aquacross

D2.2 Review and analysis of policy data, information requirements and lessons learnt in the context of aquatic systems

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List of Abbreviations

AIS	Automatic Identification System
API	Application Programming Interface
BAP	Biodiversity Action Plan
BD	Birds Directive
BDC	Biodiversity Data Centre
BISE	Biodiversity Information System for Europe
BQEs	Biological Quality Elements
BWD	Bathing Water Directive
CAP	Common Agricultural Policy
CBD	Convention on Biodiversity
CDDA	Common Database on Designated Areas
CFP	Common Fisheries Policy
CICES	Common International Classification of ES
CSI	Core Set of Indicators
DG AGRI	Directorate General for Agriculture and Rural Development
DG ENV	Directorate General for the Environment
DG MARE	Directorate General for the Maritime Affairs and Fisheries
DOPA	Digital Observatory for Protected Areas
EASIN	European Alien Species Information Network
EBM	Ecosystem Based Management
EC	European Commission

EEA	European Environment Agency
EIONET	European Environment Information and Observation Network
EMIS	Environmental Marine Information System
EMODnet	European Marine Observation and Data Network
EU BON	Building the European Biodiversity Observation Network
EUNIS	European Nature Information System
FADA	Freshwater Animal Diversity Assessment
FIP	Freshwater Information Platform
GBIF	Global Biodiversity Information Facility
GEF	Global Environment Facility
GEO BON	Group on Earth Observations Biodiversity Observation Network
GOOS	Global Ocean Observing System
HD	Habitats Directive
HELCOM	The Helsinki Commission
IAS	Invasive Alien Species
ICES	International Council for the Exploration of the Sea
JRC	Joint Research Council
LME	Large Marine Ecosystem
LPIS	Land Parcel Identification System
MAES	Mapping and Assessment of Ecosystems and their Services
MEA	Millennium Ecosystem Assessment
MSFD	Marine Strategy Framework Directive
MSY	Maximum Sustainable Yield

ND	Nitrates Directive
OSPAR	Oslo and Paris Convention
PESI	Pan-European Species directories Infrastructure
RBMPs	River Basin Management Plans
SDG	Sustainable Development Goal
SDI	Spatial Data Infrastructure
SEBI	Streamlining European Biodiversity Indicators
TEEB	The Economics of Ecosystems and Biodiversity??
TWAP	Transboundary Waters Assessment Programme
UK	United Kingdom
UNECE	United Nations Economic Commission for Europe
UWWTD	Urban Wastewater Treatment Directive
VMS	Vessel Monitoring System
WDPA	World Database of Protected Areas
WFD	Water Framework Directive
WISA	Water Information System Austria
WISE	Water Information System for Europe
WMS	web map services
WISS	Water Information System Sweden
WPWP	Western Pacific Warm Pool

About AQUACROSS

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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Executive Summary

Policy Data Sources and Users

The overarching headline target of the EU Biodiversity strategy (EC, 2011) is to "halt the loss of biodiversity and ecosystem services by 2020, to restore ecosystems in so far as is feasible, and to step up the EU contribution to averting global biodiversity loss." Progress towards the overarching objective has been limited. The mid-term review of the Strategy (EC, 2015) found no overall progress to the overarching goal and no progress or insufficient progress toward all bar one of the main targets.

Whereas achieving the targets of the Biodiversity Strategy is an international commitment under the Convention on Biological Diversity, it is not a legal obligation for Member States under European Legislation, and the targets of the Strategy have been variously aligned with commitments under several European policies and pieces of legislation, including the Habitats Directive (EC, 1992), the Common Agricultural Policy (CAP), and the Common Fisheries Policy (CFP). Success in achieving these targets is also dependent on a range of other Directives that have developed over time and reflect a variety of environmental norms which may be categorised as 'Practical', 'Popular' or 'Pure'.

Practical policies are largely aligned with natural resource management concepts (i.e. management of stocks to meet human ends) through the exploitation or stewardship of the natural environment and often relate to the systematic use of provisioning ecosystem services. ***Popular*** norms are defined by their focus on cultural ecosystem services. This impact may be associated with non-use cultural ecosystem services or on direct use cultural services, where public goods are directly used by individuals without the intermediary of a specific economic sector (e.g. recreational fishing, swimming) and may be considered popular as they relate to the public good rather than economic development of any particular specific sector. The ***Pure*** perspective is encapsulated by the slogan adopted by the US environmental movement of the early 1970s: "we have met the enemy and he is us." Policies which aim to minimise or eliminate human effects principally for the sake of the environment itself or for its 'intrinsic value' can be categorised as Pure. Figure 1 summarises some policies and directives relevant to the protection of aquatic biodiversity and characterises their associated norms.

Ideally, the Good Ecological Status of the Water Framework Directive (WFD) (EC, 2000) should be harmonised with the Good Environmental Status of the Marine Strategy Framework Directive (MSFD) (EC, 2008), which in turn should be equivalent to Favourable Conservation Status under the Habitats Directive. Further, if these directives are to be the means to achieving the ends of the EU Biodiversity Strategy, the process of compliance with these directives should also be harmonised with the goals of the strategy, such that complying with

the environmental legislation would also involve reducing the levels of biodiversity loss incrementally toward the final goal of halting biodiversity loss by 2020.

Policy/Directive/Regulation	Acronym	Year
Common Agricultural Policy	CAP	1962
Bathing Water Directive	BWD	1976
Birds Directive	BD	1979
Common Fisheries Policy	CFP	1983
Urban Waste Water Treatment Directive	UWWTD	1991
Nitrates Directive	ND	1991
Habitats Directive	HD	1992
Water Framework Directive	WFD	2000
Marine Strategy Framework Directive	MSFD	2008
Regulation on Invasive Alien Species	IAS	2014

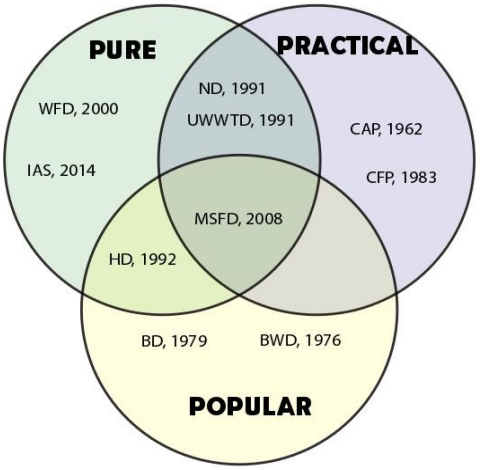


Figure 1: List of the major EU directives and policies relevant to the biodiversity strategy in the EU and a normative categorisation.

Data and information relevant to the goals of the EU Biodiversity Strategy may be generated by any of these directives and policies, which also have different spatial and temporal scales of implementation and fall under different directorates within the EU. Different groups of potential users of this information have differing data and information needs (Figure 2). Scientists and technicians require detailed information, policy practitioners required reliable synthesised data with less detail, decision-makers require reliable robust data. Under ecosystem-based management (EBM), where public participation is considered to be an essential element, data must also be presented to the public or stakeholders in a format which is accessible to them and European and national governments have obligations under the directive establishing an *Infrastructure for Spatial Information in the European Community* (INSPIRE) as well as the *Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters* (Aarhus Convention, UNECE, 1998), to make environmental information publicly available.

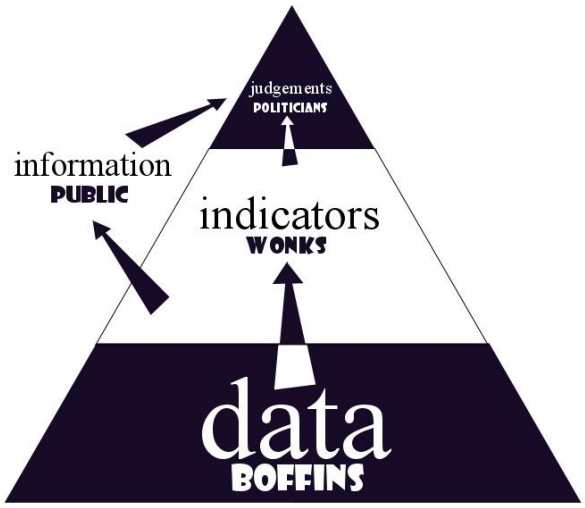


Figure 2: Idealised flow of data through different user groups- Boffins, wonks, the public and politicians for implementation of ecosystem-based management

Spatial Data Infrastructure for the EU Biodiversity Strategy

A review of data and information systems relevant to the goals of the Biodiversity Strategy in the aquatic environment (freshwater and marine) identifies a vast array of Spatial Data Infrastructure relevant to implementation of the EU Biodiversity Strategy.

Marine

For the marine environment, there is a range of spatial data infrastructure serving the scientific community both at the European scale (SeaDataNet, Copernicus, EMODnet) and at the global scale (e.g. TWAP, GOOS), which provide a large amount of data but are mainly directed specifically at scientific experts. A range of other sites also provide policy-relevant information and data, these include data portals established by the Regional Seas Conventions such as OSPAR and HELCOM, as well as many other national initiatives and topic-specific portals in line with INSPIRE and the Aarhus convention, including the International Council for the Exploration of the Sea (ICES) spatial data website. The Vessel Monitoring System (VMS) data, mandatorily collected under the CFP are, in general, not readily available for analysis. While the science community is largely well served with respect to data, and some policy portals do exist, general data relevant to biodiversity are scattered and an interested policy-maker or member of the public would have great difficulty in interpreting the vast array of spatial data and its relevance to the biodiversity strategy. There is a clear need to focus on geospatial data infrastructures and tailor them towards specific audiences. The ICES popular advice portal provides a good example of how this kind of focused delivery can be achieved in that it delivers data at several different levels of aggregation catering to several different levels of expertise.

Freshwater

There are four major institutions concerned with supplying water-related data resources on EU environmental water policy, and these are the Directorate General for the Environment; the Joint Research Centre (JRC) Eurostat and the European Environment Agency (EEA), each of which maintains its own data or information pages (separately). The Water Information System for Europe provides a central point to link these sources together. The page consists of links to the DG Environment, the EEA and the JRC; of these primary links, only those to the EEA are functional. However, any user with an interest in water quality but without specialisation in European environmental policy have great difficulty finding a suitable narrative thread to carry them through the site to the information they were seeking.

Biodiversity

In terms of biodiversity, there are several important resources at the European level that can support the analysis of biodiversity. The Biodiversity Information System is designed as a centralised platform for collating information on biodiversity and ecosystem services, as well as providing links to policies, data centres and assessments, many of which are on the EEA Biodiversity Data Centre or in the European Nature Information System. The major resource held by the EEA is the Natura 2000 ecological site network.

As for the marine environment- these sites are aimed mainly towards scientists rather than the general public, so that professionals may be able to find relevant data, but interesting data and information for the lay reader are not easy to find.

Ecosystem Services

The emerging focus on ecosystem services in European environmental policies (e.g., in the MSFD) may promote the incorporation of the values of nature into natural resource management decisions. Yet, scientific understanding of the role of biodiversity in the supply of ecosystem services remains low (Mace et al., 2012). Scientists, therefore, have a role in elucidating these links through further research and effectively communicating their findings to policy-makers and to the public. While the theory behind ecosystem services has been developing rapidly over the past decade, our ability to accurately map ecosystem services remains very limited.

A major limitation of much of the ecosystem services mapping at the European scale to date, under the *Mapping and Assessment of Ecosystem Services* project, has been the difficulty in moving beyond the mapping of ecosystem processes relating to specific habitat types and listing of their associated services toward consideration of the demand side of ecosystem services, which requires data on human usage patterns. There are many possible approaches to the modelling of ecosystem services, including modelling approaches such as InVEST, ARIES and ESTIMAP. However, the modelling tools are still not capable of providing an integrated and overall picture of transboundary ecosystem services. Terrestrial, coastal and marine ecosystem services are still identified, monitored, analysed and mapped separately with an important lack of integration.

In relation to the collaborative science applied to the dissemination of knowledge about ecosystems, the increasing use of mobile telephones and their associated cameras has resulted in an enormous number of geotagged photographs being posted on the web. There is great potential for development of methodologies to assess ecosystem services based on these 'big data'.

Indicators

A suite of indicators has been selected to assess progress toward the goals of the Biodiversity Strategy, including indicators from the EEA's Core Set of Indicators. Considerable efforts have been expended on developing indicators to assist with attaining Europe's biodiversity targets through the Streamlining European Biodiversity Indicators (SEBI) initiative. The aim of the initiative was to develop a set of biodiversity indicators for Europe based on existing data and develop new indicators where necessary.

The two most important indicators in the list are SEBI03 and SEBI05, conservation status of species and habitats, respectively, with each being relevant to four of the six biodiversity targets of the Biodiversity Strategy. SEBI03 the *Conservation status of species of European Interest* covers the species listed in Annexes II, IV and V of the Habitats Directive (i.e. species of European interest: these were selected for inclusion in the Directive as they were perceived to be under threat). Species are categorised under the Habitats Directive into one of five categories of conservation status: favourable, unfavourable inadequate, unfavourable bad, unknown or not assessed. As the data are a direct product of the Habitats Directive, they reflect the status of its implementation rather than the status of biodiversity. At present, the indicators do not include data from the Birds Directive.

Biodiversity or water indicators at European scale are purely informative for European policy-makers and provide the base for comparison amongst Member States. Policy practitioners and policy-makers may not find the information provided by these indicators useful for their daily work at a national, regional or local scale.

Recommendations

Two major processes need to occur if European environmental policies are to be aligned with the goals of the Biodiversity Strategy (Figure 3):

1. A process of policy reform needs to occur to ensure that the 'Practical' policies – the CAP and the CFP – which represent over 99% of EU budget for natural resource management, need to be aligned with the goals of achieving environmental quality under the 'Pure' norms of the WFD and the Habitats Directive.
2. There is considerable evidence to suggest that, at the European-scale, public understanding of the causes and consequences of biodiversity loss is limited (Potts et al., 2016). The lack of public engagement with the concept of biodiversity and with the types of problems that are occurring within the environment may help explain the apparent low priority, in terms of budget and progress toward environmental objectives, within the two

major 'Practical' policies. Aligning the 'Pure' with the 'Popular' is therefore another major challenge to achieving the goals of the Biodiversity Strategy.

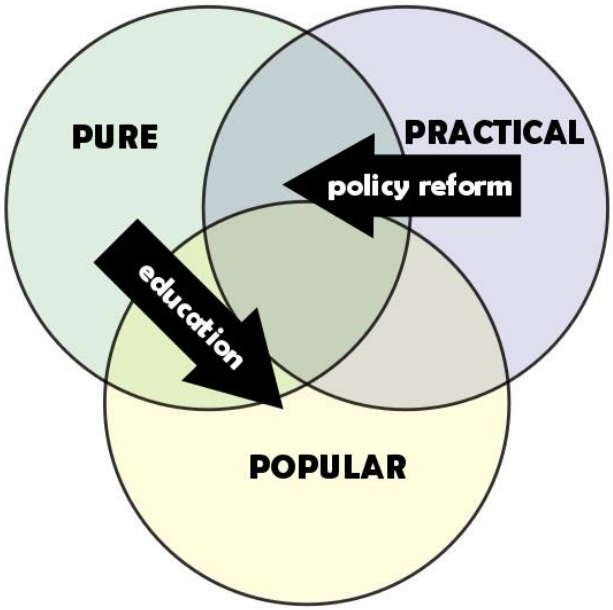


Figure 3: Changes required for the alignment of European environmental and natural resource management laws and policies.

Spatial Data Infrastructures (SDIs) have a crucial role to play in the integration of data and information to facilitate and enable both policy reform and education. Overall, while there is a great abundance of relevant data which can or should contribute to the EU Biodiversity Strategy in the aquatic environment, and despite new initiatives to improve integration, the data tend to be very scattered, diffuse and inaccessible to the lay person as suggested by the number of unrelated portals devoted to different aspects of the environment. In particular, policy data, though generally available, are not readily accessible, and centralised attempts to improve accessibility do not indicate that a great deal of effort is being taken in rendering the data more accessible (with the notable exceptions of VMS and Land Parcel Identification System (LPIS)). A similar situation exists for commercial shipping data. Although some live Automatic Identification System (AIS) data are accessible publicly through commercial websites) and some countries provide AIS data for purchase, few datasets are available to analyse the pressures caused by commercial shipping traffic at the Europe-wide level, with the main focus of AIS data being that of maritime safety, rather that environmental integrity.

Collection of spatial data under the two major practical policies – CAP and CFP – is mandatory. In order to implement the CAP direct payments scheme, a LPIS is in use. Similarly, under the CFP, the reporting of the activities of all vessels over 15m in the form of VMS data is mandatory. These two policies have the largest direct impacts on the environment and on biodiversity. Yet, the vast data archives on the specific locations of environmental pressures contained in these databases and in the electronic logbook data

associated with the VMS data are held centrally at the European level and are not readily accessible for analysis.

Overall, aquatic environmental policy data are not well aggregated. There is no online site that clearly illustrates compliance or non-compliance with a range of environmental legislation and suggests management measures in an integrated way.

The complex challenges of sustainable development and meeting environmental objectives are permanent. The linkages and interrelations between economic activities, environmental pressures and biodiversity and human welfare are complex. In order for SDIs to enable a better understanding and a more efficient analysis of the causes and consequences of biodiversity loss, they need to integrate data from multiple different sources.

Fundamentally, there is no centralised, long-term SDI designed to meet the needs of the EU Biodiversity Strategy (aquatic or otherwise) and the data are in many different locations. The AQUACROSS project, through its Information Platform, can provide this service for the short-term and for a limited number of case studies. The fragmented policy landscape with its diverse norms and priorities remains a barrier to efficient delivery of environmental policy objectives.

The establishment of a more integrated SDI may facilitate the analysis needed to support policy reform. However, these data requirements are not the same as those required to promote public understanding of biodiversity and its loss. Increasing public awareness and understanding require enhanced science communication and maps as powerful communication tools. There are choices to be made about the way information is displayed and disseminated and the level of complexity with which such information is communicated. The metrics and indicators that may concern a scientist, policy- or decision-maker are not the same as those of the general public. In this regard, SDIs have a role to play in effective science communication.

Priority recommendations for developing SDI to meet the needs of the EU Biodiversity Strategy are:

1. **Enable transparency in Members State's achievements and failures in terms of environmental policy data.**
2. **Make available the existing data on fisheries and agricultural pressures that are centrally held in the LPIS as part of the CAP and are gathered by VMS under CFP.**
3. **Fund and maintain single long-term spatial data infrastructure for European natural resource use laws and policies.**
4. **Facilitate and encourage INSPIRE compliance.**

1 Introduction

1.1 Policy and Project Context

This Deliverable is part of AQUACROSS Task 2.4 entitled "End-user needs to fulfil data and information systems policy requirements for the implementation of the EC [European Commission] Biodiversity Strategy". The general aim of the deliverable is to provide an overview of the existing Spatial Data Infrastructure (SDI) that is in use to support Europe's environmental legislation, which contributes to the European Biodiversity Strategy. According to the project's description of work, the review is designed to provide guidance to the AQUACROSS project on the most suitable information systems, data, and indicators available to support the project's needs to "*enhance the resilience and stop the loss of biodiversity of aquatic ecosystems as well as to ensure the ongoing and future provision of aquatic ecosystem services*" and "*advancing the knowledge base and application of the ecosystem-based management concept for aquatic ecosystems*". More specifically, this report is designed to inform the production of the AQUACROSS WP6 Information Platform led by IOC-UNESCO; the purpose of which is to:

1 Provide project partners with a tool and data repository to support the implementation of the project.
2 Provide the end-user community with a platform to search for and visualise geospatial data and documents: overview of data and metadata (including links to data repositories); indicators and tools; technical documentation and guidelines; geospatial exploration and visualisation of the collected data.

In terms of supporting the overall objectives of AQUACROSS, promoting resilience and stopping the loss of biodiversity through the promotion of an Ecosystem-Based Management approach (EBM), this deliverable will provide a general overview on the data and information needs, indicators and tools related to the current policy implementation processes. In order to address these needs, it is necessary to understand the complex policy landscape surrounding the Biodiversity Strategy, the multiple strands of legislation and policies, as well as the aspirations of an EBM implementation and its potential data requirements. The deliverable is divided accordingly: Section 1 introduces the structure and progress to date of the Biodiversity Strategy, provides definitions of EBM and considers the data and information needs for the implementation of an ecosystem-based approach to management; Section 2 provides a review of information systems and their data relating to freshwater and marine systems. Section 3 provides a critique of existing SDI, data and information and provides recommendations for generating an information platform that can promote the goals of the AQUACROSS project and the EU Biodiversity Strategy.

1.2 The Biodiversity Strategy

Under the UN Convention on Biological Diversity (CBD) (UN, 1992), the EU and its Member States made a commitment in 2002 to significantly reduce the rate of biodiversity loss by 2010. In May 2006, the EU launched its Biodiversity Action Plan (BAP) (EC, 2006) with a commitment to halting biodiversity loss in the EU by 2010 and beyond. The final report of the action plan identified a number of areas where progress had been made, but noted the overall failure of the plan to achieve its goals of halting biodiversity loss within the EU, recognising the need for a post-2010 action.

Table 1: Targets of the EU Biodiversity Strategy and mid-term assessment of progress (data from EC, 2015)

Target		Progress
Headline	Halt the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restore them in so far as feasible, while stepping up the EU	No significant overall progress
1	Halt the deterioration in the status of all species and habitats covered by EU nature legislation and achieve a significant and measurable improvement in their status so that, by 2020, compared with current assessments: (i) 100% more habitat assessments and 50% more species assessments under the Habitats Directive show an improved conservation status; and (ii) 50% more species assessments under the Birds Directive show a secure or improved status.	Progress toward target but at an insufficient rate
2	By 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15% of degraded ecosystems.	Progress toward target but at an insufficient rate
3	Increase the contribution of agriculture and forestry to maintaining and enhancing biodiversity.	No Significant progress
4	Achieve Maximum Sustainable Yield (MSY) by 2015. Achieve a population age and size distribution indicative of a healthy stock, through fisheries management with no significant adverse impacts on other stocks, species and ecosystems, in support of achieving Good Environmental Status by 2020, as required under the Marine Strategy Framework Directive (MSFD).	Progress toward target but at an insufficient rate
5	By 2020, Invasive Alien Species (IAS) and their pathways are identified and prioritised, priority species are controlled or eradicated, and pathways are managed to prevent the introduction and establishment of new IAS.	On track to achieve target
6	By 2020, the EU has stepped up its contribution to averting global biodiversity loss.	Progress toward target but at an insufficient rate

In order to provide insight into the process of the BAP and to design a more effective strategy to the prevention of biodiversity loss, the EC commissioned a report on the functioning of the BAP, which identified a number of major weaknesses in the process, and made

recommendations for an improved procedure. This included a smaller and more clearly defined set of actions, the provision of appropriate financial resourcing; a more structured, logical and measurable approach, as well as the harmonisation of the data collection and monitoring process. In 2010, the EC proposed a long-term (2050) vision for biodiversity, with a set of mid-term (2020) target options (COM 2010, 4 final).

The EU Biodiversity Strategy (EC, 2011) is the successor to the EU BAP. The overarching headline target of the strategy is to "halt the loss of biodiversity and ecosystem services by 2020, to restore ecosystems in so far as is feasible, and to step up the EU contribution to averting global biodiversity loss." As with the BAP, despite considerable efforts, progress towards the overarching objective has been limited. In this regard, the mid-term review of the Biodiversity Strategy (EC, 2015) found no overall progress to the overarching goal and no progress or insufficient progress toward all bar one of the main targets (Table 1). Notably, the metric used for assessing the successful target (related to invasive species) was based on the identification and prioritisation of the threats of invasive alien species (IAS) rather than concrete actions toward their control or eradication.

While achieving the targets of the Biodiversity Strategy is an international commitment under the CBD, it is not a legal obligation for Member States under European legislation, and the targets of the Strategy have not been always aligned with commitments under several pieces of European legislation. Target one, for example, relates directly to the Habitats Directive (HD) and the Birds Directive (BD). Target two is not related specifically to any piece of EU environmental law (though ecosystem service concepts are contained within some pieces of European legislation e.g. EU, 2008), but attempts at developing appropriate methods to assess ecosystem services at the European scale are currently in progress (Maes et al., 2013, 2014). The management of agriculture, which falls under target three, is subject to a range of legislative instruments, both concerning the environment and the efficient production of food. Similarly, target four for achieving Maximum Sustainable Yield (MSY) in commercial fisheries is associated at the European level with the Common Fisheries Policy (CFP) and its complex suite of rules and regulations, while also broadly aligned with the Marine Strategy Framework Directive (MSFD). Target five is addressed by the new regulation on IAS (EC, 2014) while target six relates to obligations under the Convention on the Trade in Threatened and Endangered Species, as well as to commitments to international aid. For each specific target of the Biodiversity Strategy, a number of specific actions have been identified (Figure 4).

Successful implementation of the Biodiversity Strategy, therefore, requires efficient alignment of several major strands of policy and legislation within the EU as well as development of suitable metrics of ecosystem services. To understand how these policies are aligned, it is important to consider the historical and philosophical contexts in which different pieces of legislation were conceived.

Target 1 Fully implement the Birds and Habitats Directives	1 Complete the establishment of the Natura 2000 Network and ensure good management 2 Ensure adequate financing of Natura 2000 sites 3 Increase stakeholder awareness and involvment and improve enforcement 4 Improve and streamline monitoring and enforcement
Target 2 Maintain and restore ecosystems and their services	5 Improve knowledge of ecosystems and their services in the EU 6 Set priorities to restore and promote the use of green infrastructure 7 Ensure no net loss of biodiversity and ecosystem services
Target 3 Increase the contribution of agriculture and forestry to maintaining and enhancing biodiversity	8 Enhance direct payments for environmental public goods in the EU Common Agricultural Policy 9 Better target rural development to biodiversity conservation 10 Conserve Europe's agricultural genetic diversity 11 Encourage forest holders to protect and enhance forest biodiversity 12 Integrate forest biodiversity in forest management plans
Target 4 Ensure the sustainable use of fisheries resources	13 Improve the management of fished stocks 14 Eliminate adverse impacts on fish stocks, species, habitats and ecosystems
Target 5 Combat invasive alien species	15 Strenghthen the EU Plant and Animal Health Regimes 16 Establish a dedicated Instrument on Invasive Alien Species
Target 6 Help avert global biodiversity loss	17 Reduce indirect drivers of biodiversity loss 18 Mobilise additional resources for global biodiversity conservation 19 ‚Biodiversity proof' EU development cooperation 20 Regulate access to genetic resources and the fair and equitable sharing of benefits arising from their use

Figure 4: Targets and Actions of the EU Biodiversity Strategy to 2020

1.3 A normative classification of policy[1]

The normative role of sustainability science, by all modern definitions, is that of balancing conservation with sustainable use, where sustainability is defined as meeting current needs without compromising the needs of the future (CBD, 1992; UN, 2015). The Sustainable Development Goals (SDGs) set out the most comprehensive suite of 17 social, economic and environmental goals and 169 targets to which sustainability science might aspire. Achieving these goals is a major challenge to humanity. At current efficiencies of resource use the goals of eliminating poverty and hunger, promoting equality, providing jobs, economic infrastructure and growth demand an increase in the resources available to many of the world's seven billion population. At the same time, considerations of ecological footprints suggest that many wealthier people are living beyond sustainable levels of consumption (Wackernagel et al., 2002; Ewing et al. 2010) and will need to decrease levels of consumption to achieve sustainability. Against this backdrop of global inequality, biodiversity globally is declining as humans continue to appropriate wild areas (Fahrig, 2003). At the core of sustainability science lie trade-offs between equitability and affluence as well as human use and non-use. These trade-offs are 'wicked problems' which will involve winners and losers, and their solutions require moral judgements (Jentoft and Chupedangee, 2009).

The international outlook on the role of man and nature set out in the SDGs, have changed considerably since Darwin and the advent of modern biological science. The theory of evolution with its challenges to literal reading of the book of Genesis, coincided with the industrial revolution and a new era of human achievement. The focus of evolution on 'survival of the fittest' began to inform other areas of human endeavour, notably the field of economics with its analogous focus of capitalism on competition (Nelson and Winter, 2002). By the early 20th century, the role of biology in human (economic and social) development was a major area of scientific interest and the science of eugenics and genetics were mainstream scientific pursuits (e.g. Huxley, 1962).

Following World War II, the foundation of the United Nations and the declaration of human rights, human populations were approaching the peak of their growth, and human impacts on the global environment were growing rapidly. The major scientific responses to this apparent crisis were two-fold. The population movement (successor to the eugenics movement and precursor for the modern environmental movement) identified human populations as the major threat to global environmental integrity (Ehrlich, 1968; Ehrlich and Holdren, 1971). While some argued for the adoption of a new ethical framework in a resource constrained planet (Hardin, 1974), some states, notably China, took direct action to control population (Wang, 2012). Concurrently agricultural sciences engaged in a programme of improving agricultural yields, known as the green revolution. This programme was so

[1] This section is adapted from O'Higgins, T (submitted) You Can't Eat Biodiversity: Agency and irrational norms in European aquatic environmental law. Challenges in sustainability.

successful that rather than experiencing severe famines, prices of food decreased around the world (Evenson and Gollin, 2003; Pingali, 2012).

The intensification of agricultural production around the globe, however, has led to increasing environmental degradation of terrestrial and aquatic habitats (Nixon, 1995; Vitousek, 1997; Tilman et al., 2002; Mee, 2006; Menesguen et al., 2010; Hering et al., 2010) and growing global pressures brought into focus the increasing rate of species extinctions (Ehrlich and Wilson, 1991). In 1992, the CBD recognised the "intrinsic value" of the diversity of life (CBD, 1992), which ultimately contributed to the SDGs which recognise the 'integrated and indivisible' balance between social economic and environmental aspects of sustainability (UN, 2015).

The prevailing narrative in modern conservation science (and that espoused by the AQUACROSS project -Gomez et al., 2016) connects biodiversity with ecosystem processes and human well-being through ecosystem services (MEA, 2003; TEEB, 2010; MAES, 2013). This narrative accommodates the norms of the SDGs recognising that social systems are connected to ecological systems and viewing biodiversity as an underpinning natural resource enabling development. However, there remains great uncertainty about the mechanisms connecting biodiversity to ecosystem processes, ecosystem services and benefits (Hooper et al., 2005; Mace et al., 2012). Despite ongoing global declines in biodiversity and ecosystem services, human well-being at the global level has continued to increase (Raudsepp-Hearne et al., 2010).

The EU Biodiversity Strategy is aligned with SDGs 14 and 15, the protection and sustainable use of the oceans and terrestrial (including freshwater) environments, respectively. The shifting role of biological science in social development has left a legacy of economics, politics and legislation which have formed the current models for European environmental governance and have potential to enable or to hamper productive development of environmental governance systems. Changing norms have shaped European environment and development policies over time, and the application of environmental regulation has been subject to social and political trade-offs, generally favouring economic development (sustainable or otherwise). The aim of this section is to identify the norms informing environmental legislation in the European context with a particular focus on their relevance to the Biodiversity Strategy and the aquatic environment. Three dominant themes in European environmental legislation are identified and these norms are traced through the sequential development of environmental legislation (focusing on the aquatic ones) and the implications for these norms in developing effective agency for environmental management are explored.

