presentations, can be found at the [AQUACROSS Information Portal](#).

isolation, the Azores command an Exclusive Economic Zone of 953,633 km². However, the absence of continental shelf means that only 2.2% of the EEZ is of an easily usable depth of less than 1000m (Ojamaa 2015).

Ecological characterisation

Macaronesia (which consists of the Azores, Madeira, and the Canary Islands) is rich in biodiversity, with 5,728 endemic species (Madruga, Wallenstein, and Azevedo 2016), and valuable ecosystems that are recognised as of “exceptional

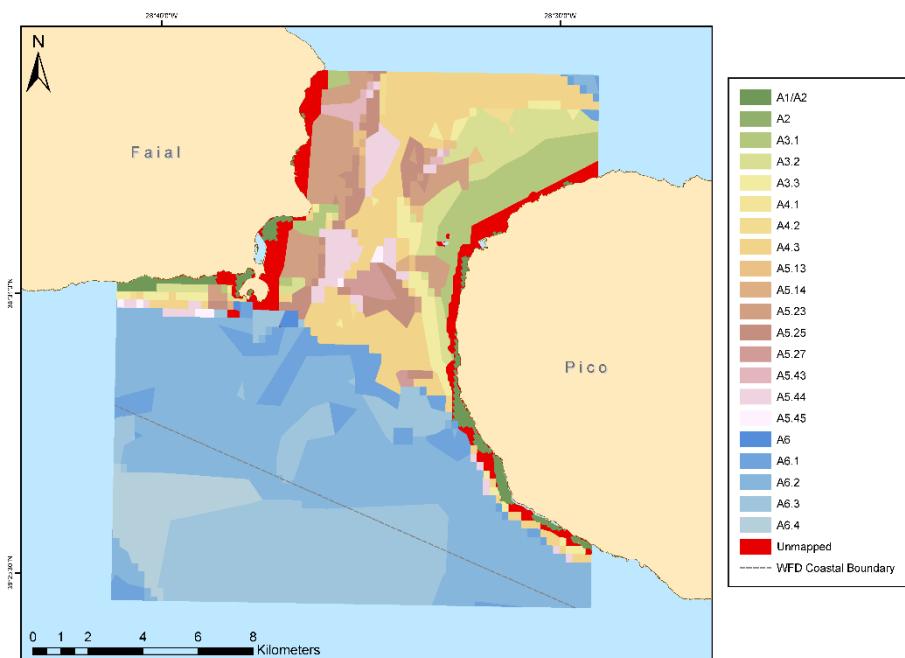


Figure 1 Faial–Pico Channel MPA: ecosystem types (EUNIS level 3)

importance to locals, the EU, and the world” (Message from Reunion Island 2008). The Pico–Faial Channel MPA itself represents some of, “the most diverse and representative complex of habitats in the (Azores) archipelago” (MarBEF Data System 2006). Indeed, due to the “large number of species, habitats and ecological processes” at the site, it is one of the best examples of Macaronesian coastal ecosystems in the Azores (OSPAR Commission 2016). Hundreds of species of animals can be found in the MPA. This includes endangered cetaceans such as common and bottlenose dolphins, endangered commercial fish, the European eel, loggerhead turtles, as well as some endemic fish, plants and invertebrates (OSPAR Commission 2016). Additionally, it hosts a number of endangered or threatened marine birds (MarBEF Data System 2006). The protected area features a number of distinctive habitats, including large shallow inlets and bays, reefs, and submerged or partially submerged caves and coral gardens (OSPAR Commission 2016). However, the limited biodiversity monitoring data available for the Channel and stakeholders agree that biodiversity in the Channel is falling (AQUACROSS 2018; Afonso et al. 2014). Extraction of species by recreational and commercial fishing has been identified as a key threat.

Socio-economic characterisation

At €16,000 per capita in 2016, the Azores GDP is equal to 55% of the European average, growing at an average of 2.7% per year since the year 2000². Key sectors dependent on the Faial–Pico Channel that contribute significantly to the local economy include commercial fisheries and tourism; primary industries contribute 9% of Azorean GVA. Commercial fisheries are a historically important driver of the local economy, and still employ 1.5– 3.2% of the total working population (Ojamaa 2015; Statistics Portugal 2017)³. Tourism has swiftly become central to the local economy, with the number of tourist nights in the Azores tripling from

² EUROSTAT: GDP at current market prices by NUTS2 region

³ Statistics Portugal: own calculations, Fishermen registered at 31 December 2015 in Azores. This compares to a rate of 0.6% for Portugal.

1995–2015. As one indicator of the sector's importance, in 2015, the accommodation sector directly employed 2% of the total Azorean workforce.⁴ The increased demand by tourists (and tourism providers) for eco-tourism in the Channel is leading to conflict with commercial fishers and other stakeholders fishers as to how the Channel should be managed (AQUACROSS 2017).

Policy characterisation

As an autonomous region of Portugal, the Azores have autonomous political and administrative status under the Portuguese Constitution, and are responsible for the administrative and political decisions in most sectors (Benzaken and Renard 2011). As an Outermost Region of the EU, the Azores are required to enforce European law, including all environmental directives, including the Birds and Habitats Directives (BHD), Water Framework Directive(WFD), Marine Strategy Framework Directive (MSFD), and Biodiversity Strategy to 2020. Other European and Portuguese sectoral policies also apply and can drive pressures on biodiversity (Rouillard et al. 2017), such as the Common Fisheries Policy.

Governance of the Faial–Pico Channel MPA itself is split between multiple government institutions: the Faial and Pico Island Nature Parks (which report to the environment directorate, Direcção Regional do Ambiente, DRA) and the Regional Directorate for Sea Affairs (Direcção Regional dos Assuntos do Mar, DRAM). The Azores Regional Directorate for Fisheries (Direcção Regional das Pescas, DRP) also influences Channel management.

The Faial–Pico Channel MPA has been subject to various national and international policy initiatives for environmental protection over the past thirty years. While in line with national/international policy developments, bottom-up stakeholder pressure drove the most recent significant change to management, Fishing Ordinance no. 53/2016, which came into force on the 21st of June, 2016. This increased the level of protection for three high-biodiversity areas within the Channel, whilst allowing some mixed use and leaving the rest of the Channel unaffected; the current management of the Channel is summarised in the central column of Table 2.

Stakeholder characterisation

Due to the small spatial size of the Faial–Pico Channel and its relatively small neighbouring population of approx. 30,000, the number and type of stakeholders affecting and affected by the ecosystem are generally local and perhaps know each other on an informal level. Key stakeholder groups include commercial fishers, recreational fishers, tourism operators (such as diving operators and other tourism-dependent industry), tourists, scientists, civil society groups (such as local environmental NGOs), other local stakeholders, and Azorean policy-makers. Figure 2 provides an overview of key stakeholders in the Faial–Pico Channel. It orders them by their level of interest in Faial–Pico Channel MPA management and their influence. The third column of Table 2 shows how key stakeholder groups value different Channel areas.

⁴ Eurostat: own calculations, SBS data by NUTS 2 regions and NACE Rev. 2 (2014–2016). This compares to a rate of 2.3% for Portugal.

Table 2: Current Faial–Pico Channel management, and value to stakeholders

Faial-Pico Channel Area	Current Faial–Pico Channel Management: Ordinance. 53/2016 <i>Red: total fishing ban, orange: mixed use</i>	Value to stakeholders/ biodiversity ⁵ <i>Darker colour = higher value</i>			
		Biodiversity	Commercial fishers	Recreational fishers	Tourism operators
Monte da Guia - Volcanic crater and surrounding coast and marine area on SE coast of Faial	All professional and recreational fishing banned around Monte da Guia, except: - shore angling along specific sections of the coast - capture of live bait				
Ilheus da Madalena - Underwater volcano crater and small islands just off E coast of Pico and Madalena harbour area	All professional and recreational fishing banned around Ilheus da Madalena, except: - capture of live bait				
Baixa da Barca - Northern-most pinnacle/shallows in the Channel (20m depth)	All professional and recreational fishing banned				
Baixa do Sul - Southern-most pinnacle/shallows in the Channel (6m depth)	No additional restrictions				
Valuable Marine Ecosystems - Deep-sea coral reefs on S slope of Channel	No additional restrictions				
Rest of Channel	Ban on: -depositing organic or inorganic waste -extracting aggregates -gillnet fishing				

2 Establishing objectives

Establishing policy and stakeholder objectives is the first step of the AQUACROSS Assessment Framework. Key conclusions of this section include that biodiversity, tourism, and fishing objectives (and their associated policies and measures) both increase and decrease pressure on biodiversity in the Channel. To meet the multiple objectives, our analysis supports increased biodiversity monitoring, integrating management across policy areas, and coordinating management at the whole Channel scale, in line with EBM principles. Our analysis of existing stakeholder participatory processes and stakeholder objectives suggests that stakeholders would support EBM in the Channel. While recreational fishers, commercial fishers, tourism operators and other stakeholders hold competing objectives, they collectively prioritise greater participation, increased monitoring and enforcement, and simplified, holistic management.

2.1 Identifying policy objectives

This chapter characterises policies and the policy institutions that significantly impact biodiversity in the Faial–Pico Channel. In section 2.1.1 we introduce and summarise the key environmental, fishing, and tourism policies and their impact on biodiversity. In section 2.1.2

⁵ All biodiversity and stakeholder values are based on Schmiing et al. (2015) and Afonso et al. (2014), as well as and personal communication with Enrico Villa, Pedro Afonso and Mara Schmiing, Adriana Ressurreição , and Hugo Diogo.

we describe the overlapping institutions that manage the Faial–Pico Channel. In section 2.1.3 we conclude the policy analysis by identifying key challenges.

2.1.1 Policy instruments influencing local biodiversity

As outlined in the opening section, Ordinance 53/2016 is the most recent direct policy instrument affecting the management of the Channel MPA; Table 2 summarises this and current protections for the Faial–Pico Channel MPA. In this section, we identify the impact of this policy instrument and assess how other environmental and sectoral policies affect biodiversity in the Channel.

Biodiversity in the Channel is protected by environmental policies. However, as described in Rouillard et al. (2017), the positive impact of these policies can be undermined by sectoral policies, which support drivers (fishing, tourism) that place pressures on biodiversity. Accordingly, in Table 3 we summarise the key features and management measures of the most important local environmental, fishing, and tourism policies, and apply the Driver–Pressure–State–Impact–Response model to identify the expected pathway through which the management measures are expected to impact biodiversity in the Faial–Pico Channel, i.e. how they affect the ecosystem state pressures, or drivers.

As an Outermost Region of the EU (and an autonomous member of Portugal, an EU Member State), the Azores regional government is obliged to implement the full European law (*acquis communautaire*). Accordingly, international sectoral and environmental objectives also influence management of the Faial–Pico Channel. In terms of international biodiversity protection, the UN Convention on Biological Diversity (CBD) and its Aichi Biodiversity Targets set overarching policy goals. At the European level, these Aichi Biodiversity Targets are reflected in the EU Biodiversity Strategy to 2020 (AQUACROSS 2016), which aim to “halt the loss of biodiversity and ecosystem services in the EU and help(ing) stop global biodiversity loss by 2020” (European Commission 2015). This headline aim is broken down into six targets, the most relevant of which for the Faial–Pico Channel are *Target 1: Protect species and habitats* and *Target 4: Make fishing more sustainable and seas healthier*. These are operationalised through the EU environmental directives, including the Marine Strategy Framework Directive (MSFD), the Birds and Habitats Directives (BHD), and Water Framework Directive (WFD). International sectoral policies and funding decisions also impact Faial–Pico Channel biodiversity management, such as the EU Common Fisheries Policy and the European Maritime and Fisheries Fund (EMFF). As these European-level Directives are discussed in preceding project outputs (Rouillard et al. 2017), in this report we focus on the local Azorean and regional policies that translate these directives into action at the case study level, whilst still indicating the links to EU policies.

