

AQUACROSS – Final Summary

Knowledge, Assessment, and Management for AQUATIC Biodiversity and Ecosystem Services across EU policies

The interdisciplinary research project [AQUACROSS](#)¹ has supported European efforts to protect biodiversity in Europe’s lakes, rivers, coasts and oceans. These aquatic ecosystems provide numerous economic and societal benefits to Europe – but they are at risk of irreversible damage from human activities. To counter this and to support achievement of the EU Biodiversity Strategy to 2020 targets, AQUACROSS has developed practical guidance on identifying threats to biodiversity, understanding links between ecosystems and the services they provide, data management, modelling and scenario development, and policy analysis, which fit together as parts of the integrated AQUACROSS Assessment Framework for ecosystem-based management of aquatic ecosystems². This final summary summarises the project and identifies key results and impact.

1 AQUACROSS and its objectives

Aquatic ecosystems are home to an array of different species and habitats, and provide numerous benefits called ‘ecosystem services’ to society. These ecosystems are under significant threat by human activity. If the degradation of aquatic ecosystems is not soon reversed, the effects will affect their capacity to provide ecosystem services and ultimately human well-being. In response, the EU 2020 Biodiversity Strategy has been put in place to tackle the loss of species and habitats and establish targets to protect and preserve biodiversity.



Figure 1: The Faial Pico Channel Marine Protected Area, Case Study 8: Azores (Credit: Ben Boteler)

AQUACROSS Objectives

The AQUACROSS Project aims to support EU efforts to halt biodiversity loss across freshwater, coastal and marine ecosystems. Made up of a consortium of 16 European partners and running from 2015–2018, AQUACROSS had the following four goals:

1. To support the implementation of the EU 2020 Biodiversity Strategy for an improved functioning of aquatic ecosystems as a whole;

¹ AQUACROSS (Knowledge, Assessment, and Management for AQUATIC Biodiversity and Ecosystem Services across EU policies), 2015–2018, has received funding from the European Union’s Horizon 2020 Programme for Research, Technological Development and Demonstration under Grant Agreement no. 642317. More information: aquacross.eu

² All AQUACROSS guidance and outputs are freely available online at <https://aquacross.eu/outputs>

2. To explore, advance and support the implementation of the ecosystem based–management concept, which is understood as management or policy options intended to restore, enhance and/or protect the ability of an ecosystem to remain in good health;
3. To specifically identify and test management and business models and tools to identify the benefits of aquatic ecosystems for stakeholders, businesses, and policy–makers; and,
4. To mobilise policy–makers, businesses, and societal actors at global, EU, Member State, and case–study levels.