Sustainable development is often represented as having three distinct, interrelated components of economy, environment and society. The model presented by Giddings et al., (2002) of concentric circles with environment containing society and society containing economy represents an ideal frame, but in practice disciplinary silos generally result in a more fragmented perspective and three competing sets of values or norms, 'Practical', 'Popular' and 'Pure' can be distinguished.

Environmental policies with an anthropocentric focus may be considered ***Practical***. These norms are largely aligned with natural resource management concepts, management of stocks, e.g., to meet human ends, through the exploitation or stewardship of the natural environment. These may be loosely aligned with the concept of economic well-being, where individuals seek to maximise their own profits or production. Practical policies often relate to the systematic use of provisioning ecosystem services.

Popular norms are defined by their focus on cultural ecosystem services. This impact may be associated with non-use cultural ecosystem services, e.g., with species that are highly visible, the "warm glow" (Khanman and Kenetsch, 1992) of protecting charismatic species, such as the giant panda, the polar bear or cetaceans, which elicit strong responses toward conservation. Similarly, sustainability policies that have clear impacts on direct-use cultural services, where public goods are directly used by individuals without the intermediary of a specific economic sector (e.g. recreational fishing, swimming), may be considered popular as they relate to the public good rather than economic development of any particular or specific sector. The values or cultural ecosystem services associated with these conservation norms may not necessarily be aligned with scientific justification (e.g. Potts et al., 2016).

Table 2: Major Directives relating to the EU biodiversity Strategy in the Aquatic environment based on the results of analysis being carried out for AQUACROSS Deliverable 2.1.

Policy/Directive/Regulation	Acronym	Year
Common Agricultural Policy	CAP	1962
Bathing Water Directive	BWD	1976
Birds Directive	BD	1979
Common Fisheries Policy	CFP	1983
Urban Waste Water Treatment Directive	UWWTD	1991
Nitrates Directive	ND	1991
Habitats Directive	HD	1992
Water Framework Directive	WFD	2000
Marine Strategy Framework Directive	MSFD	2008
Regulation on Invasive Alien Species	IAS	2014

The ***Pure*** perspective is encapsulated by the slogan adopted by the US environmental movement of the early 1970s, "We have met the enemy and he is us". This viewpoint considers human activities as inimical to the functioning of ecology, juxtaposing man against nature. The norms associated with this narrative of purity seek a return to pre-anthropogenic disturbance. This concept of naturalness or purity often represents the norm of the hard environmental conservationists and, as in the CBD, recognises the "intrinsic worth" of the natural environment. Policies which aim to minimise or eliminate human effects principally for the sake of the environment itself or for its 'intrinsic value' are categorised as Pure in this analysis.

Individual pieces of European legislation may be **Hybrids** exhibiting a mixture of the three characteristics described above. Table 2 summarises the main pieces of EU environmental legislation directly related to the aquatic environments. Figure 5 maps the legislation onto a Venn diagram of the three value sets. The following section provides a narrative on the sequential development of the legislation over time.

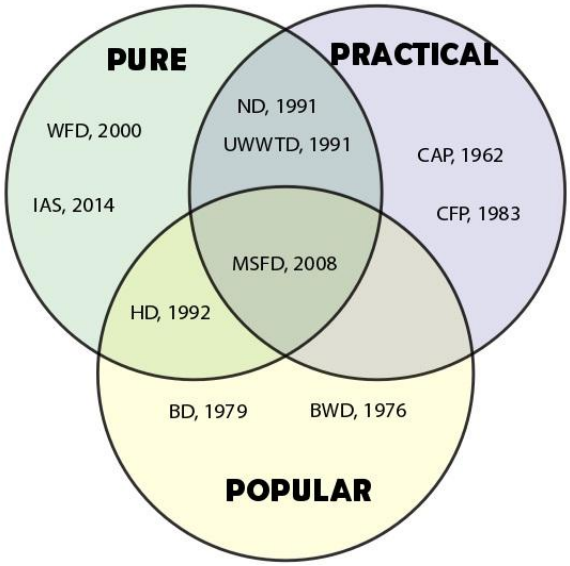


Figure 5: Venn diagram showing the overlap in values between different EU environmental directive and policies relating to the biodiversity in aquatic environments.

PRACTICAL

Though not explicitly a policy directed at the management of the aquatic environment, agricultural nutrient sources play a major role in determining European water quality, and for this reason, the Common Agricultural Policy (CAP) cannot be omitted from any analysis of aquatic environmental policy in Europe. A CAP, with the aims of achieving food security in Europe through modernisation and ensuring good prices for farmers, was put in place in 1962; since its inception, food security within Europe has been maintained (Zahrnt, 2011). The CAP includes subsidies to farmers as well as import tariffs to ensure prices for European farmers. The early CAP was criticised as a protectionist policy having created price distortions in global food markets (Borrel and Hubbard, 2000), but recent revisions have removed some of the more distorting subsidies (Kleijn and Sutherland, 2003). The CAP has a budget of €362.8 billion (almost 40% of the EU's budget) to subsidise agriculture in the period 2014-2020. In its current form, the policy is comprised of two 'pillars', direct payments or subsidies which make up 70% of the CAP budget and the European Agricultural Fund for Rural Development which accounts for the remaining 30% and provides co-funding for national programmes of rural development. In addition to continued food production, the most recent reforms in the CAP aim to encourage farmers to provide public goods, enhance biodiversity and play a role in climate mitigation. 30% of direct payments are now nominally conditional on greening measures, including maintenance of permanent grasslands and crop diversification. In practice, most farms, particularly smaller ones, are exempted from having

to take any action to receive these subsidies (Pe'er et al., 2014). This proportion of the CAP budget assigned to the production of food (a provisioning service) clearly categorises the CAP as a 'Practical' policy.

A CFP began to emerge in the late 1970s as new Member States began to join the European Economic Community, catalysing arrangements for existing Member States to gain free access to community fishing grounds. The CFP was formalised in 1983 (EEC, 1983) and has subsequently undergone a number of reforms (EC, 2002; EC, 2009; EC, 2013). Fisheries under the policy aim to achieve MSY. This objective has been criticised both on an economic basis (theoretically a more efficient fishery would aim for Maximum Economic Yield) as well as on a technical basis – achieving MSY in a mixed species fishery is notoriously difficult to achieve. The operation of the CFP itself has also been heavily criticized on many fronts, in particular for the systematic rejection of scientific advice on catch levels (Daw and Gray, 2005); in recent years, for example, catches have on average been set 20% higher than the scientific advice (Carpenter et al., 2016), as national political interests try to ensure a the best deal for their national fishing industries. The setting of quotas has also led to the practice of discarding, now been banned under the most recent reforms, which mark a shift toward EBM. Though there has been a long history of dysfunction in the CFP, currently 58% of assessed commercial stocks are considered to be below levels of MSY (EEA, 2016), though some stocks are beginning to recover within Europe (STECF, 2015). The target of MSY clearly marks the CFP as a 'Practical' policy since the aim is to maximise the amounts of fish extracted from the seas.

The European project was originally designed as a free trade organisation to facilitate trade between European nations, with the goal of averting war mainly through economic means, and the major policies controlling sustainable development continue to have a chiefly economic outlook. Figure 6 illustrates the budget breakdown for sustainable growth and natural resources in the EU for 2015, the total budget for which is over €55.9 billion. Components of the CAP combined with those of CFP make up over 99% (97.5% and 1.68% respectively) of this budget, less than 1% is assigned to other aspects (including environment and climate).

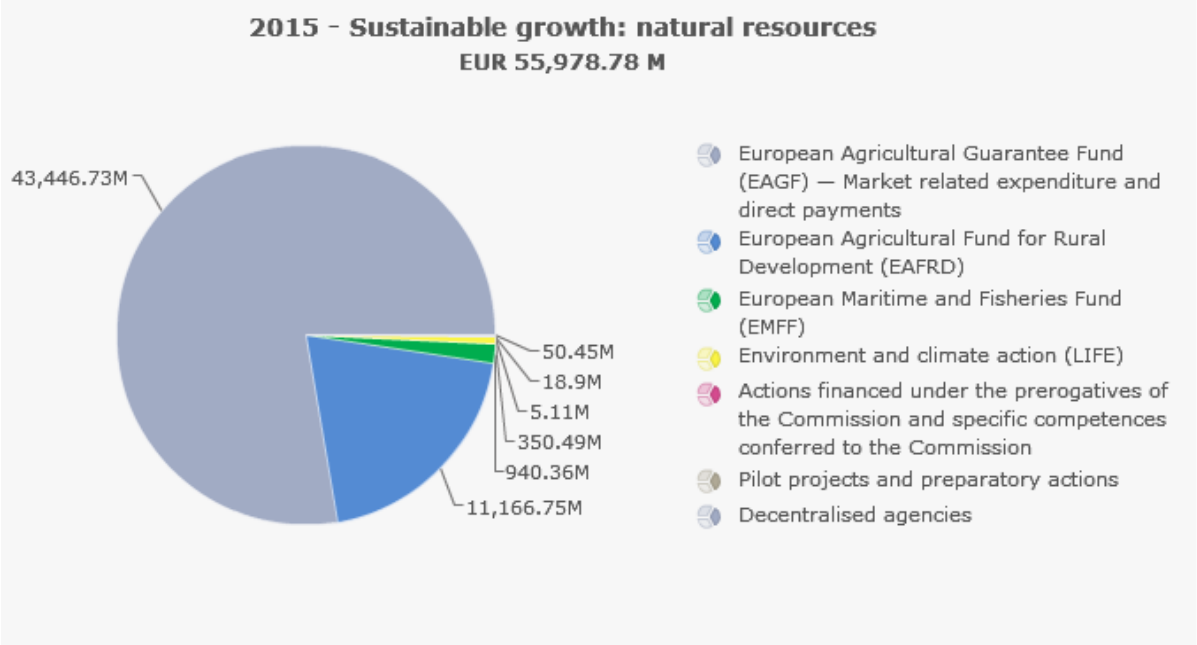


Figure 6: Sustainable growth: natural resources budget of the EU for 2015

source: http://ec.europa.eu/budget/annual/

Conservation measures under "Greening of the CAP" and reformed CFP have placed the expectation on farmers and fishers to be the major agents of biodiversity conservation. Following half a century of centrally facilitated intensification administered at the level of nation states, this marks a major shift in expectation, which has not been backed up by institutional support.

POPULAR

The first piece of law in the EU with the aim of improving aquatic environmental quality was the Bathing Water Directive (BWD). It was introduced "in order to protect the environment and public health" (EEC, 1976). The directive sets limits on the levels of bacteria (coliforms and enterococci) which are permitted to occur at locations designated for public bathing, in fresh and marine waters. Compliance with the directive has been supported by the EC since 1987 through the Blue Flag Program, which promotes public awareness, where beaches that comply with water quality standards (and certain other criteria) are awarded a blue flag for cleanliness. The implicit focus of the directive on (direct use) cultural ecosystem services categorises the BWD as 'Popular'.

The Directive on conservation of wild birds, or Birds Directive (BD) was established in 1979 and updated in 2009 (EC, 2009) to halt the decline in the numbers of wild bird species in the EU. This trend is ascribed to agricultural intensification (Donald et al., 2002). The Directive lists various species that must be conserved (Annex I) and others, which may be taken for game subject to certain conditions (Annex II). Both "natural balance" and "cultural heritage" are motivations for the Directive (EEC, 1979), this latter, illustrates the 'Popular' nature of the directive. Article 2 mandates that birds' species are maintained at "*a level which corresponds*

in particular to ecological, scientific and cultural requirements, while taking account of economic and recreational requirements, or to adapt the population of these species to that level." The perspective of the BD includes both ecological and cultural considerations, but its focus on "recreational and cultural requirements" as well as its scope focusing on popularly appealing, charismatic species, which provide active and passive use cultural ecosystem services makes the case for its inclusion in the 'Popular' set. However, despite its early introduction, EU avian biodiversity continues to be eroded (Eurostat, 2015).

PURE

The Water Framework Directive (WFD)(EC, 2000) was introduced to harmonise the growing body of aquatic environmental legislation. This directive regulates water quality in freshwaters (rivers, lakes and groundwater) and saltwater (estuarine/transitional and coastal) areas. The goal of the directive is to achieve or maintain Good Ecological Status, which is defined with reference to a relatively clean or "pristine" reference condition; thus, the norms of the directive are clearly 'Pure'. The directive takes a 'deconstructing structural' approach (EC, 2000; Borja, 2010) dealing with the characteristics of specific elements of water quality. These water quality elements are measured by a suite of indicators which include hydromorphologial parameters (hydrological regime, namely the connection to groundwater, and morphological conditions like the structure of the riparian zone in freshwater or structure of the intertidal zone or of the coastal bed), physicochemical parameters (concentrations of nutrients and oxygen) as well as Biological Quality Elements (BQEs) parameters, such as the composition of aquatic benthic flora and fauna the abundance of specific sensitive insect species for freshwater and benthic fauna in the marine. Among these BQEs, fishes are especially sensitive indicators for riverine ecosystems, as they show a significant response to various stressors (Omerod, 2003). Given the long history of human settlement and development in Europe, aquatic ecosystems have been experiencing anthropogenic disturbance for millennia (Bennion et al., 2011), and to some, the goal of good ecological status is a 'dream' (Bouleau, 2008), particularly given the non-linear responses of aquatic system to relaxation of anthropogenic pressures (Duarte et al., 2009; Schinegger et al., 2013). The WFD permits the designation of heavily modified water bodies, where specified uses of water bodies (including navigation, hydropower, and recreation) would be significantly affected by restoration measures and no feasible cost-effective option exists to maintain the benefits (EC, 2000; Kampa and Hansen, 2004). In these cases, the goal is to reach a potential good ecological status. Nevertheless, since its introduction, the WFD has resulted in a major concerted effort in the measurement and monitoring for the improvement of the quality of surface water bodies around Europe (Hering et al., 2010). The norms of the directive are clearly 'Pure', since they aspire to achieve pre-anthropogenic conditions, with baseline targets set on ecological rather than anthropocentric grounds.

HYBRIDS

The Nitrates Directive (ND) (EC, 1991a) and Urban Waste-Water Treatment Directives (UWWTD) (EC, 1991b), both deal directly with the prevention of undesirable emissions from what are essentially 'Practical' activities. Hence, they are included in the subset of 'Practical'

and 'Pure'. While the UWWTD provides for end-of-pipe solutions to the release of polluted waste waters, the ND deals with the more difficult issue of diffuse pollution. Practical measures to ensure compliance with the ND include the creation of buffer strips in farm land to prevent agricultural run-off. In practice, the success of the ND is complicated by the difficulties in enforcement of local actions over the large spatial scales covered by the Directive (O'Higgins et al., 2014). The ND is considered to have reduced nitrogen outputs from agriculture by between 3% and 19% depending on the type of nitrogen considered (Velthof et al., 2014).

The UWWTD provides for end-of-pipe solutions to the release of polluted waste waters. The maintenance of clean water has elements of 'Practical' natural resource management (supply of a provisioning service for human health) and 'Popular' aspects, in terms of supply of clean water for cultural service such as bathing, and is, therefore, classified as a hybrid of 'Practical' and 'Pure'.

Following its commitments under the CBD, the Habitats Directive (HD) came into force (EC, 1992). The directive is concerned with the development of a network of Special Areas of Conservation for specific habitat types and species in which biodiversity is prioritised. The Natura 2000 network is the largest network of reserves in the world, and its development was seen as one major achievement of the BAP (EC, 2010). Sites are designated according to the presence of particular target habitats or species listed in the Annexes of the directive. Despite its size, the Natura 2000 network has met with mixed success: 60% of species and 77% of habitats covered by the directive are reported to be in unfavourable condition (EEA, 2014). The Natura 2000 network has also fallen far short of its targets in assigning protected status to agricultural areas. On a Europe-wide basis, only 11.5% of the agricultural area targeted to be designated as Special Areas of Conservation has been assigned (EEA, 2012). Though the HD arose from the CBD, and was published in the same year, it may be considered as a hybrid of 'Pure' and 'Popular' in terms of its norms because it includes a mix of obscure and popularly unrecognised species as well as charismatic species (for example all species of whales are protected under the directive), and the process of designation of species for inclusion within the Annexes of the directive included value-based as well as ecologically-based decisions (Bryan, 2012).

The MSFD (EC, 2008) aims to achieve Good Environmental Status for each of 11 descriptors, uniting several environmental Directives for the marine environment, including the WFD, along with the ND and CAP, the HD and the CFP. The MSFD uses the language of the ecosystem-based approach and recognises the concepts of ecosystem services and may be seen as a hybrid of all three norms. In practice, during the first round of application, the approach of many Member States has been to collate the measures taken under existing directives and attribute them as measures in the implementation of the MSFD. Despite the high goals of the directive, economic constraints have overridden novel activities to implement a more holistic and sustainable approach to marine management in many cases. For example, in the UK, Ireland and Portugal, the official descriptions of measures have

mainly involved repackaging of existing measures rather than development of new measures designed to meet the needs of the MSFD.

One relatively new initiative under the EU Biodiversity Strategy has been the introduction of the recent regulation on invasive alien species (IAS) (EC, 2014). For the purposes of the directive an alien species is "*any live specimen of a species….introduced outside of its natural range*". The objective of the law is "*to prevent, minimise and mitigate the adverse impact on biodiversity of the introduction and spread of invasive alien species."*

This law obliges Member States to prevent the establishment and control the spread of non-indigenous species around Europe. The particular species to be addressed are contained within a list of European concern. The current, first list differs from the "list of 100 worst alien invasive species" (Lowe et al., 2000) in that it omits species, such as the Pacific Oyster (Crassostrea gigas), which are of economic importance but also considered invasive.

While the language of the directive does recognise ecosystem service concepts, the emphasis is in ecology on the concept of non-indigenous species. This narrative of invading aliens has been heavily criticised (Davis et al., 2011), and the evolution of invasion science in the 1990s is closely linked with the coining of the term biodiversity (O'Higgins 2015). This regulation includes exceptions for species of economic importance in aquaculture under *the Regulation concerning use of alien and locally absent species in aquaculture* (EC, 2007), which provides a loophole to prioritise aquaculture development in pursuit of the European Blue Growth agenda over environmental integrity.

While the theory behind IAS research certainly falls into the normative category of 'Pure', the list of species of union concern also reflects the 'Practical' norm and the regulation may, therefore, be seen as a hybrid of 'Practical' and 'Pure'.

Amidst all these competing policies and pieces of environmental legislation, European Member States have an obligation under the Aarhus convention (Aarhus, 1998) to make environmental data publicly available. The INSPIRE Directive (2008) obliges European Member States to develop Spatial Data Infrastructure (SDI) facilitating the exchange of data in digital form amongst public institutions; and, while standards are developing toward the production of integrated environmental spatial data infrastructure, the pace of the development of technology along with the varying capacity within EU Member States has led to a mixed level of spatial data availability, which varies from region to region and nation to nation. A number of competing softwares and platforms, from open-source to proprietary, are being used to comply with the Directive. The common principles of the Directive are:

- Data should be collected only once and kept where it can be maintained most effectively.
- It should be possible to combine seamless spatial information from different sources across Europe and share it with many users and applications.
- It should be possible for information collected at one level/scale to be shared with all levels/scales; detailed for thorough investigations, general for strategic purposes.
- Geographic information needed for good governance at all levels should be readily and transparently available.

- Easy to find, what geographic information is available, how it can be used to meet a particular need, and under which conditions it can be acquired and used.

Figure 7 shows the roadmap for Europe to full INSPIRE Compliance. The relevance of the INSPIRE principals to the implementation of the Biodiversity Strategy across national boundaries and institutions is clear. Due to INSPIRE, there is also a legally binding obligation with regards to metadata. Separate metadata regulations under INSPIRE (1205/2008/EC) placed obligations on public authorities and third parties to create full metadata for spatial data sets and data services. Metadata must include information about the data on: quality and validity; the party responsible for creating, managing, maintaining and distributing the data or service; and any restrictions on public or other use or charges for access.

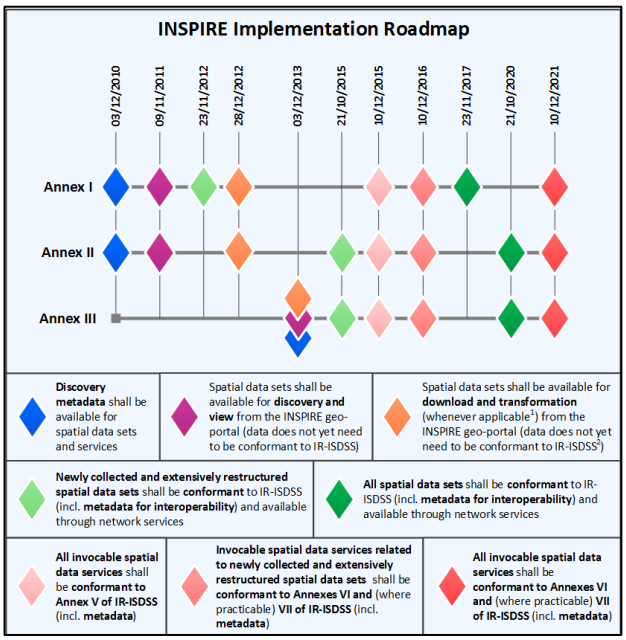


Figure 7: Roadmap to INSPIRE compliance.

As implementation of the Directive progresses, increasing amounts of data and metadata are becoming freely available, resulting in an increasing amount of public information freely available in public data repositories.[2] Although such data are present, they are frequently not easy to interrogate or readily accessible.

Agency and irrational trade-offs

The first EU BAP (EC, 2006) was met with limited success; its target of halting biodiversity loss by 2010 was not achieved (EC, 2010). The EU Biodiversity Strategy aims to halt this loss by 2020. The norms underlying EU environmental law have shifted from the 'Practical' through 'Popular' toward 'Pure' and increasingly represent a fuller range of perspectives, but

[2] e.g. www.data.gov

the fundamental challenges to achieving sustainability in the frame of European environmental law remain the implicit trade-offs between the provision of food, economic growth and protection of nature.

Within Europe, the funding available for implementation for 'Practical' policies eclipses funding for focused environmental legislation. The major relationship between humans and the environment promoted by the EU – the two main 'Practical' policies (CAP and CFP) – is one of consumption. Efforts to reduce the amount of environmental damage of the major 'Practical' policies have been compromised by political negotiation to ensure the economic livelihoods of small farmers and of fishers. As demonstrated by negotiations in the CAP and CFP, politicians, on a five-year re-election cycle, lack the agency to impose costs on their constituents for the purposes of poorly understood concepts, such as biodiversity and ecosystem services. For fisheries and agriculture, despite recent reform, economic gains are more immediately felt than environmental gains, and the production of private goods is more profitable than the production of public ones. Under the current system, trade-offs between food production and biodiversity are generally economically irrational; that is, individuals do not stand to increase their own economic welfare by protecting the environment. Strategies for incorporating effective biodiversity conservation into the 'Practical' polices are, therefore, a clear area for targeted further research.

The "intrinsic worth" of biodiversity, as articulated by the CBD, is not necessarily self-evident, and there are not clear links between all components of nature and human well-being. Though limited data exists at the European scale, at least for the marine environment, public understanding and awareness of environmental problems is poor (Potts et al., 2016). This imbalance could be redressed through education to develop public understanding of the benefits of nature, to better align the 'Popular' and 'Pure' environmental norms.

The emerging focus on ecosystem services, for example, in the MSFD may provide a mechanism to balance these trade-offs. While full accounting for ecosystem service values and internalisation within European policy can, in theory, more fully elucidate and re-balance these trade-offs (as advocated by the MSFD), scientific understanding of the role of biodiversity in the supply of ecosystem services remains low (Mace et al., 2012). Scientists, therefore, have a role in elucidating these links through further research and effectively communicating their findings to policy-makers and to the public.

In contrast to funding for rural development and fisheries exploitation, at the European level, there is no dedicated, centralised organisation for the funding enforcement of environmental legislation. While the European Environment Agency (EEA) has a duty to "*to support sustainable development and to help achieve significant and measurable improvement in Europe's environment through the provision of timely, targeted, relevant and reliable information to policy-making agents and the public,*" it has no mandate or means to enforce regulation. This responsibility, instead, falls to national and local governments. Existing legislation might be enforced more effectively through rebalancing the sustainable growth budget toward centralised, financial support for environmental protection outside of the sectoral CAP and CFP policies.

Even within environmental legislation, loopholes exist; the designation of heavily modified water bodies, the exceptions in the IAS regulation, the trade-off between economy and environment have already been made at the legislative and policy level.

At the individual level, the goal of halting biodiversity loss along with achieving the other indivisible SDGs comes down to choices in consumption. In order to achieve these goals, European individuals may be required to make personal sacrifices for the long-term greater good and to act against short-term self-interest in the cause of equity. Reducing levels of consumption may require individuals to make choices from which they personally do not benefit. This is a "wicked problem" as it requires moral judgements and result in winners and losers. While science can expose the resource constraints of a finite planet (Rockstrom, 2010), it is not best suited to making moral choices or subjective decisions.[3]

At the European scale, these policies fall under different legislative remits with, for example, the HD and the MSFD being the domain of the Directorate General for the Environment (DG ENV), while the CFP is administered by the DG for the Maritime Affairs and Fisheries (DG MARE) and the CAP is administered under DG for Agriculture and Rural Development (DG AGRI). While in theory all these sectoral directorates are committed to attaining the targets of the Biodiversity Strategy, in practice, the prime objectives of sectoral directorates tend to rest within their sector. For example, the main business of DG AGRI is in administering the CAP with its goal of food security, and compliance with the HD or WFD is in reality a secondary concern.

1.4 Ecosystem-Based Management

There is increasing international recognition that less sectoral, more holistic approaches to environmental management are required for economic growth, in order to remain sustainable and to avoid undesirable environmental consequences. This recognition is also increasingly incorporated into EU law (for example in Europe's Integrated Maritime Policy). Though not specifically legally mandated under European legislation, the ecosystem-based approach to management is considered the principal framework for such holistic actions under the CBD. In this context, the AQUACROSS project focuses on advancing the knowledge base and application of the EBM concept for aquatic ecosystems, including freshwater, transitional and marine waters. EBM may be defined as:

> *"Any management or policy options intended to restore, enhance and/or protect the resilience of the ecosystem. This encompasses any course of action purposely intended to improve the ability of ecosystems to remain within critical thresholds, to respond to change and/or to transform to find a new equilibrium or development path."*
>
> *Gomez et al., 2016*

[3] Excerpted text ends here.

While there are many different definitions of EBM, some important defining characteristics of the approach are the inclusion of ecosystem services, the incorporation of multiple stakeholder perspectives and the recognition of the tight coupling between social and ecological systems (Tallis et al., 2010).

Sarda et al. (2014) designed an EBM System (EBMS) that recognised three pillars necessary for the systematic implementation of EBM: the information pillar, the participation pillar and the managerial pillar. Essentially, in order to make appropriate decisions about the management of public goods (in this case of AQUACROSS biodiversity), decision-makers in line with the principals of EBM need appropriate data and information, as well as participation from individuals to inform the decisions. Once a particular objective has been defined based on information and stakeholder input, a defined and verifiable set of actions is set out under the well-known and established sequence of: Plan, Do, Check, Act.

Given that there is no legal commitment for European Member States to achieve the aims of the European Biodiversity Strategy (though achieving the CBD targets are legal commitments for EU Member States), integrating environmental measures under the range of existing legislation relevant to the Strategy is the only practical means of progressing toward the practice of EBM, the target of halting biodiversity loss and the degradation of ecosystem services. However, relevant legislation, data and information come from many different sources, in terms of geographical as well as in terms of policy domains. Understanding the variety of types of data and information sources, as well as the different reasons for the collection and collation of data, can help inform the analysis of challenges of data integration for the purposes of the Biodiversity Strategy. The main body of this deliverable deals with the practical implications of the multiple legislative and policy drivers for change in biodiversity and provides recommendations for prioritising and synthesising data and information in the context of the AQUACROSS project with a specific focus on the AQUACROSS Information Platform being developed in WP6.

1.5 Who are the data users and what are their requirements?

Figure 8 shows a schematic diagram of data flow for an ecosystem-based approach to management. There are at least four distinct groups of users; scientific information is gathered by scientists (boffins) and summarised for policy (wonks) and decision-making (politicians). Under EBM, where public participation is considered to be an essential element, data must also be presented to the public or stakeholders in a format that is accessible to them. In general, the flow of information and data for any given policy follows a similar process.

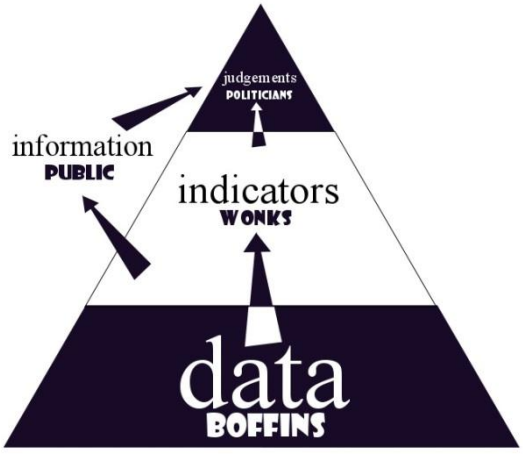


Figure 8: Idealised flow of data through different user groups, boffins, wonks, the public and politicians for implementation of EBM.

Scientists require detailed information. At the level of scientific enquiry typical for environmental data, large numbers of technical observations are gathered. For example, nutrient samples for river water quality might be collected on a daily or weekly basis. From the perspective of the environmental scientist, the resulting temporal patterns in nutrient concentrations might be used to understand how biogeochemical fluxes vary over time, or how patterns in weather and climate act to control abiotic conditions, which in turn may alter the temporal patterns in biological activity over an annual cycle. While this detailed information may help to understand the functioning of ecosystems, the functional roles of biodiversity or habitat distribution may not be directly applicable to understand whether a particular system is achieving its policy targets.

Policy practitioners require reliable synthesised data with less detail. For policy, specific metrics or indicators are generally developed to synthesise and simplify information and to allow for assigning threshold values to quantify specific assessment criteria for and thresholds of these criteria as policy targets. Synthesis may involve simple statistical metrics such as average values, percentiles or more complex relationships about the relative proportions of particular biological components of systems (e.g. Ecological Quality Ratios) (Van De Bund and Solimini, 2007). Typically, such criteria synthesise large amounts of data and can be used to communicate them in a policy-relevant way to people with a less specialised knowledge of a particular ecological system.