2.1.2 Governance of the Faial–Pico Channel

While the Faial–Pico Channel is relatively small (240km²), currently, five Azorean institutions are involved in its management. Since 2007, when the Azores consolidated their national park system, all protected areas on an island or in its territorial waters (within 12 nautical miles of an island) are managed by the relevant Nature Island Park (Autonomous Region of the Azores 2007). The administration and regulation responsibilities of the Channel separating Faial and Pico, which is 4.5 nautical miles wide, is legally split between the Faial and Pico Nature island Park, who operate under the Regional Directorate for the Environment (Direcção Regional do Ambiente, DRA). In turn, the Regional Directorate for Sea Affairs (Direcção Regional dos

Assuntos do Mar, DRAM) is responsible for managing the marine component inside the Nature Island Parks, which includes the Channel Faial–Pico, being also responsible for the implementation and management of MPAs outside territorial waters (Abecasis et al. 2015). DRAM constitutes therefore the environmental authority for the marine environment, whose competence includes contributing to the definition of the integrated regional and EU policy for biodiversity conservation and licensing of uses of the maritime space. On the other hand, the Regional Directorate for Fisheries (Direcção Regional das Pescas, DRP) is responsible for setting up measures for the conservation, management and exploitation of living marine resources in the Azores, including restrictions on gear or fishing areas. As DRAM is a policy department rather than an operational department, it cooperates closely with DRA, the Nature Parks (and their rangers), and DRP for policy development in the Channel. Indeed, DRP, in collaboration with DRAM, drove the most recent adjustment to the protection in the Channel, establishing the Fishing Ordinance 53/2016, issued by the Regional Government responsible for fisheries.

Table 3: Features and expected impact of key environmental, fishing, and tourism policies affecting biodiversity in the Faial–Pico Channel: Green – decrease pressure on biodiversity; red – increases pressure on biodiversity; Orange – increases and decreases pressure on biodiversity.

	Local policy instrument	Key features	Expected impact	Link to EU policy
Environmental policies	Island Nature Parks – Regional Legislative Decree 15/2012/A and Pico Island Nature Park– Regional Legislative Decree n.º20 / 2008 / A, July 9 AND Faial Island Nature Park–Regional Legislative Decree n.º46 / 2008 / A , November 7	The Island Nature Parks regulations (the overall framework policy, as well as the Faial Nature Park and Pico Nature Park regulations) jointly create the MPAs within the marine waters of Pico and Faial and establish Island National Parks that are responsible for managing terrestrial protected areas as well as marine/coastal areas within 12 nautical miles of the respective islands coast (including Faial–Pico Channel). They also standardise and improve management and administration of protected areas.	The MPAs directly reduce pressures on biodiversity by banning fishing in some areas. This, along with regulation of other threats and pressures (such as underwater noise, release of toxic substances in waterways, etc.) will indirectly improve the state of biodiversity. The policies also decrease drivers of extraction of species by increasing environmental education and information.	BHD, MSFD, Biodiv. Strategy
	Azores Marine Park – Regional Legislative Decree No. 13/2016/A	Protect and manage marine areas protected for environmental reasons located in the seas of the Azores, excluding those within Island National Parks (i.e. beyond 12 nautical miles from an island). The specific management measure used is spatial exclusion i.e. marine protected areas. The exact management measures differ by MPA. Some restrict all activities in a particular area that could negatively impact particular habitats or species (including fishing), while others restrict mining activities, or limit tourism activities such as diving. Most relevant for the Faial–Pico Channel, the legislation establishes two relatively nearby MPAs: the Condor Seamount (17km from Faial) and the Princess Alice Bank (83km from Faial).	Closing fishing grounds outside of the Faial–Pico Channel can have the perverse effect of driving extraction of species within the Channel, as fishers have fewer alternative fishing locations. At the same time, the positive impact on biodiversity resulting from these other MPAs could potentially have positive flow on effects on the state of the Channel. Overall, the impact on extraction of species within the Faial–Pico Channel is unclear.	BHD MSFD, Biodiv Strategy
Fisheries policies	Faial–Pico Channel Fishing ordinance no. 53/2016	Establishes spatial exclusion areas within the Faial–Pico Channel to protect biodiversity. High levels of protection apply to the biodiversity-rich and historically protected Monte da Guia and Ilheus da Madelena. In these areas, with the exception of shore fishing from some sections of coast and "live bait" fishing, the regulation forbids all commercial and recreational fishing. Additionally, it excludes all commercial and recreational fishing around Baixa da Barca. Other areas of the Channel are unaffected.	Decreases extraction of species from biodiversity hotspots. Ordinance 53 should improve the overall state of local biodiversity, fish stocks, reproduction, and population structure.	CFP, MSFD, Biodiv. Strategy
	Legal framework for fisheries-tourism – Regional Legislative Decree no. 36/2008 / A	Allows commercial fishers to gain licenses to use their boats for tourism activities, touristic fishing, potentially reducing extraction of species.	This measure reduces drivers of extraction of species in the Faial–Pico Channel. Allowing commercial fishing vessels to become tourist boats increases alternative sources of income for Azorean fishers, decreasing the need to extract species to make a living. Offering fishers the opportunity to share the benefits of increased	BHD, MSFD, Biodiv. Strategy

		tourism in the Azores will synergistically decrease pressure on biodiversity.	
	Legal framework for Azorean fisheries (29/2010/A and 31/2012/A) (and other subsidiary regulations)	Establishes a framework for sustainable management of fisheries in the Azores and of the fishing industry. Management measures are often implemented through subsequent ordinances. These include measures that limit the impact of fisheries in the Channel, including: licensing restrictions for catching certain fish; spatial closures (i.e., marine protected areas); vessel size restrictions; gear restrictions (such as a ban on bottom trawling, particular nets, and minimum hook size); and catch quotas, among others. It also includes funding and other support for the commercial fishing industry.	Regional Legislative Decree no. 31/2012/A of July 6 addresses commercial fishing through a number of means (e.g. restrictions, quotas, spatial bans, etc.) in effort to reduce pressures due to over extraction of commercial species. However, its role in providing financing and other support to commercial fishers increases pressure on biodiversity, thus making its overall impact unclear.
Tourism policies	PEMTA – Strategic and Marketing Plan of the Azores Tourism (2016) AND Liberalisation of air traffic to the Azores March 29, 2015	The management measures established in PEMTA are tangentially related to the management of marine ecosystems. PEMTA establishes measures to increase the amount and positive impact of tourism in the Azores. The liberalisation of air traffic to the Azores removes priori restrictions on carriers, allowing low-cost airlines (such as Ryanair and Easyjet) to enter the market, decreasing cost and increasing the number of tourists,	While the strategy aims to support sustainable tourism, the proposed growth of tourism (supported by the liberalisation of air traffic) will lead to more tourists, which will increase pressures on biodiversity (for example through increase eco-tourism, sport-fishing, consumption of local fish, and other potential pressures).

2.1.3 Key policy synergies, conflicts and gaps

The policy analysis identifies that current policy targets and institutional settings will both support and hinder biodiversity protection in the Faial–Pico Channel. While there are many synergies between policies, in this section, we focus on policy gaps, as these suggest opportunities to better align current policy with ecosystem-based management principles; these are made concrete in the ecosystem-based management plan that we evaluate in section 5 of this report.

Policy gap one: Lack of coordinated management of the Channel limits synergies

The current dispersion of responsibilities and management between environmental directorates (Faial and Pico Island Nature Parks, DRA), DRAM, and DRP hinders integrated and coordinated management, implementation, monitoring, and evaluation of the Faial–Pico Channel. Leaders of the Island Nature Parks have reported lacking expertise and interest in non-terrestrial protected areas (AQUACROSS 2017). DRAM has the expertise and the mandate for coordinating and regulating the MPAs but is currently lacking operational means to implement monitoring or enforcement. EBM principle 5 (*EBM supports policy coordination*) suggests that regular, formalised cooperation between environmental, fishing, and tourism governing institutions could increase MPA effectiveness and efficiency. The legal framework for fisheries–tourism policy is suggestive of the sorts of synergies that could be achieved: this policy allows commercial fishers to take up eco-tourism, sharing the benefits of tourism growth whilst potentially decreasing pressures on biodiversity from commercial fishing.

Policy gap two: Issues of scale of marine resources not reflected in policy or governance

The current split of the Channel into two separate Faial and Pico management units fails to recognise the Channel's interconnected ecosystem, and its links to the wider Azores marine ecosystem. A key benefit of MPAs are the potential positive spillover effects: MPAs have been shown to increase species richness and catch rates in neighbouring waters (Russ and Alcala 2011). Negative spillover effects can also occur, where closure of one area increases fishing effort in boundary or neighbouring zones (Murawski et al. 2005). While the Azores Marine Park legislation increase protection for nearby fishing grounds, such as the Condor Seamount, as target species and fleet differ to Channel fishers, negative externalities are not expected. Likewise, Ordinance 53/2016's increased protection for parts of the Channel may increase pressure for the unprotected areas (see Table 2). EBM principle 2 suggests that ecosystems and their biodiversity should be managed at “appropriate spatial scales” that “considers ecosystem rather than jurisdictional boundaries” (Josselin Rouillard et al. 2017). Managing the Channel as one integrated unit could help balance these competing spillover and network effects to meet local and Azorean biodiversity goals. In this way, Ordinance 53/2016 suggests a way forward: it was developed by DRAM in collaboration with DRP, who also manage the Azores Marine Park. An MPA management plan that established an integrated, cross-institutional policy group could address policy gap one and two.

Policy gap three: lack of monitoring data limits target setting and adaptive management

At present, a key policy gap identified by our policy analysis is a lack of clearly defined local biodiversity targets, and the monitoring data to evaluate their attainment. Ecosystem-based management requires decision-makers to monitor policy impact and regularly revisit management tools if objectives are not being met effectively, efficiently, and equitably (Rouillard et al. 2017). This requires monitoring and data at the appropriate spatial scale (i.e.,

Faial–Pico Channel), as well as clearly defined and spatially consistent policy objectives and targets. Ideally, this should include both ecological data (i.e., measures of biodiversity state, such as fish stocks) and socio-economic data (benefits and costs for society, e.g. fishing income, MPA visits). Our analysis indicates that a key challenge is that policy objectives are set – and existing biodiversity and economic data collected – at the national (or, in some cases, island) scale, rather than at the Faial–Pico Channel-level, making it challenging to set and evaluate quantitative local targets. Additionally, and as explored in section 3 of this report, Channel monitoring data is currently insufficient to manage biodiversity. EBM and our policy analysis suggest that a scientific biodiversity monitoring programme, supported by stakeholder evaluation, would support MPA effectiveness, and increase stakeholder buy-in; indeed this was a condition of fisher support for ordinance no. 53/2016, which in turn stipulates regular monitoring (AQUACROSS 2017).

2.2 Co-design: Stakeholder contribution to the identification of policy targets and management alternatives

Following section 2.1's identification and assessment of policy objectives, section 2.2 assesses stakeholder objectives, and how they are currently integrated into the policy process. In section 2.2.2, we summarise stakeholder objectives that differ from policy objectives. But first, in section 2.2.1, given the centrality of stakeholder participation to ecosystem-based management, we also critically appraise existing stakeholder processes within and around the Channel and make recommendations to improve future stakeholder participation, which we include in our EBM plan in section 5 of this report.