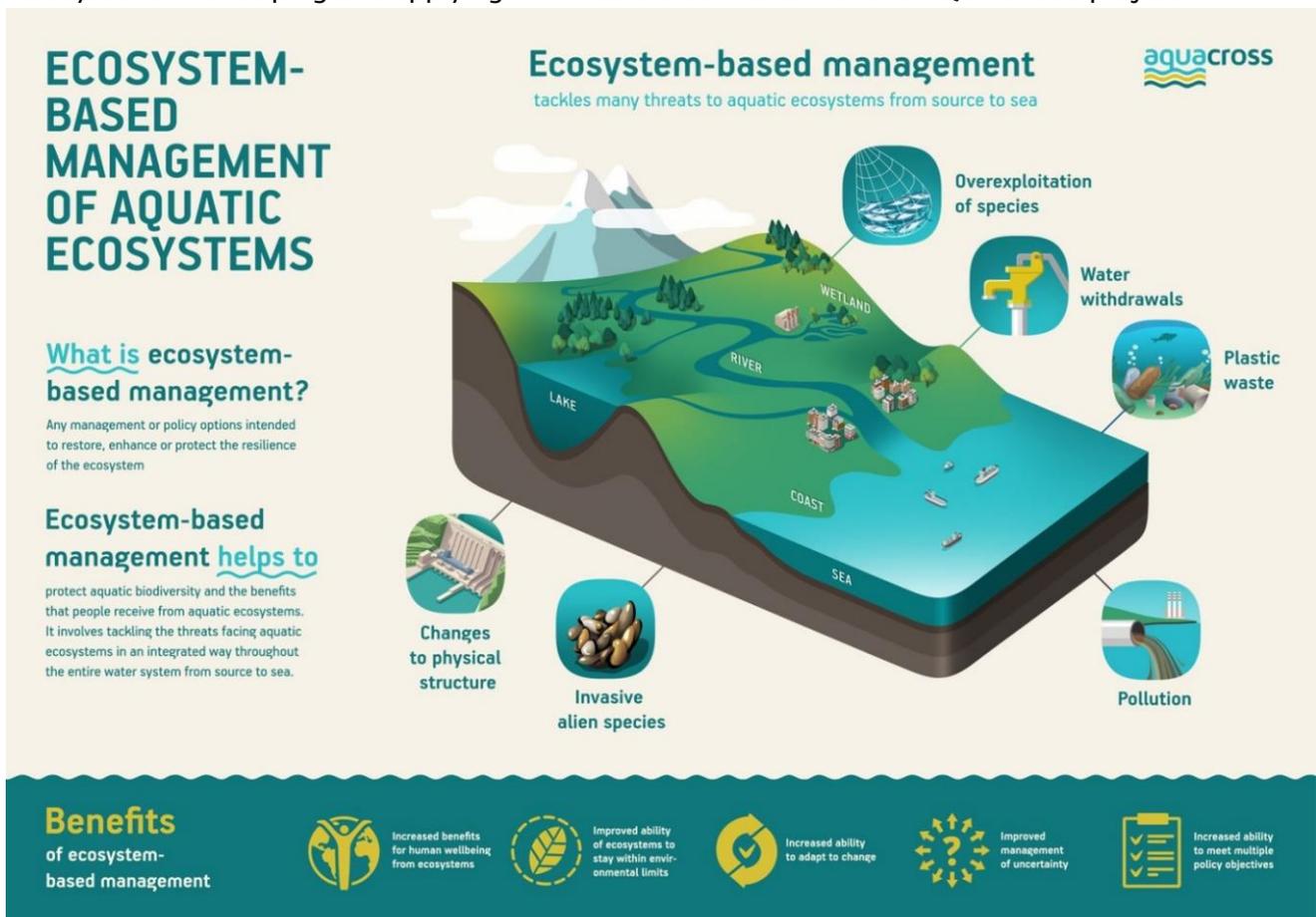
This summary report reflects on the past 3.5 years of work, first introducing the concept of ecosystem–based management, summarising key results, introducing tools developed in the project, then reflecting on impact and lessons learned.

AQUACROSS Ecosystem–based management cookbook

For more information, we recommend the final publication of the project, Deliverable 3.3 – AQUACROSS Ecosystem–Based Management Cookbook, which provides a more detailed (but still succinct) summary of every aspect of the project. It consists of 38 interlinked and dynamic short briefs, presenting a step–by–step introduction to how to implement ecosystem–based management, and also the key conclusions and policy, business, and research messages of the project. It is freely available online at <https://aquacross.eu/results>.

2 Ecosystem–based management

Ecosystem–based management (EBM) is a nature–based and integrative approach to managing ecosystems. Developing and applying EBM was the central aim of the AQUACROSS project.



3 Key project outputs

AQUACROSS has furthered the science and practice of ecosystem-based management through the development of an integrative approach to efficiently, effectively, and equitably manage the sustainability of ecosystems and aquatic biodiversity to increase social welfare. Ultimately, the key innovation of the project has been the interdisciplinary work across aquatic realms. Here, we highlight three key results of the project that illustrate this interdisciplinary, cross-realm, and cross-sectoral work. These also evidence the projects focus on theory *and* practice, with the scientific excellence demonstrated by the Assessment Framework and practical impact shown by the case studies and the AQUACROSS Ecosystem-Based Management Cookbook.

The [AQUACROSS Assessment Framework](#) is the key theoretical achievement of the project and offers a conceptual guide for implementing ecosystem-based management (EBM) in aquatic ecosystems. It defines EBM as 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 (i.e. benefits provided by nature to society) and conserve its biodiversity. It was developed collaboratively, using the same interdisciplinary and pragmatic approach that the Assessment Framework proposes for managing aquatic biodiversity. It draws on theoretical work from economics, biology and ecology, policy, resilience thinking, and more, and from practical experience with ecosystem-based management in marine, coastal, and freshwater realms to propose pragmatic methods and tools, establishing a common framework for assessing complex systems and developing integrated management plans that reflect the complexity, interdependencies, and uncertainty of socio-ecological ecosystems.