Decision-makers require reliable robust data. At the decision-making level, based on selected criteria, decisions need to be made about what measures should be put in place to comply with a particular regulation. Frequently, these decisions are made by more powerful individuals, the decision-makers and budget holders, who deal with many competing policy objectives under constraints of limited resources. For such busy individuals, the detail of the synthetic criteria may be too great, as they are often required to give yes or no answers to questions involving the allocation of resources. In this case, the primary concern may be that

the data on which a decision is made are robust and reliable. Figure 8 illustrates this pyramid of data users for the policy process from boffins (scientists) through wonks (policy analysts) and the decision-makers, as well as illustrating the flow of data that is required to facilitate the participatory pillar of EBM.

Ideally, in the interests of transparency and in compliance with the Aarhus conventions, the detailed scientific data, synthesised policy information and the simplified indicators for decision-makers should all be readily accessible and the interrelationships between the different information types should be made obvious so that an individual (depending on the level of interest) can get as much or as little information on a specific aspect of the environment as they desire. For example, the decision-maker deciding on an urban waste-water treatment plant should have WFD and UWWTD indicators readily available online and the links between these indicators and the underlying data should be readily accessible and inter-comparable with neighbouring regions and countries.

The specific purpose of the data being gathered has implications for its dependability and reliability. For example, if data (in the lowest section of the pyramid) are being gathered on an oceanographic research cruise, the data may be used to understand how the oceans are behaving, e.g. their currents or their biological productivity. On any given research cruise, continuous (or very high frequency) measurements may be taken over a broad geographical area to map or monitor specific aspects of ocean biogeochemistry. The scientist may have very specific temporal or spatial requirements for data to answer specific questions. The data resulting from the cruise are used for academic analysis and scientific research, they are not generated directly to support policy decisions, and the consequences of sampling errors may result in analytical difficulty but does not have legal or financial consequences.

By contrast, data collected for the purposes of specific policies require accurate and verifiable information on specific sites for legislative reporting under international conventions such as the Oslo and Paris Convention (OSPAR), or for the purposes of complying with European Directives. A Member State may be obliged to report on a set of sites with regard to specific legislatively-designated parameters at specific sites with a high degree of certainty. Given the potential legal consequences of failing to meet particular water quality standards, data for the purposes of legislative reporting are required to meet higher data quality standards and to follow comparable inter-calibrated methods.

As a contribution to international and national decision-making, these data must be dependable and also must be relatively easily communicated to non-experts. In the case of European environmental law, the flow of policy information generally follows the pyramidal structure shown in Figure 8, but often the data and information are not readily accessible to the public and this may be considered a barrier to EBM. The following sections provide a review of the SDI relevant to the implementation of the EU Biodiversity Strategy. Data and information were gathered according to a standardised template. The normative analysis of European natural resource management and environmental policy provided above identifies several specific areas that require improvement in order to meet the targets of the Biodiversity Strategy:

- An improved understanding amongst policy-makers and the public of the concepts of biodiversity;
- Improved understanding of the benefits of nature; and
- A recognition of the trade-offs between consumption and biodiversity

In addition to the functional role of the AQUACROSS Information Platform in supporting project partners in access and storage of data, the analysis above suggests that any contribution the Information Platform can make to the three points above would add value to the project and to the platform.

The final section of this report will use the information categories shown in Figure 8 to analyse how policy information and data are synthesised using SDI and to assess how existing SDI might meet the needs of various data end-users with specific reference to improved understanding of the concepts of biodiversity, the benefits of nature and the trade-offs between consumption and biodiversity and to provide recommendations for the AQUACROSS Information Platform.

2 Review of Information Systems Data and Information

2.1 Marine

For the marine environment, there is a vast range of spatial data available relevant to implementing the EU Biodiversity Strategy; this data includes oceanographic data and biological data hosted on a number of portals, policy data collated on individual policy portals, information collated by the EU DG MARE, data contributed by individual Member States under Regional Seas Conventions, various national and local data portals compiled for specific purposes by individual local administrative or sectoral user groups, and still more relevant data are gathered by sectoral groups (e.g., NGOs, associations for environmentally-related activities, like hunters, anglers and birdwatchers, and academia). This section provides an overview of the major initiatives and is structured according to Figure 8: Idealised flow of data through different user groups, boffins, wonks, the public and politicians for implementation of EBM., commencing with the data rich scientific portals, then treating specific policy portals followed by a brief description of some national geoportals and some sectoral SDI gaps.

2.1.1 Scientific data portals

There are three major Europe-wide oceanographic data portals of note, specifically dealing with European oceanographic and climatic data.

SeaDataNet

SeaDataNet[4] is an international marine data infrastucture project with the aim of providing access to historical (i.e. not real time) oceanographic datasets. The project involves 90 national oceanographic and marine data centres in 35 countries in all European seas and provides a suite of quality controlled and validated historical oceanographic datasets of parameters. Most data are freely available. The data may be visualised, for example, by downloading the Ocean Data View software.[5]

One major technical achievement of the SeaDataNet project was the development of a set of common vocabularies, allowing full interoperability of the data kept at the various data centres in the network. The project is largely aimed at the technical and analytical community

[4] www.seadatanet.org/

[5] www.odv.awi.de/

to facilitate research and contains physical, chemical, biological and geological data. For example SeaDataNet has a searchable directory[6] that allows many types of searches, using open queries, time and location stamps, specific seas or marine areas, specific oceanographic instruments, projects, institutions or nations. Data and query results are generally highly technical, relevant mainly to scientists and of less immediate relevance to policy-makers or the general public. SeaDataNet provides an invaluable tool for research and a valuable data repository, but its target stakeholders are the scientific community; and while data relevant to the EU Biodiversity Strategy are freely available within the platform, the platform has not been designed specifically to inform environmental policies such as the Strategy.

Copernicus – Marine environment monitoring service

Copernicus[7] is a European enterprise initiative with the aim of establishing an integrated EU-wide expertise in monitoring and forecasting in the marine environment. The Copernicus front page includes a list of geographic locations for which data are available; these data are further searchable according to a range of search criteria, including temporal coverage and resolution, types of outputs (modelled or measured) as well as types of parameters such as physical, chemical and biological parameters. Access to the data requires registration.

Similarly to SeaDataNet, the Copernicus data portal is directed chiefly at the oceanographic research community, and many of the products contained within it are quite technical in nature. Copernicus has been designed to support a wide range of applications, including environment protection, management of urban areas, regional and local planning, agriculture, forestry, fisheries, health, transport, climate change, sustainable development, civil protection and tourism, but is directed more toward the scientific and analytical communities rather than towards specific EU environmental policies and their associated indicators. As such, the site is quite technical and not necessarily targeted at direct policy support of EBM.

EMODnet

The European Marine Observation and Data Network (EMODnet)[8] consists of more than 100 organisations assembling marine data, products and metadata to make these fragmented resources more available to public and private users relying on quality-assured, standardised and harmonised marine data, which are interoperable and free of restrictions on use. EMODnet is currently in its second development phase with the goal to be fully deployed by 2020. Several components of EMODnet make use of the SeaDataNet infrastructure. Unlike Copernicus and SeaDataNet, the data are presented under reasonably accessible categories, including bathymetry, geology, seabed habitats, chemistry, biology, physics, and human activities. For each category, there is a separate portal that provides maps illustrating the

[6] http://seadatanet.maris2.nl/v_cdi_v3/search.asp
[7] http://marine.copernicus.eu/
[8] http://www.emodnet.eu/

data and links for the download of the data layers. The separate portals also allow users to access information of particular interest to their needs. Within EMODnet, there has been clear effort in producing tools that are accessible to less-technical users; nevertheless, it is still aimed at the science/policy community rather than decision-makers or the general public. This is because in order to understand the relevance of the various types of data on the portal to particular environmental issues and their related EU environmental policies, considerable training and expertise are required and the data are relatively inaccessible to the interested lay-person.

2.1.2 Policy data sources

The European Commission Joint Research Centre (JRC) has established a MSFD Competence Centre.[9] As well as providing relevant, official policy documentation on each of the MSFD descriptors and their assessment, the site provides links to a number of spatial data portals with information relevant to MSFD implementation. These official EU sites include the European Atlas of the Seas[10]; the Environmental Marine Information System (EMIS),[11] which contains a range of oceanographic and biological parameters reported at 2km and 4km resolutions, also accessible as a web map service; the European Alien Species Information Network (EASIN);[12] the INSPIRE data portal[13], which is currently under development; as well as the Copernicus marine monitoring service (described above). All of these portals hold information relevant to the implementation of the MSFD at the European scale, though none are specifically dedicated to it and all have other information that are only peripherally relevant to the MSFD. The iMarine initiative,[14] facilitated by the JRC, provides a portal for discovery of data and information related to EBM of marine fisheries.

The EEA has a responsibility for holding and disseminating environmental information and this includes data relevant to all EU environmental directives, including the WFD, the HD and the MSFD. The EEA makes spatial data available for download as well as allowing download of non-spatial data. Many relevant products deal with implementation; one particularly relevant initiative is DiscoMap,[15] which provides a list of over 40 environmental web map services (WMS) containing official EU reporting data that may be displayed on any geospatial portal. Figure 9 shows a screenshot of the DiscoMap WMS available for water.

[9] http://mcc.jrc.ec.europa.eu/index.py
[10] http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#
[11] http://mcc.jrc.ec.europa.eu/emis/
[12] http://easin.jrc.ec.europa.eu/?AspxAutoDetectCookieSupport=1
[13] http://inspire-geoportal.ec.europa.eu/
[14] http://www.i-marine.eu/Content/OurServices.aspx?menu=1
[15] http://discomap.eea.europa.eu/home.html

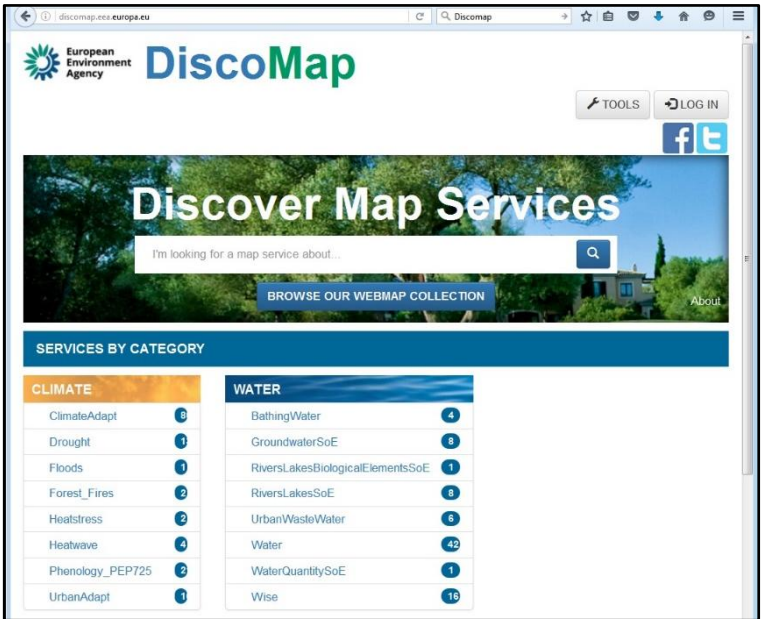


Figure 9: Screenshot of DiscoMap website

2.1.3 International initiatives and Regional Seas Conventions

Both the MSFD and the Maritime Spatial Planning Directive (2014/89/EU) mandate cooperation on the regional seas basis, and there are a number of international bodies that support this goal. The International Council for the Exploration of the Seas (ICES) is an intergovernmental organisation that provides scientific advice and information to national and regional bodies at the regional scale. There are a number of conventions that support such regional seas cooperation, these include the Oslo-Paris Convention (OSPAR), which focuses on the North Sea and North East Atlantic, The Helsinki Commission (HELCOM), which is active in the Baltic, the Black Sea Commission and cooperative activities under the United Nations Environment Program Mediterranean Action Plan and the Barcelona Convention on the Protection of the Marine Environment and the Coastal Region of the Mediterranean. The status and levels of activity of these regional seas bodies varies as does their capacity in terms of SDI.

ICES has considerable data holdings (Figure 10). ICES maps and the spatial data information webpage[16] provide a comprehensive suite of products relevant to the EU Biodiversity Strategy. In particular, Target 4 of the Strategy which deals with MSY for commercial fisheries; ICES provides information on the levels of exploitation of commercially fished stocks in each management zone. These can all be viewed in one place using the ICES spatial facility[17] and include the DATRAS-ICES (Database of Trawl Surveys) Survey Area query tool, a station dictionary, ICES statistical rectangle and the ICES popular Advice and Marine Habitat Mapping information (also relevant to descriptors 1 and 6). Figure 11 shows the dedicated ICES

[16] http://ices.dk/marine-data/maps/Pages/default.aspx
[17] http://gis.ices.dk/sf/

popular advice page- which provides the MSFD-relevant information for locations in all seas throughout Europe. Users can select a species in a ICES subdivision and can chose a brief summary of the species, read the ICES advice digest (which, where possible, includes information on F_{MSY}); the more involved user can follow links to the full ICES advice. ICES acts as a data centre for both OSPAR and HELCOM conventions and the ICES site effectively delivers scientific as well as policy data and the visual representations of different species provide a user-friendly interface for interested members of the general public.

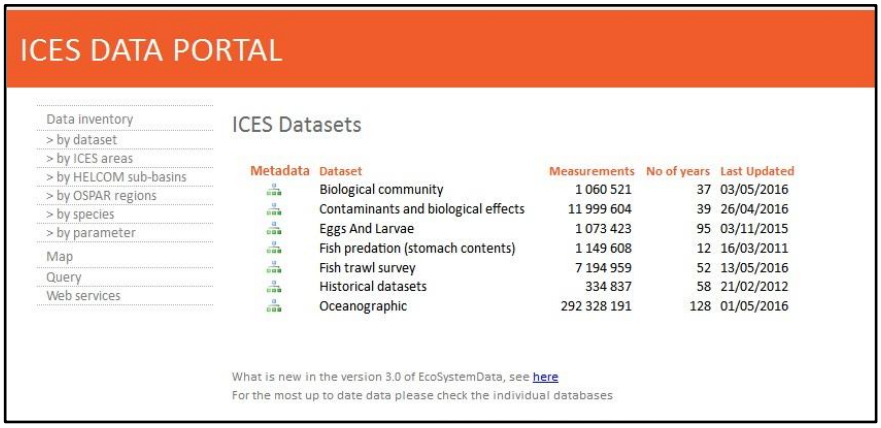


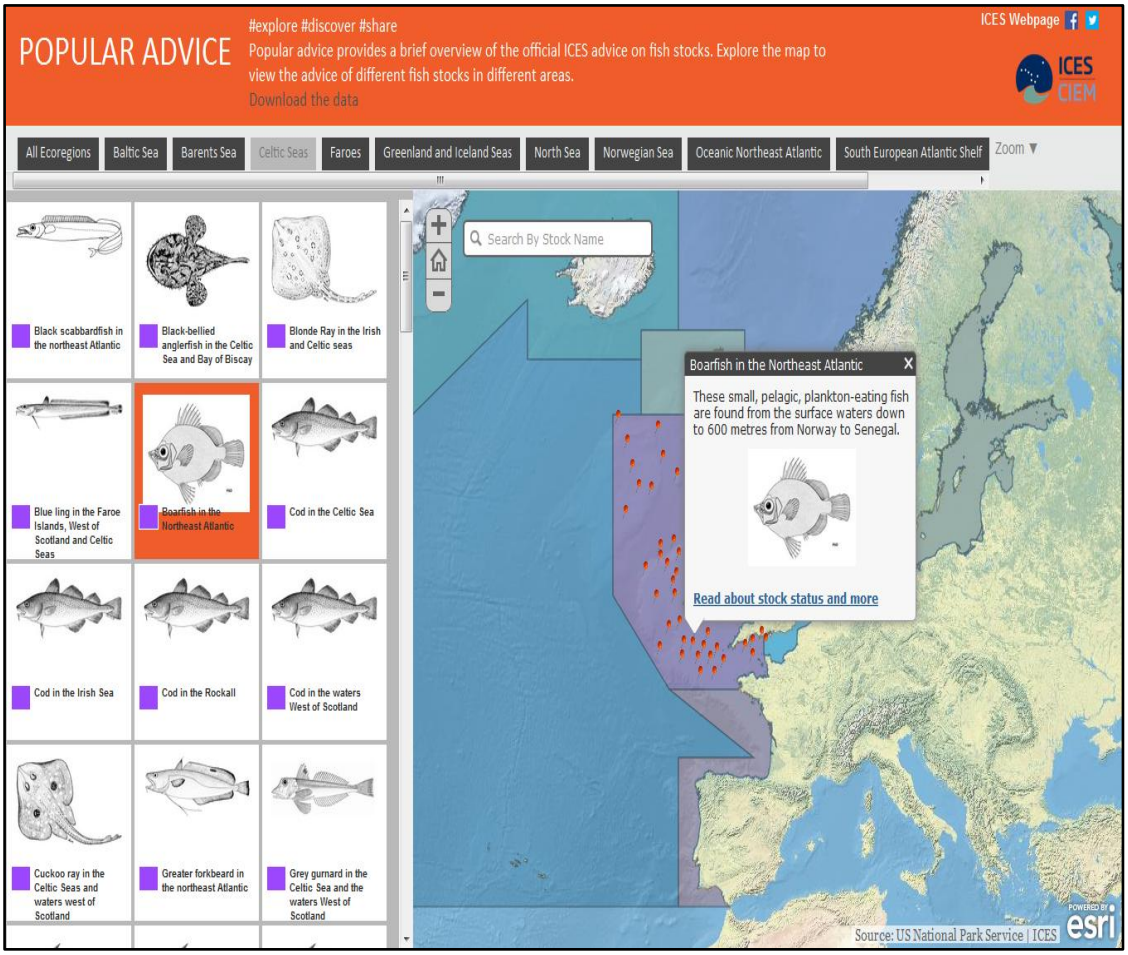
Figure 10: Screenshot if ICES data portal illustrating the huge number of measurements available

Of the regional seas commission spatial data platforms, the most developed example is in the Baltic Sea, that of HELCOM data and map services.[18] This site provides a general data and map viewer along with six thematic portals, aimed at particular users or individuals with a specific interest: Environmental monitoring, Environmental status, Pressures and Human Activities, Biodiversity, Maritime and Response and Maritime Spatial Planning.

A similar data portal for OSPAR has recently been released.[19] While this portal is not yet fully populated with data, OSPAR have significant data holdings (Table 3).

[18] http://www.helcom.fi/baltic-sea-trends/data-maps

[19] http://odims.ospar.org/



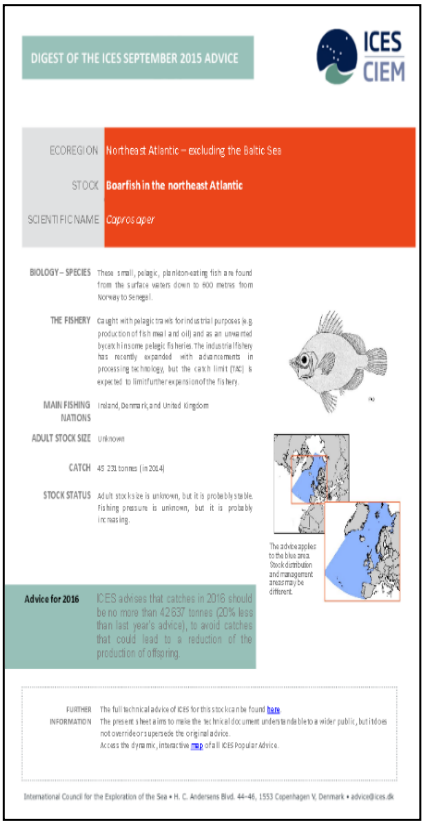


Figure 11: ICES Popular Advice Map

The ICES Popular Advice Map provides information on a diverse range of fish species from the entire ICES area. A brief description of the area is available. Users can select a species of interest (above) and click on the species to receive a digest of the most recent ICES advice based on the most recent assessments. The information provided includes Stock Size, Landings, Status and ICES advice. The popular advice page provides a link for the interested reader to the most recent full ICES advice on the stock including landings and stock size time series, of advice and landings by nation. Data are reported at the spatial scale of ICES areas. Link to map: http://gis.ices.dk/popadvice/.

Table 3: Major categories of OSPAR datasets

	OSPAR Datasets
1	Comprehensive study on riverine inputs and direct discharges
2	Comprehensive Atmospheric Monitoring Programme
3	Discharges of radionuclides from non-nuclear sectors
4	Discharges, spills and emissions from offshore oil and gas installations
5	Dumping of wastes or other matter at sea
6	Encounters with Dumped Chemical and conventional munitions
7	Environmental monitoring of radioactive substance
8	Inventory of offshore installations
9	Joint OSPAR/HELCOM Ballast water management
10	Levels and trends in contaminants and their biological effects
11	Liquid discharges from nuclear installations
12	Marine litter beach monitoring
13	Marine Protected Area Network
14	Mercury Losses from the Chlor-alkali industry
15	Offshore Wind farms
16	OSPAR Habitats in the North-East Atlantic Ocean
17	Plastic Particles in stomach of seabirds

The Black Sea Commission runs a rudimentary data portal[20] and the details of a Black Sea Information System have been described, though it is not clear whether the portal is operational. There are also a number of data portals that include information on the Mediterranean and Black Seas. The strategic partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership) has developed Integrated Coastal Zone Management plans[21] for a number of areas, as well as the MEDICIP[22] "portal of portals," which contains information on climate hazards and anthropogenic pressures in the Mediterranean region. MED GIS,[23] the geographic information system on biodiversity in the Mediterranean also holds information on biodiversity and protected sites in the Mediterranean.

TWAP

The Global Environment Facility (GEF)-funded Transboundary Waters Assessment Programme[24] (TWAP) aims to guide interventions to improve the environment and provide benefits for human well-being. This work is based on assessing transboundary aquifers,

[20] http://www.blacksea-commission.org/_bsgis2.asp
[21] http://pap-thecoastcentre.org/projects/coastal_plans.html
[22] http://medicip.grid.unep.ch/
[23] http://medgis.medchm.net/
[24] http://www.geftwap.org/

reservoirs and lakes, river basins, Large Marine Ecosystems (LMEs) and the open ocean. TWAP aims to provide a baseline assessment to identify and evaluate changes in such water systems that are caused by human activities and natural processes, and the consequences to dependent human populations.

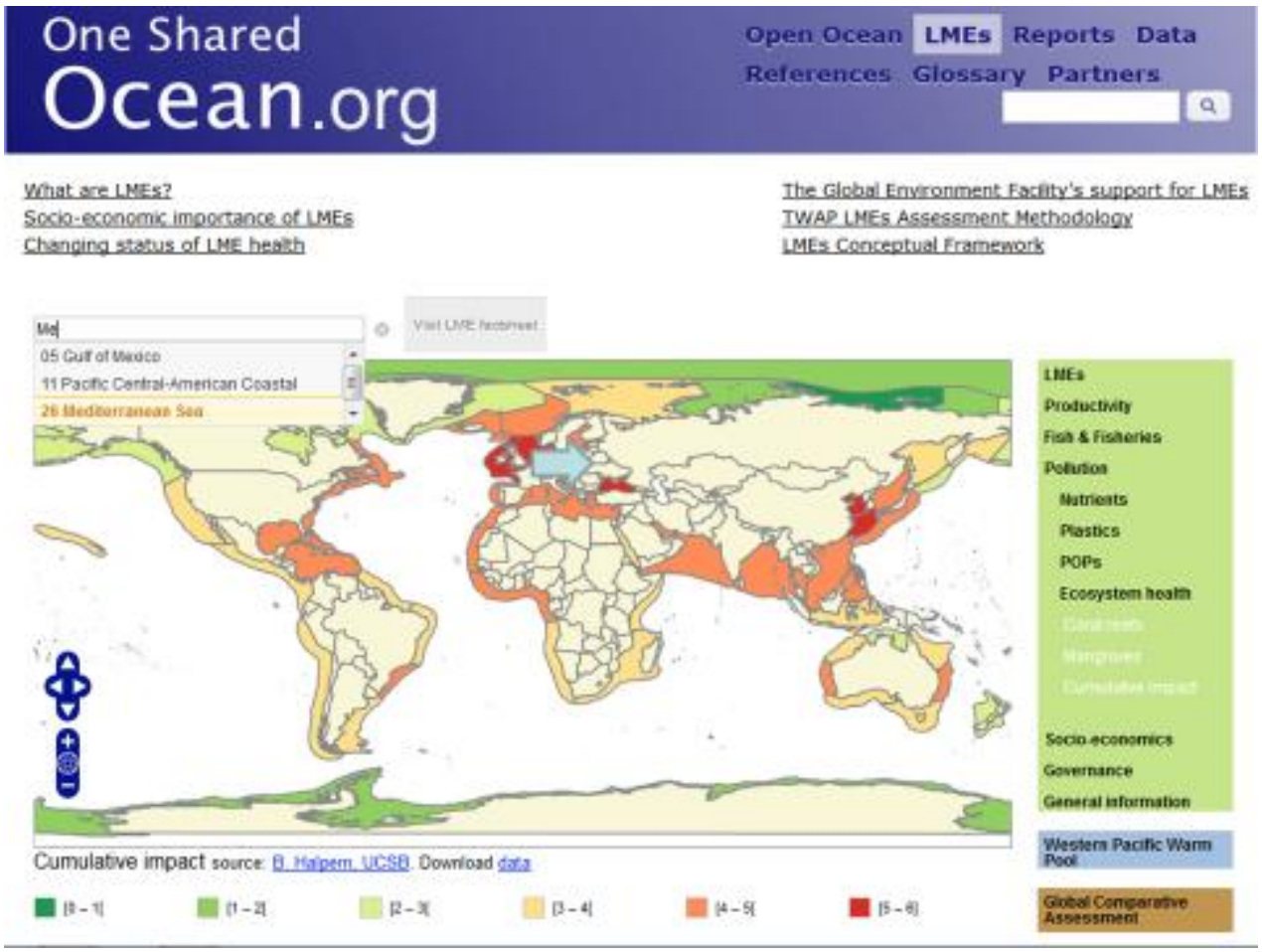


Figure 12: Onesharedocean web portal

Source: IOC-UNESCO

Information on the status of the Large Marine Ecosystems (LMEs), based on the TWAP LMEs assessment, is represented through a series of indicators and indices, arranged according to the five LME modules: Productivity, Fish and Fisheries, Pollution and Ecosystem Health, Socio-economics and Governance. In addition, patterns of risk among LMEs from human activities are explored by integrating multiple indicators. Some of the indicators are also presented for the Western Pacific Warm Pool (WPWP). The 66 LMEs are displayed in green on the above map (Figure 12), and the WPWP is displayed in blue.

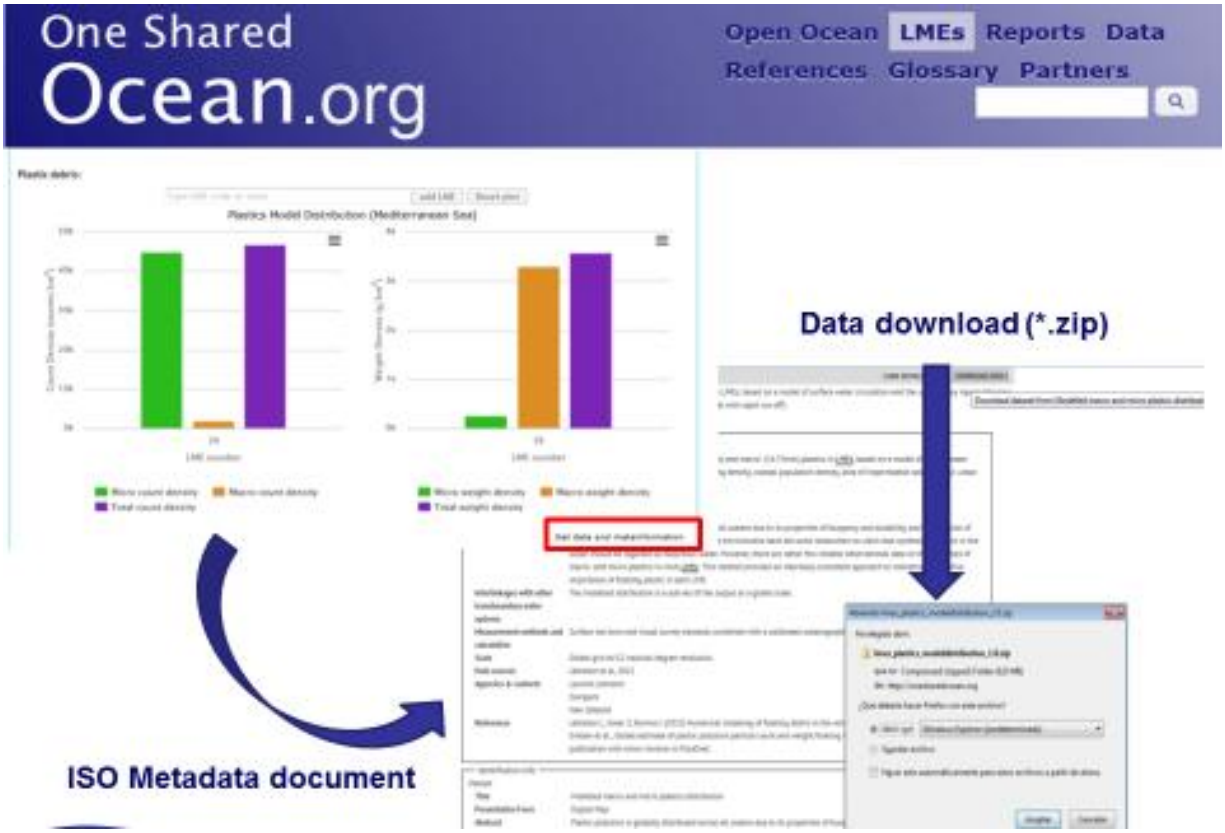


Figure 13: Derived information and data accessibility

Source: IOC-UNESCO

Despite efforts, management of the ocean is constrained by the lack of a systematic, global comparative baseline assessment of its changing conditions in response to human-induced and natural stresses.

For the open ocean and areas beyond national jurisdictions, emphasis was on establishing baselines of ocean ecosystem health and, wherever possible, projected future changes for 5 themes listed below. In addition, the governance arrangements of the global ocean were investigated.

- Climate
- Ecosystems and Biodiversity
- Fisheries
- Pollution
- Integrated Assessment/Human Impact

This website summarises this assessment, provides access to the data that underpinned the results, and as well provides links to the full Open Ocean Technical Assessment Report (2015) and Open Ocean Summary for Policy Makers (2015) (Figure 13). In the first instance, the results are being used by GEF to help set science-based priorities for financial resource allocation and the institutional arrangements for conducting periodic future assessments of the ocean. Furthermore, the work provides an access point for other policy-makers and

international organisations to be guided by these results for pertinent decision-making. This assessment is significant in allowing GEF and others to track the results of their interventions.

GOOS

Global Ocean Observing System (GOOS)[25] is a collaborative system of observations, where the components of the system are funded by national sources. The system includes satellite observations and in situ observations, as well as operational observing networks and sustained research-funded observing networks and platforms. The data from these observations feeds into data management systems and the generation of products to reach users, with impacts in science and more directly for society. GOOS encompasses global-scale and coastal observations.