Stakeholder engagement and participation has value in its own right and is also a fundamental component of ecosystem-based management. Reed (2008) reviewed stakeholder engagement literature and found that it promotes active citizenship, increases public trust, empowers stakeholders through co-generation of knowledge, improves public perception of policy, promotes social learning, and can reduce conflict between stakeholders and lead to creative solutions to environmental problems.

In addition, stakeholder engagement is one of the defining principles of EBM (Long, Charles, and Stephenson 2015). Stakeholder involvement supports each of the EBM principles (see Table 1). It increases the quality of EBM through better information regarding the complex social-ecological system (i.e. to support EBM principles 1, 2, 3, and 4, stakeholders help to understand the current state of the ecosystem and surrounding social-ecological system, current ecosystem use, and the opportunities for improved management). Additionally, stakeholder engagement increases human welfare by ensuring that EBM accurately targets society's objectives (i.e. to support EBM principles 4 and 5, we need stakeholder engagement to understand their priorities and to identify potential conflicts, synergies, or trade-offs). Finally, ongoing stakeholder engagement is essential for adaptive management (EBM principle 6), which requires regular evaluation of management and its impacts on the ecosystem and society, the weighing off of short and long-term objectives, all under new information and with shifting stakeholder priorities.

2.2.1 Critical appraisal of existing stakeholder engagement processes in the Faial–Pico Channel

To evaluate existing stakeholder processes in the Channel we use the example of stakeholder engagement in the most recent relevant policy, Fishing Ordinance no.53/2016 (see Table 2).⁶ Theoretically, stakeholders can contribute to all stages of the policy process in the Channel: policy development/design, implementation, and ex-post evaluation (and any resulting adaptation to the evaluated management measure). At each stage, we assess the actors involved in the process, the compromises made, and the processes followed, which illustrate the current role of stakeholders in current Faial–Pico Channel management – and also suggest how stakeholder engagement can be altered from its current baseline to better match EBM principles. We pick up these conclusions in our proposed EBM plan in section 5 of this report.

Policy development/design

Ordinance no.53/2016 arose due to both bottom-up stakeholder pressure and a top-down push from the Azorean government to further protect biodiversity in the Channel. From above, Azores government has protected biodiversity in parts of the Channel since 1980 (MarBEF Data System 2006), which as discussed in section 2.1 has increased as a result of the EU (e.g. MSFD, EU Biodiversity Strategy, BHD, CFP) and Azorean policy (see Table 3). From below, stakeholder processes leading to increased biodiversity protection in neighbouring islands and seamounts increased stakeholder demand for participation in management and renewed calls for increased Faial–Pico Channel protection. Ultimately, with support from local scientists and Azores government, this culminated in an open letter by a prominent underwater photographer, Nuno Sá, calling for stronger biodiversity protection in the Channel. Unlike previous regulations, in this policy development/design stage, the responsible regional directorate (DRAM) gathered stakeholder input to support the policy design/development process, which consisted of three steps.

Firstly, DRAM engaged local scientists to prepare an independent, context-setting report on potential Faial–Pico Channel management options in the Faial–Pico Channel (Afonso et al. 2014). Succinct and written in non-technical Portuguese, the scientists shared the report with stakeholders. DRAM presented the results of this report and solicited stakeholder input at one stakeholder workshop on each island: Faial on the 23rd July, 2015, and Pico on the 25th of July, 2015. DRAM invited all stakeholders. Ultimately, 30 participants in total attended the two meetings, consisting of eleven scientists, seven policy-makers, six commercial fishers, two sport fishers, three tourism operators, and one local recreationalist. Stakeholders found the workshops productive and useful, describing a feeling of “momentum” and shared purpose. However, they were critical of the lack of representation of recreational fishers and environmental groups, and low representation of the important tourism sector; DRAM also recognised the need for better representativeness in the workshop minutes. While some stakeholders expected a follow-up meeting, or ongoing communication, following these two workshops, DRAM limited stakeholder engagement to one-on-one sectorial discussions with

⁶ This section is informed by phone and in person interviews with the following stakeholders: Joao Melo, Faial Island National Park, 12/06/2017; Paulo Reis, Azores Association of Diving Operators, 01/06/2017; Eva Giacamello, IMAR/University of Azores, 29/06/2017; Pedro Afonso and Mara Schmiing, IMAR/University of Azores, 09/05/2017; Enrico Villa, Cetacean Watching Azores, 28/06/2017; Hugo Diogo, IMAR/University of Azores, 22/06/2017; Luis Rodrigues – Faial Terra Mar Sportfishing, 12/07/2017; João Freitas, Azores Recreational Fishing Association, 4/10/2017; and multiple interviews with Adriana Ressurreição, IMAR/University of Azores, and Gilberto Carreira, DRAM. We also drew on the unpublished official minutes of these meetings, prepared by DRAM, entitled “Review of the Protected Marine Areas of the Faial–Pico Channel and surrounding area,” dated 21/7/2016, and the AQUACROSS stakeholder workshop (AQUACROSS 2017).

the most prominent group negatively affected by the new regulations, the commercial fishing representatives, which in part resulted in a commitment to monitoring impact. Some stakeholders were then surprised by the announcement of Ordinance no. 53/2016 on 21st of June, 2016.

Policy implementation

Stakeholders were not involved in the implementation, monitoring, or enforcement of Ordinance no. 53/2016. Monitoring and enforcement are the responsibility of DRP, responsible for planning, coordinating and executing, in collaboration with other agencies and institutions, the monitoring and control of fishing activity in the Autonomous Region of the Azores.

Policy evaluation

DRAM took the opportunity provided by the October 2017 AQUACROSS stakeholder workshop to gather stakeholder feedback on the policy; before this date there was no additional official stakeholder engagement in the Channel. As of August 2018, while the ordinance requires the government to annually monitor impact and disseminate results, this has not yet occurred, though it is planned to occur by late 2018. DRAM will invite stakeholders to review and discuss these monitoring results.

Stakeholder processes – gaps

The analysis of existing stakeholder processes compares the current situation of stakeholder processes to the EBM principles (see Table 1). The analysis identifies that, while the regional government has made effort and progress in stakeholder engagement, greater participation is necessary to achieve the EBM management principles. Here, we identify gaps that offer opportunities for future management to better align baseline management with EBM; these are picked up in section 5.

Stakeholder process gap one: lack of representation

While the non-technical scientific report and stakeholder workshops organised by DRAM enabled stakeholders to contribute to policy design/development, low participation from two key sectors – recreational fishing and tourism operators – meant the process was not representative. While DRAM invited these sectors to participate, ultimately only commercial fishing representatives were consulted on the final policy. EBM principle 4 calls for transparent, inclusive stakeholder engagement, to ensure resulting management considers diverse objectives. Additionally, broad local and traditional stakeholder knowledge is an essential and low-cost input for understanding the socio-ecological system. Accordingly, broader representation supports all other EBM principles.

Stakeholder process gap two: lack of ongoing stakeholder engagement

Stakeholders should be involved throughout the policy cycle, not just in the policy development stage. Adaptive management (EBM principle six) requires ongoing monitoring, evaluation, and, if necessary, adaptation of any management measures. Ongoing stakeholder engagement, for example through clear communication or regular workshops, ensures that decision-makers have full information on stakeholder objectives and priorities and feedback on whether current management is optimal or needs adjustment. Additionally, stakeholders can support implementation through participating in monitoring and supporting enforcement.

2.2.2 Co-creation: stakeholder objectives

In part due to the limitations in stakeholder processes identified in section 2.2.1, stakeholders hold additional objectives to current policy objectives (section 2.1), some of which are shared, and some which are in conflict. Drawing on AQUACROSS workshops and interviews (see section 1.2), we identify these stakeholder objectives and how they can be incorporated in section 5's proposed Faial–Pico Channel EBM plan.

Synergies: Shared stakeholder objectives

Stakeholders recognise that they share the Faial–Pico Channel MPA and come from the same community. They share four central objectives: long-term sustainability, simplified and holistic management of the Channel, regular monitoring, and ongoing participatory management (AQUACROSS 2017, 2018).

Long-term sustainability: Stakeholders agree that their central long-term objective is the long-term resilience and sustainability of the Faial–Pico Channel MPA ecosystem. Without the sustainable management of the resources, all users will suffer.

Monitoring and compliance: To ensure the long-term sustainability of the MPA, all stakeholders agree that monitoring and evaluation is necessary. In particular, fishing stakeholders, who are bearing costs of increased fishing restrictions, want to ensure that current management is effective. Accordingly, increased monitoring and reporting of the results was a top priority for all stakeholders. Commercial fishing stakeholders and diving operators also emphasised the importance of ensuring compliance, and that all stakeholders are monitored (including recreational fishers and dredgers).

Ongoing participatory management: Stakeholders want to be involved in the ongoing management of the Faial–Pico Channel, e.g. to evaluate the monitoring and compliance results and have input into any adjustments to management. A majority of workshop stakeholders support the development of an official stakeholder working group process.

Simple and holistic management: Due to the overlapping governance and regulations covering the Faial–Pico Channel, and a lack of clear and centralised information, stakeholders are confused by the current MPA management. They desire simplified management and clearer communication of regulations.

Conflicts: differing stakeholder objectives

The major stakeholder groups within the Channel also have conflicting objectives (AQUACROSS 2017, 2018). While stakeholder groups are not homogenous, here we identify the general, group-wide conflicts between key stakeholder groups. As the Channel consists of many distinct ecosystems, stakeholders also place different value on different parts of the Channel (Schmiing et al. 2015; Afonso et al. 2014). Table 2 covers this spatial dimension. Below, we focus on the Channel as a whole.

- **Commercial fishers'** top priority is access to fishing grounds and right to fish. Accordingly, there support for MPA expansions or increased fishing regulations could be contingent on proof that the MPA effectively protects biodiversity and provides benefits to fishers (e.g. increased fish stocks); monitoring and evaluation are very important.
- **Recreational fishers** prioritise protecting their right to fish, in terms of access and catch limits. They also demand increased monitoring, enforcement, and evaluation of existing

fishing restrictions, and propose environmental education to increase fishing conservation awareness.

- **Tourism operators** (diving operators) were relatively happy with Ordinance 53/2016 but would favour further MPA expansion, both for their own access and to protect and promote the Channel as an eco-tourism destination.
- **Scientists** want continued access for scientific research. Additionally, on scientific grounds, they favour MPA expansions to ensure sustainability and resilience (Afonso et al. 2014).
- **Environmental NGOs** desire increased environmental protection and education.
- **Other stakeholders:** Stakeholders such as ferry operators and dredgers prioritise their ability to continue operating

Additional stakeholder objectives – gaps in current management

This chapter's review of stakeholder processes present in the Faial–Pico Channel and of local stakeholder objectives suggests a couple of key conclusions for ongoing EBM of the Channel. The gap between policy objectives identified in chapter 2.1 and the stakeholder objectives identified in this chapter offer opportunities for improved EBM of the Faial–Pico Channel:

Stakeholder objective one – increase in stakeholder participatory management

Stakeholders want to be consulted and involved Faial–Pico Channel MPA management decisions. The stakeholder workshops in the development of Fishing Ordinance 53/2016 show that this is somewhat aligned with local policy objectives, but stakeholders' desire greater and ongoing input (AQUACROSS 2017). This is aligned with EBM principle 4's call for transparent and inclusive governance and stakeholders believe that this could additionally decrease conflict, increase knowledge, and motivate greater environmental protection (AQUACROSS 2018).