The Assessment Framework is broken into two sections. The opening ‘What to Assess’, discusses existing analytical frameworks and identifies the distinctive features of the AQUACROSS Assessment Framework. These include an ecosystem-based management approach, an understanding of ecosystems as complex and adaptive, and the importance of interdisciplinary and stakeholder knowledge, among others. The second section, ‘How to Assess’, provides a practical and sequential guide to assessing complex ecosystems and realising integrated management. This includes how to analyse drivers and pressures, how these link to ecosystem state and biodiversity, and in turn how this causally affects the ecosystem services enjoyed by society. Crosscutting issues such as information flows for analysis, uncertainty, and the challenge of assessment and management at different scales are also considered. The overall focus is on how ecosystem-based management can support the achievement of EU and international biodiversity targets.

The AQUACROSS Case Studies

The second most significant achievement of the AQUACROSS project was the implementation of the Assessment Framework in the [eight AQUACROSS case studies](#). The AQUACROSS Case Studies provide eight real-world examples of applying ecosystem-based management in Europe’s inland, transitional,

and marine waters to protect local biodiversity from diverse threats. The eight AQUACROSS case studies were diverse, with differing:

- Scale – from the 240km² Faial–Pico Channel, Azores, to the Danube river basin and North Sea.
- Realms – freshwater lakes and rivers, as well as transitional estuaries and coasts and marine, with some case studies (such as Ria de Aveiro) covering all realms.
- Threats – all significant threats to aquatic biodiversity were covered, including nutrient pollution, species abstraction, invasive alien species, alterations to morphology, among others, and the associated drivers – agriculture, fishing, energy, tourism, among others.
- Stakeholders – EBM calls for transdisciplinary co-creation with relevant stakeholders, which was a priority at the case study level.

Each case study worked closely with local policy-makers and environmental managers, as well as diverse stakeholders (including fishers, farmers, tourism operators, and environmental groups) to apply and test ecosystem-based management on the ground. Each case study followed the steps laid out the AQUACROSS Assessment Framework, and therefore offer useful examples of the approach in practice, in diverse settings. As well as having local policy impact, which will increase in the years following the project, the wide range of threats, realms, key sectors, and strengths mean that these eight case studies offer diverse specific examples and practical insight into how and when ecosystem-based management can be used. The case study experiences also directly fed back into overall project conclusions, as shown in the *What does ecosystem-based management involve?* figure above.



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Guidance

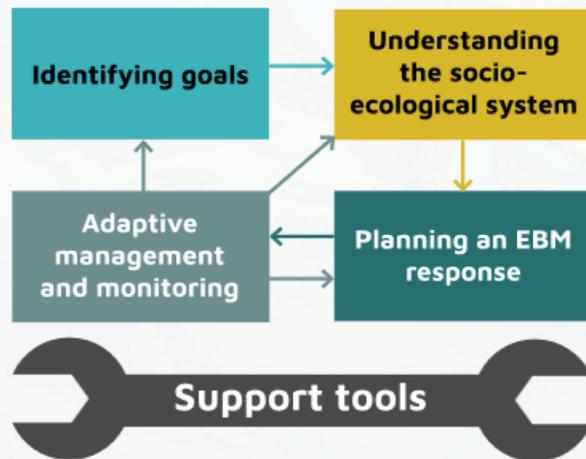


Figure: The AQUACROSS Ecosystem-Based Management Cookbook also includes sections on context, practical case study examples, and AQUACROSS Lessons and Recommendations .
<https://aquacross.eu/results>

Ecosystem-Based Management Cookbook

A practitioner-friendly version of the Assessment Framework has also been developed. Based on the application of the Assessment Framework in the case studies, we have developed a practice-focused [Ecosystem-Based Management Cookbook](#) for local policymakers and environment managers. As well as succinctly describing each element of the AQUACROSS project and how to apply ecosystem-based management (in a series of interlinked short briefs), the Cookbook summarises the key lessons of the project.