GOOS is a permanent global system for observations, modelling and analysis of marine and ocean variables to support operational ocean services worldwide. GOOS provides accurate descriptions of the present state of the oceans, including living resources, continuous forecasts of the future conditions of the sea for as far ahead as possible, and the basis for forecasts of climate change. In general, GOOS is a system of programmes, each of which is working on different and complementary aspects of establishing an operational ocean observation capability for all of the world's nations. UN sponsorship and the IOC-UNESCO assemblies assure that international cooperation is always the first priority of the GOOS.

GOOS is designed to:

- Monitor, understand and predict weather and climate
- Describe and forecast the state of the ocean, including living resources
- Improve management of marine and coastal ecosystems and resources
- Mitigate damage from natural hazards and pollution
- Protect life and property on coasts and at sea
- Enable scientific research

GOOS (Figure 14) is a platform for international cooperation for sustained observations of the oceans, generation of oceanographic products and services and the interaction between research, operational, and user communities.

GOOS caters to oceanographic researchers, coastal managers, parties to international conventions, national meteorological and oceanographic agencies, hydrographic offices, marine and coastal industries, policy-makers and the interested general public.

[25] http://www.ioc-goos.org/

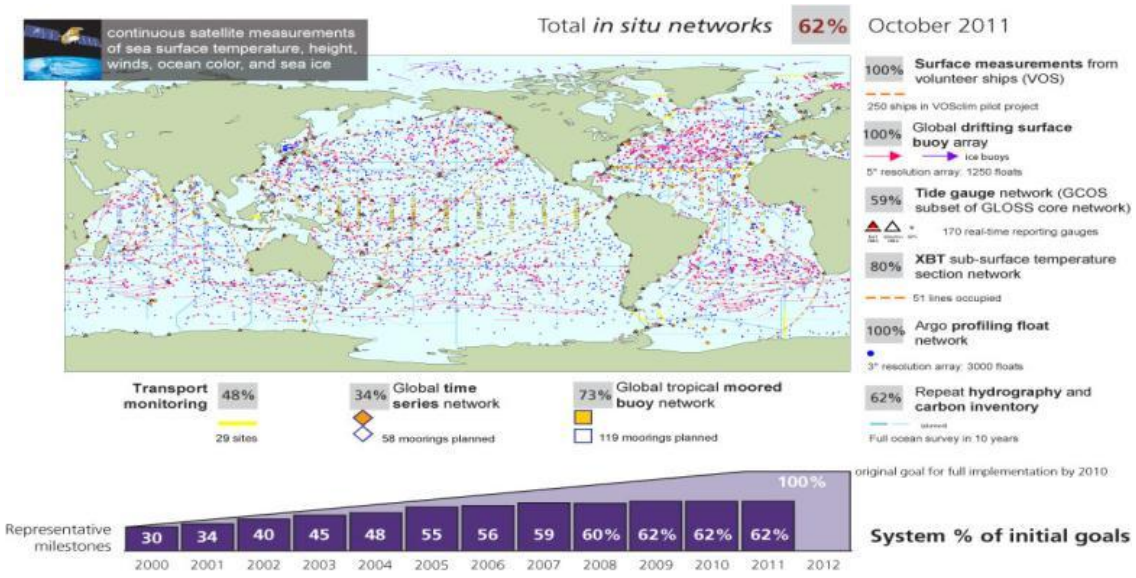


Figure 14: In-situ networks supporting GOOS

Source: IOC-UNESCO

GOOS is made of many observation platforms:

- 3000 Argo floats that collect high-quality temperature and salinity profiles from the upper 2000m of the ice-free global ocean and currents from intermediate depths.
- 1250 drifting buoys which record the currents of surface, the temperature and the atmospheric pressure.
- 350 embarked systems on commercial or cruising yachts which collect the temperature, salinity, the oxygen and the carbon dioxide (CO_2) in the ocean and the atmosphere, and the atmospheric pressure.
- 100 research vessels that measure all the physical, chemical and biological parameters, between the surface of the sea and the ocean floors every 30 nautical miles out of 25 transoceanic lines.
- 200 marigraphs and holographs which transmit information in quasi real time, thus providing the possibility of detecting tsunamis.
- 50 commercial ships that launch probes measuring the temperature and salinity between the surface and the ocean floor on their transoceanic ways.
- 200 moorings in the open sea that are used as long-term observatories, recording weather, chemical and biological parameters on a fixed site between the surface and the bottom.

2.1.4 National SDI

There are many national initiatives to provide marine spatial data, and these vary nation by nation and depending on national capacity and the specific management structures in individual nations. A brief examination of individual portals relevant to biodiversity in the marine environment in the United Kingdom (UK) helps to illustrate a relationship between the

structure of national governance and the availability of data (as well as illustrating the powerful political messages that information platforms can send).

The UK is comprised of one central government (in Westminster, England) and three devolved authorities, the governments of Wales, Northern Ireland and Scotland. Table 4 shows the major marine spatial data platforms for each devolved authority.

Table 4: Some UK data portals containing marine data

Country	Institution	Site
England	Marine Management Organisation	http://mis.marinemanagement.org.uk/marine-planning-evidence-base
Scotland	Marine Scotland	https://marinescotland.atkinsgeospatial.com/nmpi/
		http://www.marine.ie/Home/site-area/data-services/interactive-maps/fisheries-resource-maps
Wales	Welsh Government	http://lle.gov.wales/apps/marineportal/#lat=52.5145&lon=-3.9111&z=8

The most developed of these portals is the Marine Scotland web atlas. The atlas contains layers related to implementation of the MSFD, with data categories entitled 'clean and safe' 'healthy and biologically diverse' and 'productive' deliberately mimicking the language of the MSFD and indicating Scotland's explicit recognition of its commitments under EU legislation. In addition to these categories, the administrative boundaries layers show Scotland's proposed national EEZ (Figure 15). By contrast, the portal of the England's Marine Management Organisation contains data specifically relevant to EU legislation that is not explicitly focused toward European legislation (this is in line with the UK national policy of not 'gold plating' EU legislation). The clear focus on European legislation in the Marine Scotland web portal compared, for example, to Wales may belie the ambitions of the Scottish government to become an independent European state and certainly reflects the Scottish government's recognition of its marine resources (oil and gas, renewable energy potential and fisheries) as particularly important components of its economy. The displayed data on maps convey political messages (Woodman and Fehls, 2001), and the power of mapping and of SDI not just to relay data but to communicate a message to a particular target audience is highly relevant to the goals of the AQUACROSS project in promotion of EBM and the EU Biodiversity Strategy. These differences illustrate the (conscious or un-conscious) non-neutral decisions made when selecting data for inclusion in geo-portals.

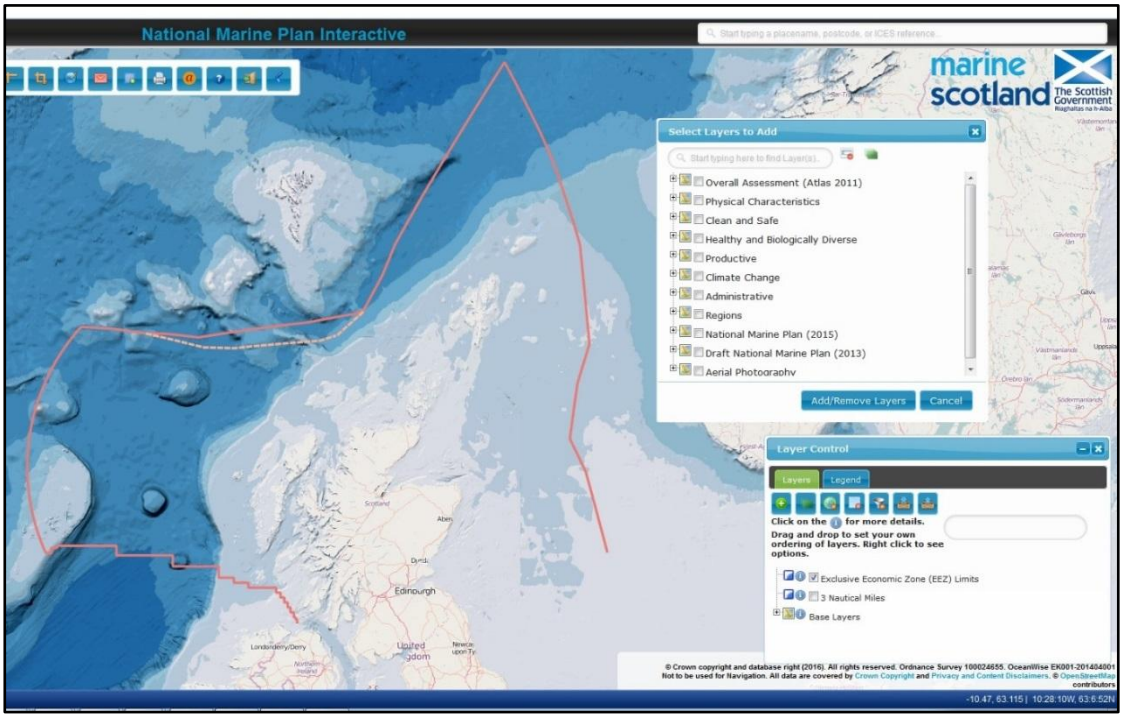


Figure 15: Composite screenshot of the marine Scotland's "National Marine Plan Interactive" showing the proposed Scottish national EEZ.

2.1.5 Sectoral data

In addition to freely available data, there are a number of sectoral datasets which are highly relevant to the EU Biodiversity Strategy but where data availability is a constraint toward achieving the goals of the Strategy. For the marine environment, commercial fisheries are considered to be the major threat to biodiversity, and this is reflected in Target 4 of the Strategy. Under the CFP, Vessel Monitoring Systems (VMS) are now mandatory for fishing vessels over 15m in length. VMS data for fishing vessels can be processed to give accurate assessments of the spatial distribution of fishing effort. While there have been some efforts to harmonise and centralise approaches to VMS data analysis, as yet, there is no single location where these data may be accessed. These data are generally compiled and processed at the national level; however, due to concerns over privacy and commercial sensitivity of the data, these data are generally difficult to obtain and often only processed products are released. While there is clearly an important link between Target 4 and the availability of VMS data, this issue also has implications for Action 17 under Target 6 of the Biodiversity Strategy, which aims to reduce impacts of consumption patterns of EU activity. In recent years, the EU has signed a number of third country fishing agreements under "sustainable fisheries partnership agreements," generally with developing nations. In order to ensure that EU activities under these agreements is in line with the goals of the strategy, VMS data from third country fisheries should be gathered and collated according to current best practices.

A similar situation exists for commercial shipping data. Although some live Automatic Identification System (AIS) data are publicly accessible through commercial websites,[26] few datasets are available to analyse the pressures caused by commercial shipping traffic at the Europe-wide level. While individual efforts have been made at the national level (for example by the Marine Management Organisation in the UK[27]) and regional seas level for the Baltic Sea, there is no comprehensive source for accessing and visualising AIS data. This issue is addressed by DG MARE in the EMODnet call for tenders published end of May 2016, in the "Human activities" lot.

2.1.6 Summary

Overall, for the marine environment, there is a diverse array of SDI. While the science community is well served with respect to data, and some policy portals do exist, general data relevant to biodiversity are scattered and an interested policy-maker or member of the public would have great difficulty in interpreting the vast array of spatial data and its relevance to the Biodiversity Strategy. There is a clear need to focus geospatial data infrastructure and tailor it towards specific audiences, the ICES popular advice portal provides a good example of how this kind of focused delivery can be achieved. Data sources and SDI for the marine are summarised in Table 5: Summary of marine SDI and datasets.

[26] e.g http://www.marinetraffic.com/

[27] https://data.gov.uk/dataset/mmo1066-anonymised-ais-derived-track-lines-2012

	PORTAL	URL	G	EU	R	N	S	V	DM	M	A	Policy
1	EMODNET	http://www.emodnet.eu/chemistry		X					X	X		MSFD, WFD, HABITATS
2	EMODNET	http://www.emodnet.eu/bathymetry		X					X	X	X	
3	EMODNET	http://www.emodnet-geology.eu/emodnet/srv/eng/home		X					X	X		
4	EMODNET	http://www.emodnet-seabedhabitats.eu/		X					X	X	X	MSFD, WFD, HABITATS
5	EMODNET	http://www.emodnet-biology.eu/portal/index.php		X					X	X	X	MSFD, WFD, HABITATS
6	EMODNET	http://www.emodnet-physics.eu/map/		X					X	X		MSFD, WFD, HABITATS
7	EMODNET	http://www.emodnet-humanactivities.eu/view-data.php		X					X		X	
8	EMODNET	http://coastal-mapping.eu/		X					X	X		
9	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-2.506:38.909:6;bkgd=5:0.52;gra=0;mode=0;theme=46:0.5:1:0,2:0.75:1:1;		X				X				MSFD, WFD, HABITATS
10	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=10.963:36.29:4;bkgd=5:0.52;gra=0;mode=0;theme=76:1:1:0,24:1:1:0,25:1:1:0;		X				X				MSFD, WFD, HABITATS
11	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=6:0.45;gra=0;mode=0;theme=14:0.7:1:0,120:1:1:0,73:1:1:0;selection=-7.033:35.979;		X				X				MSFD, WFD, HABITATS
12	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=5:0.62;gra=0;mode=0;theme=85:1:1:0,41:1:1:0;time=2012;		X				X				
13	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=6:0.45;gra=0;mode=0;theme=73:1:1:0,120:1:1:0,88:1:1:1,89:1:1:1;		X				X				
14	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=5:1;gra=0;mode=0;theme=3:0.78:1:0,88:1:1:1;		X				X				
15	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=6:0.72;gra=0;mode=0;theme=120:1:1:0,27:0.52:1:0,28:1:1:0,50:1:1:0;		X				X				
16	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=6:0.52;gra=0;mode=0;theme=71:1:1:0,19:1:1:0,13:1:1:0,120:1:1:0;		X				X				
17	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=6:0.5;gra=0;mode=0;theme=7:0.49:1:0,73:0.8:1:0,9:1:1:0,9999104:1:1:0;		X				X				MSFD, WFD, HABITATS
18	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=5:0.62;gra=0;mode=0;theme=59:0.58:1:0,61:0.9:1:0;time=2014;		X				X				MSFD, WFD, HABITATS
19	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=5:1;gra=0;mode=0;theme=34:0.81:1:1;time=2009;		X				X				MSFD, WFD, HABITATS
20	EMIS - Marine Geodat	http://mcc.jrc.ec.europa.eu/emis/dev.py?N=45&O=280&titre_chap=Marine%20Database%20%28EMIS%29&titre_page=Physical%20datasets		X					X			MSFD, WFD, HABITATS
21	EMIS - Marine Geodat	http://mcc.jrc.ec.europa.eu/emis/dev.py?N=45&O=286&titre_chap=Marine%20Database%20%28EMIS%29&titre_page=Bio-optical%20datasets		X					X			MSFD, WFD, HABITATS
22	EMIS - Marine Geodat	http://mcc.jrc.ec.europa.eu/emis/dev.py?N=45&O=287&titre_chap=Marine%20Database%20%28EMIS%29&titre_page=Environmental%20indices		X					X			MSFD, WFD, HABITATS
23	Waterbase	http://www.eea.europa.eu/data-and-maps/data/waterbase-transitional-coastal-and-marine-waters-11		X					X			MSFD, WFD, HABITATS
24	EIONET	http://cdr.eionet.europa.eu/ReportekEngine/searchdataflow?dataflow_uris=http%3A%2F%2Frod.eionet.europa.eu%2Fobligations%2F608&years%3Aint%3Aignore_empty=&partofyear=&reportingdate_start%3Adate%3Aignore_empty=&reportingdate_end%3Adate%3Aignore_empty=&country=&release_status=released&sort_on=reportingdate&sort_order=reverse&batch_size=		X					X	X		
25	ICES	http://gis.ices.dk/sf/		x					x			MSFD,CFP
26	HELCOM	http://www.helcom.fi/baltic-sea-trends/data-maps			x				x			MSFD, WFD, HABITATS
27	ODIMS (OSPAR)	http://odims.ospar.org/			x				x			MSFD, WFD, HABITATS
28	Medgis	http://medgis.medchm.net/			x				x			MSFD, WFD, HABITATS
29	SeaDataNEt	http://seadatanet.maris2.nl/v_cdi_v3/search.asp		X					X			MSFD, WFD, HABITATS
30	GOOS	http://www.ioc-goos.org/index.php?option=com_content&view=article&id=91&Itemid=71	X	X					X			
31	GOOS	http://www.ioc-sealevelmonitoring.org/stations.kml	X	X					X			
32	Marine Management	http://mis.marinemanagement.org.uk/marine-planning-evidence-base				X	X					
33	Marine Scotland	https://marinescotland.atkinsgeospatial.com/nmpi/				X	X					MSFD
34	Welsh Government	http://www.marine.ie/Home/site-area/data-services/interactive-maps/fisheries-resource-maps				X	X					

Table 5: Summary of marine SDI and datasets.

	PORTAL	URL	G	EU	R	N	S	V	DM	M	A	Policy
1	EMODNET	http://www.emodnet.eu/chemistry		X					X	X		MSFD, WFD, HABITATS
2	EMODNET	http://www.emodnet.eu/bathymetry		X					X	X	X	
3	EMODNET	http://www.emodnet-geology.eu/emodnet/srv/eng/home		X					X	X		
4	EMODNET	http://www.emodnet-seabedhabitats.eu/		X					X	X	X	MSFD, WFD, HABITATS
5	EMODNET	http://www.emodnet-biology.eu/portal/index.php		X					X	X	X	MSFD, WFD, HABITATS
6	EMODNET	http://www.emodnet-physics.eu/map/		X					X	X		MSFD, WFD, HABITATS
7	EMODNET	http://www.emodnet-humanactivities.eu/view-data.php		X					X		X	
8	EMODNET	http://coastal-mapping.eu/		X					X	X		
9	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-2.506:38.909:6;bkgd=5:0.52;gra=0;mode=0;theme=46:0.5:1:0,2:0.75:1:1;		X				X				MSFD, WFD, HABITATS
10	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=10.963:36.29:4;bkgd=5:0.52;gra=0;mode=0;theme=76:1:1:0,24:1:1:0,25:1:1:0;		X				X				MSFD, WFD, HABITATS
11	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=6:0.45;gra=0;mode=0;theme=14:0.7:1:0,120:1:1:0,73:1:1:0;selection=-7.033:35.979;		X				X				MSFD, WFD, HABITATS
12	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=5:0.62;gra=0;mode=0;theme=85:1:1:0,41:1:1:0;time=2012;		X				X				
13	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=6:0.45;gra=0;mode=0;theme=73:1:1:0,120:1:1:0,88:1:1:1,89:1:1:1;		X				X				
14	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=5:1;gra=0;mode=0;theme=3:0.78:1:0,88:1:1:1;		X				X				
15	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=6:0.72;gra=0;mode=0;theme=120:1:1:0,27:0.52:1:0,28:1:1:0,50:1:1:0;		X				X				
16	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=6:0.52;gra=0;mode=0;theme=71:1:1:0,19:1:1:0,13:1:1:0,120:1:1:0;		X				X				
17	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=6:0.5;gra=0;mode=0;theme=7:0.49:1:0,73:0.8:1:0,9:1:1:0,9999104:1:1:0;		X				X				MSFD, WFD, HABITATS
18	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=5:0.62;gra=0;mode=0;theme=59:0.58:1:0,61:0.9:1:0;time=2014;		X				X				MSFD, WFD, HABITATS
19	EU atlas of the seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;pos=-4.077:36.859:7;bkgd=5:1;gra=0;mode=0;theme=34:0.81:1:1;time=2009;		X				X				MSFD, WFD, HABITATS
20	EMIS - Marine Geodat	http://mcc.jrc.ec.europa.eu/emis/dev.py?N=45&O=280&titre_chap=Marine%20Database%20%28EMIS%29&titre_page=Physical%20datasets		X					X			MSFD, WFD, HABITATS
21	EMIS - Marine Geodat	http://mcc.jrc.ec.europa.eu/emis/dev.py?N=45&O=286&titre_chap=Marine%20Database%20%28EMIS%29&titre_page=Bio-optical%20datasets		X					X			MSFD, WFD, HABITATS
22	EMIS - Marine Geodat	http://mcc.jrc.ec.europa.eu/emis/dev.py?N=45&O=287&titre_chap=Marine%20Database%20%28EMIS%29&titre_page=Environmental%20indices		X					X			MSFD, WFD, HABITATS
23	Waterbase	http://www.eea.europa.eu/data-and-maps/data/waterbase-transitional-coastal-and-marine-waters-11		X					X			MSFD, WFD, HABITATS
24	EIONET	http://cdr.eionet.europa.eu/ReportekEngine/searchdataflow?dataflow_uris=http%3A%2F%2Frod.eionet.europa.eu%2Fobligations%2F608&years%3Aint%3Aignore_empty=&partofyear=&reportingdate_start%3Adate%3Aignore_empty=&reportingdate_end%3Adate%3Aignore_empty=&country=&release_status=released&sort_on=reportingdate&sort_order=reverse&batch_size=		X					X	X		
25	ICES	http://gis.ices.dk/sf/		x					x			MSFD,CFP
26	HELCOM	http://www.helcom.fi/baltic-sea-trends/data-maps			x				x			MSFD, WFD, HABITATS
27	ODIMS (OSPAR)	http://odims.ospar.org/			x				x			MSFD, WFD, HABITATS
28	Medgis	http://medgis.medchm.net/			x				x			MSFD, WFD, HABITATS
29	SeaDataNEt	http://seadatanet.maris2.nl/v_cdi_v3/search.asp		X					X			MSFD, WFD, HABITATS
30	GOOS	http://www.ioc-goos.org/index.php?option=com_content&view=article&id=91&Itemid=71	X	X					X			
31	GOOS	http://www.ioc-sealevelmonitoring.org/stations.kml	X	X					X			
32	Marine Management	http://mis.marinemanagement.org.uk/marine-planning-evidence-base				X	X					
33	Marine Scotland	https://marinescotland.atkinsgeospatial.com/nmpi/				X	X					MSFD
34	Welsh Government	http://www.marine.ie/Home/site-area/data-services/interactive-maps/fisheries-resource-maps				X	X					

G=global, EU= Europe-wide, R=regional, N=national, S=subnational DM=Data and Metadata, M=Metadata only A=Freely accessible (downloadable).

2.2 Freshwater

2.2.1 Scientific data portals

In contrast to the data portals for the marine environment, to our knowledge, most of the international data portals specific for freshwater[28] are at the same time targeting policy and the scientific community. A straightforward classification in specific categories as "scientific data portals", "policy data portals" etc. therefore is difficult. The WISE European Water Information Systems for example sees itself as source of information meant for a wide audience including EU, national, regional and local administrations working in water policy development, as well as scientists, professionals and the general public. Table 6 gives an overview on relevant data portals and the chapters in which they are discussed.

2.2.2 General EU water policy data sources

WISE

The first information platform under "General water policy data sources" is the Water Information System for Europe (WISE)[29] initiative. WISE is a partnership between the EC (formed by DG ENV, JRC and Eurostat) and the EEA. It is a gateway to information on European water issues, divided into four sections: (1) EU water policies (e.g. directives, implementation reports and supporting activities), (2) data and themes (e.g. reported datasets, interactive maps, statistics, indicators), (3) modelling (e.g. current and forecasting services across Europe) and (4) projects and research (e.g. inventory for links to recently completed and ongoing water related projects and research activities). It covers water-related information from inland to marine waters, but is mostly focused on freshwater. WISE aims to reach a wide audience covering EU, national, regional and local administrations working in water policy development, as well as scientists, professionals and the general public interested in water issues.

In its current format, the WISE platform provides a useful starting point to explore water-related issues; however, the central page is very general and has not been targeted specifically at any particular user group and does not provide instructions as to which sub-sites may be relevant to which users. In particular, there is no integrated approach towards policies or regions. For example, from the starting site, a policy-maker or member of the

[28] Data and information relevant for freshwater management and policy can be found at platforms which also cover other realms. Freshwater specific platforms, data sources and datasets are indicated with an asterisk (*).

[29] http://water.europa.eu

public interested in the state of regional or national compliance with the WFD does not have access to a site where, in one place, the state of compliance, the indicators used to measure compliance and the data used to generate these specific indicators are available. One drawback of this directing rather than integrating approach is that links between sites are not guaranteed to be fully operational, as different institutions change and update the structure of their own particular portals.

In terms of availability of data and information, WISE redirects visitors to three portals: the EEA Water Data Centre, the Eurostat Water Statistics website and the FATE (impact of pollutants in terrestrial and aquatic ecosystems) website related to pollutants monitoring campaigns. These three portals are described in more detail below.

EEA Water Data Centre datasets

The EEA Water Data Centre is a major source of a wide variety of datasets with relevance to water managers and policy-makers. In addition to the raw data and metadata, several data products are made available in more digestible ways, such as interactive maps and summary graphs. Users can, for instance, browse and access a wide range of spatial data through the "Interactive maps and data viewers by category" section.[30] As discussed under section 2.1.2, much of these data are also spatial data layers and available through WMS on DiscoMap.[31] Additionally, datasets are linked with "related content" if available. Datasets can be downloaded without charge and are generally free of use restrictions, according to the specifications of the metadata (although the user is asked to indicate the sectors/topics for which the data will be used). Datasets of special interest to implementation of the BAP are e.g. the "WISE State of Environment" datasets.[32] These include:

- Ammonium in groundwater
- Ammonium in rivers
- BOD in rivers
- Macroinvertebrates in rivers
- Macrophytes in lakes
- Nitrates in groundwater
- Nitrates in rivers
- Nitrites in groundwater
- Orthophosphates in rivers
- Phytobenthos in rivers
- Phytoplankton in lakes
- Total phosphorus in lakes
- Water quality monitoring station density
- Water quality monitoring stations
- Water quantity monitoring stations

Other datasets included in the Water Data Centre are, for example, the *"ECRINS-European Catchments and Rivers Network System"*,* which is a geographical information source of Europe's hydrographical systems with full topological information. It acts as a baseline database for integrating Member States' reporting on "main rivers and main lakes". Moreover,

[30] http://www.eea.europa.eu/themes/water/interactive

[31] http://discomap.eea.europa.eu/

[32] http://icm.eionet.europa.eu/Databases

ECRINS includes information on *"Dams on larger rivers in Europe"**, which is also available as a separate downloadable map or image.

Other datasets within the Water Data Centre such as *"Waterbase – Rivers"** and *"Waterbase – Lakes"** include reported data on, for instance, nutrients, hazardous substances and biological quality elements (BQEs). The *"WISE WFD Database"** available on-line mostly contains summary statistics from River Basin Management Plans (RBMP) reported by EU Members States (from the 1st and 2nd edition 2009 and 2015).

Other resources hosted by the EEA Water Data Centre include more advanced map products that combine and visualise data from several datasets, such as the *"Water Exploitation Index plus (WEI+) for summer and Urban Morphological Zones (UMZ)"** and GIS data such as *"Ecoregions for rivers and lakes"*,* which are the typological base units required by the WFD and are often used as background information layers in freshwater ecological studies.

In addition, the EEA also hosts datasets such as the *"CORINE Land Cover"* and related land use map products such as *"Spread of artificial and/or agricultural surfaces into previously 'core natural/semi-natural' landscapes"* and *"Landscape fragmentation per 1 km² grid"*. These resources are not directly related to freshwater environments and pertain to land characteristics, but they are mentioned here as they are typically used to evaluate impacts of the surroundings on aquatic environments in landscape ecology.

Eurostat Water Statistics*

The Eurostat Water Statistics are summarised for the general public on a dedicated *"Statistics Explained"* webpage,[33] whereas the original data are contained in its *"Water Database"*.[34] This database contains information on topics related to "water as a resource", including water use, wastewater treatment, floods and droughts. Statistics data are freely available to use, downloadable and are available at national and subnational (NUTS2 regions and River Basin Districts) level. Data are compiled through a biennially OECD/Eurostat Joint Questionnaire on Inland Waters.

FATE and impact of pollutants in terrestrial and aquatic ecosystems*

The FATE website[35] features an interactive viewer to explore monitoring data on chemicals and to visualise modelling results for nutrients. This site aims at bringing together the activities of the *"Fate and impacts of pollutants in terrestrial and aquatic ecosystems"* initiative carried out at the Institute for Environment and Sustainability of the JRC. The website is currently labelled as archived since 18/03/2015, supposedly these data are now integrated in the JRC Water Portal (see next).

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[33] http://ec.europa.eu/eurostat/statistics-explained/index.php/Water_statistics

[34] http://ec.europa.eu/eurostat/web/environment/water/database

[35] http://fate.jrc.ec.europa.eu/

JRC Water Portal & WFD Ecological methods database

The JRC Water Portal[36] provides visualisation and download options for JRC's products on freshwater and marine water resources and offers tools to calculate summary statistics for the available data. JRC also maintains the "WFD Ecological methods database", which gives access to information about the national assessment methods used to classify the ecological status of rivers, lakes, coastal and transitional waters as applied by EU Member States in their monitoring programmes according to the EU WFD. Both resources can be freely consulted.

2.2.3 International and regional initiatives

TWAP

As mentioned in the previous section for marine databases, TWAP[37] is funded by GEF to assess transboundary aquifers, reservoirs and lakes, river basins, LMEs and the open ocean. It aims to provide baseline assessments to identify and evaluate changes in these water systems caused by human activities and natural processes, and their consequences to dependent human populations.

Regarding freshwater, TWAP provides data on groundwater,[38] lakes,[39] and river basins,[40] each presented on a specific website and each providing indicator results, again on different websites. Additionally, the Central TWAP Data Viewer is available – a tool to showcase and visualise the main indicator results. It harvests the results and indicators from the water-system specific databases (see above), enabling users to simultaneously explore the results of all five assessments, including cross-cutting issues and synthesis results. It also provides access to the meta-data information. Additionally, the portal offers a variety of publications including summaries of the findings for policy-makers.

Data on one of Europe's largest transboundary streams, the Danube, are collected by the International Commission for the Protection of the Danube River.[41] The TWAP website offers in-depth information about the Danube, related policies and the different expert groups in place, as well as the 1st and 2nd RBMPs and data from the Joint Danube Surveys and the TransNational Monitoring Network (see chapter below).

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36 http://water.jrc.ec.europa.eu/
37 http://www.geftwap.org/twap-project
38 http://isarm.org/twap/twap-groundwater
39 http://www.ilec.or.jp/en/twap
40 http://twap-rivers.org
41 https://www.icpdr.org

The UNECE Water Convention

The Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention)[42] of the United Nations Economic Commission for Europe (UNECE) aims to protect and ensure the quantity, quality and sustainable use of transboundary water resources by facilitating cooperation. It provides an intergovernmental platform for the day-to-day development and advancement of transboundary cooperation. Initially negotiated as a regional instrument, it turned into a universally available legal framework for transboundary water cooperation, following the entry into force of amendments in February 2013, opening it to all UN Member States. As of 1st March 2016, countries outside the ECE region can accede to the Convention.