Stakeholder objective two – increase monitoring and enforcement

Monitoring and compliance were not a priority in policy implementation but are very important to stakeholders who participated in the AQUACROSS process. Stakeholders desire greater monitoring and regular evaluations of the effectiveness of the MPA policy. Stakeholders also placed a priority on increased enforcement to ensure compliance. This objective aligns with adaptive management (EBM principle 6).

Stakeholder objective three – holistic management

Stakeholders find the current patchwork of overlapping policies, institutions, and regulations confusing, and argue for simplified management. At the same time, as interrelated members of a relatively small community, they take a broad, cross-sector view of Faial–Pico Channel. They recognise that they as a community all benefit when individual sectors benefit, and all depend on the Channel's sustainability. In line with EBM principle 1's focus on ecological integrity and EBM principle 5 (policy coordination), they argue for an integrated management approach that considers the cumulative and spillover effects of tourism, and recreational and commercial fishing, and the overall sustainability and resilience of the ecosystem.

3 Assessing the current state of the social–ecological system

Having identified current policy and stakeholder objectives, in this chapter we assess the current state of the Faial–Pico Channel Social–Ecological System (SES), the second step in the

AQUACROSS Assessment Framework. EBM relies on multi-disciplinary knowledge (EBM principle 3) and depends on understanding the dynamic interlinkages within the ecosystem (EBM principle 1). To understand these aspects of the SES, we use the AQUACROSS Butterfly; see Figure 2 (Gómez et al. 2017). Section 3.1 summarises societal drivers (and associated activities), the resulting pressures, and the state of biodiversity in the ecosystem (the right hand side of the butterfly). Section 3.2 presents our understanding of how biodiversity links to ecosystem functions, and how they support the delivery of the ecosystem services enjoyed by society (left side of the butterfly).

We apply the semi-quantitative AQUACROSS Linkage Framework to identify the Faial–Pico Channel's most important drivers, pressures, ecosystem components (which stand in for ecosystem state/biodiversity), ecosystem-functions, and ecosystem-services (Nogueira et al. 2016; Pletterbauer et al. 2017). Where, possible, we then use the limited quantitative data to understand their current baseline state. This understanding of the state of the SES and the

important links between the elements informs our summary of the baseline scenario in section 4 of this report, and helps to identify and evaluate the system-wide impact of EBM measures in section 5.

AQUACROSS Linkages Framework

The AQUACROSS Linkage Framework aims to operationalise the concept of SES by developing linkage matrices, based on the AQUACROSS Assessment Framework (Nogueira et al. 2016; Pletterbauer et al. 2017). These are useful for policy management, as they show how changes in one element of the system (for example, due to new management), can impact other elements of the system, and ultimately flow through to affect ecosystem supply. To apply this methodology, we identified comprehensive lists of activities in the Faial–Pico Channel, and linked these to pressures that

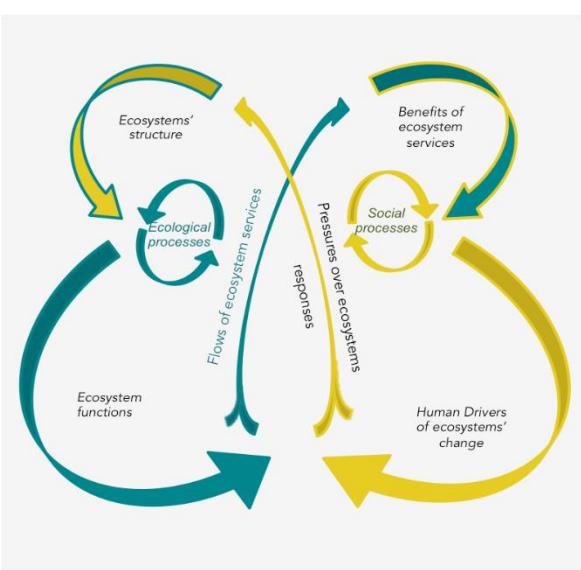


Figure 2: AQUACROSS Social-Ecological System Butterfly

they placed on different ecosystem components (i.e. EUNIS habitats and mobile bioitic groups (e.g. fish), within the Faial–Pico Channel. We then linked these ecosystem components with associated ecosystem functions, and these functions with ecosystem services. We then analysed the resulting linkage framework, along with stakeholder input, to identify the most important elements⁷ of the Faial–Pico Channel ecosystem. The full AQUACROSS Linkage Framework is shown graphically in section 3.3. In section 3.1 and 3.2, we report summary results and use this and stakeholder feedback to identify the key elements of the Faial–Pico Channel system, and to assess interesting relationships within it. We also present an overview of quantitative data describing the current state of these key elements.

⁷ We use connectance to identify the most central and important elements. Mathematically, an element's connectance equals the fraction of all possible links in a network that include the element. Greater connectance implies greater centrality, implying wider impacts. Two caveats to this measure: the structure of the network affects connectance scores. Additionally, connectance does not express the strength of relationships, just their existence. Accordingly, we combine our assessment of the AQUACROSS Linkage Framework (using connectance) with insights from stakeholders and policy.

3.1 Assessment of current Drivers–Pressures–State

3.1.1 D-P-S: AQUACROSS Linkage Framework insights

For the Faial–Pico Channel, the AQUACROSS Linkage Framework identifies a total of 24 primary activities (out of the possible 54 aggregate activity types in the AQUACROSS typology), including residential and commercial development, coastal defences, shipping, scientific research, and exogenous pressures related to climate change. These exert a wide variety of types of pressures: out of 41 potential pressures, primary activities in the Faial–Pico Channel

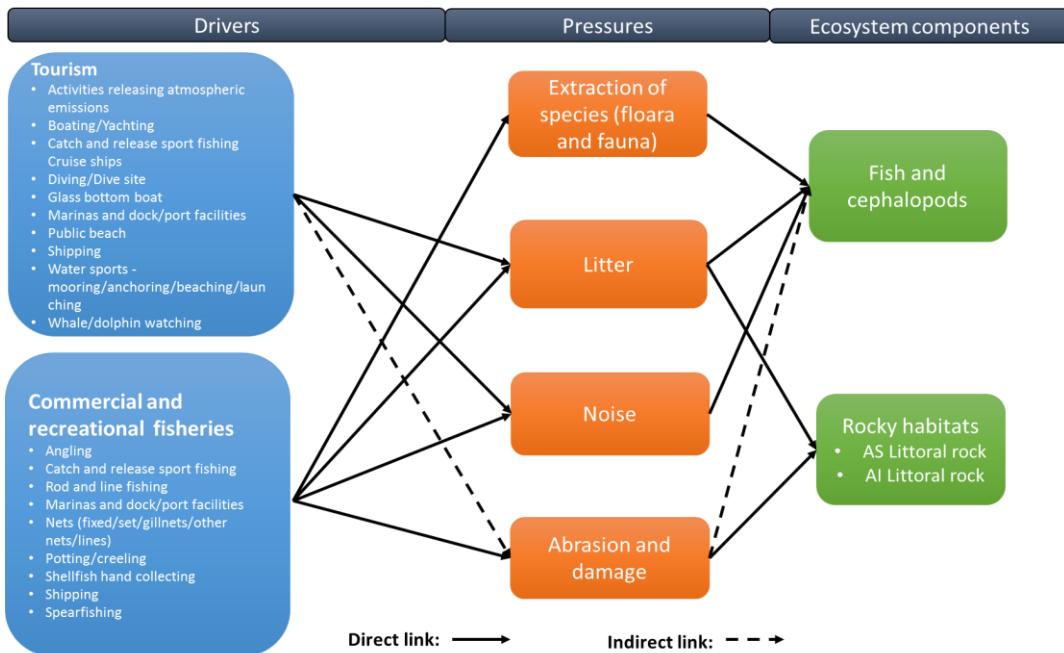


Figure 3: Simplified driver–pressure–state linkage framework for the Faial–Pico Channel SES

introduce 34⁸. Overall, at the EUNIS 2 level, we identify 2084 interactions between an activity, a pressure and an ecosystem component. Figure 3 presents a simplified driver–pressure–state linkage framework that summarises the results of this analysis and stakeholder input.

The linkage framework lends itself to analysis of links between activities, pressures, and environmental state. Due to space constraints, we focus only on conclusions related to trade-offs between tourism and fishing, a key concern of policy-makers and stakeholders (see section 2). Our analysis shows that both sectors place many of the same pressures on the ecosystem, such as litter and noise. Unsurprisingly, fishing is most associated with the key pressure of extraction of fauna and flora. The linkage framework also assesses impacts over time: we find that fishing exerts more acute pressures, while tourism is associated with pressures that are more chronic. Accordingly, policies targeting fisheries will more swiftly decrease pressures than tourism–targeted policies.

3.1.2 D-P-S: Selected indicators of baseline state of SES

After identifying key drivers, pressures, and state, we attempt to identify indicators for each key element, and summarise its baseline state, in line with the AQUACROSS Assessment Framework and Nogueira et al.’s (2016) indicator selection guidance. To be selected, an indicator must adequately represent the complex process it simplifies, and must have a

⁸ These pressures have differing weights and frequencies, and accordingly differing impacts on biodiversity.

measure that is regularly collected and publically available. Policy-makers can use these indicators to understand the system, set quantitative targets, and monitor and evaluate trends and the impact of management measures. Table 4 reports our selected indicators, their current level, and discusses trends, as well as commenting on the adequacy of the indicator to support EBM.

The key conclusion of this analysis is that lacking quantitative Faial–Pico Channel data limits ability to apply EBM. The small scale and trans-boundary nature of the case study makes it difficult to use Azores-level data. EBM management of the Channel calls for collecting and developing more specific Faial–Pico Channel data, especially to measure environmental state.

Measuring environmental state

As Table 4 makes clear, the paucity of useful data is a particular challenge when it comes to assessing and monitoring environmental state, especially in the small and unique Faial–Pico Channel. Data is also currently lacking at the national scale, for example, the Azores is still identifying MSFD indicators for Descriptors 1 (Biodiversity) and 3 (Commercial fish and shellfish), and has not yet collected and published data (Carreira 2016), though the development of indicators and implementation of the MSFD is in progress. While University of Azores researchers have maintained an intermittent visual fish census in the Channel (see Schmiing et al. 2014), its funding has not been a management priority and data has not been published. DRAM recognises these issues and is now funding the Channel monitoring and seeking more sustainable financing. . faced inter not currently funded to continue. It is important to note that the Azores govern

Given the data restrictions, our understanding of the ecosystem state is dependent on one-off scientific studies (Schmiing et al. 2014), which are unable to shed light on trends, qualitative stakeholder reports (AQUACROSS 2018), and inadequate indicators (e.g. fish catch at local ports). Overall, the available research and qualitative reports indicate that biodiversity and ecosystem state is below where it was in the 1950s and even 1980s, but still remains in moderate to good health. However, local stakeholder groups (recreational fishers, commercial fishers, and scientists) anecdotally report decreasing fish stocks (AQUACROSS 2018).

A conclusion of this section is that the Faial–Pico Channel needs consistent monitoring of biodiversity. At a minimum, these should focus on fish (commercial fish stock assessments, visual assessment of fish abundances in the Channel), but it would also be useful to include broader measures of biodiversity, for example the number and condition of dolphin populations, seabed habitats, invertebrates and marine plants. Potential indicators include number of commercial fish taxa in the Channel (Schmiing et al. 2014), and diversity indices based on these data. Additionally, management could also target birds and marine mammal population, where there may be more data. Management should also monitor habitat state. Without these data and the related indicators, regulators cannot understand current state or trends, which are essential for setting and evaluating policy targets. These targets are in turn essential to measure the effectiveness and efficiency of environmental protection measures.