4 AQUACROSS Tools

AQUACROSS also developed specific tools to support local policymakers and environmental managers overcome the practical challenges of implementing ecosystem-based management to protect biodiversity in aquatic ecosystems. A key challenge of managing aquatic biodiversity is that it is part of a complex, interlinked social-ecological system, meaning management changes can have far-reaching and surprisingly complex impacts. EBM recognises that the causes of aquatic biodiversity decline are complex, involving societal drivers and human activities (e.g. commercial fishing, agriculture) that place diverse pressures (e.g. nitrogen pollution, underwater noise) on different components of ecosystems (fauna and flora). This affects the sustainability and resilience of the ecosystem, which in turn decreases its ability to function effectively and deliver society with valuable ecosystem services (e.g. fish, recreational opportunities, climate regulation), which ultimately impacts society and social welfare – with different stakeholders affected and affecting each step. To effectively and efficiently protect aquatic biodiversity whilst meeting other societal objectives, managers need to be able to understand these complex and interlinked social-ecological systems. The AQUACROSS Linkage Framework and AquaLinks tool are complex enough to meaningfully describe social-ecological systems, whilst simple enough for to be used by local government scientists and managers to develop practical measures and policies to protect aquatic biodiversity.

The three key tools developed in the project to increase understanding of aquatic ecosystems and biodiversity are the **AQUACROSS Linkage Framework**, the **AquaLinks Tool** and the **AQUACROSS Information Platform**.

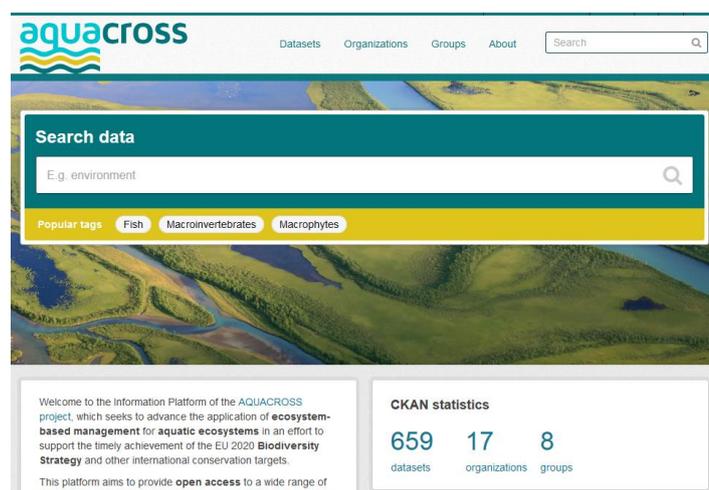
The **AQUACROSS Linkage Framework**, a set of linked matrices (in excel sheets), encompasses all of the interactions between human activities and ecosystem services in a particular ecosystem. It accounts for the pressures that are being introduced by human activities and that can impact ecosystem state. Changes in ecosystem state can then affect the supply of services through altered ecosystem functioning. The Framework’s integrative approach is important when it comes to considering these interactions because different activities can introduce the same pressures, and

multiple ecosystem services can be supplied by the same parts of the ecosystem. Thus, by managing one activity, the key pressures are not necessarily removed, because other unmanaged activities could still be introducing these pressures. In addition, focusing on protecting one specific ecosystem service could result in the loss of multiple others. The Linkage Framework is implemented in three steps. First, the manager identifies all the relevant activities, pressures, ecosystem components and ecosystem services that are relevant for the system. Second, the manager identifies the connections between all of these elements. This requires expertise and evidence of the system you are working in. Once this has been carried out, the output is already useful as a description of the system and can be analysed. The final step is to identify the importance of different links (the weighting). This requires expertise and careful cross checking for consistency. The output of this will allow a detailed characterization of the system with is a precondition to establish priorities for management. This can be done for the impact risk to the ecosystem, the service supply capacity of the ecosystem and the risk to the supply of services. The AQUACROSS Linkage Framework was implemented, tested, and refined in the AQUACROSS case studies.

The [AquaLinks tool](#) compiles the results of applying the AQUACROSS Linkage Framework in the AQUACROSS case studies into an interactive, searchable database to support policy makers and environmental managers. It contains a database of real ecosystem linkage chains relating human activities, the associated pressures, the ecosystems components on which they act and the services and functions that they provide. The links between the different components are based on information produced by the eight case studies using expert judgement within the AQUACROSS project. The database underlying the different linkage chains is quite comprehensive, capturing a wide diversity of spatial scales, ecosystem components, geographic contexts and social contexts at European level. The AquaLinks tool provides valuable information for policy makers and environmental managers on how human activities and pressures affect ecosystems, their services and biodiversity, through to the capacity of aquatic ecosystems to continue providing the services society depends on. The tool provides insight into what linkage chains are more likely to be vulnerable and helps decide which management measures are likely to reduce vulnerability of specific parts of the ecosystem. These measures might involve the management of activities and associated pressures or increasing the coverage/representativeness of the vulnerable components. The AquaLinks tool is free of charge.