No open-accessible databases are available via the UNECE Water Convention. However, two assessments on UNECE territory were already conducted in the last years. Especially, the "Second Assessment of transboundary rivers, lakes and groundwaters"[43] provides a comprehensive overview of the status of transboundary waters in the European and Asian parts of the UNECE region, covering more than 140 transboundary rivers, 25 transboundary lakes, about 200 transboundary groundwaters and 25 Ramsar Sites or other wetlands of transboundary importance. It has been carried out under the Water Convention in close cooperation with water and/or environment administrations of some 50 countries and with involvement of more than 250 experts. Utilising data and information provided by national governments and river commissions, maps, graphs and statistical data, the Second Assessment presents a broad analysis of transboundary water resources, pressure factors, quantity and quality status, and transboundary impacts, as well as responses and future trends. It also documents national and transboundary legal and institutional frameworks for water management and cooperation. The Second Assessment seeks to provide a picture of the expected impacts on transboundary water resources, including the measures planned or in place to adapt to climate change.

2.2.4 National data portals

In the freshwater realm, most portals are governed by national or regional policy bodies implementing the WFD. In general, such portals are typically providing access to summarised data on biological and chemical water quality. The information retrieved is quite variable, ranging from maps with sampling/monitoring stations to water quality metrics represented by colour code on a map or even access to raw data from individual or multiple sampling stations. Unfortunately, the provided data are rarely available for download and/or in a standardised format that allows easy integration with data from other sources. In addition, as most portals only use the official language of the country or region, it can be hard to navigate and understand them if the user is not familiar with this language. Thus, the automatic

[42] Paragraphs taken from http://www.unece.org/env/water.html

[43] http://www.unece.org/env/water/publications/pub/second_assessment.html

integration of such national/regional data portals into the EU-wide EEA database would be very relevant from a biodiversity perspective. Currently, this EU-wide database only covers those data which Member States are required to report, and excludes raw data in any case. Below, we discuss a few examples of national/regional portals, which are not integrated into EU wide databases yet:

For the Flemish region of Belgium, water quality information is for instance integrated in a geodatabase[44] containing environmental data related to water. Although this viewer allows users to consult detailed analysis results on the different BQEs for individual sampling sites, it does not seem possible to get summary data for an entire region or get access to or download a selection of raw data. Information on flood risk is included in a dedicated portal for informing the public.[45]

The Water Information System Austria (WISA)[46] is, among other important functions, a new type of guarantee in the water management planning in Austria with a focus on "public active participation". WISA is both an online data viewer, which offers a comprehensive overview of water quality metrics, and a data section with all relevant WFD data. In order to involve the interested public, all WFD documents, including background documents, are provided electronically. A possible easy to use the homepage and the use of digital forms for public participation will support and facilitate the work of users.

The UK Environment Agency Catchment Explorer[47] offers an interface to explore and download data at different (sub)catchment scales. Visitors can reach lower catchment levels by clicking on a map which gets more and more detailed as they progress. At the lowest level, water body classifications based on ecological and chemical assessments are shown.

The Irish Environmental Protection Agency[48] has a dedicated water (and WFD) section on its website, and offers rich background information on a wide range of water quality related issues, but the location of any actual data other than information presented in report form (e.g. for the Integrated Water Quality Assessment) was not found.

The Dutch tool “WFD Explorer”[49] is an analysis tool designed to support the implementation of the WFD. The tool makes it possible to calculate the effect of restoration and mitigation measures on the ecological and chemical quality of surface waters. Users can see how effective programmes of measures are in relation to WFD objectives. Measures can be defined in relation to point sources, such as wastewater treatment plants, and diffuse sources, such as agriculture and traffic. Similarly, it is possible to calculate the effectiveness of restoration measures, such as stream re-meandering, or the construction of near-natural riparian zones.

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[44] http://geoloket.vmm.be/Geoviews/map.phtml
[45] http://www.waterinfo.be
[46] http://wisa.bmlfuw.gv.at
[47] http://environment.data.gov.uk/catchment-planning
[48] www.epa.ie
[49] https://www.deltares.nl/en/projects/water-framework-directive-explorer

A cost module is available to calculate and map the costs of measures, making it possible to assess the cost-effectiveness of different programmes of measures.

In Sweden, a the Water Information System Sweden (WISS) database has been developed by the Competent Authorities of the Swedish Water Districts, the County Administrative Boards and the Swedish Agency for Marine and Water Management.[50] In WISS, there are classifications and maps of all Swedish major lakes, rivers, groundwater and coastal waters. For these waters, information on status classification, environmental quality standards, environmental monitoring, protected areas, programme of measures and general information on reporting the WFD data to EU is available.

2.2.5 Sectoral terrestrial data portals

The Land Parcel Identification System (LPIS) is a geodatabase used to aggregate and monitor information on the distribution of EU CAP funds as part of Integrated Administration and Control System. In order to receive direct payments, all Member States are obliged to report geospatial data for the agricultural parcels of land. Access to the centralised data are restricted at the European level though depending on the status of INSPIRE compliance the data are available for some nations.

[50] http://viss.lansstyrelsen.se/About.aspx

Table 6: Summary of Freshwater SDI and datasets.

	PORTAL	Name	URL	g	EU	R	N	S	DM	M	A
1	WISE	WISE–The Water Information Syst	http://water.europa.eu		X					X	
2	WISE	Water Data Centre	http://www.eea.europa.eu/themes/water/dc		X				X		
3	WISE	Waterbase - Lakes	http://www.eea.europa.eu/data-and-maps/data/waterbase-lakes-10		X				X		
4	WISE	Waterbase - Rivers	http://www.eea.europa.eu/data-and-maps/data/waterbase-rivers-10		X				X		
5	WISE	ECRINS–European catchments and	http://www.eea.europa.eu/data-and-maps/data/european-catchments-and-rivers-network		X				X		
6	WISE	WISE WFD Database	http://www.eea.europa.eu/data-and-maps/data/wise_wfd		X				X		
7	WISE	Ecoregions for rivers and lakes	http://www.eea.europa.eu/data-and-maps/data/ecoregions-for-rivers-and-lakes		X				X		
8	WISE	Others…									
9		Dams on larger rivers in Europe	http://www.eea.europa.eu/data-and-maps/figures/dams-with-reservoirs-on-rivers		X				X		x
10		CORINE Land Cover	http://www.eea.europa.eu/publications/COR0-landcover		X				X		x
11		Spread of artificial and/or agricult	http://www.eea.europa.eu/data-and-maps/figures/figure-1-spread-of-artificial		X				X		
12		Water Exploitation Index plus (WE	http://www.eea.europa.eu/data-and-maps/figures/water-exploitation-index-plus-wei		X				X		
13		Landscape fragmentation per 1 km	http://www.eea.europa.eu/data-and-maps/figures/landscape-fragmentation-per-1-km2-3		X				X		
14	EUROSTAT	eurostat–Water Statistics	http://ec.europa.eu/eurostat/statistics-explained/index.php/Water_statistics		X				X	X	x
15	EUROSTAT	eurostat–Water Database	http://ec.europa.eu/eurostat/web/environment/water/database		X		X	X	X		x
16	FATE	FATE and impact of pollutants in t	http://fate.jrc.ec.europa.eu/		X						
17	EEA	EEA-Water-Interactive maps and d	http://www.eea.europa.eu/themes/water/interactive						X		
18	TWAP		https://www.icpdr.org								
19	IDCPR		https://www.icpdr.org								
20	GeoCOunter		http://geoloket.vmm.be/Geoviews/map.phtml					X			
21	Waterinfo		http://www.waterinfo.be				x				
22	WISA		http://wisa.bmlfuw.gv.at				X				
23	Catchment Explorer		http://environment.data.gov.uk/catchment-planning								
24	EPA		www.epa.ie								x
25	WFD Explorer		https://www.deltares.nl/en/projects/water-framework-directive-explorer				x				
26	WISS		http://viss.lansstyrelsen.se/About.aspx				x				
27	LPIS				x						

G=global, EU= Europe-wide, R=regional, N=national, S=subnational DM=Data and Metadata, M=Metadata only A=Freely accessible (downloadable).

2.3 Biodiversity

2.3.1 Biodiversity data sources to support European policy

BISE

The Biodiversity Information System for Europe (BISE) platform[51] focuses on biological diversity in general and covers all realms including freshwater. BISE is a partnership between the EC (DG ENV) and the EEA and is supported by the collaboration of the European Clearing House Mechanism network and the CBD Secretariat.

BISE is a gateway for data and information on biodiversity supporting the implementation of the EU Biodiversity Strategy and the Aichi Targets in Europe. It focuses on (1) bringing together facts and figures on biodiversity and ecosystem services and (2) linking to related policies, environmental data centres, assessments and research findings from various sources. The BISE portal offers six entry points: policy (e.g. policy, legislation and supporting activities related to the Common Implementation Framework of the EU Strategy), topics (e.g. state of species, habitats, ecosystems, genetic diversity, threats to biodiversity, impacts of biodiversity loss), data (e.g. data sources, statistics and maps related to land, water, soil, air, marine, etc.), knowledge (e.g. important EU-wide research projects related to biodiversity and ecosystem services), countries (e.g. links to information available from European countries) and networks (e.g. links to Europe-wide networks supporting information sharing across national borders).

As is the case for WISE, BISE does not host actual data, but links to major sources of data and information including: the EEA - Biodiversity Data Centre, the European Nature Information System and others.

EEA - Biodiversity Data Centre

One of the main datasets hosted by the Biodiversity Data Centre (BDC) is the *"Natura 2000 data - European network of protected sites"* dataset. It contains data from the monitoring activities in the Natura 2000 ecological site network, including site descriptions, species data and management details, as well as article 17 reporting data.

In addition, the data centre hosts several reference datasets such as *"Biogeographical regions"* (containing official delineations used in the HD and for the EMERALD network, set up under the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)), "*EUNIS habitat classification*" (comprehensive pan-European system to facilitate the harmonised description and collection of habitat related data across Europe through the

[51] http://www.biodiversity.europa.eu

use of criteria for habitat identification) and the earlier mentioned CORINE "*Ecosystem types of Europe*" dataset.

EUNIS

The European Nature Information System (EUNIS)[52] is also hosted by the EEA and offers reference databases on species (particularly those mentioned in legal texts), habitat types and protected and other designated areas in Europe. EUNIS is described as being "a reference information system for anyone working in ecology and conservation or those with an interest in the natural world". EUNIS can be freely consulted. Data is not directly downloadable from the EUNIS webpage, but can be found on the EEA – BDC (cfr. the "EUNIS habitat classification" as mentioned above).

OBIS

The concept of Ocean Biogeographic Information System (OBIS)[53] was first developed at a conference sponsored by the Census of Marine Life[54] in 1997. At the time, a comprehensive system for the retrieval of ocean biological data did not exist. The databases that did exist to distribute ocean biological data failed to "usefully summarize known distributions and abundance of marine life nor are they organized to encouraged frequent use or intercomparison of datasets".

The problems generated by this disenfranchisement of marine data from the frequent user are very serious ones: if scientists cannot efficiently collect and effectively share data about the oceans with each other, how will anyone be able to generate new, comprehensive hypotheses about our oceans? If new findings about the oceans remain localised and hidden from the rest of the marine science community, then the data fails to have an impact on research in the marine science community at large.

Not long after the initial meeting, OBIS was established as a project of the Census of Marine Life within IOC-UNESCO, to help facilitate global enfranchisement of data within the scientific community. The goal of OBIS is: to create "an online, user-friendly system for absorbing, integrating, and accessing data about life in the oceans" (Grassle 2000) (Figure 16). The system would stimulate taxonomic and systematic research and generate new hypotheses concerning: evolutionary processes, factors related to maintenance of species distributions, roles of marine organisms in marine ecosystem function (Grassle 2000) (Figure 17).

Subsequently, the OBIS community has worked to make sure that all data contributed to OBIS from hundreds of providers is available to the public through its search interface. The EurOBIS data infrastructure is the central hub for making biological data available within the

[52] http://eunis.eea.europa.eu
[53] www.iobis.org
[54] http://www.coml.org/

EMODnet portal. Further improvements to OBIS aim to increase user friendliness, appealing to both the scientific community and the common internet user. The OBIS community promotes an open access policy and so that data collected about the oceans is easily accessible to a diverse set of users.

OBIS provides a portal or gateway to many datasets containing information on where and when marine species have been recorded. The datasets are integrated so a user can search them all seamlessly by species name, higher taxonomic level, geographic area, depth, and time; and then map and find environmental data related to the locations. The OBIS portal has a large spectrum of users: researchers, fishery scientists and managers, policy-makers, educators, amateur naturalists, environmental NGOs, consultants, nature conservation organisations, and students.

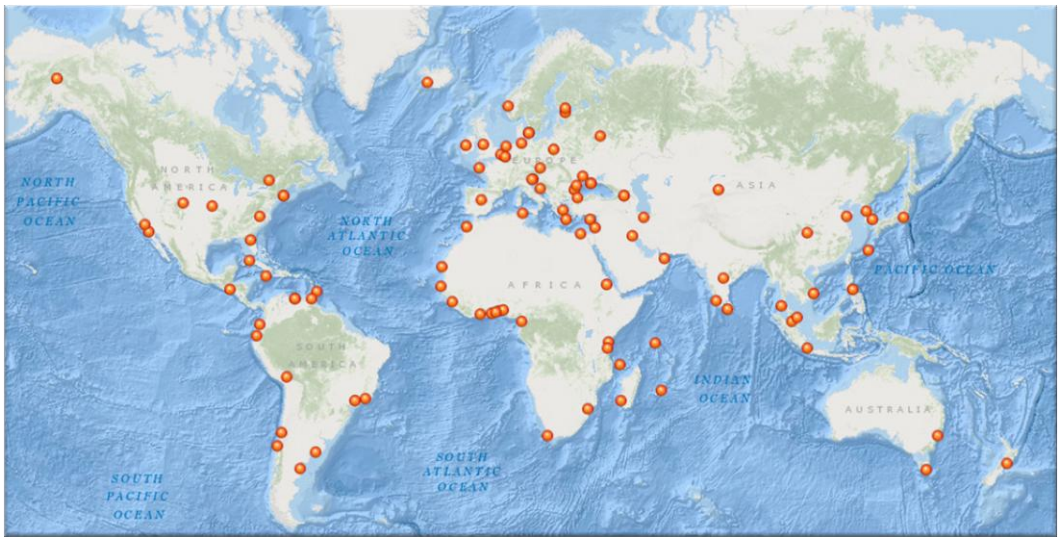


Figure 16: Distribution of Ocean National Data Centres providing inputs to OBIS (Source: IOC-UNESCO)

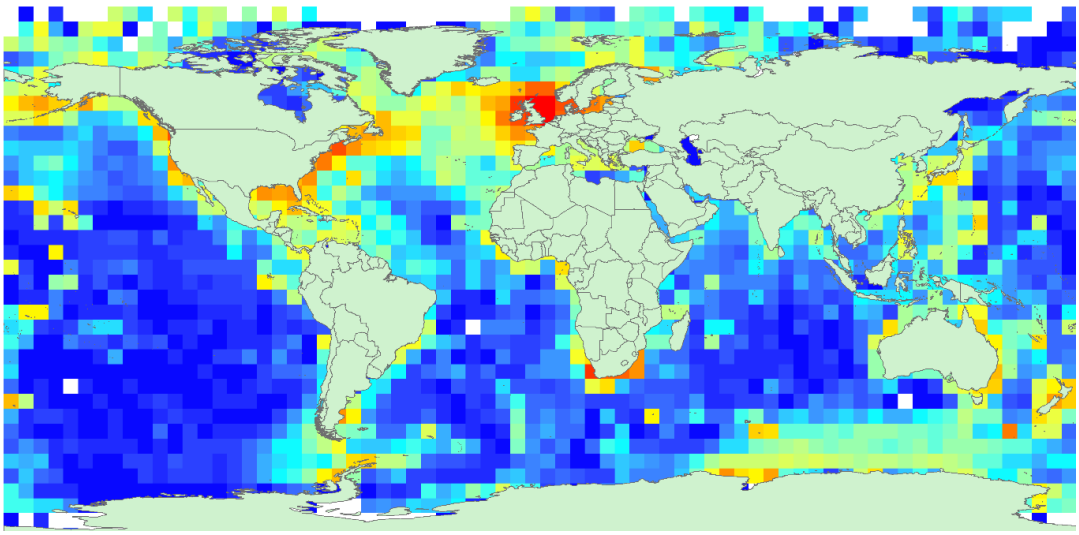


Figure 17: Distribution of species using OBIS data (Source: IOC-UNESCO)

2.3.2 International Freshwater Biodiversity Resources

GBIF

The Global Biodiversity Information Facility (GBIF)[55] is an international open data infrastructure, funded by governments and supported by member countries and other associated participants. GBIF started its efforts to collate global diversity data back in 2001 with the aim to provide free and open access to species occurrence data from one single online gateway. Currently GBIF offers more than 680 millions of occurrence records related to 1.6 million species, provided by about 810 data publishers. The data portal covers all realms and represents a major source of occurrence data.

FIP*

The Freshwater Information Platform (FIP)[56] represents an effort to regroup web-products from several freshwater related European research projects. It was initiated by 4 leading partners from the FP7 EU BioFresh project (Biodiversity of Freshwater Ecosystems: Status, Trends, Pressures, and Conservation Priorities), which focused on raising awareness around freshwater biodiversity data, collating and mobilising freshwater occurrence data and using those data in large scale analyses. The platform consists of different complementary sections relevant to water managers, policy-makers, scientists and the interested public. The Freshwater Policies section, for instance, provides access to policy briefs.

The Freshwater Metadatabase and Biodiversity Data Portal provide access to information on datasets, species and occurrence data. The metadatabase gathers information on freshwater datasets, thus making them discoverable regardless whether the data are publicly available or not. The data portal focuses on species and occurrence data. For species data, it links with the Freshwater Animal Diversity Assessment database (see further), whereas for occurrence data, it provides access to freshwater data on GBIF and acts as a data-publishing platform for freshwater data.

The Global Freshwater Biodiversity Atlas is another major component of the platform. The atlas features interactive maps on freshwater biodiversity richness, threats to freshwaters and the effects of global change on freshwater ecosystems.

The IUCN Red List

The IUCN has been working on its Red List of Threatened Species[57] to assess the conservation status of species, subspecies and varieties on a global scale for the past 50 years in order to highlight taxa threatened with extinction, and thereby promote their conservation. It provides

[55] http://www.gbif.org/
[56] http://www.freshwaterplatform.eu
[57] http://www.iucnredlist.org

taxonomic, conservation status and distribution information on plants, fungi and animals that have been globally evaluated using specifically defined categories and criteria. The Red List assessments bring together extensive knowledge of thousands of regional experts regarding status and threads of freshwater species. Regarding freshwaters, most comprehensive assessments are currently available for fishes, molluscs (mainly unionid bivalves), decapods (crabs, crayfish and shrimps), Odonata (dragonflies and damselflies), and selected plant families.

GEO BON, [under construction] EU BON & EuMon

The Group on Earth Observations Biodiversity Observation Network (GEO BON)[58] is a voluntary partnership of governments and organisations, which aims to improve the acquisition, coordination and delivery of biodiversity observations and related services to users, including decision-makers and the scientific community. At this stage the FP7 Building the European Biodiversity Observation Network (EU BON) project,[59] which is a European contribution to GEO BON, is developing a data platform[60] (currently in beta stage), aiming to be a central access point for biodiversity data from different sources. In addition to data from the GBIF network, this platform links to the Long-Term Ecological Research network, the Global Earth Observation System of Systems and the Pan-European Species directories Infrastructure.

2.3.3 Protected areas

Protected areas: CDDA

The Common Database on Designated Areas (CDDA)[61] is more commonly known as nationally designated areas. It is the official source of protected area information from European countries to the World Database of Protected Areas (WDPA).[62] The inventory began in 1995 under the CORINE programme of the EC. It is now one of the agreed Eionet priority data flows maintained by the EEA with support from the European Topic Centre on Biological Diversity. The CDDA data can be queried online in the EUNIS.

The latest version of the CDDA, version 13 from 2015, covers the entire geographical area of the countries that make up the EEA (including the six West Balkan countries that are 'cooperating countries' of the EEA) and includes the full geographical area under the responsibility of European countries as well as other states and territories related to key initiatives in the European region.

Protected Planet – WDPA

58 http://geobon.org
59 http://www.eubon.eu/
60 http://beta.eubon.ebd.csic.es
61 http://www.eea.europa.eu/data-and-maps/data/nationally-designated-areas-national-cdda-10
62 https://www.iucn.org/theme/protected-areas/our-work/world-database-protected-areas

Protected Planet.net[63] is the online interface for the World Database on Protected Areas (WDPA), a joint project of IUCN and UNEP, and the most comprehensive global database on terrestrial and marine protected areas. ProtectedPlanet.net enables the discovery of the protected areas of the world through exploring maps and intuitive searching, feeds of information from the WDPA, photos from Panoramio and text descriptions from Wikipedia.

DOPA

The Digital Observatory for Protected Areas (DOPA)[64] initiative is developed by the JRC and aims to support monitoring, assessment, reporting and forecasting the state and pressures on protected areas. The main service, the DOPA explorer[65] combines data from several sources to visualise these data in a single viewer and to consult the resulting indicators.

Key Biodiversity Areas

Designating Key Biodiversity Areas is a methodology developed by IUCN to designate areas of high significance for biodiversity. The Freshwater Key Biodiversity Areas website,[66] which is part of the BirdLife data zone, was supported through the BioFresh project and includes the results of assessments in Europe, the Mediterranean hotspot and Kerala and Tamil Nadu (India).

Critical Site Network Tool

The Critical Site Network tool[67] is similar to the Key Biodiversity Area approach but focuses on critical sites for bird conservation. This tool and the related area delineation are focusing mostly on migratory water birds. It was developed through a partnership between Wetlands International, BirdLife International and UNEP-WCMC.

2.3.4 Taxonomic data sources (see also EUNIS)

PESI

The Pan-European Species directories Infrastructure (PESI)[68] aims at delivering an integrated, annotated checklist of species occurring in Europe. The PESI checklist (also called EU-nomen) serves as a taxonomic standard and backbone for Europe. Databases from Euro+Med PlantBase, Fauna Europaea, World Register of Marine Species and Species Fungorum Europe are the base of the PESI web portal. PESI includes interactions with the geographic focal point

63 http://www.protectedplanet.net
64 http://dopa.jrc.ec.europa.eu/
65 http://dopa-explorer.jrc.ec.europa.eu/dopa_explorer/
66 http://www.birdlife.org/datazone/freshwater
67 http://www.wingsoverwetlands.org/
68 http://eu-nomen.eu/

networks, a network of taxonomic experts and global species databases. Freshwater information is available via dedicated species search. Results link to GBIF, the Biodiversity Heritage Library,[69] GenBank and BOLDSYSTEMS (see below).

FADA

The Freshwater Animal Diversity Assessment (FADA)[70] is an informal network of scientists specialised in freshwater biodiversity. The FADA database is an information system dedicated to freshwater animal species diversity. The system provides access to authoritative species lists and global distributions compiled by world experts. The data are also integrated in the Freshwater Biodiversity Data Portal, to which it acts as a taxonomic backbone.

FishBase[71] is a global species database of fish species (specifically finfish). It is the largest and most extensively accessed online database on adult finfish on the web. Over time it has "evolved into a dynamic and versatile ecological tool" that is widely cited in scholarly publications. FishBase provides comprehensive species data, including information on taxonomy, geographical distribution, biometrics and morphology, behaviour and habitats, ecology and population dynamics as well as reproductive, metabolic and genetic data. There is access to tools such as trophic pyramids, identification keys, biogeographical modelling and fishery statistics and there are direct species level links to information in other databases such as LarvalBase, GenBank, the IUCN Red List and the Catalog of Fishes. As of April 2015, FishBase included descriptions of 32,900 species and subspecies, 304,500 common names in almost 300 languages, 55,300 pictures, and references to 51,600 works in the scientific literature.

2.3.5 Invasive species

EASIN

The European Alien Species Information Network (EASIN)[72] is a platform developed by the JRC that enables easy access to data on alien species reported in Europe. It facilitates the exploration of existing alien species information from a variety of distributed information sources (e.g. GBIF, the Global Invasive Species Information Network or the Regional Euro-Asian Biological Invasions Centre) through freely available tools and interoperable web services. It also links to the factsheets produced by for example Delivering Alien Invasive Species Inventories for Europe, European Network on Invasive Alien Species or SeaLifeBase. Generally, the network aims to assist policy-makers and scientists in their efforts to tackle alien species invasions. It has been appointed as the information exchange mechanism

[69] http://www.biodiversitylibrary.org
[70] http://fada.biodiversity.be
[71] http://www.fishbase.org
[72] http://easin.jrc.ec.europa.eu

supporting the implementation of European Regulation 1143/2014 on prevention and management of introduction and spread of Invasive Alien Species (IAS).

Additionally, a wide range of other (regional) IAS-related websites exist, which are, in fact, partly linked to EASIN, but where supplementary details about alien species may be found, like the ones mentioned above or the Invasive Species Compendium by CABI,[73] MedMis,[74] or the Belgian Harmonia Information System.[75] Data sources and SDI for the biodiversity are summarised in Table 7.

[73] http://www.cabi.org/isc/

[74] http://www.iucn-medmis.org

[75] http://ias.biodiversity.be/species/all

Table 7: Summary of Biodiversity SDI and datasets.

	Type	Name	G	EU	R	N	S	DM	M
1	BISE–Biod	http://www.biodiversity.europa.eu		X					X
2	Biodiversi	http://www.eea.europa.eu/themes/biodiversity/		X				X	
3	Natura 20	http://www.eea.europa.eu/data-and-maps/data/natura-7		X				X	
4	Biogeogra	http://www.eea.europa.eu/data-and-maps/data/biogeographical-regions-europe-3		X				X	
5	EUNIS–the	http://eunis.eea.europa.eu		X				X	
6	Others…								
7	GBIF–Glob	http://www.gbif.org						X	
8	FIP–Fresh	http://www.freshwaterplatform.eu						X	
9	Policy Brie	http://www.freshwaterplatform.eu/index.php/freshwater-policy-briefs.html		X					
10	Freshwate	http://data.freshwaterbiodiversity.eu/						X	
11	Global Fre	http://atlas.freshwaterbiodiversity.eu/						X	
12	[under co	http://beta.eubon.ebd.csic.es/		X				X	
13	Protected	areas							
14	Protected	http://www.protectedplanet.net						X	
15	Protected	http://www.protectedplanet.net						X	
16	DOPA–Dig	http://dopa.jrc.ec.europa.eu		X				X	
17	The Critic	http://wow.wetlands.org/INFORMATIONFLYWAY/CRITICALSITENETWORKTOOL/tabid/1349/language/en-US/Default.aspx						X	
18	Freshwate	http://www.birdlife.org/datazone/freshwater		X				X	
19	Taxonomic	data sources (see also EUNIS)							
20	PESI–Pan-	http://www.eu-nomen.eu		X				X	
21	FADA–Fre	http://fada.biodiversity.be/						X	
22	Invasive	species							
23	EASIN–Eu	http://easin.jrc.ec.europa.eu		X				X	
24	Others… i	http://www.europe-aliens.org/ ; http://www.cabi.org/isc/						X	
25									
26	Other								
27	FEOW–Fre	http://www.feow.org							
28									
29	Global Ch	http://gcmd.nasa.gov							X
30	IW:LEARN	http://iwlearn.net/community/community-platform							
31	Water foo	http://waterfootprint.org/en/resources/water-footprint-statistics/	X					X	
32	Global Hu	http://www.riverthreat.net/data.html	X					X	

G=global, EU= Europe-wide, R=regional, N=national, S=subnational DM=Data and Metadata, M=Metadata only.

2.4 Ecosystem Services

At the European scale, the major initiative for the mapping and assessment of ecosystem services was established in the frame of Action 5 of the Biodiversity Strategy set for 2020. This action foresee that Member States, with the guidance from the EC, would '*map and assess the state of ecosystems and their services in their national territory by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020'* (Maes et al., 2014). The EU assessment of ecosystem services was set to provide a critical evaluation of the best available information for guiding decisions on complex environmental, socio-economical systems (Maes et al., 2013, 2014, 2015). This assessment is in line with the priorities arising from the Millennium Ecosystem Assessment (MEA), initiated in 2001, and with the EU objectives set forth in 2010 by the EU Biodiversity Strategy to 2020.

In 2012 the EC created a working group on 'Mapping and Assessment of Ecosystems and their Services' (WG MAES).[76] WG MAES started by proposing a conceptual framework linking biodiversity, ecosystem condition and ecosystem services to human well-being (MAES 2013). Then, it developed a typology for ecosystems in Europe and proposed an indicator framework to be used at European and Member States' level using spatially explicit biophysical maps (Maes et al., 2013, 2014). WG MAES steers the implementation of Action 5 and the proposed methodology aims for the identification and assessment of the ecosystems provided services, and for the quantification of synergies and trade-offs among different ecosystem services, and between ecosystem services and biodiversity. Furthermore, WG MAES tested the proposed methodology on ecosystem services provided by Europe's main ecosystem types: agro-ecosystems, forest ecosystems, freshwater ecosystems and marine ecosystems (Maes et al., 2014).

In addition, the group focused on conservation status data for assessing the state of ecosystems and of the provided services (see also Article 17 of the HD), and on the challenge of addressing natural capital accounts (see also Action 5 of the EU Biodiversity Strategy). WG MAES followed the Common International Classification of ecosystem services (CICES), adopting the CICES latest version (V4.3) (Haines-Young and Potschin, 2013). By definition, in the adopted version, natural capital includes the abiotic outputs from ecosystems and the ecosystems capital, whereas ecosystem services are restricted to the outputs of ecosystems dependent on living processes (Figure 18). However, CICES also proposes a provisional accompanying classification table of abiotic outputs from natural systems (Haines-Young and Potschin, 2013; Maes et al., 2015). Tables Table 8 and Table 9 show, respectively, the CICES latest version (V4.3)[77] with the proposed indicators after Maes et al. (2014), and the provisional accompanying classification table of abiotic outputs from natural systems. For the classification of ecosystem services, CICES is organised in a hierarchical structure, which

[76] http://biodiversity.europa.eu/maes

[77] http://cices.eu

includes at its highest-level three categories following the nomenclature used by the MEA (Provisioning; Regulating and maintenance and Cultural services). Below these three major categories, there is a further sub-division into 'divisions', 'groups' and 'classes' (Haines-Young and Potschin, 2013; Maes et al., 2014). This classification was developed for environmental accounting purposes with a hierarchical structure that links with the framework of the UN System of Environmental-Economic Accounts (SEEA, 2003).