3.2 Assessment of current Biodiversity–Ecosystem Functioning–Ecosystem Services

3.2.1 B-EF-ESS: AQUACROSS Linkage Framework insights

We apply the AQUACROSS Linkage Framework to understand the ecological side of the Faial–Pico SES: its ecosystem state (biodiversity), ecosystem functions, and ecosystem services (Nogueira et al. 2016). The Faial–Pico Channel case study covers two realms (oceanic and coastal), and consists of eleven ecosystem components: four biotic groups (birds, mammals, reptiles, fish and cephalopods), and seven EUNIS 2 habitat types. These support a total of nineteen ecosystem functions, including primary and secondary production, nutrient cycling, carbon sequestration, and provision of breeding, nursery and feeding grounds. These in turn support fifteen ecosystem services, including provisioning (e.g. fish), regulation and maintenance services (e.g. lifecycle maintenance, maintenance of water conditions), and cultural services (e.g. recreational interactions and existence value), as well as nine abiotic outputs. Figure 5 shows the simplified SES summarising this system, as well as identifying the stakeholder groups that benefit from the ecosystem services.

Of most relevant to policy management, we identify fish and infralittoral rock and other hard substrata habitats as the central ecosystem components in the Channel SES. Fish are highly valued by all stakeholders. We find that rocky habitats support the most ecosystem functions and were associated with the most ecosystem services. This aligns with recent research on values of biodiversity indices around the Faial and Pico islands, which shows that the highest values were linked to rocky habitat, which provide refuge and substrate for various marine species, making rocky habitats important sites for fishing and diving (Schmiing et al. 2014). In line with EBM principle 1, management should prioritise protection of these central and valued ecosystem components.

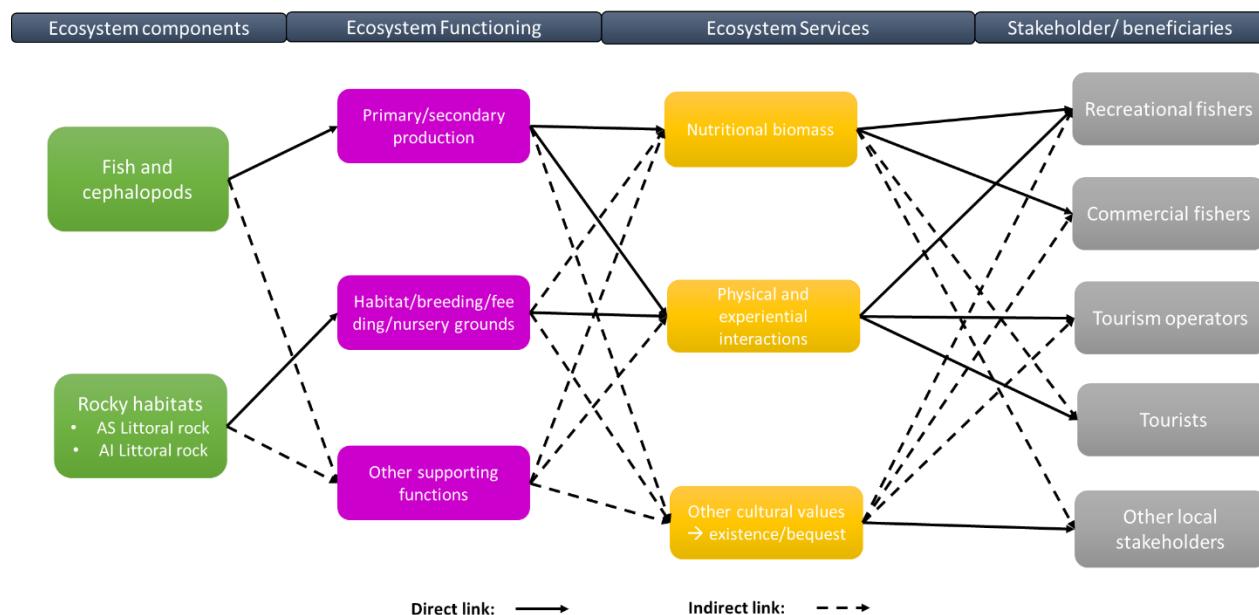


Figure 4 Simplified state (biodiversity) – ecosystem–functioning – ecosystem services – beneficiaries linkage framework for the Faial–Pico Channel SES

Table 4: Selected indicators for elements of the simplified Faial–Pico Channel SES, current levels, baseline trends (2018–2050), and discussion

	Indicator analysis				Baseline trend analysis (2018–2050)	
	Element	Selected indicator	Current state	Indicator quality comments	Trend	Discussion
External driver	Climate change	Sea level	Currently rising at 16.8 mm/year <i>Source: (Calado et al. 2011)</i>	Adequate	↗	Climate change will have far-reaching impacts on the Azores, with increased sea levels and storms, erosion, pressure on fresh water
	Global economy	Annual Azores GDP growth per capita	2.6% (on average from 2000–2016) <i>Source: EUROSTAT: GDP at current market prices by NUTS2 region.</i>	Adequate	→	At €16,000 per capita in 2016, the Azores GDP is equal to 55% of the European average.
Driver	Tourism	Annual number of nights stayed in Faial and Pico	228,329 (2016) <i>Source: SREA: Nights stayed on Faial and Pico islands</i>	Adequate	↗	This has increased on average by 5.1% annually every year between 2001 and 2016.
	Fishing	Fishermen employed in Azores	3151 (2015) <i>Source: INE, Fishermen registered at 31 December on national ports (No.)</i>	Low quality, only Azores data available. Alternative indicators include average fish price, value of fisheries catch.	↘	Fisheries employment has fluctuated over last twenty years.
Pressures	Extraction of species	Commercial fishing: Nominal annual catch (tonnes) landed at Faial or Pico ports	1,282,000 tonnes (2016) <i>Source: INE: Nominal catch (t) by Landed port and Specie; Annual (2)</i>	Very low quality, as vast majority of catch is landed outside Channel	?	Annual catch landed at Faial–Pico ports has fluctuated between 1.2 – 6.8 million tonnes between 2000–2016, making this a very difficult indicator to apply
		Recreational fishing: Boat fishing licences Spearfishing licences	– Available from DRAM but not collected in time for report.	Low quality, does not include angling, rough estimate of pressure.	?	No indicators for size of recreational catch, despite being equivalent to 49.5% of commercial fish extracted from around Faial and Pico islands (Diogo and Pereira 2013). Can potentially extrapolate from spear and boat fishing licences.
	Others	No indicators for litter, noise, abrasion	–	No indicator	?	
Ecosystem state/biodiversity	Fish /cephalopods	No indicators– see discussion in text	–	No indicator, serious challenge for management	↘	Global trends show declining marine biodiversity; in absence of data, local stakeholders and scientists report anecdotally confirm this trend in Channel.
	Rocky habitats	No indicators– see discussion in text	–	No indicator, serious challenge for management	?	
Ecosystem functioning		Not investigated for this study	–	Not investigated		
Ecosystem services	Provisioning: biomass: nutrition	Commercial fishing: Annual catch (value, €) landed at Faial/Pico ports	€4,951,000 (2016) <i>Source: INE: Nominal catch (value, €) by Landed port and Specie; Annual (2)</i>	Very low quality, as vast majority of catch is landed outside Channel	?	Value of annual catch has fluctuated from 3.2– 12.0 million Euro between 2000–2016, making this a very difficult indicator to apply
		Recreational fishing: No indicator for value of catch	–	No indicator	?	No indicators for value of recreational catch, despite equivalence to 49.5% of commercial fish catch around Faial and Pico islands (Diogo and Pereira 2013)
	Cultural: Experiential/ physical interactions with ecosystem	Overall: Annual number of nights stayed in Faial and Pico	228,329 (2016) <i>Source: SREA: Nights stayed on Faial and Pico islands</i>	Low quality: tourists visit Faial–Pico hotels for many reasons, not just Channel experiences.	↗	This has increased on average by 5.1% annually every year between 2001 and 2016.
		Recreational fishing: Boat fishing licences Spearfishing licences	–Available from DRAM but not collected in time for report.	Adequate for boat and spear fishers No indicator for anglers	?	Boat and spear fishers require a licence; data are available from DRAM. However, currently no licence required for angling, and thus no data.

	Diving: Annual dives in the Channel	32–45,000 (2017) Source: own calculations based on personal communications.	No official indicator, collecting/publishing this data would support management	↗	No official statistics exist. Anecdotally, diving tourism is growing swiftly.
Cultural: existence/bequest	No indicator	-	No indicator, challenging to collect indicators of non-use value.	?	-

3.2.2 B-EF-ESS: Selected indicators of baseline state of SES

Table 4 shows selected indicators for ecosystem state/biodiversity (section 3.1.2 discusses these indicators for environmental state) and ecosystem services. We do not investigate indicators for ecosystem functioning in this study.

Our analysis of indicators for ecosystem services identifies further quantitative data gaps that limit management. The AQUACROSS linkage framework and stakeholders identified three key ecosystem services that beneficiaries value in the Channel. Commercial and recreational fishers value fish caught for consumption. However, no current indicators adequately measure this ecosystem service flow: with the exception of one-off studies (e.g. Diogo and Pereira 2014), recreational fishing is poorly monitored, and the best commercial fishing indicator we can propose is a poor measure of fish caught from the Channel; EBM requires development of better indicators of this important ecosystem service. The second key ecosystem service, experiential and physical interactions provided by the ecosystem (e.g. diving, recreational fishing, other recreational activities) is broad, so we propose three indicators: tourist nights on Faial and Pico islands (as an overall measure of tourism enjoyment of this ecosystem service), the number of dives in the Channel, and the number of recreational fishers on Faial and Pico islands (spear fishers, boat fishers and anglers). Only the first indicator is currently collected. The development of the other indicators offers opportunity for improved EBM management. Local stakeholders place great value on the final ecosystem service, existence/bequest value of the Channel (AQUACROSS 2017; Ressurreição et al. 2012). However, it is very difficult to measure these non-use values with an indicator.

3.3 Linkage framework

The diagram of the full linkage framework is reported in the Appendix.

3.4 Assessing the knowledge base of the ecological system

Understanding an SES is essential for EBM. In sections 3.1–3.3, we present our current understanding of the Faial–Pico Channel SES, based on the current knowledge base. However, this knowledge base is not static. We follow Piet et al. (2017) and analyse the knowledge base underlying our understanding of the Faial–Pico Channel (3.4), and assess its adequacy for applying EBM. We conclude that a lack of environmental data is the most pressing gap in the current knowledge base. The Channel lacks long-term, time-series data measuring biodiversity, which limits our ability to understand current trends and threats, and to manage biodiversity and ecosystem integrity. Additionally, existing local-level socio-economic data is inadequate to set targets, monitor, or evaluate EBM. EBM principle 3 calls for the use and development of interdisciplinary data. In light of this and this clear knowledge gap, in section 5 we evaluate increased monitoring as part of our proposed EBM plan.

3.5 Assessing the knowledge base of the social system

The current governance and policy settings also determine current management in the Faial–Pico Channel, ultimately determining local capacity to implement EBM. We described these in

sections 2.1 and 2.2. Here, we follow Piet et al. (2017), and analyse the Faial–Pico Channel social system to identify weaknesses in current governance and opportunities for better alignment with EBM principles. As identified in section 2, current governance is split both geographically (between Faial and Pico island) and by policy area (environmental, fishing, and tourism goals are set in isolation). EBM principles call for integrated, coordinated policy-making, and that this occurs at the ecosystem scale. EBM also calls for greater stakeholder participation. In our EBM plan in section 5, we address these weaknesses in the social system.