Finally, the [AQUACROSS Information Platform](#) (IP) was developed to represent the central access point for project partners and scientists for publishing data on different types of aquatic ecosystems, biodiversity and Ecosystem-Based Management (EBM) practices in the context

of the AQUACROSS project. The IP aims to provide a single and free of charge point of access to a wide range of resources related to aquatic (freshwater, marine and coastal) ecosystem and biodiversity management at the European level. The AQUACROSS IP was internally published at the beginning of the year 2016 and it has now more than 655 datasets (11 December 2018) from the 17 registered organizations. The platform currently has 46 active users with representatives from all the AQUACROSS project partners.



[AQUACROSS Information Portal, http://dataportal.aquacross.eu/](http://dataportal.aquacross.eu/)

5 Impact

AQUACROSS has furthered the science and practice of ecosystem-based management through the development of an integrative approach to efficiently, effectively, and equitably manage the sustainability of ecosystems and aquatic biodiversity to increase social welfare. Ultimately, the key innovation of the project has been the interdisciplinary work across aquatic realms. Our key deliverable, the AQUACROSS Ecosystem-Based Management Cookbook, along with AquaLinks tool and Linkage Framework approach, and the examples of applying EBM in the case studies, will have practical impact as they support managers of local biodiversity (be that in lakes, rivers, coasts, or oceans) to effectively manage threats to these ecosystems types and their supporting biodiversity.

The project has chased policy impacts by promoting its integrative approaches that have been developed – and then tested and documented in the case studies. Our results can support the ongoing achievement of Europe’s aquatic biodiversity goals. As shown by the work in the project, ecosystem-based management can protect biodiversity more efficiently (i.e. with higher benefits and/or lower costs) than non-integrative management. The approaches developed in the project can thus support improved management of aquatic ecosystems, especially using nature-based solutions.

Specifically, methods and tools developed within the project can practically contribute to the achievement of the EU Biodiversity Strategy’s targets. For example, supporting target 1 through the assessment of impacts risks of human activities on European aquatic ecosystems allows for the identification of habitats and species most at risk and in need of protection. In addition, potential



applications of the AQUACROSS Linkage Framework have been explored to assist for the implementation of the EC Water Framework Directive, the Marine Strategy Framework Directive and the Nature Directives.

AQUACROSS has also had significant local impact in each of the eight case studies. Some impacts will have already occurred – for example, increasing the knowledge of local stakeholders about biodiversity and

ecosystem-based management has already occurred through workshops, meetings, interviews, presentations in the case studies. Other impact will take longer, for example, due to policy timeframes. Some Examples of local impact achieve during the project timeline include:

- Swiss Case study – local policy-makers will use case study models to adapt or develop indicators of specific human impacts on biodiversity. Additionally, the method applied for prioritising where to restore ecosystems has potential for use for the selection of new monitoring sites and future collaboration with local authorities.

- Azores Case Study – “The AQUACROSS work is being used directly in the creation of Marine Protected Area Management for the Azores, along with other sources” – Gilberto Carreira, Azores Regional Directorate for Sea Affairs (DRAM)
- Danube Case Study – This case study has been invited to present their results – regarding an ecosystem-based management approach to selecting restoration sites that meet Habitats Directive, Water Framework Directive, and Flood Directive objectives – at the International Commission for the Protection of the Danube River (ICPDR), the international organization responsible for Danube river basin management.
- Intercontinental Biosphere of the Mediterranean (Spain/Morocco) – Local Spanish policymakers will deploy the methodology developed in the project, “to estimate ecosystem condition of habitats and a network of multifunctional and interconnected areas (Green and Blue Infrastructure) not only in the case study area but in other areas in Andalusia”. – (REDIAM – Environmental Information Network of Andalusia, Regional Ministry of Environment and Spatial Planning of Andalusia), Spain.

All AQUACROSS outputs are available free of charge on the [project website](#) and in public repositories such as [zenodo](#), this includes the academic papers featured in the Special Issue with Science of the Total Environment, the forthcoming book with Springer, the AquaLinks tool, and all public deliverables and reports of the project.