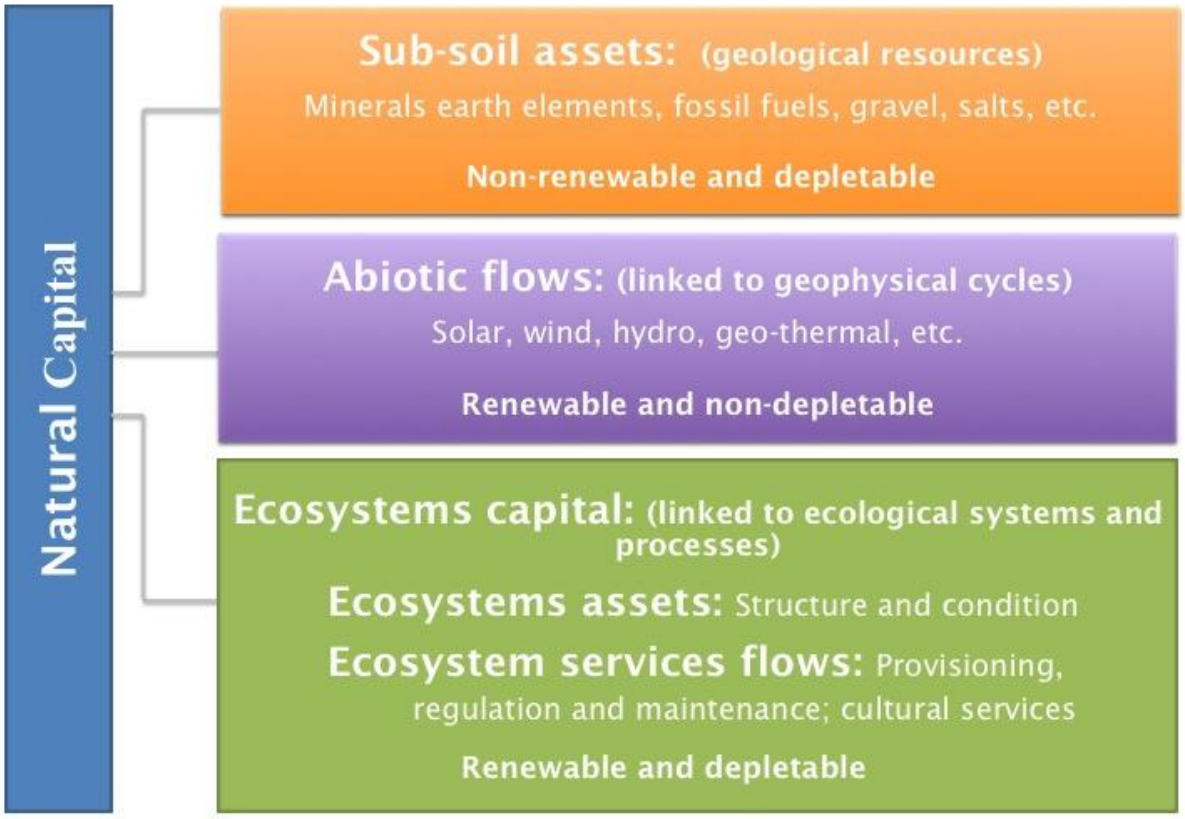


Figure 18: Schematic representation of natural capital components (after Haines-Young and Potschin, 2011).

Table 8: CICES (Version 4.3) classification table of ecosystem services with the proposed indicators after Maes et al. (2014)

Section	Division	Group	Class	Indicators
Provisioning	Nutrition	Biomass	Cultivated crops	
			Reared animals and their outputs	
			Wild plants, algae and their outputs	Harvest (ton y^{-1})
			Wild animals and their outputs	Landings (ton)
			Plants and algae from *in-situ* aquaculture	Harvest (ton y^{-1})
			Animals from *in-situ* aquaculture	
		Water	Surface water for drinking	
			Ground water for drinking	
	Materials	Biomass	Fibres and other materials from plants, algae & animals for direct use or processing	Harvest (ton y^{-1}) Landings (ton)
			Materials from plants, algae & animals for agricultural use	
			Genetic materials from all biota	Patents & published scientific papers (no.)
		Water	Surface water for non-drinking purposes	
			Ground water for non-drinking purposes	
	Energy	Biomass-based energy sources	Plant-based resources	
			Animal-based resources	
		Mechanical energy	Animal-based energy	
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	Nutrient load to coast (ton y^{-1}); metals & POP deposition (ton y^{-1}); oxyrisk
			Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals	
		Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems	
			Dilution by atmosphere, freshwater and marine ecosystems	
			Mediation of smell/noise/visual impacts	
	Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates	
			Buffering and attenuation of mass flows	
		Liquid flows	Hydrological cycle and water flow maintenance	
			Flood protection	Composite indices (Maes, et al., 2014)
		Gaseous / air flows	Storm protection	
			Ventilation and transpiration	
	Maintenance of physical, chemical, biological	Lifecycle maintenance, habitat and gene pool	Pollination and seed dispersal	
			Maintaining nursery populations and habitats	Habitats diversity (no.); O_2 (mg L^{-1}; %)

	conditions	protection		turbidity (%); species distribution (km^2; ha); abundance and richness (ton y^{-1}); MPA (km^2; ha); nursery areas (km^2; ha)
		Pest and disease control	Pest control	Presence (no.); distribution (km^2) of alien species
			Disease control	
		Soil formation and composition	Weathering processes	
			Decomposition and fixing processes	N removal (%); water residence time (months); depth/water residence time ($m.y^{-1}$)
		Water conditions	Chemical condition of freshwaters	
			Chemical condition of salt waters	Nutrient load to cost (ton y^{-1}); metals & POP deposition (ton y^{-1}); oxyrisk
		Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	C stock (ton C); C sequestration (ton C y^{-1}); pH; blue C (ton C); primary production (ton C y^{-1})
			Micro and regional climate regulation	
Cultural	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings	Extent of marine protected areas (km^2; ha); presence of iconic/endangered species (no.); in water activities occurrence (no.); recreation trips (no. y^{-1})
			Physical use of land-/seascapes in different environmental settings	
		Intellectual and representative interactions	Scientific	Scientific studies (no.); documentaries, educational publications (no.); visits to scientific and artistic visits exhibits (no.)
			Educational	
			Heritage, cultural	
			Entertainment	Documentaries, educational publications (no.); visits artistic visits exhibits (no.)
			Aesthetic	
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes	Spiritual and/or emblematic	Symbolic	
			Sacred and/or religious	
		Other cultural outputs	Existence	Extent of marine protected areas (km^2; ha); presence of iconic/endangered species (no.)
			Bequest	

Table 9: CICES (Version 4.3) provisional accompanying classification table of abiotic outputs from natural systems with some examples.

Section	Division	Group	Examples
Abiotic Provisioning	Nutritional abiotic substances	Mineral	Salt
		Non-mineral	Sunlight
	Abiotic materials	Metallic	Metal ores
		Non-metallic	Minerals, aggregates, pigments, building materials (mud/clay)
	Energy	Renewable abiotic energy sources	Wind, waves, hydropower
		Non-renewable abiotic energy sources	Coal, oil, gas
Regulation & Maintenance by natural physical structures	Mediation of waste, toxics and other nuisances	By natural chemical and physical processes	Atmospheric dispersion and dilution; adsorption and sequestration of waters in sediments; screening by natural physical structures
	Mediation of flows by natural abiotic structures	By solid (mass), liquid and gaseous (air) flows	Protection by sand and mud flats; topographic control of wind erosion
Cultural settings dependent on abiotic structures	Physical and intellectual interactions land-/seascapes [physical settings]	Physical and experiential interactions or intellectual and representative interactions	Land and sea breezes; snow
			Caves
	Spiritual, symbolic and other interactions land-/seascapes [physical settings]	By type	Sacred rocks or other physical structures or spaces

CICES provides a hierarchical system, building on the MEA and The Economics of Ecosystems and Biodiversity (TEEB)[78] classifications but tailored to accounting. However, although CICES differs from these two classification systems, as it only considers the outputs of ecosystems dependent on living processes, the Haines-Young and Potschin (2013) report shows that they can be related, meaning that Member States that have already applied MEA or TEEB to regional or national ecosystem service assessment can convert to CICES, and proceed with the following step to the spatially explicit mapping of ecosystem services. A detailed relation between MEA, TEEB and CICES ecosystem service classification systems is available online.[79]

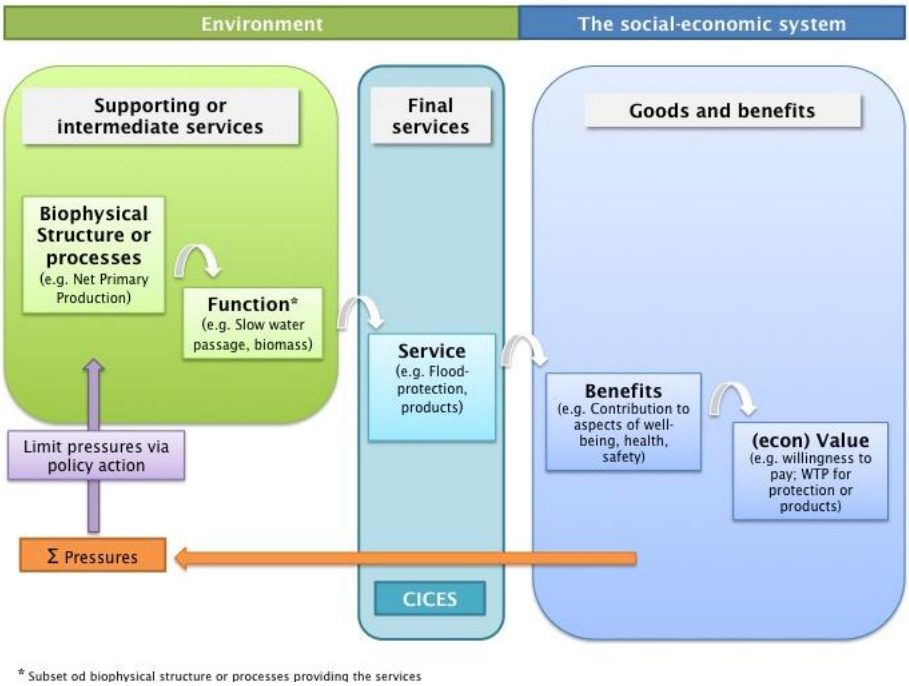
To support Member States to proceed with the ecosystem service mapping step, namely the indicators assessment, the WG MAES (Maes et al., 2014) proposed a tiered approach for mapping and assessment of ecosystem services: (i) mapping using available indicators; (ii) mapping linking different indicators; and (iii) model-based approaches to map ecosystem

[78] http://www.teebweb.org/

[79] http://biodiversity.europa.eu/maes/ecosystem-services-categories-in-millennium-ecosystem-assessment-ma-the-economics-of-ecosystem-and-biodiversity-teeb-and-common-international-classification-of-ecosystem-services-cices

services, which can also be used to assess uncertainty in quantification and valuation (e.g., InVEST (Guerry et al., 2012); ARIES (Villa et al., 2014); and the Ecosystem management tool: Ecopath with Ecosim and Ecospace (EwE) (Pauly et al., 2000). In addition, the WG MAES made available a set of ancillary cards with ecosystem service supply and demand indicators and the respective source of information at the EU level. These indicators are organised into the six WG MAES Pilots (nature data, agriculture, forest, freshwater, marine, and natural capital accounting) considering the supply and demand perspectives of ecosystem services and made available under registration at the European Commission Authentication Service (ECAS) web page.[80] Maes et al., (2015) also propose a set of indicators following the cascade flow model (originally part of the TEEB framework), considering the ecosystems capacity to deliver a service, the flow of the service and the corresponding benefit (Figure 19). As an example, for the water provision service, specifically the reserves of renewable freshwater, the indicator for capacity would be the total area of inland water bodies and inland wetlands (ha), the indicator for flow would be the total annual renewable freshwater supply (m^3 $year^{-1}$) by surface waters, and the indicator for benefit would be the total annual freshwater consumption per sector.

Figure 19: Schematic representation of the ES cascade flow model (redrawn after Haines-Young and Potschin, 2013).



Regarding the valuation of ecosystem services (part of Action 5 of the Biodiversity Strategy for 2020), to date, there is no specific methodology proposed by WG MAES to Members States. However, there are some networks and projects on the valuation of ecosystem

80 https://circabc.europa.eu/webdav/CircaBC/env/ecosystem_assesment/Library/Working%20Group%20on%20Mapping%2c%20Assessment%20of%20Ecosystems%20and%20their%20Services

services that have been applied at regional or national level by some countries, namely TEEB, Nature Valuation and Financing Network,[81] Integrating biodiversity Science for human well-being (DIVERSITAS),[82] and Rationalising Biodiversity Conservation in Dynamic Ecosystems (RUBICODE).[83] The review and assessment of data and indicators above have highlighted the need for a more developed suite of ecosystem services indicators.

A major limitation of much of the ecosystem services mapping at the European scale to date, under the WG MAES project, has been the difficulty in moving beyond the mapping of ecosystem processes relating to specific habitat types and listing of their associated services toward consideration of the supply side of ecosystem services which requires data on human usage patterns. For example, under WG MAES a Recreational Potential Index was developed.

Recreational potential was assumed to be correlated with the degree of naturalness, presence of protected areas, presence of coastlines (seas or lakes) and to quality of bathing waters. Naturalness was assessed based on *hemeroby*, a measure of human influence on landscape and flora derived from CORINE Land Cover. Presence of protected area was assessed using the Natura 2000 database and the presence of coastlines was also based on CORINE Land Cover while bathing water quality was based on Bathing Waters Directive data collected annually by the EEA. Accessibility was assessed based on the European road network- the data were aggregated according to NUTS statistical areas.

The authors recognise the lack of measured visitor information rates as a bottleneck to more accurate assessment. During the course of the review (this document) we have recognised one potential solution based on big data. The increasing use of mobile telephones and their associated cameras has resulted in an enormous number of geotagged photographs being posted on the web. One of the major outlets for geotagged photography is in Google Maps- the software which enables the display of photographs in Google Maps is known as Panoramio and its Application Programming Interface (API) and open source script to query the Panoramio API and to output a map of the density of photographs taken in any given location around the world has been developed by an Estonian group called Bluemoon. The outputs of the script that they call a "touristiness map" received some attention when it was released in 2010, but the potential of the mapping tools as a semi-quantitative tool for the assessment of cultural ecosystem services and recreation has not been fully explored. There may be potential to combine these maps with quantitative assessments of tourism and recreation to develop a more detailed spatial understanding of the distribution and location of cultural ecosystem services in the AQUACROSS case studies.

Regarding the valuation step, the WG MAES proposed indicators do not directly address a linkage to economic assessments, requiring, in this sense, to be validated (Heink et al., 2015).

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[81] www.naturevaluation.org

[82] http:/www.diversitas-international.org/

[83] http://www.rubicode.net/rubicode/index.html

3 Final Assessment of Status of Existing Data

3.1 State of Indicators

> *"An indicator in ecology and environmental planning is a component or a measure of environmentally relevant phenomena used to depict or evaluate environmental conditions or changes or to set environmental goals. Environmentally relevant phenomena are pressures, states, and responses as defined by the OECD (2003)."*
>
> *Heink and Kowarik, 2010*

In European aquatic environmental policy and legislation, indicators serve many different purposes at many different levels of the policy process. However, it could be seen as an opportunity for integration of monitoring across EU legislation and international agreements (Nikolaos et al., 2012), plus, the available data on these monitoring requirements could be used for the development of proxies for specific ecosystem service indicators (Lillebø et al., 2016).

Section 1.5 of this document identifies many different potential users of data and information for the implementation of environmental policies, and just as different types of users have different types of data requirement, so to different indicators have different purposes.

Some authors have discussed how ecosystem services can be used in the ecosystem risk assessment and decision-making processes (Munns et al., 2016), others suggested that ideally all indicators should be directly linked with human pressures, providing opportunity for the relevant mitigation measures (Egoh et al., 2012). However, much of the experience in environmental indicators in the European context has been developed through implementation of the WFD. The WFD sets out a series of BQEs for which Member States must achieve Good Ecological Status; these are: phytoplankton, aquatic flora, benthic macroinvertebrates and fish. In determining ecological status of the BQE, Member States built on their existing traditions of measuring and sampling to determine levels of specific flora and fauna. With the directive covering surface waters in freshwater (rivers and lakes), estuarine and coastal environments across 28 different Member States, it is not surprising that there were a range of different methodologies used. Because of the use of many different techniques and methodologies to assess status of waters relative to the goal of Good Environmental Status, extensive programmes of intercalibration were required; Birk et al., (2012) summarised 300 different bioindicators methodologies used across Europe for the assessment of Good Ecological Status for these BQEs. Bioindicators represent one level of

data aggregationn, whereby specific metrics of community composition might be summarised according to a particular method (e.g. AZTI, BQI). These types of indicators have most resonance with scientists of a particular specialisation; for example, those specialising in marine benthic macrofauna may find common ground through an indicator tools such as AZTI, based on the levels gradients of ecological disturbance. The directive proscribes that waters bodies much achieve Good Ecological Status, assessed relative to an undisturbed reference condition for each particular type of water body. Values for each BQE are ascribed to one of five categories: high, good, moderate, poor and bad. The ecological status being determined by an aggregation rule whereby, the lowest score amongst the various BQEs measured determines the resulting assessment of environmental status. This so called "one out all out" rule is included in the directive in the interests of maintaining a precautionary approach

Good Ecological Status as an indicator, therefore, combines data from the assessment of various BQEs and aggregates it together with a simple rule to provide more readily understood indicator, with a clear pass or fail criterion on the basis of the Good moderate boundary. Good Ecological Status is ascribed to a specific water body (e.g. lake, river segment, estuarine zone), and the individual ecological status of each water body can then be further aggregated to give national or Europe-wide overviews of the ecological status of surface waters across the continent, thus using the higher level of indicator aggregation. At each step of the process from bio indicator to Good Ecological Status of a water body to aggregated national and Europe-wide assessments of ecological status, detail in the assessment is sacrificed for clarity of the overall picture, and the "one out all out" principle helps to ensure the precautionary approach, such that the higher level statistics are more prone to pessimistic than optimistic interpretation. The reporting requirement of the directive also mean that the national reports submitted to and collated by the commission included aggregate data on indicators of environmental status while the raw data used to generate the indicators remain in the hands of the specific Member States or local authorities tasked with gathering with the implementation of the directive.

While the extensive data gathering collation and intercalibration exercises conducted as part of the WFD have been invaluable in terms of fostering cross-European cooperation and collaboration in the field of aquatic environmental legislation, these exercises, in harmonising a single directive across the entire EU, have been time consuming and expensive.

Borja et al., (2010) discuss the lessons learned from implementation of the WFD and suggest methods for the integrated implementation of MSFD and WFD. They recognise the differing "deconstructing structural" (Pure) approach of the WFD and contrast it with the holistic functional approach of the MSFD and recognise interlinkages between several elements of the two directives. The expanded scope of the MSFD with 11 qualitative descriptors, 29 criteria and 55 specific sub-criteria for the determination of Good Environmental Status provides new challenges both in terms of defining suitable aggregation rules for the combination of descriptors as well as the harmonisation of Good Ecological Status with Good Environmental Status beyond the 1nm boundary of the WFD.

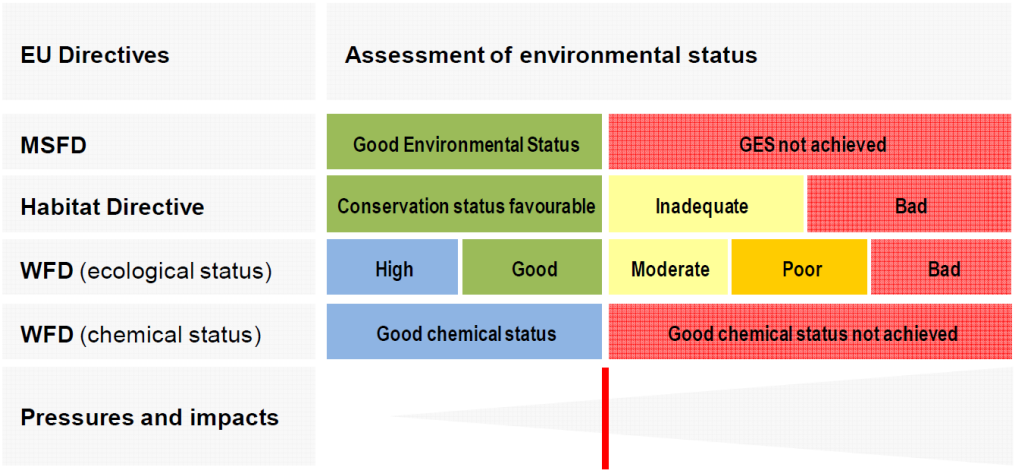

Figure 20: Cross compliance between EU environmental directives from (EU 2010).

Ideally, the Good Ecological Status of the WFD should be harmonised with the Good Environmental Status of the MSFD, which in turn should be equivalent to Favourable Conservation Status under the HD (Figure 20). Further, if these directives are to be the means to achieving the ends of EU Biodiversity Strategy, the process of compliance with these directives could also be harmonised with the goals of the strategy such that complying with the environmental legislation would also involve reducing the levels of biodiversity loss incrementally toward the final goal of halting biodiversity loss by 2020.

The EU Biodiversity Strategy sets out a series of targets 6 and 20 actions to achieve its strategy and these are detailed in Table 10. A suite of indicators has also been selected to assess progress toward the goals of the Biodiversity Strategy; these include indicators from the EEA's Core Set of Indicators (CSI). Considerable efforts have been expended on developing indicators to assist with attaining Europe's biodiversity targets through the Streamlining European Biodiversity Indicators (SEBI) initiative. The aim of the initiative was to develop as set of biodiversity indicators for Europe based on existing data and develop new indicators where necessary.

SEBI was set up in 2005 and involves several working groups with more than 120 experts. The first set of SEBI indicators was selected in 2006. SEBI indicators are structured around existing monitoring data and have been carefully aligned with the DPSIR framework. The most recent updates for each of the indicators for all the SEBI and CSI indicators are available from the EEA indicators website,[84] while the most up to date agricultural indicators are available through Eurostat.[85] Table 11 lists the indicators relevant selected to assess progress toward the targets of the EU Biodiversity Strategy; 24 from a total of 26 SEBI indicators are used for the purposes of the Strategy with five CSI indicators and eight agri-environmental indicators being incorporated. While all the indicators are relevant to achieving the goals of

[84] http://www.eea.europa.eu/data-and-maps/indicators/

[85] http://ec.europa.eu/eurostat/web/agri-environmental-indicators

the Strategy, not all are directly relevant to biodiversity in the aquatic environment. For example, SEBI01 relates to birds and butterflies, SEBI17 and SEBI18 relate to forestry management practices, which principally affect terrestrial biodiversity but may have peripheral effects on aquatic biodiversity through, for example, habitat provision for fish (SEBI18: Deadwood) but are not considered further here. Similarly, Ecological Footprint which relates to Target 6 is not directly relevant to assessment of aquatic biodiversity.

Table 10: Targets and Actions of the EU Biodiversity Strategy

Target		Action	
1	Protect Species and Habitats	1	Complete the Natura 2000 network and ensure its good management
		2	Make sure Natura 2000 sites get sufficient funding
		3	Raise awareness of Natura 2000, get citizens involved and improve the enforcement of the nature directives
		4	Make the monitoring and reporting of the EU nature law more consistent, relevant and up-to-date; provide a suitable ICT tool for Biodiversity
2	Maintain and restore ecosystems	5	Map and assess the state and economic value of ecosystems and their services in the entire EU territory; promote the recognition of their economic worth into accounting and reporting systems across Europe
		6	Restore ecosystems, maintain their services and promote the use of green infrastructure
		7	Assess the impact of EU funds on biodiversity and investigate the opportunity of a compensation or offsetting scheme to ensure that there is no net loss of biodiversity and ecosystem services
3	Achieve more sustainable agriculture and forestry	8	Enhance CAP direct payments to reward environmental public goods such as crop rotation and permanent pastures; improve cross-compliance standards for GAEC (Good Agricultural and Environmental Conditions) and consider including the Water Framework in these standards
		9	Better target Rural Development to biodiversity needs and develop tools to help farmers and foresters work together towards biodiversity conservation
		10	Conserve and support genetic diversity in Europe's agriculture
		11	Encourage forest holders to protect and enhance forest biodiversity
		12	Integrate biodiversity measures such as fire prevention and the preservation of wilderness areas in forest management plans
4	Make fishing more sustainable and seas healthier	13	Ensure that the management plans of the Common Fisheries Policy are based on scientific advice and sustainability principles to restore and maintain fish stocks to sustainable levels.
		14	Reduce the impact of fisheries by gradually getting rid of discards and avoiding by-catch; make sure the Marine Strategy Framework Directive is consistently carried out with further marine protected areas; adapt fishing activities and get the fishing sector involved in alternative activities such as eco-tourism, the monitoring of marine biodiversity, and the fight against marine litter.
5	Combat alien invasive species	15	Make sure that the EU Plant and Animal Health legislation includes a greater concern for biodiversity.
		16	Provide a legal framework to fight invasive alien species
6	Help stop the loss of global biodiversity	17	Reduce the impacts of EU consumption patterns on biodiversity and make sure that the EU initiative on resource efficiency, our trade negotiations and market signals all reflect this objective.
		18	Target more EU funding towards global biodiversity and make this funding more effective.
		19	Systematically screen EU action for development cooperation to reduce any negative impacts on biodiversity.
		20	Make sure that the benefits of nature's genetic resources are shared fairly and equitably.

Table 11: Indicators used for the EU Biodiversity strategy: those indicators marked with **X** are directly relevant to aquatic environments, and those marked with x are peripherally relevant.

	Indicator	Target					
		1	2	3	4	5	6
1	SEBI 01 Abundance and distribution of selected species: Common farmland birds and grassland butterflies	x		x			
2	SEBI 03 Conservation status of species of European interest	**X**	**X**	**X**	**X**		
3	SEBI 04 Ecosystem coverage		**X**				
4	SEBI 05 Conservation status of habitats of European interest	**X**	**X**	**X**	**X**		
5	SEBI 07 Nationally designated protected areas		**X**				
6	SEBI 09 Critical load exceedance for nitrogen		**X**				
7	SEBI 10 Invasive alien species in Europe					**X**	
8	SEBI 13 Fragmentation of natural and semi-natural areas		**X**				
9	SEBI 16 Freshwater quality		**X**				
10	SEBI 17 Forest: growing stock, increment and fellings			x			
11	SEBI 18 Forest: deadwood			x			
12	SEBI 19 Agriculture: Nitrogen Balance			**X**			
13	SEBI 20 Agriculture: area under management practices supporting biodiversity			**X**			
14	SEBI 21 Fisheries: European commercial fish stocks				**X**		
15	SEBI 23 Ecological Footprint of European countries						x
16	CSI14 Land take		**X**				
17	CSI019 Oxygen consuming substances in rivers		**X**				
18	CSI 020 Nutrients in freshwater		**X**				
19	CSI 025: Gross nutrient balance			**X**			
20	CSI 026 Organic farming			**X**			
21	AEI 01: Agri-environmental commitments			**X**			
22	AEI 02: Agricultural areas under Natura 2000			**X**			
23	AEI 4 Area under organic farming			x			
24	AEI 15: Gross nitrogen balance			**X**			
25	AEI 18: Ammonia emissions from agriculture			**X**			
26	AEI 23 High Nature Value farming			x			
27	AEI 27.1: Water quality – Nitrate pollution			**X**			
28	AEI 28: Landscape – state and diversity			x			

3.1.1 SEBI 03 and SEBI 05– Conservation status of species and habitats

The two most important indicators in the list are SEBI03 and SEBI05 (conservation status of species and habitats, respectively), with each being relevant to four of the six biodiversity targets. SEBI03, the Conservation status of species of European Interest, covers the species

listed in Annexes II, IV and V of the HD (i.e species of European interest, these were selected for inclusion in the HD as they were perceived to be under threat. Species are categorised under the HD into one of five categories of conservation status: favourable, unfavourable inadequate, unfavourable bad, unknown or not assessed. As the data are a direct product of HD reporting, they reflect the status of HD implementation (rather than the status specifically of biodiversity). At present the indicator does not include data from the BD.

The EEA website acknowledges a number of weaknesses in the indicator:

- Limited trend information: the underlying data is not yet available and only one data set will become available before 2010. The data will only be reported in a six-year cycle.
- The indicator is based on the EU HD; a transfer to the global/ pan-European level is not possible.
- There are no EU-wide standards for data collection. The robustness of the indicator could, therefore, be limited.

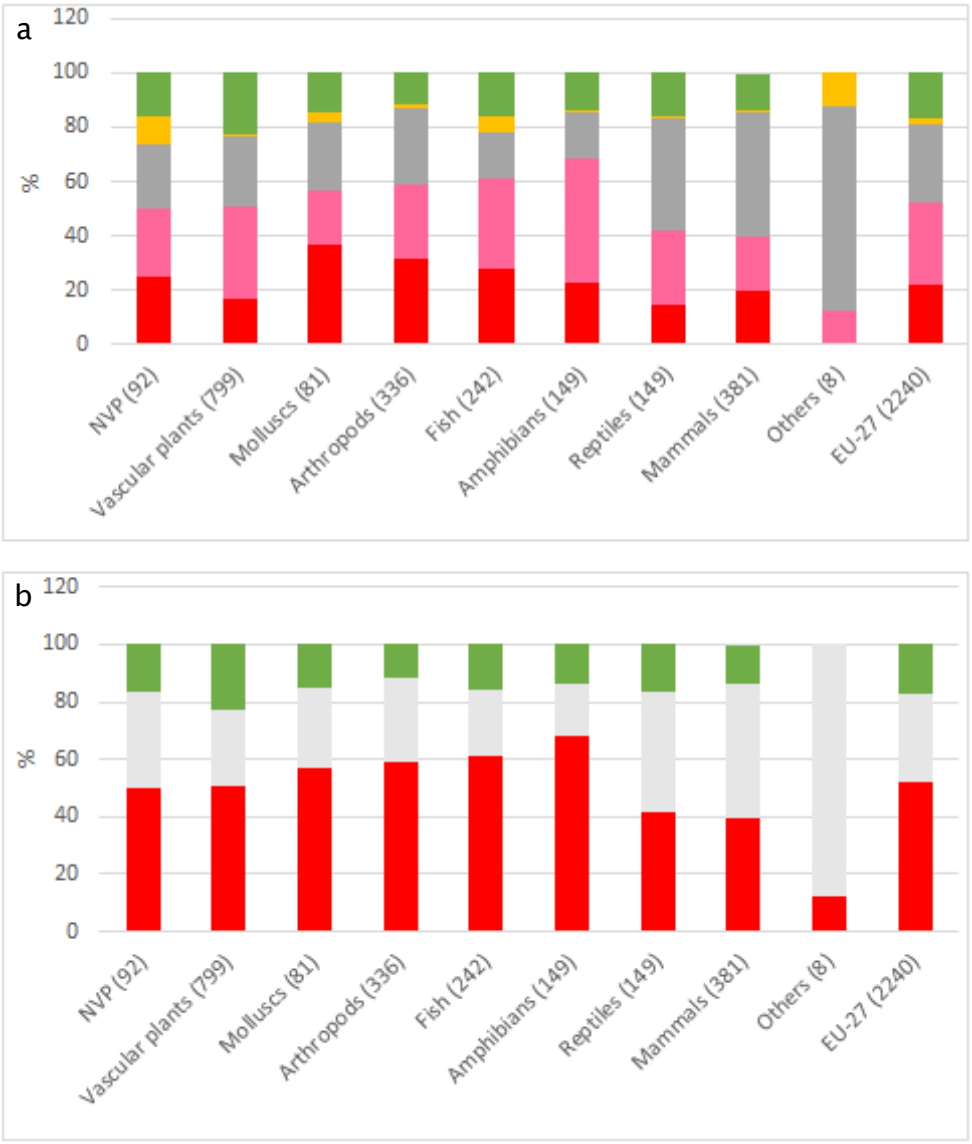

Figure 21: a) SEBI03 indicator as reported by EEA with 5 categories: green (favourable), yellow (not assessed), grey (unknown), pink (unfavourable, inadequate), and red (unfavourable bad); b) SEBI03 indicator with 3 categories: favourable (green), unfavourable (red), and unknown (grey). (NVP = Non Vascular Plants)

While the indicator may be informative on the progress in implementation of the HD, it does not convey information on the success of the directive in protecting diversity within the designated sites. illustrates the data from SEBI03. The data are displayed in three formats, the first (a) shows the complete data as downloaded from the EEA website with five categories: one favourable, two unknown and two unfavourable; the second image shows the same data with the categories simplified into favourable, unfavourable, and unknown.