3.6 Co-design

Local stakeholders supported our characterisation of the Faial–Pico Channel. They supported the development of simplified linkage framework and proposed indicators by giving feedback on identified linkages and data for quantitative indicators. They also gave feedback on the resulting simplified linkage framework (i.e. Figure 4 and Figure 5) and the proposed indicators (Table 4) (AQUACROSS 2018).

4 The baseline and future scenarios

Having characterised the policy/stakeholder objectives, and current governance/policy settings in section 2, and characterising the current state of the Faial–Pico SES in section 3, in this section we use this information to look forward and create a baseline scenario, 2018–2050. Scenarios are valuable as they provide a vehicle for incorporating diverse information into a comprehensive, actionable vision of the expected future (Gómez et al. 2017). EBM demands a holistic and long-term perspective, as SES are complex and interlinked and can evolve slowly, with the impact of some management measures taking decades to have full affect.

In section 4.1, we describe our baseline scenario. We then perform a deficit analysis, comparing this baseline scenario to the policy and stakeholder objectives identified in section 2. Section 4.2 describes our scenario methodology. Due to data limitations and the objectives of our case study, we apply qualitative methods to develop our baseline scenario. We use the available quantitative data (see section 3.1 and 3.2) to identify trends in the key elements of the SES. We also draw on external climate, biodiversity, and economic forecasts. Scientists, decision makers, and other stakeholders have co-created the scenarios by providing feedback and data.

4.1 Identifying gaps between baseline and objectives

Our baseline scenario (2018–2050) assumes that existing policies (identified in chapter 2.1) will continue in their current form and be implemented in the same way, and integrates scientific projections about the future of economic development, climate change, and biodiversity (as identified in chapter 3). In the scenario, we focus on the development of drivers (especially in fisheries and tourism), biodiversity trends, and impacts on stakeholders. Since all elements of the SES are interlinked, the impacts on drivers and stakeholders will affect and be affected by other elements of the SES. Trends in the key elements of our simplified SES are shown in the 5th and 6th column of Table 4.

4.1.1 Baseline scenario: summary

Based on the conditions outlined above, between 2018–2050, we expect the following:

- Though there will be some positive regulatory impacts on **marine ecosystems and species**, marine biodiversity will continue to deteriorate overall, counteracting and limiting some

positive developments in tourism as this key touristic asset declines. Other local stakeholders will also bear the negative impact of a loss of physical and experiential interactions with the ecosystem, and existence and bequest value.

- **Tourism** income, visitors, and associated ecosystem pressures will increase. Especially marine, nature, and sports tourism will increase, with an increase on associated pressures on ecosystems (see Chapter 3). However, tourism demand will remain subject to macroeconomic instability, leading to periods of high and low income for **tourism operators**. With declining ecosystem conditions, it will become more difficult to offer high-quality tourism experiences. **Tourists** will have mixed changes to their welfare, as there will be more opportunities to partake in marine-related tourism and leisure, but the quality of the nature overall will decline, having a negative impact on the quality of the tourist experience.
- **Fisheries** are likely to experience declining fish stocks if the Faial–Pico channel follows current global trends. Climate change will result in changes in fish distributions, meaning fisheries will have to adapt to the movement/decline of some species and potential increases in others. The final impact on **commercial and recreational fishers'** welfare is yet unclear, as it is uncertain how fish prices will develop based on current data.
- Overall, there are large uncertainties, especially in regards to biodiversity and environmental trends. This demands an adaptive approach to managing the Channel, with regular monitoring, evaluation, and if necessary, change in management.

4.1.2 Baseline scenario gap analysis

This baseline future will fail to achieve objectives or to take advantage of some of the EBM opportunities for improved management identified in chapters 2 and 3. Here, we summarise these objectives and identify the likely deficit in the baseline scenario. The EBM Plan Goals column shows how each deficit motivates our EBM plan in chapter 5.

Table 5 Baseline scenario gap analysis and implications for EBM plan goals

Objective	Deficit in baseline scenario	EBM Plan Goals
Conserve marine biological resources and establish protection mechanisms to preserve and manage ecosystems and biodiversity (see Island Nature Parks – Regional Legislative Decree n.º15/2012/A And Faial Island Nature Park and Pico Island Nature Park (DLR46/2008/A, DLR20/2008/A))	Marine biological resources , including fisheries, will continue to decline.	1. Sustain marine biodiversity
Ensure that fisheries contribute to environmental sustainability and economic and social development in the long term (see Faial– Pico Channel Fishing Ordinance no. 53/2016)	Current lack of biodiversity or fishing data or monitoring limits accurate assessment of fishery activities' contribution to environmental sustainability.	2. Improve monitoring
Protect and soundly manage marine protected areas for marine environmental reasons (see Island Nature Parks – Regional Legislative Decree n.º15/2012/A And Faial Island Nature Park and Pico Island Nature Park (DLR46/2008/A, DLR20/2008/A))	Stakeholders identify poor compliance with existing regulations and low enforcement , meaning current policies cannot avert biodiversity loss.	3. Increase compliance with biodiversity/fishing regulations
Comprehensive management of the channel according to ecological boundaries (AQUACROSS 2017, 2018)	Fragmented management of the Channel (e.g. marine nature parks) will continue according to administrative and sectoral boundaries and not ecological boundaries, limiting coordination and achievement of multiple objectives.	4. Integrate Channel management

Stakeholder participation in management (decision making, implementation, evaluation) (AQUACROSS 2017, 2018)	<p>Stakeholder engagement will continue to be informal and somewhat non-representative as was the case with Fishing Ordinance 53/2016, limiting understanding of SES, adequate recognition of whole society values, and adaptive management</p>	<p>5. Increase stakeholder engagement and participation in management</p>
Promote sustainable development (see Island Nature Parks – Regional Legislative Decree n.º15/2012/A And Faial Island Nature Park and Pico Island Nature Park (46/2008/A, 20/2008/A))	<p>Income and tourism (especially marine tourism) is likely to increase. This tourism will lead to additional pressures on the ecosystem, but will also result in increased financing for biodiversity protection.</p>	<p>6. Sustainably finance biodiversity protection</p>

4.2 Scenario development

Figure 7 illustrates how we apply an explorative, descriptive methodology to define our baseline scenario (Martin 2017). This matches our objective, of co-developing a scenario with diverse stakeholders to understand current challenges, set shared objectives, and evaluate potential EBM measures. This descriptive approach was also motivated by the lack of quantitative data, as discussed in section 3 of this report. A qualitative, narrative approach, however, provides information about the likely trajectory of key indicators, in a format that is easy to discuss with stakeholders (Martin 2017). The limitation of this approach is that it is not possible to present precise or quantified estimates of future developments, and that estimates based heavily on global rather than local data and carry a high degree of uncertainty.

As well as the quantitative data described section 3, our scenario builds on a literature review of relevant external scenarios. These include global economic trends (International Monetary Fund 2018; Garda and Ziemann 2014), climate change impacts for the Azores (Calado et al. 2011), as well as climate impacts on fish species and their changing distributions (Monllor-Hurtado, Pennino, and Sanchez-Lizaso 2017; Stefanni et al. 2015; Muhling et al. 2015).

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graph LR; A[Literature review] --> B[Data collection]; B -.-> C[1st Workshop]
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The diagram illustrates the research process. It starts with a box labeled "Literature review". An arrow points from this box to a larger box labeled "Data collection". Inside the "Data collection" box, there is a smaller box labeled "1st Workshop". A dashed arrow points from the "Data collection" box towards the "1st Workshop" box.

Finally, we rely on stakeholder input. Along with the two stakeholder workshops with diverse stakeholder participants, our scenarios are based on interviews with local scientists, fisheries, tourism, and environmental stakeholders, and policy-makers. We also draw on synergies with existing/ongoing local processes and projects (e.g. existing stakeholder engagement in local MPA planning, and the MarSP project on maritime spatial planning).

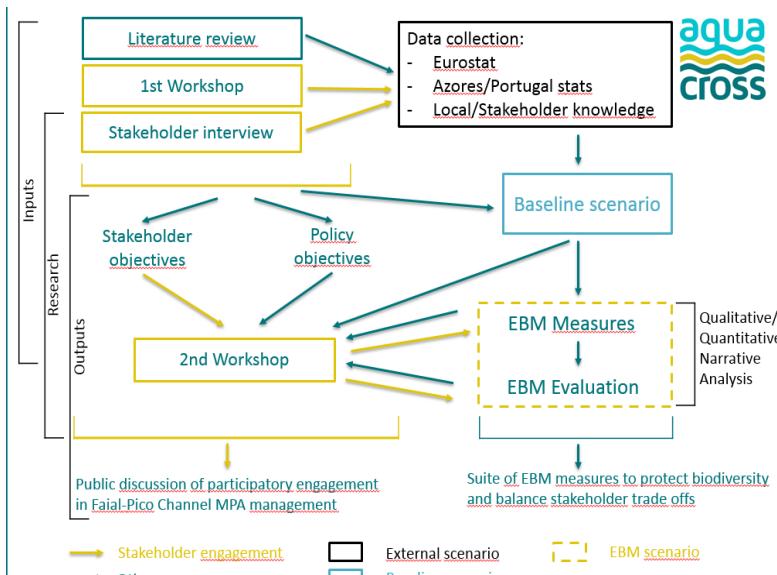


Figure 5: Model analysis and scenario development in the Faial–Pico Channel Case Study

5 Ecosystem-based management plan evaluation

In section 5, we propose an ecosystem-based management plan, and evaluate it before making recommendations for its potential implementation. The EBM plan was co-created with input from local stakeholders and policy-makers. They suggested a long list of potential measures/policy instruments in interviews and at an initial workshop (AQUACROSS 2017). At the subsequent workshop, they selected priority options and developed how these policy instruments should be implemented in the Channel (AQUACROSS 2018). While the EBM plan aims to increase the long-run sustainability of the Faial–Pico Channel SES, it does not propose measures that directly target the Channel’s environmental state. While stakeholders discussed such measures, e.g. changing the size or location of the MPA or introducing new fishing regulations (AQUACROSS 2018), given the recent 2016 changes to the MPA, stakeholders and policy-makers were disinterested of having a renewed discussion on general MPA objectives. Instead, as the baseline scenario gap analysis shows (Table 5), stakeholders and policy-makers prioritised policy instruments and supporting implements to increase the effectiveness of existing measures. This also aligns with our overall research goal of identifying how EBM can increase the efficacy and equity of existing MPAs to achieve biodiversity goals.

Section 5 proceeds as follows: in 5.1 we describe the basket of measures and policy instruments that make up the EBM plan. In section 5.2 we evaluate the effectiveness, efficiency, and equity of the EBM plan, relative to the baseline scenario. In section 5.3 we evaluate the plan relative to the EBM principles. Section 5.4 briefly discusses the preconditions for implementation. Throughout, we draw on policy and stakeholder objectives identified in section 2, the characterisation of the Faial–Pico Channel SES in chapter 3, and the baseline scenario gap analysis in chapter 4.

5.1 Detailed specification of relevant EBM solutions

The Faial–Pico Channel EBM plan consists of five elements: increased biodiversity monitoring, raising awareness of biodiversity’s importance and clearly communicating biodiversity-related rules and regulations to all stakeholders, increased enforcement of those rules and regulations, and greater stakeholder participation and better-coordinated governance of the Channel. To cover the costs of the EBM plan and distribute the benefits of the swiftly growing tourism industry, we consider how a tourist tax or diving fee can cover the direct financial costs of the plan.