6 Key challenges and lessons learnt

Like any significant research project, AQUACROSS faced a number of challenges. Here we identify three key challenges faced and lessons learned for future projects.

- The challenge of **interdisciplinary work** – to protect biodiversity in lakes, rivers, coasts, and oceans, we have to understand the root causes and effects, and their interactions. This requires social and natural science – economists, policy makers, ecologists, fisheries experts, and many more all need to be involved so that we can understand the impact that a policy (such as a sustainability tax) or management measure (such as agricultural nitrogen leaching changes) will have on human activity and the ecosystem, and how society will be affected. However, this sort of interdisciplinary work is challenging – it can be difficult to work across disciplines, with differing methodologies, definitions, references, and questions. While not unexpected, this was also a significant and ongoing challenge that we faced in the project. Practically applying the different theoretical work in the case studies was the solution to this challenge. Each case study implemented the different aspects of the AQUACROSS project (analysing policies, working with stakeholders, understanding the social-ecological system, developing scenarios, and identifying and evaluating practical management measures and policies) to a practical local problem. The practical challenge posed by each case study provided a space for different researchers in the project to collaborate. Working with stakeholders in each case study ensured that communication had to be clear and focused on the problem and finding solutions.
- **Collaborating with data** – there are ever increasing amounts of data available to support management of aquatic biodiversity. A real challenge is working collaboratively and storing, sharing, and searching the interdisciplinary data that is needed for ecosystem-based management, and data at different scales (local, regional, national, and transboundary). To solve this challenge, the project developed the AQUACROSS Information Platform. The Information Platform offers a consolidated data portal for continuously improving collaboration between scientists, environmental managers and policy makers by building common knowledge and sharing data between organisations, project partners and

stakeholders. It hosts more than 650 different datasets are easily available free of charge in the platform. Other organisations can also sign up to use the platform to host their own data. This can be powerful – the Intercontinental Biosphere Reserve of the Mediterranean (see ibrm.aquacross.eu) and Danube case studies illustrate the insight that collaborative data work can provide.

- Ecosystem-based management is a **transdisciplinary approach**, calling for stakeholder co-creation. Working with stakeholders in the different case studies was challenging, as each local situation called for different approaches and engagement, and dependent on goodwill from locals, close cooperation with local policymakers outside the project, and an understanding of context. To assess impact, AQUACROSS carried out a review of stakeholder processes and impact in the project, with 25 researchers and stakeholders interviewed. The results of this study are being finalised and will be published (see below).

7 The future of AQUACROSS

While the project has concluded, AQUACROSS researchers and partners in the case studies are continuing to progress and implement AQUACROSS work. A key focus is the finalisation of academic work documenting the project, including:

- A special issue in Science of the Total Environment, entitled Ecosystem Based-Management (EBM) in aquatic ecosystem, is currently under preparation (with 15 out of a total of 17 submitted papers already accepted for publication by the journal). This special issue covers all of the aspects of the interdisciplinary AQUACROSS project as well as detailing research in the case studies.
- A book will be published in early 2020 by Springer. As well as including chapters by AQUACROSS researchers in Europe, it will also include ecosystem-based management application and advances from the USA.
- Given the central role of transdisciplinary work and stakeholder collaboration to the project, a final review of stakeholder engagement and processes within AQUACROSS. A report will be finalised and publicised in the AQUACROSS website by March, and will then be finalised for academic publication
- Additionally, consortium members are collaborating on new project proposals to continue with the existing AQUACROSS network.

As well as academic work, at the local case study level, work and collaboration is continuing with some local policy-makers to ensure that the results of the AQUACROSS project are exploited.

AQUACROSS PARTNERS

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Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC-UNESCO) | France

Wageningen Marine Research (WMR) | Netherlands

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Universidade de Aveiro (UAVER) | Portugal

ACTeon – Innovation, Policy, Environment (ACTeon) | France

University of Liverpool (ULIV) | United Kingdom

University College Cork, National University of Ireland (UCC) | Ireland

Royal Belgian Institute of Natural Sciences (RBINS) | Belgium

Stockholm University, Stockholm Resilience Centre (SU-SRC) | Sweden

Danube Delta National Institute for Research & Development (INCDDD) | Romania

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