In b, the degree of uncertainty and the predominance of unfavourable status are more readily apparent. It is reasonable to argue that under a precautionary approach unknowns might be assigned to the unfavourable categories as in Figure 22.

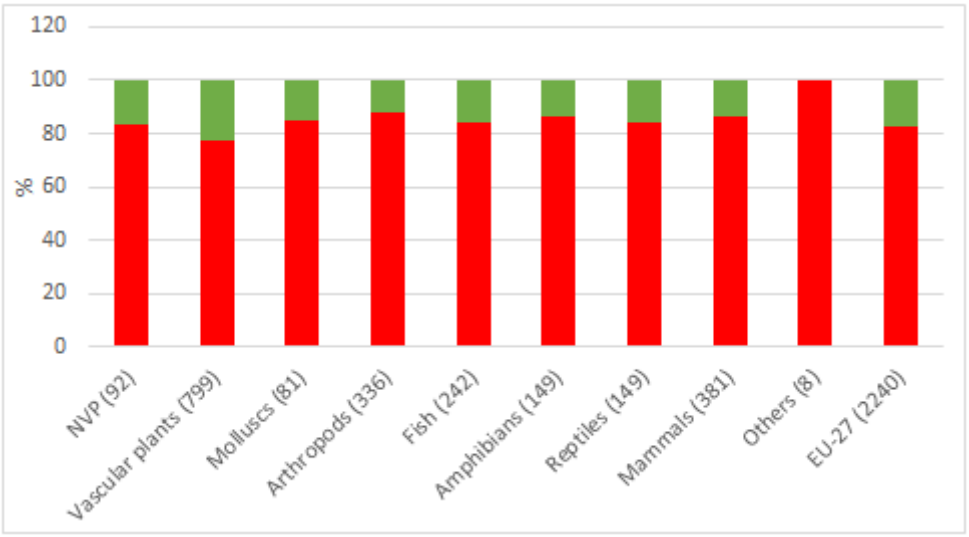

Figure 22: SEBI03 indicator with unknown categories assigned unfavourable according to a precautionary principle.

In the above examples, the decision to display the data in percentages gives equal visual weighting to all the groups despite the varying number of species within each group and despite the fact that the largest group of species of community interest (Vascular plants) is 100 times as large as the smallest category (others). Figure 20 (a) shows the HD categories (for each group) based on number of species rather than percentage and the overall number of species assigned to each category at the EU-27 level.

Comparing a with Figure 23a, it is clear that the extent to which this indicator conveys a message is highly dependent on subjective choices on how it is displayed. To some extent, it is visibly apparent that the amount of information contained in a visually dilutes the information that conservation status of the vast majority of species under the HD is either unfavourable or unknown.

The data for the SEBI05 Indicator (conservation status of habitats) take the same format as those displayed above for SEBI03, and the same comments on the efficacy of display and the complexity of the information can be directly applied. One further criticism to the SEBI05

indicator is that habitats, in particular, clearly have a very important spatial dimension. Yet the indicator relates to number of habitats in various states of conservation rather than areas.

Finally, at a more fundamental level, there it is unknown whether completion of the Natura network under the HD can achieve the overarching goal of halting biodiversity loss.

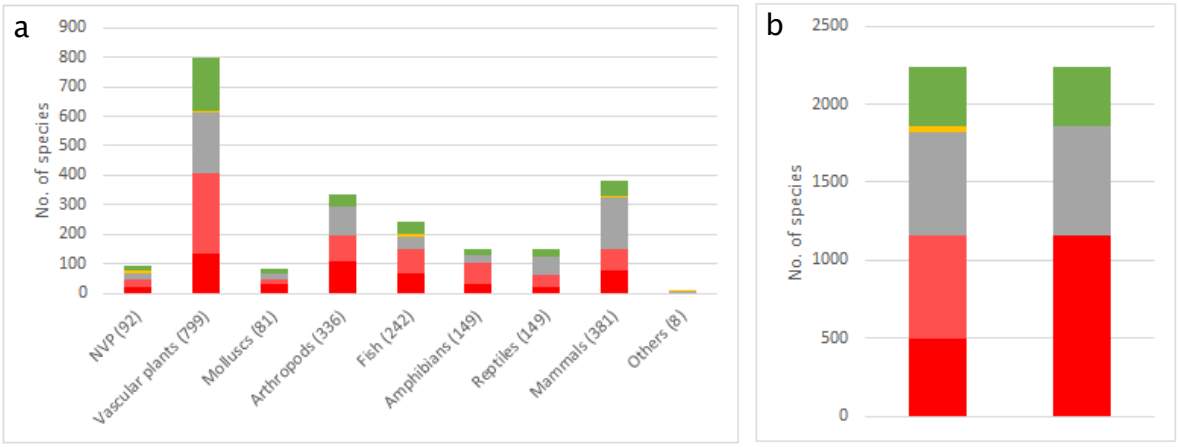

Figure 23: a) Number of species in each conservation category and b) combined for all categories, divided according to habitats directive classification and aggregate into three categories, favourable (green) unfavourable (red) and unknown (grey).

3.2 Task Summary

The aim of this deliverable was to provide an overview of the existing SDI that is in use to support Europe's environmental legislation, which contributes to the European Biodiversity Strategy. The deliverable also aimed more generally to support the overall objective of the AQUACROSS project to "*enhance the resilience and stop the loss of biodiversity of aquatic ecosystems as well as to ensure the ongoing and future provision of aquatic ecosystem services*" and specifically to inform the development of the AQUACROSS Information Platform with its goal of providing project partners with a data repository tool to support implementation of the project and provide "end-users" with a platform to search for and visualise geospatial data. Four specific subtasks were identified as part of the overall task

- An inventory and review on water information systems (e.g. WISE), river information networks (e.g. ECRINS), biodiversity information systems (e.g. BISE) and mapping and assessment of ecosystem services (e.g. MAES) were made.
- At the same time, an inventory and assessment of data and information systems stemming from relevant initiatives was compiled.
- A stakeholder data management orientation workshop (in parallel with task 2.1 in Month 4) was organised.
- A final assessment on the status of existing data, including indicators, and proposals for improving data and information systems to support EBM for aquatic ecosystems.

Sections 2 of this document address the subtasks 1 and 2 above. The stakeholder data management orientation workshop (subtask 3) was held in the offices of Ecologic Institute in Berlin, Germany on the 1st of March 2016. The workshop documents, terms of reference, preparatory note and final synopsis are included as appendices to this document. The objectives of the workshop were:

- To identify information gaps in data policy repositories
- Gather project relevant feedback on priorities and perceived weaknesses in integration of existing data infrastructure.
- Identify potential solutions and determine barriers to policy data interoperability and INSPIRE compliance.
- To assess the major operational barriers to use of existing databases for the purposes of EBM.
- To determine which operational features can best enhance the utility, visibility and communications potential of existing datasets.

In addition to detailed discussion on many aspects of SDI and the challenges of delivering integrated approaches to the EU Biodiversity Strategy, the major output from the workshop was that any innovative features which might be developed as part of the AQUACROSS Information Platform were likely to be the products with the most impact.

At present, the plans for developments of the Information Platform contain a range of innovative features including the development of techniques using CKAN technology for the purposes of story mapping. Our review of spatial data and indicators has also led to the potential for including at least one innovative data solution, the use of the Panaromio API to provide demand-side information on cultural ecosystem services which can advance understanding of ecosystem services in the context of the project case studies.

3.3 Discussion

This section provides an overview of the findings of the research and provides a list of overarching recommendations (Table 12) and a list of project specific “pointers” (Table 13).

The EU Biodiversity Strategy is failing. The mid-term assessment of progress indicates no significant progress overall toward the headline target of halting biodiversity loss, and progress on all but one target is insufficient (see Table 1). A normative classification of European Environmental policies was developed in section 1.3. Figure 24 summarises the results of this analysis, which identified two major processes that need to occur if European environmental policies are to be aligned with the goals of the Biodiversity Strategy. A process of policy reform needs to occur to ensure that the ‘Practical’ policies, the CAP and the CFP, which are the recipients of practically all the EU budgets for natural resource management need to be aligned with the goals of achieving environmental quality under the WFD and the HD. While there has been considerable reform of both these CAP and CFP in recent years, these reforms are insufficient to ensure the halting of biodiversity loss as demonstrated by the mid-term review of the Biodiversity Strategy. Progress toward long term environmental

objectives through policy reform is generally a very slow process (O'Higgins et al., 2014). Even without further reform there are areas where the objectives of transparency in environmental management as set out in the Aarhus convention and embodied in the INSPRIRE directive could currently be improved.

Collection of spatial data under the two major practical policies, CAP and CFP, is mandatory. In order to implement the CAP direct payments, scheme a LPIS is in use similarly under the CFP the reporting of the activities of all vessels over 15m in the form of VMS data is mandatory. These two policies are in receipt of over 99% of the sustainable resource use budget and through the spatial scales of their implementation have the largest direct impacts on the environment and on biodiversity, yet the vast data archives on the specific locations of environmental pressures contained in these databases and held centrally at the European level is not readily accessible for analysis.

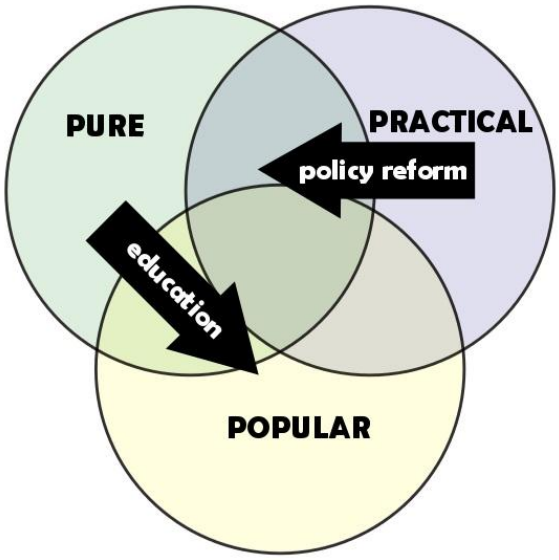

Figure 24: Changes required for the alignment of European environmental and natural resource management laws and policies.

Given that these databases exist, that the European tax payer subsidises these activities (both the sectors and the collection of the data), that European public goods are suffering the environmental consequences of the policies, and further, that the EU has an legal obligation under the Aarhaus convention to make such data available, there is a clear requirement to more fully incorporate the goals of the Biodiversity Strategy into the two major 'Practical' policies **[recommendation 1]**.

There is considerable evidence to suggest that at the European-scale public understanding of the major environmental problems facing the continent is limited. Figure 25 shows the levels of public understanding of the term biodiversity as measured by Eurobarometer polls. The most recent data (from 2013) indicate that 56% of participants have not heard of biodiversity or do not know what it means. For the marine environment, there is a pronounced gap between what scientists and the public perceive to be marine environmental threats (Potts et al., 2016). The lack of engagement with the concept of biodiversity and with the types of

problems which are occurring within the environment may help explain the apparent low priority, both in terms of sustainable resource use budget and progress toward environmental objectives, within the two major 'Practical' policies. Aligning the 'Pure' with the 'Popular' is, therefore, another major challenge to achieving the goals of the Biodiversity Strategy. Public participation is considered essential in conducting EBM (Sarda et al., 2015), but in order for public participation to be successful in achieving environmental goals, the public require information and need to understand the problems.

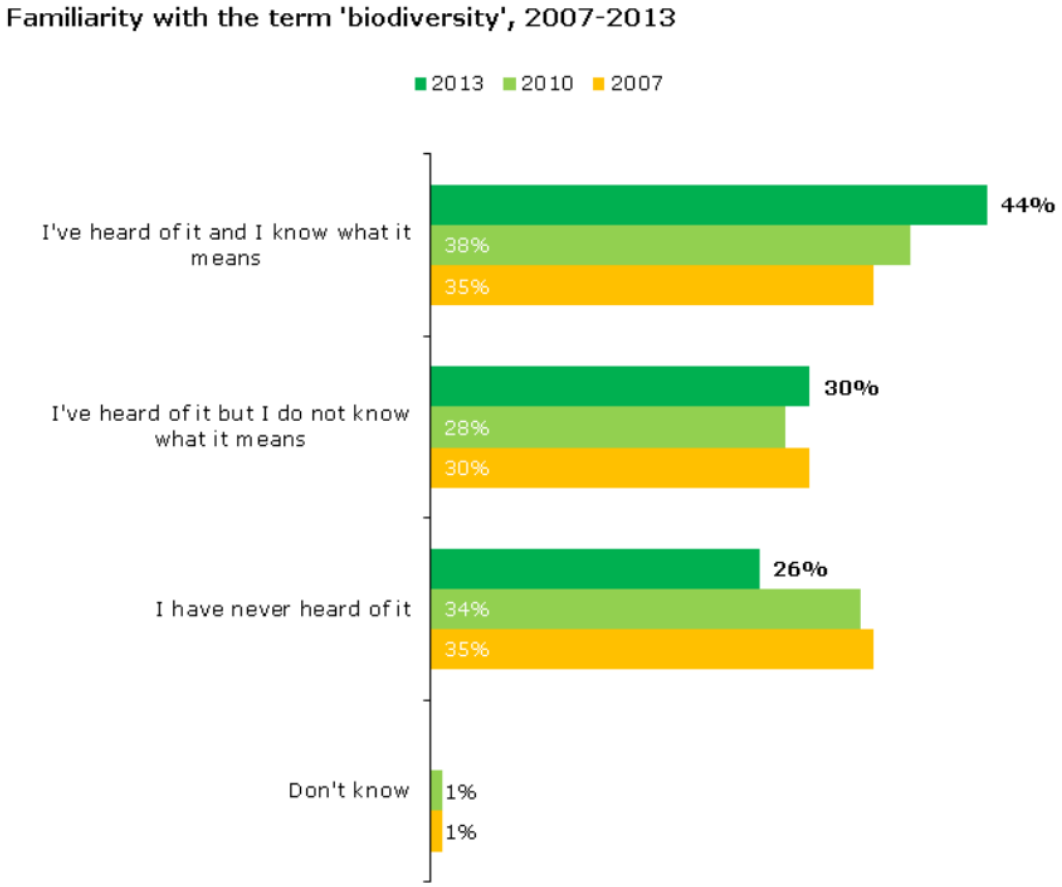

Figure 25: European levels of familiarity with the term biodiversity (Eurobaromenter 2013)

In order to develop an Information Platform that can support EBM toward achieving the goals of the EU Biodiversity Strategy, the presentation of data and information must to be tailored toward raising levels of understanding of biodiversity **[pointer 1]** and the pressures which can lead to biodiversity loss **[recommendation 2]**.

Section 2 of this document provides a review of spatial data infrastructure and data under the five categories: Marine, Freshwater, Biodiversity, and Ecosystem Services. These sections provide an overview of the amounts of data potentially relevant to the implementation of the EU Biodiversity Strategy, both good and bad examples of data and information display and communication. Data requirements for individual AQUACROSS case studies will vary on a case-by-case basis, and few recommendations will be made on specific datasets to be included in the IP, as these will vary on a case-by-case basis. Nevertheless, there are some specific examples of data and information which relate directly to the targets of the

Biodiversity Strategy that could potentially be of general interest to any user of the platform and serve to communicate important messages about the progress toward the aims of the Biodiversity Strategy based on its 6 individual targets.

Conservation status of species and habitats are identified as the most important indicators of progress toward the Biodiversity Strategy (each being applicable to four of the six targets, the indicators SEBI03 and SEBI05), but of particular relevance to **Target 1** are illustrated by graphs as critiqued in the previous section. The level of abstraction in these indicators (% of total numbers of species/habitats) also masks the spatial dimension of the problems. Conservation status is reported under article 17 of the HD and spatially explicit summaries of the data are hosted by the EEA[86] and shown in Figure 26.

Target 2 involves the maintenance and restoration of ecosystems and their services. The MAES initiative has provided European scale maps of ecosystem types based on CORINE Land Cover, and these could be reproduced as well as combined with the conservation status data to communicate the diversity of ecosystem types and their status within Europe. At present, there is insufficient information to map ecosystem services at the European scale, though products emerging from the AQUACROSS project could provide ecosystem services information at the scale of the individual case studies **[pointer 2].**

Target 3 is to achieve more sustainable agriculture and forestry. Ideally, data from the LPIS could be incorporated into the Information Platform. In the absence of this data, data on high nature-value farming combined with information on nitrogen critical load exceedance or agricultural nitrogen balance could be incorporated. Forest data based on CORINE Land Cover should also be included.

Target 4 relates to the sustainable use of fisheries. The most reliable and user friendly data are the ICES popular advice data, and these should be included **[pointer 3].**

Target 5 is focussed on the combat of non-indigenous species, relevant data for the AQUACROSS Information Platform could focus on the maps of the major pressures or vectors for introduction of IAS.

Target 6 relates preventing the loss of global biodiversity- SEBI23 the ecological footprint for individual nations could be used to illustrate Target 6.

Overall, while there is a great abundance of relevant data which can or should contribute to the EU Biodiversity Strategy in the aquatic environment, the data tend to be very scattered, diffuse and inaccessible to the lay person as suggested by the number of different portals devoted to different aspects of the environment. In particular, policy data, though generally available (with the notable exceptions of VMS and LPSIS), are not readily accessible and centralised attempts to improve accessibility have to date not been fully successful.

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86 http://www.eea.europa.eu/data-and-maps/data/article-17-database-habitats-directive-92-43-eec-1#tab-gis-data

At the policy level, data are not well aggregated. There is no website that clearly illustrates compliance or non-compliance with specific legislation and suggests management measures in an integrated way. For example, WISE is not sufficiently maintained, at the time of writing containing several broken links on its first page. The page consists of links to DG ENV, the EEA and JRC, of these primary links only those to the EEA are functional. Any user with an interest in water quality but without specialisation in European environmental policy have great difficulty finding a suitable narrative thread to carry them through the site to the information they were seeking **[recommendation 3]**.

Similar comments can be made for several other websites. For example, the MAES digital atlas provides a map of ecosystem types, but the links to ecosystem service maps do not appear to be functional.

Fundamentally, there is no centralised long-term SDI designed to meet the needs of the EU Biodiversity Strategy (aquatic or otherwise) and the data are in many different locations. While the AQUACROSS project Information Platform can provide this service for the short term and for a limited number of case studies, the underlying problems, the fragmented policy landscape with its diverse norms and priorities, remains a barrier to efficient delivery of environmental policy objectives **[recommendation 4].**

Overall, the analysis has identified a vast number of data sets that are potentially relevant to the modelling, assessment and communication of biodiversity with respect to the goals of the EU Biodiversity Strategy. In the process of this inventory and review, a number of clear issues have been highlighted. There is a vast array of existing SDIs and data portals containing an enormous amount of data. While these portals serve well the needs of the data hungry boffins, with specialised knowledge of databases, geographic information systems and ecological data, they are at best impenetrable to the lay person.

The 'Practical' policies identified in Section 1 of this document are major drivers of change in terms of biodiversity, but the raw pressure data gathered are not available for analysis. This is true of both the VMS data collected on a mandatory basis under the CFP as well as the LPIS data collected on a statutory basis under the CAP. Given that these policies are the two major recipients of funding for sustainable natural resource management and the major contributors of pressures to terrestrial and aquatic ecosystems and that these data fall under INSPIRE, it can be seen as a major failure of EU SDI (and general transparency) that these pressures are not available to contribute to the scientific analysis to achieve the international commitments of the EU under the CBD thorough implementation of the Biodiversity Strategy **[recommendation 5].**

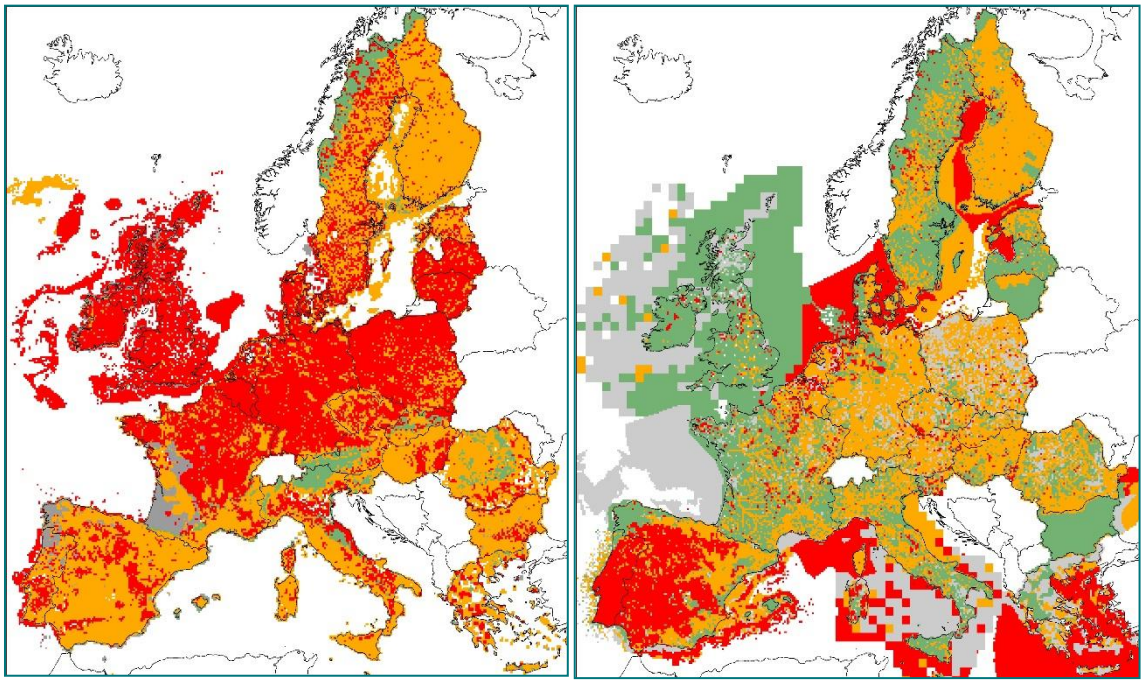

Figure 26: Conservation Status of European habitats (a) and species (b).

Red= Unfavourable-Bad, Orange = Unfavourable inadequate, green= favourable, grey = unknown (EEA 2015).

Table 12: List of Recommendations to improve the use of SDI in biodiversity related policies.

	Recommendations
1	Make available the existing data on fisheries and agricultural pressures that are centrally held in the LPIS as part of the CAP and are gathered by VMS under CFP.
2	Effectively communicate the links between pressures and biodiversity loss.
3	Enable transparency in members States achievements and failures in terms of environmental policy data.
4	Fund and maintain single long-term spatial data infrastructure for European natural resource use laws and policies.
5	Facilitate and encourage INSPIRE compliance.

Table 13: List of project specific pointers arising from the research

	Pointers
1	Present data on conservation status in a spatially explicit way and make use of colours to maximize communication potential of the dataset (which might require some sacrifice of detail in terms of levels of different categories of conservation status.
2	Explore the potential of combining bluemoon “touristiness map” with visitor numbers data from Eurostat to provide quantitative estimates of ecosystem service values.
3	Make use of the ICES popular advice dataset

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5 Annexes

5.1 Annex I

Terms of Reference for AQUACROSS WP2- Policy data integration and application workshop

SUMMARY: Meeting the goals of the EU Biodiversity Strategy and delivering EBM across aquatic environments poses a major challenge for European decision makers in many sectors. Integration of data across different policy strands is one essential element required to meet this challenge. The AQUACROSS project has considerable time and expertise dedicated to the purpose of developing an integrated policy data information platform. Inputs from policy data users and expert are essential to the economy and efficiency of delivering this information platform to the EC. The AQUACROSS project has set aside funds to achieve the objective through a one day policy data integration and applications workshop.

INTRODUCTION: European environmental policy and legislation have evolved steadily over the past 35 years in tandem with global environmental awareness and a developing conceptual **understanding of the enormous challenges of environmental management.** The BD (EEC, 1979) and the subsequent HD (EEC, 1992) adopted in response to the UN CBD, had goals of establishing a coherent network of environmental conservation areas, achieving favourable conservation status and minimising threats to biodiversity. The 'deconstructing structural approach of the WFD (EC 2000; Borja, 2010) has the goal of achieving Good Ecological Status in Europe's aquatic environments freshwater, transitional and coastal. Following the MEA (MEA, 2005) more recent legislation and policy including the MSFD (MSFD) (EU 2008), the Strategy on Biodiversity (2011) and the regulation on IAS (EC 2014) have all **recognised the importance of ecosystem services; the ecosystem approach to management** and the requirement to integrate the connections between land air water all living things including human beings and their institutions. To date these policies and instruments, major efforts at the community level, have resulted in the collection and collation of tremendous amounts of information reported by Member States. These environmental policies also have significant overlap with major sectoral policies, such as the CFP and the CAP and the Biodiversity Strategy envisages clear synergies between environmental and sectoral policies.

Data gathered under the various environmental initiatives are available from a number of different information platforms including, – WISE, BISE and the associated MAES portal as well as the ECRINS, while many relevant data on fisheries and farming are available through Eurostat. Despite clear potential synergies and complementarities **efforts at data gathering and synthesis between directives and policies have largely occurred in parallel**. The potential to combine and harmonise data gathered across these (and other) major initiative is beginning to become apparent as European environmental policy moves towards a more 'holistic functional' (Borja, 2010) ecosystem based approach required under the MSFD and

mandated by the biodiversity policy. For example, a recent technical report (ETC/ICM, 2015) examined the relationships and potential synergies between different WFD and HD Status and Pressures and **identified many potential synergies between directives as well as noting a number of operational barriers** including differences between WFD and HD typologies currently in use. Similarly, Evans et al. (2014) examined the linkages between marine habitat typologies in the EUNIS and those gathered under EU Sea Map; their potential to contribute to the MAES exercises and the necessity for harmonisation of marine habitat types under the MSFD 'predominant' habitat types.

WORK PLAN: AQUACROSS is a research and innovation action under Horizons2020 which aims to "*support EU efforts to enhance the resilience and stop the loss of biodiversity of aquatic ecosystems as well as to ensure the ongoing and future provision of aquatic ecosystem services*". **A major component of the project** is the development of an Information Platform which will combine data and information about aquatic ecosystems from the freshwater, transitional, coastal and marine ecosystems across policy domains with the aim of providing users with a platform to search for and visualise geospatial data and documents: overview data and metadata technical documentation and guidelines; and facilitate geospatial exploration and visualisation of the collected data. The AQUACROSS consortium has considerable skills and experience in the implementation of web atlases and information systems containing many leading European experts. The preliminary technical work and specifications for the platform have already been established. Past experiences with the development of information platforms have generated **considerable insight into the strengths and weaknesses of existing information platforms, not least the realisation that their technology, rather than utility, have driven many past efforts**– as evidenced by the abundance of high specification, but rarely-used, spatial data platforms.

Through an internal expert working group, the consortium has already developed a template for delivery and suite of objectives for the Information Platform. However in the interests of economy and efficiency and with the goal **adding value to existing synthesis initiatives**, it is vital to the aims of the project to obtain the inputs of information users from the policy community. In order to facilitate this dialogue the AQUACROSS team is organising a one day data/policy workshop to be held PARIS/COPNEHAGEN in February 2016.

OBJECTIVES:

The overall **AIM of the workshop is to support the EU biodiversity strategy** by identifying the major data barriers to integration of EU environmental policies. The specific sub-objectives of the workshop are:

- To identify information gaps in list of data policy repositories (Annex 1)
- Gather project relevant feedback on priorities and perceived weaknesses in integration of existing data infrastructure.).
- Identify potential solutions and determine barriers to policy data interoperability and INSPIRE compliance.

- To assess the major operational barriers to use of existing databases for the purposes of Ecosystem Based Management.
- To determine which operational features can best enhance the utility, visibility and communications potential of existing datasets.

EXPECTED OUTPUTS:

- To develop a comprehensive list of policy data sources
- Prioritized list of policy data for integration
- Develop a project interoperability strategy
- Develop a list of barriers and potential solutions to enhance accessibility to environmental data to facilitate ecosystem based management
- Develop a priority list of information platform features

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5.2 Annex II

Policy data integration and application workshop-Discussion document.

The purpose of this document is to provide some background to the major European directives relevant to the aquatic component of the EU Biodiversity Strategy and to provide a starting point for discussion on the technical and operational challenges in designing and implementing Spatial Data Infrastructure (SDI) that are coherent form the data- heavy collection, collation and processing phase of development through to maximising data impact through summarisation and communication. The document provides a brief overview to the relevant policies and introduces the two related sessions of the workshop. It is not intended to be a review of progress in EU SDI, rather it is a starting point to help prioritise the possible contributions of the AQUACROSS project to development of best practice in European SDI.

European environmental policy and legislation have evolved steadily over the past 35 years in tandem with global environmental awareness and a developing conceptual **understanding of the enormous challenges of environmental management.** The BD (EEC, 1979) and the subsequent HD (EEC, 1992) adopted in response to the UN CBD, had goals of establishing a coherent network of environmental conservation areas, achieving favourable conservation status and minimizing threats to biodiversity. The 'deconstructing structural approach of the WFD (EC 2000; Borja, 2010) has the goal of achieving Good Ecological Status in Europe's aquatic environments freshwater, transitional and coastal. Following the MEA (MEA, 2005) more recent legislation and policy including the MSFD (EU 2008), the Strategy on Biodiversity (2011) and the regulation on IAS (EC 2014) have all **recognised the importance of ecosystem services; the ecosystem approach to management** and the requirement to integrate the connections between land air water all living things including human beings and their institutions. To date these policies and instruments, major efforts at the community level, have resulted in the collection and collation of tremendous amounts of information reported by Member States. These environmental policies also have significant overlap with major sectoral policies, such as the CFP and the CAP and the Biodiversity Strategy envisages clear synergies between environmental and sectoral policies.