As described above, the EBM policy instruments were co-created with stakeholders, drawing on the analysis presented in the previous chapters. After stakeholders prioritised measures, we then follow Piet et al. (2017) and pre-screen all measures/instruments to ensure that they were cost effective (i.e. achieved their objective at lowest cost), politically and administratively feasible within the 2018–2050 timeline, among other conditions.⁹

Policy instruments

1: Long-term monitoring by scientists: A clear priority measure for stakeholders is increased environmental monitoring of the Channel (AQUACROSS 2017, 2018). The lack of biodiversity state or trend data for the Channel is a challenge for ecosystem-based management, which is

⁹ This pre-screening resulted in the exclusion of a number of policy instruments, including a voluntary monitoring programme, a biodiversity education programme for tourism operators, a community reporting line for enforcement, among others.

reliant on a clear understanding of the social-ecological system. Accordingly, we evaluate an ongoing biennial biodiversity monitoring programme by local scientists that extends the existing fish visual census data collected by scientists at the University of the Azores (used for example in Schmiing et al. 2015). This monitoring requires teams of two scuba divers to complete approximately 60 dives per year¹⁰, and then a trained computer scientist to process the data. DRAM should store and publically disseminate the data, to maximise its use and value. While monitoring can be expensive, Lovett et al. (2007) conclude that these costs are tiny relative to the overall costs of implementing environmental regulation; the expected benefits of better-informed decisions outweigh the costs of collecting the information (Nygård et al. 2016), especially when starting with little monitoring (Grantham et al. 2008).

2: Stakeholder Advisory Group: Faial-Pico Channel stakeholders would like to have greater say in managing the Faial-Pico Channel, whether that is in the form of informal consultation, input on specific policies, or a formal Stakeholder Advisory Group (AQUACROSS 2018). We propose establishing a stakeholder advisory group, which would be made up of a representative group of stakeholders (based on the Island Nature Parks' "grupo consultivo") who meet annually and would have a supervisory role, contributing to monitoring/evaluation, proposing solutions, and promoting multiple-use and synergies. Luyet et al. (2012) list the following advantages of stakeholder participation in natural resources management: better trust in and acceptance of decisions; improved project design by integrating local knowledge and diverse interests; improved implementation of plans and projects; fostering and developing social learning. Applied to Faial-Pico Channel, the Stakeholder Advisory Group would improve the overall effectiveness of current management through greater stakeholder participation. In the context of the two AQUACROSS workshops, local stakeholders specified that the setup of such a group would lead to reduced conflict between beneficiaries of Channel ecosystem services, improved knowledge, and increased environmental protection (AQUACROSS 2018). These advantages of a participatory management approach need to be weighed against potential risks, i.e. the direct and indirect costs related to the implementation of such an approach (Luyet et al. 2012). If managed properly, however, stakeholder participation in public decision-making and specifically in natural resource management may create benefits for both policy-makers and local stakeholders.

3: Integrated policy coordination group: The policy gap analysis identified the need for integrated and coordinated management of the Channel. We propose that the Faial-Pico Channel is managed as one unit by a coordinating policy group. To maximise policy synergies and to manage across jurisdictional boundaries, the policy coordination group should feature representatives from DRAM, the Faial and Pico Island Nature Parks, and the Regional Directorates for fisheries, biodiversity, and tourism. The group should meet quarterly to coordinate policy, enforcement, and monitoring and evaluation. This "whole-of-government approach" entails that "public service agencies work across portfolio boundaries to achieve a shared goal and an integrated government response to particular issues" (Australian Management Advisory Committee 2004). This can result in more efficient allocation of human resources and finances amongst departments, and increase communication from local to national levels (Christensen and Lægreid 2007). In the context of the Faial-Pico Channel, the practical implementation of such an approach could facilitate the joint management of the Channel as one unit, thereby overcoming the siloed (and thus less effective) management

¹⁰ Schmiing et al. (2014) report that data collection for their paper consisted of 462 dives over 7 years.

approaches undertaken by the individual departments/public entities, and streamline monitoring and evaluation.

4. Simplify and communicate existing biodiversity/fishing regulations: Low compliance with regulations has been found in recreational fisheries in the Channel (Diogo, Gil Pereira, and Schmiing 2016). Stakeholders believe that a lack of local awareness and knowledge inhibits the full enforcement of existing biodiversity and fishing regulations, and therefore inhibits the achievement of policy targets (AQUACROSS 2018). Accordingly, we propose that existing fishing and biodiversity regulations in the Channel are simplified and communicated through information panels at strategic locations: the harbour, the marina, boat ramps on both islands, and the permitted shore angling sites at Ilhas da Madelena and Monte da Guia (a total of 15 information panels).

5. Increase enforcement: Local stakeholders also desire increased enforcement. Fines are key tool for enforcing compliance with fisheries and biodiversity legislation (European Parliament 2014). Fishers respond to the level of expected sanctions, which is determined by (1) the probability of being apprehended and (2) the sanction level (Gallic and Cox 2006). As increasing fines exclusively for the Faial–Pico Channel is politically and administratively challenging, we focus on increasing the probability of being caught fishing illegally by installing surveillance cameras. This has already been trialled in the Azores at the Formigas Islets. Additionally, stakeholders desire increased punishment for repeat offenders (AQUACROSS 2018).

6. Financing – We evaluate the impact of a sustainability tax and/or a fee on diving in section 5.2.2.

5.2 Setting the evaluation criteria

Following Piet et al (2017), we evaluate the difference between the baseline scenario and the EBM scenario outlined above by applying three criteria: effectiveness, efficiency, and equity/fairness, with a timescale of 2018–2050.

5.2.1 Effectiveness

As identified in Table 6, the EBM Plan will have some direct impacts on the Faial–Pico Channel. Together, EBM elements 4 and 5 increase enforcement and awareness of existing fisheries/biodiversity regulations. This will lead to increased compliance, which will directly affect commercial fisheries, a driver, and decrease the Channel's major pressure, which is extraction of species. Additionally, the financing measure negatively affects the driver tourism: the tax or diving fee increase the cost of visiting the Channel, decreasing demand. Together, the decreases in these drivers and pressures have positive flow-on environmental effects that we identify using the AQUACROSS Linkage Framework. Generally, these will have positive biodiversity affects: the key ecosystem component fish will be positively affected (due to lower extraction of species), and to a lesser extent rocky habitats (through decreased pressures from commercial/recreational fishing and tourist boats). We discuss expected impacts on ecosystem services in Table 6, section 5.2.2.

Additionally, the EBM Plan will support management in other ways. Stakeholders identified that the policy instruments will increase knowledge of the environmental state of the Channel, understanding of the complex social–ecological system, will increase compliance with existing regulation, and will increase coordination and cooperation. Each of these benefits supports decision-makers to monitor the environmental state of the Channel, evaluate the impact of

existing regulation, and, together with societal input, adapt management in the future to best meet broad objectives, which include protecting biodiversity. In addition, the increased integration of policy management should support the different regional directorates to identify shared goals for the Channel, streamlining policy implementation and minimising the conflicting policy impacts identified in section 2.1. Finally, improved compliance will increase the effectiveness of existing regulation – and of whatever regulation the stakeholder advisory group and integrated policy coordination group implement in the future.

However, overall, we cannot evaluate the environmental effect of the EBM Plan: while the additional monitoring, stakeholder advisory group, policy coordination, and financing enable adaptive management that in turn will improve policy-makers and stakeholders ability to protect long-run biodiversity, they do not directly affect the ecosystem. The ultimate environmental impact depends on the future management decisions that are taken under the new governance arrangements. While stakeholders believe that a stakeholder advisory group would result in greater environmental protection and increases in biodiversity (AQUACROSS 2018), beyond the qualitative conclusions reported above, we cannot properly assess environmental effectiveness of the EBM plan as a whole.

5.2.2 Efficiency

Assessing economic efficiency of the EBM Plan requires an understanding of its direct and indirect costs and benefits. However, given the indirect, supporting nature of the majority of elements of the EBM Plan, we cannot quantitatively assess this. However, using the linkage framework introduced in section 3.1 and 3.2, we can qualitatively assess how the three most important ecosystem-services (identified in section 3.2) will be affected, though uncertainty of impact increases as we trace further along the linkage framework. The overall impact on the value of fish caught to be eaten is unclear: in the short run the increase in compliance (and decrease in fish caught) will mean this ecosystem service decreases, however, in the long run the positive environmental effects may increase fish stocks in the Channel, leading to higher flows; uncertainty is high. This high uncertainty argues for applying the precautionary principle, to ensure long run resilience of the ecosystem. The increase in compliance and positive environmental effects will increase existence/bequest flows, as locals and tourists will have greater confidence of future state of Channel. Regarding ecosystem-service experiential/physical interactions with the ecosystem: while the tourist tax may decrease demand from tourists, if this finances biodiversity protection that ultimately result in higher quality experiences, the decrease in tourists could be offset.

Table 6 Direct environmental impacts of EBM Plan on drivers, pressures, and state of ecosystem: red background that the driver/pressure decrease as a result of EBM Plan

Affected element of Faial–Pico Channel linkage framework			
EBM Plan	Driver/Primary activity	Pressure	Ecosystem Component
4. Simplify and communicate existing regulation	<i>Indirect impact on commercial/recreational fishing</i>	- Extraction of species - Litter (fishing gear), noise, abrasion	<i>Indirect impact on fish/cephalopods, rocky habitats</i>
5. Increase enforcement	<i>Commercial/recreational fishing: nets, potting/creeling, hand collecting, angling, rod and hand line fishing from boats</i>	- Extraction of species <i>Indirect impact on other fishing pressures</i>	<i>Indirect impact on fish/cephalopods, rocky habitats</i>
6. Financing	<i>Tourism: Tourism accommodation, diving, boating/yachting, public beach, activities producing atmospheric emissions, activities producing litter</i>	<i>Indirect impact on tourism-related pressures</i>	<i>Indirect impact on rocky habitats, other components</i>

Alongside this qualitative assessment, evidence of efficiency is provided by the fact that each of the policy instruments that form the EBM plan were co-created with local stakeholders, who prioritised and developed them over two workshops (AQUACROSS 2017, 2018). The stakeholders' selection suggests that they believe the benefits of the plan will outweigh the costs. We discuss how the diving fee/tourism tax can cover direct costs of the EBM Plan in the next section.

5.2.3 Equity

A key focus of the case study has been on how EBM can support cooperation between different stakeholders, which we have targeted both in our case study methodology and with the EBM Plan's Stakeholder Advisory Group. Section 1.2 and section 2.2 detail how representative stakeholders contributed to our application of the AQUACROSS Assessment Framework in the Channel. This co-creation with diverse stakeholders has identified an EBM Plan that recognises and balances the costs and benefits to different stakeholder groups, and focusses on synergies and a shared commitment to environmental sustainability. A Stakeholder Advisory Group offers a formal mechanism for continuing this collaborative work. Commercial and recreational fishers, tourism operators, scientists, and other stakeholders all prioritised this measure, identifying as key benefits: less conflicts between different users and policy entities through better communication, and the promotion of multiple uses of the Marine Protected Area (AQUACROSS 2018).

Financing

The final element of the proposed EBM plan is reliable ongoing financing. A lack of sustainable financing has been identified as a key challenge for sustainably maintaining "efficient and equitable" MPAs (OECD 2017). Indeed, sufficient budget was found to be the second most important predictor of an MPA's conservation impact (Gill et al. 2017).

Financing also has equity implications. Current MPA management and the proposed EBM plan place costs on fishers (who could already no longer fish in valued MPA locations, and now face increased enforcement and compliance costs), while tourists, tourism operators, and other local stakeholders benefit (both from exclusive access to diving locations and positive environmental impacts). Financing can be used as a way to share the costs between those who benefit and those who bear cost.

Finally, stakeholders motivate our focus: they suggested both a per-dive fee or a per-night tourism tax, with the proceeds earmarked to fund biodiversity protection (AQUACROSS 2018, 2017). However, local policy-makers highlighted the challenge of implementing new taxes and especially of earmarking for biodiversity any funds raised. Given these challenges, rather than propose a specific financing instrument, and in the absence of detailed cost data for the EBM Plan, we introduce the two financing options here and discuss likely income and costs distribution under different fees.

Diving fee

The first financing option we consider is a stakeholder-suggested €2 fee per dive in the Channel, levied by tourism operators, with proceeds earmarked for biodiversity protection. (AQUACROSS 2017). Examples of such a user fee already exist in other Marine Protected Areas (MPAs) in other countries (e.g. Caribbean, South-East Asia, and the Francophone countries of the Indian and Pacific Oceans (Depondt and Green 2006). This practice is supported by a number of Willingness To Pay (WTP) studies, that clearly indicate that divers are willing to pay

a significant amount for the protection of biodiversity in MPAs, if they can profit from the biodiversity while diving (Roberts and Hawkins 2000). In the Caribbean, 25% of MPAs were charging divers for entering and using their MPAs in 2006 (Green and Donnelly 2003). Depending on the pass through of the fee price, this would increase costs to tourists and to a lesser extent tourism operators, but the funds could be used to cover the costs of the EBM plan, which benefits these groups. As an additional co-benefit, the diving fee would also provide data on the number of dives in the Channel, increasing knowledge. We estimate that approximately 32–45,000 dives take place in the Channel each year, with tourism operator revenues of €1.2–1.8 million¹¹. By our calculations, a €2 fee per dive would raise €60–87,000²³. The ultimate cost to tourism operators is very uncertain, as it depends on how responsive divers are to the price increase i.e. how fewer dives occur due to the increased price; it is likely to range from €35–135,000 per year.¹²

Occupancy tax

A second option is an occupancy tax, levied on a per-night basis by hotels and other accommodation providers. Tourism taxes of this sort are relatively common, with 18 out of the EU-28 Member States setting them, with average rates between €0.40–€2.50 per night (European Commission, Directorate-General for Internal Market, and PwC 2017). Illustrative relevant examples include the Balearic Islands, which introduced a “sustainability tax” of approximately €2 per night on all accommodation, with funds hypothecated for sustainability projects. They recommend that, to simplify compliance, increase transparency, and minimize consumer resistance, occupancy taxes should be collected by accommodation providers at time of sale (European Commission, Directorate-General for Internal Market, and PwC 2017). We follow the methodology used in European Commission, Directorate-General for Internal Market, and PwC (2017) and illustrate using 2016 Faial–Pico Channel data.¹³

Table 7 Occupancy tax, (calculated with price elasticity of -1.2, bracketed results show price elasticity of -0.5 and -1.5).

Per night tax rate	0.25 €	0.50 €	1.00 €	2.00 €
Revenue raised (1000s of €)	57.5 (57.3, 57.6)	115.8 (114.9, 116.2)	235.0 (231.1, 236.7)	483.3 (467.8, 490)
% decrease in tourist nights	-0.7% (-0.3%, -0.9%)	-1.5% (-0.6%, -1.8%)	-2.9% (-1.2%, -3.6%)	-5.8% (-2.4%, -7.3%)

As shown in Table 7, even a per-night tax of €0.25 will gather €57,500 per year (not counting administration costs), which would likely be sufficient to cover the direct costs of the EBM plan. We calculate this €0.25 per night tax would imply a shift in income from hotel operators, who would incur losses of €51–86,000 due to decreased nights and their tax payments. However, this loss is only equivalent to 0.9–1.5% of annual revenue. Given that nights stayed in Faial–Pico have increased by 5% on average per year (see Table 4), under the baseline scenario, this

¹¹Assuming average per dive fee of €40, and based on our own calculations and personal communication, Enrico Villa (CW Azores); we apply price elasticities of -0.55 - -1.5.

¹²This is wholly dependent on the price elasticity of demand for diving, which is very case specific and thus difficult to estimate for specific Azores case. Accordingly, we apply a range of elasticities we apply (-0.55 - -1.5) based on average values reported in Smith and Kaoru(1990).

¹³We assume accommodation providers pass on 60% of the tax to guests, bearing 40% of the cost themselves. Average accommodation income per night for the Faial-Pico Channel was €24.68 per night (SREA 2017). Based on a review of the literature, we assume that a 10% increase in price will lead to a 12% decrease in nights stayed, i.e. a price elasticity of 1.2 (European Commission, Directorate-General for Internal Market, and PwC 2017; Nadal and Rosselló 2016).

decline in demand and income will be offset by less by ongoing expected tourism growth. However, as shown in Table 7, higher tax rates result in much greater decreases in number of nights tourists stay: as well as raising revenue, policy-makers can introduce an occupancy tax decrease tourist visitors (and associated pressures).

5.3 Results (Comparing scenarios/measures)

The EBM plan was co-created with stakeholders to increase the long-run sustainability and the overall human well-being of the Faial–Pico Channel social–ecological system. As identified with uncertainty in 5.2.1, the EBM plan is likely to positively impact the sustainability of the ecological side of the Faial–Pico Channel social–ecological system. The EBM plan also targets the sustainability of the social system, aiming to transform social and governance settings by increasing knowledge, stakeholder participation, and policy coordination and integration. Here, we assess the EBM plan’s impact on the social system relative to the baseline scenario by considering how it supports each of the six EBM principles (Josselin Rouillard et al. 2017).

Table 8 EBM Plan alignment with EBM principles

EBM principles:	EBM Scenario
1. EBM considers ecological integrity, biodiversity, resilience and ecosystem services	Monitoring provides the knowledge to understand and protect biodiversity and the ecological system. Policy coordination encourages integrative planning to maximise multiple ecosystem-services at once. This, along with stakeholder participation and sustainable financing , increases ecological and social resilience.
2. EBM is carried out at appropriate spatial scales	The integrated policy coordination group and the stakeholder advisory group enable the Channel to be managed as one unit, better representing ecosystem scale and the relevant social scale.
3. EBM develops and uses multi-disciplinary knowledge	Monitoring provides scientific knowledge, while the stakeholder advisory group will ensure that stakeholder and traditional knowledge also contribute to management.
4. EBM builds on social-ecological interactions, stakeholder participation and transparency	The EBM plan was co-created with stakeholders, representing their priorities of increased enforcement and simplification and communication of laws . Additionally, its stakeholder advisory group formally increases stakeholder participation and transparency, increasing stakeholder cooperation and decreasing conflict, and increasing overall resilience of the SES.
5. EBM supports policy coordination	The integrated policy coordination group , which will collaborate across directorates and islands to manage the Channel together, increases ability to meet multiple objectives
6. EBM incorporates adaptive management	Monitoring provides essential knowledge for adaptive management, supporting regular evaluation. The stakeholder advisory group and integrated policy coordination group will ensure that integrated, representative responses are implemented, paid for by financing that balances costs and benefits.

5.4 Pre-conditions for successful take off and implementation of “qualified” EBM solutions

Three important pre-conditions for successful implementation of the EBM plan are stakeholder acceptance, policy-maker acceptance, and financing. Stakeholders co-created the EBM plan’s policy instruments, matching their values and priorities, which increases acceptance. Additionally, the co-creation process increases stakeholder knowledge and “ownership” of the

plan, which Reed (2008) finds also increases acceptance. Due to close cooperation with DRAM, key policy-makers have also provided feedback and input on the plan. It aligns and extends existing DRAM actions, such as their will to increase stakeholder participation (see e.g. Ordinance 53/2016). Additionally, whilst developing the EBM plan, concurrent processes in the Azores support the objectives of the plan, including DRAM developing Marine Protected Area management plans in 2018 (Resolution of the Government Council No. 65/2017 of June 22, 2017). These management plans, currently in preparation, follow an integrated management approach, facilitating participatory and informed decision-making of multiple stakeholders to improve political support, ownership and accountability in managing natural resources. The closely aligned Marine Spatial Planning research project (MarSP project¹⁴) also follows an Ecosystem Based Approach to develop Maritime Spatial Planning schemes in line with the EU Directive on MSP (2014/89/EU). Finally, the financing options discussion in section 5.2.3 demonstrates how the direct costs of the plan could be covered by a diving fee or tourism tax, circumventing this common barrier to implementation.

Barriers to implementation remain. We have focussed exclusively on the Faial–Pico Channel, while the decision-makers who would implement this plan have to focus on Azores-level; Faial–Pico priorities may not be appropriate at this higher level. Stakeholders identified that while they want to participate more in Channel management, this is contingent on official recognition by regulators, good communication, and increased enforcement/compliance (AQUACROSS 2018).

6 Discussion and Conclusions

Together with support of local stakeholders and policy-makers, we applied the AQUACROSS Assessment Framework to the Faial–Pico Channel – identifying and analysing policy and stakeholder objectives, characterising the social–ecological system, establishing a baseline scenario, and identifying and evaluating an ecosystem-based management plan. Relative to the baseline, the EBM Plan established regular scientific monitoring, engaged stakeholders in an advisory group, integrated coordinated policy management of the Channel, increased communication, enforcement, and compliance with regulations, and considers sustainable financing. Overall, the plan would have positive ecological impacts in terms of increased biodiversity (and the associated increase in sustainability and resilience), as well a direct and indirect positive affect on key ecosystem services. However, there would also be costs, as fishing restrictions remain, and potentially less tourism growth than without the EBM plan. Society as a whole would benefit from better integration of diverse stakeholder views and more effective and efficient coordinated management that promotes the long-run sustainability of the Faial–Pico Channel social–ecological system.

Throughout, we collaborated with stakeholders in the development, identification, and evaluation of the EBM plan. This stakeholder co-creation is a central element of EBM. The application of this within the case study work increased the relevance, acceptance, and quality of the work, and, as recognised by stakeholders, promotes synergistic solutions that provide multiple benefits, reducing stakeholder conflict, as well as improving knowledge and justifying more biodiversity protection (AQUACROSS 2018). It also highlighted challenges of stakeholder

¹⁴ MarSP Project, Macaronesian Maritime Spatial Planning, <https://www.msp-platform.eu/projects/marsp-project-macaronesian-maritime-spatial-planning>

engagement, some of which have already been experienced by local managers – some stakeholders are harder to involve than others, and the process can be time-consuming, focused on discussion rather than action.

The Faial–Pico Channel EBM Plan, and its development and evaluation, provide an indication on how ecosystem-based management can support existing marine protected areas to be effectively and equitably managed. In this way, the report supports attainment of the EU Biodiversity Strategy to 2020, the CBD Aichi Targets, and SDG 14. A key conclusion is that the complexity and interlinkages of social–ecological systems such as the Faial–Pico Channel demand integrated and representative stakeholder management. We have shown that the participatory management of MPAs can help tackling this complexity: stakeholders support effective and equitable MPAs through clear identification of challenges and priorities, creative co-creation of solutions, low-cost knowledge and expertise, and ongoing monitoring, enforcement, and evaluation of the impact of management.

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Annex

All annexes are available on the AQUACROSS website [Case Study 8](#) page.

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