Data gathered under the various environmental initiatives are available from a number of different information platforms including, - WISE, BISE and the associated MAES portal as well as the ECRINS, while many relevant data on fisheries and farming are available through Eurostat. Despite clear potential synergies and complementarities **efforts at data gathering and synthesis between directives and policies have largely occurred in parallel**. The potential

to combine and harmonise data gathered across these (and other) major initiative is beginning to become apparent as European environmental policy moves towards a more 'holistic functional' (Borja, 2010) ecosystem based approach required under the MSFD and mandated by the biodiversity policy. For example a recent technical report (ETC/ICM, 2015) examined the relationships and potential synergies between different WFD and HD Status and Pressures and **identified many potential synergies between directives as well as noting a number of operational barriers** including differences between WFD and HD typologies currently in use. Similarly, ETC BD (2014) examined the linkages between marine habitat typologies in the EUNIS and those gathered under EU Sea Map; their potential to contribute to the MAES exercises and the necessity for harmonisation of marine habitat types under the MSFD 'predominant' habitat types.

The overall **AIM of the workshop is to support the EU biodiversity strategy** by identifying the major data barriers to integration of EU environmental policies.

Data have many different purposes, and the appropriate targeting of data delivery is key to maximising use of, and adding value to existing data sets. Figure 1 illustrates potential data needs for different groups for the purposes of the biodiversity strategy.

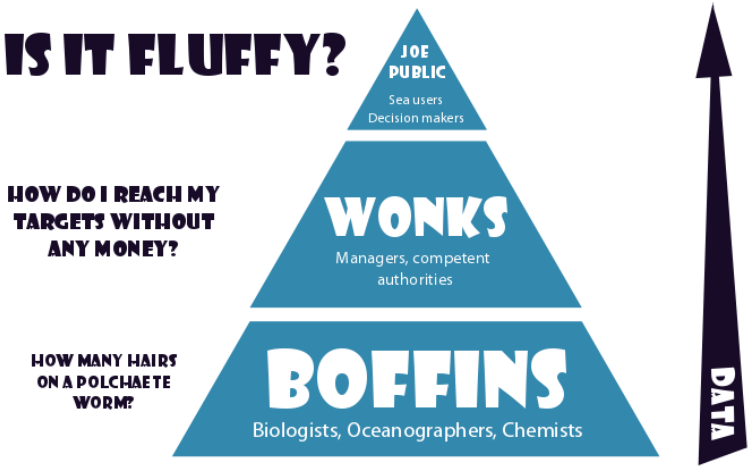

Figure 1: Data requirements for different users.

Scientists (Boffins) and other technical data users are most interested in all the details of the data, the way the data were collected, the units, short and long term temporal dynamics of data. Those charged with implementing environmental policy (Wonks) are usually more interested in various indicators and trends in the data and how these relate to their legislative obligations. To meet these needs data requires a certain degree of synthesis. For public consumption and for high level decision makers, data requirements are smaller again, a single targeted measurement or indicator may be sufficient to meet the level of understanding of these users.

This workshop will be divided into two sessions. The first session (addressing objectives one two and three) relate to the integration of technical aspects of data collection collation and synthesis across multiple policy data streams to meet the needs of the EU biodiversity

strategy. The second session will address the application and use of data platforms to promote ecosystem based management and to communicate data and information efficiently and effectively (Figure 2).

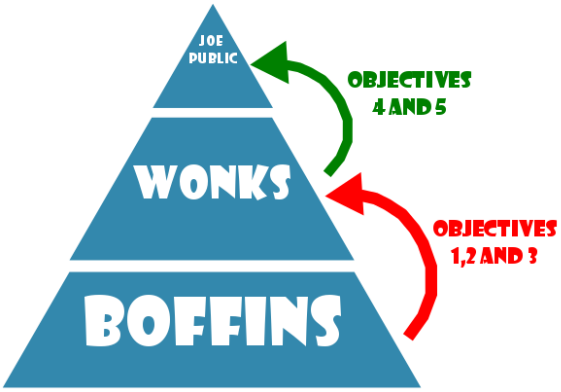

Figure 2: Relationship between workshop structure and data delivery requirements.

Session 1: Policy Data Integration

AIMS

- To identify information gaps in list of data policy repositories (Annex 1)
- Gather project relevant feedback on priorities and perceived weaknesses in integration of existing data infrastructure.).
- Identify potential solutions and determine barriers to policy data interoperability and INSPIRE compliance.

European environmental policies with relevance to the Biodiversity Strategy are aligned in several different ways. From the policy perspective the metrics of the legislation must be coherent so that for example the Good Environmental Status of the MSFD is aligned with Good Ecological Status of the WFD. Figure 3 illustrates a vision for alignment of environmental status between different Directives designed for purposes of the MSFD.

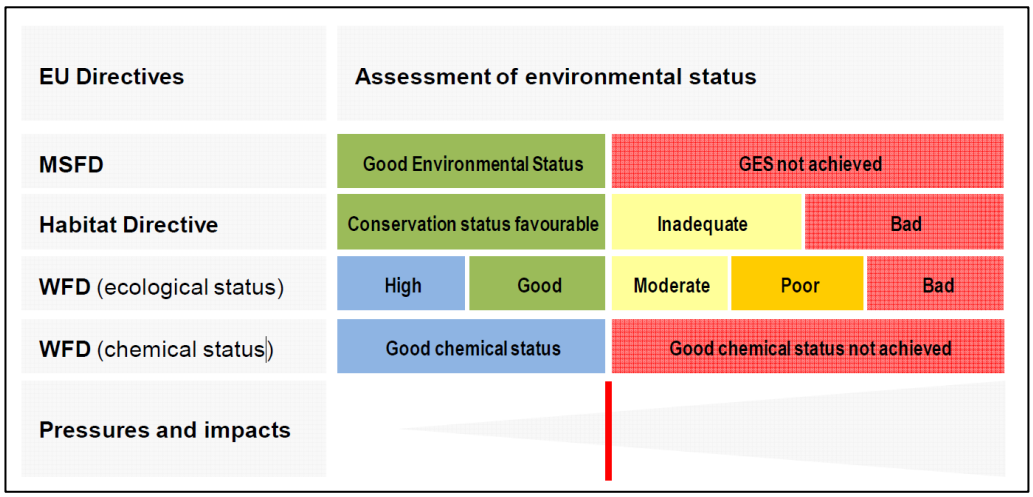

Figure 3: Classifications under EU Directives. In waters with overlappign regimes the boundayr/threshold for Good Environmental Status in the MSFD should coincide with the boundaries /thrsholds for "favourable conservations status" of the Habitats Directive and "Good Ecological Status" and "Good Chemical Status" of the MSFD. Source WG GES 2010.

Though harmonised on a reginonal basis, the boundaries and thresholds for different parameters do vary between regions, for example the cholorophyll concnentations required to meet good ecological/environmental status in the Mediterranean Sea are not the same as those required to meet the same status in the Baltic Sea. Similarly thresholds may vary between different zones within the same region so that, for example chlorphyll, or nutrient concnentrations in freshwaters vary naturally from those experienced in transitional and marine locations. The same is true of different habitats types and typologies. This natural regional variation results in variation in the appropriate techniques and method used to assess environemental status under various directives across different geographic domains.

In addition to the integration and harmonisation of policy objectives, Euroepan aquatic environmental directives also have differing spatial domains and spatial characteristics (Figure 4). While the HD covers the entire spatial domain of European territories from their terrestrial borders to the furtherst extent of their exclsuive economic zone, the WFD extends only as far as 1nautical mile from the baseline. The different spatial characteristics the environments covered under different directives dictate the appropriate scale for measuirng and monitoring of environmental parameters. For example under the WFD, rivers have linear spatial characteristics while lake habitats are characterised by area, tranistional waters have both linear and areal characteristics, similarly in coastal waters and in the open sea, while the spatial characteristics have both x and y dimensions, the scales may be much larger with consequences for measuring modelling and monitoring of environemntal parameters.

Furthermore, the spatial locations under which the directives apply are subject to different major policy Drivers such as the CAP and the CFP, which may provide for different types of data sources (and different levels of data availability) in terms of Drivers and Pressures affecting environmental States.

The multiple data sources, the multiple directives and the multiple spatial characteristics of aquatic ecosystems within under EU environmental law present a major challenge in the synthesis and presentaiton of coherent informaition across geographic and policy domains. Unifying spatial data gathered across policy domains is not trivial, and there have been several European Inititiatives which provided a precedent for the Policy data integration work to be carried out within the frame of the AQUACROSS project.

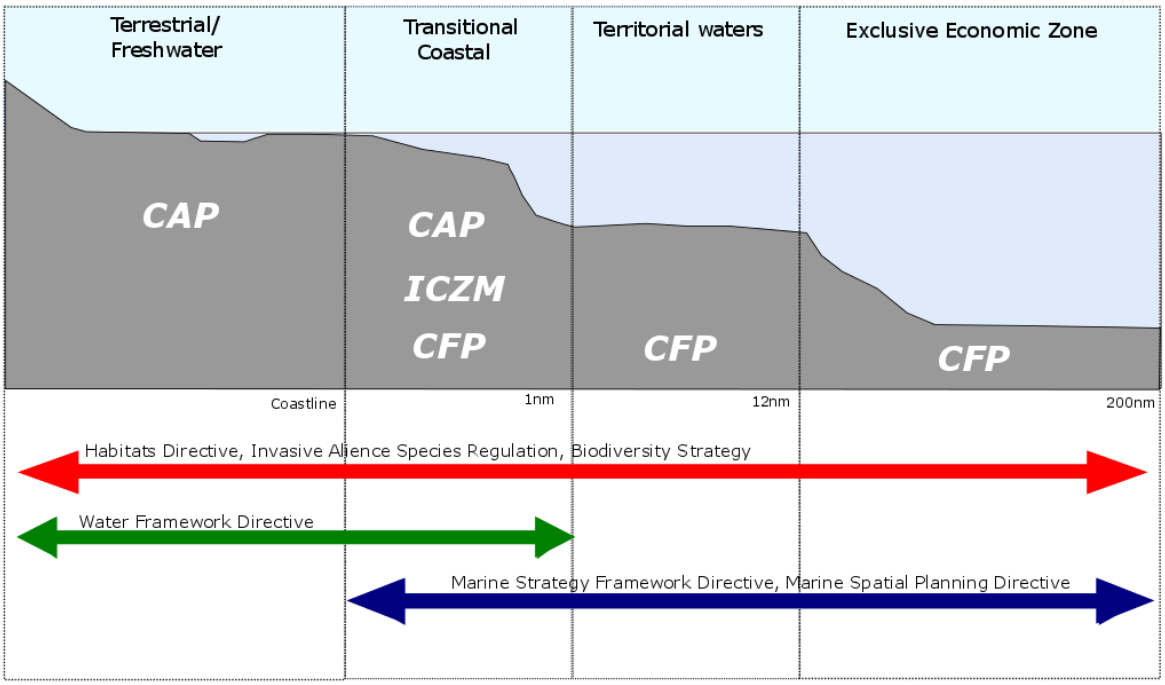

Figure 4: Ecosystems, policies and directives and their spatial extents.

At least two specfific synthesis activities are directly relevant to the work of the project and may inform the priotities for AQUACROSS. The first (ETC SIA, 2013) was aimed at developing a pan-european ecosystem assessment methodology which examine available data on environemntal State and various pressures. A summary of the finding on data availability for aquatic ecosystems is provided in Table 1.

The second relevant acitivity concerns the identificaiton for a need to link the habitat typologies of the EUNIS habitat classifiaction, the EU Sea map and the habitats of the MSFD (ETC BD, 2014). The most recent draft commission decision on descriptors also idenfities the need for cross- classification of marine benthic habitat typologies. Table 2 maps some of the relations between different habitat typologies. Integrating habitat typologies in SDI may involve complex semanitc task which is potentially an area where the AQUACROSS information platform may add value.

Table 1: Summary of data sources and availability for aquatic ecosystem types and pressures adapted from ETC SIA, 2013. Dark green=High, Light green=moderate, Pale green=Low. NB fourth category very high applies to some terrestrial habitats.

	Ecosystem Type	Habitat Change	Climate change	Overexploitation	Invasive species	Pollution and Nutrients
Rivers and Lakes	ECRINS, CLC, JRC MARS, WISE, Waterbase	CLC, ECRINS, Waterbase, IUCN European assessments, Birdlife international database	EPSON Climate	ECRINS, Loss of accessibility due to dams, Waterbase	MAS (upcoming indicators per MSFD area, Invasive Aliens specie in Europe, EASIN	Exceedance of critical loads for eutrophication, critical levels of ozone damage
Wetlands	CLC, LEAC, HRL, Satellite imagery, RAMSAR wetlands layer, WFD	CLC, LEAC, IUCN European assessments, Bridlife International database, Loss of accessibility	EPSON Climate	Satellite imagery, Wetland indicators)ETC-SIA)	Invasive alien species in Europe (SEBI), EASIN	Exceedance of critical loads for eutrophication, critical levels of ozone damage
Marine	Art 17. Species distribution, Arti 12 Birds conservations status, Ecosystem types from biodiversity baseline, EU Sea map, MSFD	CLC, LEAC, IUCN European assessments, Birdlife International database, Loss of accessibility	EPSON Climate, EMIS portal	Status of marine fish stocks, fishing fleet capacity, FAO fishstats, Aquaculture production	Invasive alien species in Europe, Trends and pathways of Marine Alien Species (EEA)	Exceedance of critical loads for eutrophication, critical levels of ozone damage, Hazardous substances in marine organisms, Regional Seas conventions monitoring

Table 2: Relatioship between EUNIS, MSFD and EU Sea Map habitat typologies (source ETC BD, 2014)

<table>
<tr><th colspan="2">EUNIS
(level 2 codes)</th><th>MSFD</th><th>EUSeaMap</th></tr>
<tr><td colspan="2">Littoral
(A1 & A2)</td><td>Littoral</td><td>Not mapped</td></tr>
<tr><td>[Hard substrates]

Infralittoral
(A3)</td><td rowspan="2">[Soft substrates]

Sublittoral

(A5)</td><td rowspan="2">Shallow sublittoral
(above wavebase)</td><td>Infralittoral</td></tr>
<tr><td>Circalittoral
(A4)</td><td>Upper Circalittoral</td></tr>
<tr><td colspan="2" rowspan="3">Deep sea

(A6)</td><td>Shelf sublittoral
(below wavebase)</td><td>Deep Circalittoral</td></tr>
<tr><td>Upper Bathyal</td><td rowspan="2">Bathyal</td></tr>
<tr><td>Lower Bathyal</td></tr>
<tr><td></td><td>Abyssal</td><td>Abyssal</td></tr>
</table>

Table 3 porvides a list of EU environemntal policies relevant to the implementation of the EU biodiversity strategy in aquatic ecosystems, along with infomration platforms and the organisations holding the information. The main aim of this session is to identify any missing data sources and priortise the list of data and potential scale, interoprability or technical mismatches between data sources. During the workshop a spreadsheet will be developed listing and prioritising informaiton sources and potential interoperability issues with these sources. One main output from the workshop will be the prioritized list of tasks and sources which can bring added value to the AQUACROSS project.

Table 3: List of policy data sources, platforms and organisations.

Policy/Directive/Regulation	Information Platform	Organisation
Habitats Directive	EIONET	ETC Bio
Birds Directive	EIONET	ETC Bio
Regulation on Alien Invasive Species	EASIN	JRC
Convention on Biodiversity	Cbd.int	UNEP
Water Framework Directive	WISE	EEA
Floods Directive	EIONET	ETC/IC
Drinking Water Directive	EIONET	EEA-WOSE
Bathing Water Directive		JRC
Urban Waste Water Treatment Directive		Eurostat/JRC
Nitrates Directive		
Water Storage and Drought Directive		ETC/ICM
Marine Spatial Planning Directive		EUMOFA

Marine Strategy Framework Directive
Common Fisheries Policy
Integrated Coastal Zone Management
Common Agricultural Policy
Sustainable Use of Pesticides
Waste Framework

Session 2: application and use of data platforms

AIMS

- To assess the major operational barriers to use of existing databases for the purposes of Ecosystem Based Management.
- To determine which operational features can best enhance the utility, visibility and communications potential of existing datasets.

Ecosystem based management or the ecosystem approach to management is an approach which integrates the connections between land air water all living things including human beings and their institutions. It is commonly recognised has having three major characterisitics, the inclusion of multiple competing drivers, a focus on ecosystem services and a recognintion of the tight coupling between human and ecological systems (Tallis, 2010). The ecosystem approach is mandated under several European Directives, notably the marine startegy framework directive, and many projects have developed tools to assist with ecosystem based management, eg. www.msfd.eu, DEVOTES tool. One key element is the provision of the relevant social and ecological data to the appropriate users with the appropriate level of spatial and temporal detail. Spatial Data Infrastructure are often identified as a key tool to help implement the ecosystem based approach to management. While there have been a plethora of spatial data portals developed particularly through European projects the extent to which such tools are actively used in management is unclear. This session aims to identify barriers to use of existing databases as well as drawing conclusions on features that may render geo-portals more useful in the future.

A major component of the project is the development of an Information Platform which will combine data and information about aquatic ecosystems from the freshwater, transitional, coastal and marine ecosystems across policy domains with the aim of providing users with a platform to search for and visualise geospatial data and documents: overview data and metadata technical documentation and guidelines; and facilitate geospatial exploration and visualisation of the collected data.

O'Higgins (2016) provides an overview of geodata portals in the Celtic Seas region which was developed as a contribution to the WWF/LIFE+ funded Celtic Seas Partnership project. The key considerations for effective impact in SDI are summarised below.

Consider the target audience and their level of technical knowledge.

Who is the ideal user of the information platform? What is their level of interest and technical knowledge? How little information do they require? While geospatial data portals offer the

ability to deliver vast amounts of data not all users need all the data. If there is too much information the ease of use the tool is reduced and the user may get lost looking at data that is not of specific relevance to their interests. Figure 1 summarises the relationship between data availability and data requirements for some existing portals and user groups.

3 Consider your message:

A web portal never simply delivers data, it is a communication tool. Designing any information platform requires data, and while the data may represent objective measures of reality, the selection of data sets for presentation is not a value neutral choice. For example, maps of cumulative human pressures, a collection of data on fishing pressures, cables, dredging, litter, energy and noise and ship traffic will tells a very different story to a compilation of data on marine mammal and sea bird abundances in the same region. The message is also reinforced by the visual style of the map- There are some strong examples of visual communication in geoportals and some very weak ones Figure 5.

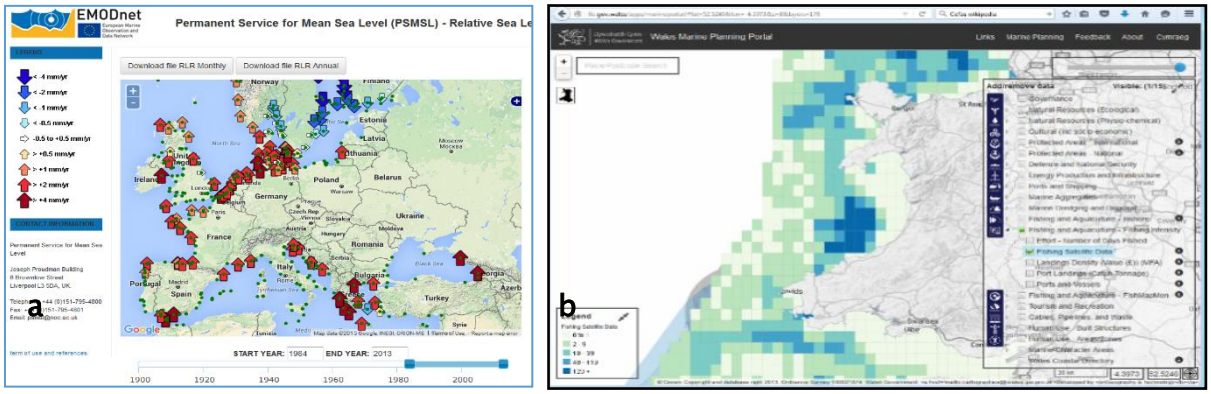

Figure 5: Good (a) and Bad (b) examples of data and information delivery through existing web portals. The first EMODNET shows sea level rise with colour coded symbols, the red and blue arrows provide a strong visual clue conveying the undesirability of sea level rise, there is a clear legend and units. The second a Welsh government data portal shows fishing pressure but no units are given rendering the data layer virtually meaningless.

(EMODNET) provides a good example here the red and blue arrows provide a strong visual clue as to the undesirability of sea level rise while also conveying objectively modelled data. Similarly there are now many different visual styles for background maps which can be used to influence the user (see appendix III).

4 Consider functionality:

What does the AQUACROSS data portal need to do? Many portals above are loaded with sophisticated search features and analytical tools to interrogate data. With the vast amount of data available and a range of analytical and search tools to select from some portal developers have opted for sophisticated tools over ease of use. As a general rule, if a particular function is not essential it should not be included.

5 Who are the stakeholders?

Outputs of the AQUACROSS project may be relevant to stakeholders of many types, bringing together environmental Non-Governmental Organisations, National governments, local government, sectoral interests and the general public. Not all of these groups have the same interest in a geospatial data. For example from the perspective of national government MSFD is being implemented through a process which combines information from many data sources and reports them directly to the EU, a data portal is at best ancillary to this process, at worst it is irrelevant. By contrast a recreational user of the sea may be interested in a geospatial portal but their interest may include information relevant to but not directly gathered under the MSFD (for example bathing water quality is a pressure to be considered under the directive but not a descriptor to be reported). The specific aspects to be included in the AQUACROSS data platform portal should be assessed based on experiences in the project judgement should be made on whether the role of the portal is in promoting the less well understood, or less popular aspects or whether the portal should target the more popular descriptors and sectors.

6 What is the Legacy of the portal?

Like any other web based media, geospatial portals have a shelf life. For web portals this often corresponds to the duration of a project, beyond which funding is no longer available to update or maintain the site. In order to maximize the legacy value of the site it is important to consider which data sources are likely to remain in the same location and continue to be maintained? To this end, should the portal point to external resources such as web map services where possible it is necessary to consider the potential longevity of the link which may be higher in the case of institutional repositories such as EEA and JRC and be lower in project related websites such as EMODnet.

7 What data should be included?

The data to be included in the portal will depend on the considerations and questions above stakeholders.

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5.3 Annex III

Policy Data workshop- summary of results

List of participants

Name	*Insitution*	*Abbreviation*
Tim O'Higgins	UCC	TOH
Dick Schaap	EMODNET	DS
David March	CSIC	DM
Juan Arevalo	UNESCO-IOC	JA
Declan Dunne	UCC	DD
Javier Martínez-López	BC3	JL

In preparation for the data policy workshop, a terms of reference document was drawn up with input from AQUACROSS Work Packages two and six. The main objectives of the data policy workshop as stated in the terms of reference document were:

- To identify information gaps in list of data policy repositories.
- Gather project relevant feedback on priorities and perceived weaknesses in integration of existing data infrastructure.
- Identify potential solutions and determine barriers to policy data interoperability and INSPIRE compliance.
- To assess the major operational barriers to use of existing databases for the purposes of Ecosystem Based Management.
- To determine which operational features can best enhance the utility, visibility and communications potential of existing datasets.

In the general plenary session all participants of the workshop were introduced to the general frame of the workshop and the objectives were divided into two distinct categories following the pyramid of user data needs (Figure 1). The morning session (1) dealt with objectives 1, 2 and 3 pertaining to the bottom two segments of the pillar and the afternoon session (2) dealt with the final two objectives pertaining to the upper two segments of the pyramid.

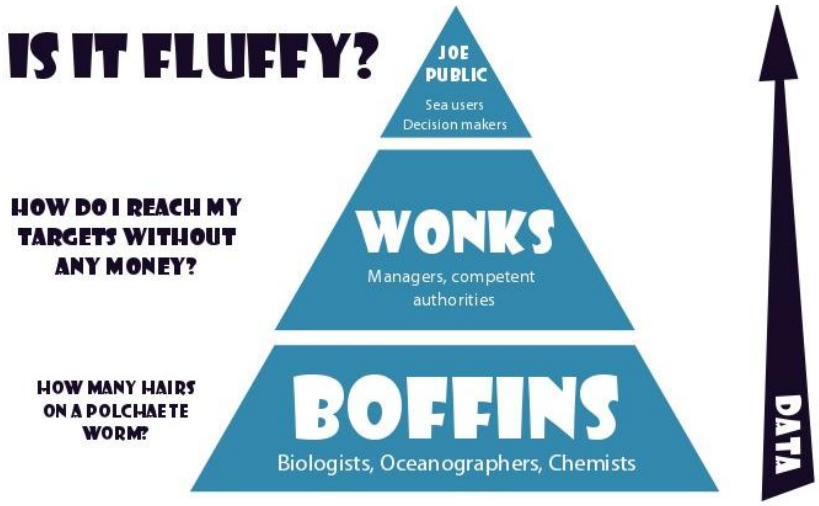

Figure 1: Information and data requirements for different types of users.

At the outset of the meeting it was noted that the expertise of the panel was predominantly marine with the exception of JL as a result the outputs of the meeting have a marine focus but also shed some light on the general issues surrounding policy data integration and application.

Session 1

The consensus was that data gaps do exist in relevant policy data infrastructures and that these were often due to the interplay between regional, national and European institutions. For the Habitats directive there was consensus that the EIONET data portal holds a subset

only of habitats data and that many more data are held at the national regional and local levels. The data in EIONET depend both on reporting obligations and national budgets. DS gave an example for the Netherlands where the national government have 60 marine monitoring stations, 12 of which are used for OSPAR monitoring. Resource constraints have led to discussions over whether to include just six of these for MSFD reporting.

Obtaining non-statutory reporting data from EU member states at the centralised level can prove challenging. For example during the first phases of the MSFD, the European Environment Agency (EEA) requested all available marine data from member states, but member states were reluctant to comply with this request. In marine cases the existing structures of regional seas conventions now act as an intermediary between member states and the European commission.

One source of data which is vitally important to biodiversity conservation in the marine context is Vessel Monitoring System (VMS) data. While all fishing vessels over 15m are obliged to collect and report this information, issues of commercial sensitivity mean that obtaining these data generally depend on having appropriate national contacts. There has been a recent DG mare tender for development of a portal for viewing VMS data.

Similarly for the Common Agricultural Policy, while CORINE land cover provides a source of data on general land use typologies, information about individual farmsteads, boundaries and associated agricultural regimes are not to be found uniformly in geo-spatial formats. While it may be the case that some member's states hold such information for other states, these data may be in hard copy in various local or regional planning or management departments. Therefore a fully detailed picture of the pressures affecting aquatic biodiversity in the terrestrial realm must rely on more generalised data.

For marine habitat data EASIN (the EEA habitats portal) was compared with EUROBIS the UN data source on biogeographic information. The EUROBIS system was considered more accessible due to the ability to query with various open source R libraries.

There was also consensus within the meeting that for some marine environmental pressures, including litter as well as energy and noise that insufficient data were available at a level of spatial aggregation and that gathering these data remains a scientific challenge (but not currently one of data management).

There was insufficient expertise within the room to assess whether the WISE database (for use with the Water Framework Directive) was sufficient for its purpose. The participants did note that when the idea of a WISE Marine system was raised for use with the MSFD, the idea was not supported by member states.

One major point relevant to information gaps is data quality. For reporting obligations under regional seas commissions and Directives, the legal status of the data (an potential ramifications of non-compliance) result in tighter data quality control than data which are gathered as part of scientific research. In general for many marine systems, data gaps may not be a problem but data reliability may be an issue.

The group agreed that the products produced by WP6 should complement the existing substantial spatial data infrastructure and that novel components could be incorporated into existing SDI. DS indicated that any novel ideas or code which could add value to the EMODNET infrastructure would be readily incorporated. DS advised against re-inventing the wheel he spoke of his 30 years of experience in the collation and management of data for the marine and suggested that in the interests of economy and efficiency the AQUACROSS WP6 team should try to identify specific tools or components that can add value to existing Spatial Data Infrastructure.

Compliance with the INPIRE directive is an on-going process. With respect to EMODNET there is an ongoing initiative, the EMODNET team have worked with the JRC to try to make EMODNET INSPRIE compliant. Until recently metadata have been an obstacle to compliance but this problem has now largely been solved. The next major problem is the choice of appropriate data models. It was agreed that this would remain an ongoing challenge for the spatial data community and that AQUACROSS could contribute by following current best practices. In terms of interoperability between portals it was agreed that common vocabularies were the most important aspect.

Session 2

The afternoon session focussed on the use of data portals for ecosystem based management and on ensuring maximum impact form web based data platforms. Major operational barriers to current web based tools to support ecosystem based management includes.

One major barrier to uptake was considered to be usability. The development of very user friendly products (for example Google Earth and Google maps) requires a high level of financial resourcing which is not available to environmental research projects.

Continuity of service was also seen to be a major issue. Since EBM platforms are often funded by research projects with a finite duration these tools are generally delivered and then remain static. This problem could be avoided if a centralised European service was available to host these types of tools. Alternatively if EBM tools generate as part of projects have the potential for commercialisation there is more potential to develop the life of the tool and the uptake of the products. One example of this is SeaDataNet which has different services some of which require payments. One idea for a potentially useful output from AQUACROSS was a potential integration of AIRES with CKAN.

The final objective of the workshop was determine which operational features of the AQUACROSS portal could most enhance visibility of the project. Many aspects of web cartography were discussed in the meeting but, effective visual communication are not automatable, it was agreed that developing a narrative for specific case studies potentially using story-mapping and using specific subsets of the most relevant data might be a useful means to enhance visibility.

Following the discussions the main finding were reported back to the larger AQUACROSS group for feedback.

ANNEX 1- Provisional list of relevant policies directives and regulations including data repositories and data holders gathered as part of contribution to AQUACORSS D2.1 "Synergies and differences between biodiversity, nature, water and marine environment EU policies: lessons learnt for coordinated implementation"

Policy/Directive/Regulation	Information Platform	Organisation
Habitats Directive	EIONET	ETC Bio
Birds Directive	EIONET	ETC Bio
Regulation on Alien Invasive Species	EASIN	JRC
Convention on Biodiversity	Cbd.int	UNEP
Water Framework Directive	WISE	EEA
Floods Directive	EIONET	ETC/IC
Drinking Water Directive	EIONET	EEA-WOSE
Bathing Water Directive		JRC
Urban Waste Water Treatment Directive		Eurostat/JRC
Nitrates Directive		
Water Storeage and Drought Directive		ETC/ICM
Marine Spatial Planning Directive		EUMOFA
Marine Strategy Framework Directive		
Common Fisheries Policy		
Integrated Coastal Zone Management		
Common Agricultural Policy		
Sustainable Use of Pesticides		
Waste Framework		

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