Deliverable 6.1 (D6.1)

Report on stakeholder engagement for integrated biodiversity information

M46

Project acronym: EU BON

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Co-ordinator: MfN, Museum für Naturkunde - Leibniz Institute for Research on Evolution and Biodiversity, Germany

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PU	Public	Yes
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Executive Summary

The EU BON project aims to *Build the European Biodiversity Observation Network*, and is the European contribution to the Group on Earth Observation Biodiversity Observation Network (GEO BON). This present deliverable (D6.1) fits under EU BON Work Package (WP) 6 "*Stakeholder engagement and science-policy dialogue*", and provides an overview of the outputs resulting from three WP6 Tasks. The objectives of this deliverable were to (1) *review policy requirements for biodiversity data at European and national levels*, (2) *carry out regular engagement with relevant political authorities and other stakeholders at European and national levels in support of EU BON delivery*, and (3) *build up stakeholder dialogue with sector-specific user communities*. These objectives have been met via a cross-WP collaborative approach and extensive external (to the project) engagement via e.g. stakeholder roundtables and interviews. Besides a total of seven peer reviewed articles, WP6 participants have met the high expectations placed upon them in terms of integrating EU BON's work across a total of eight WPs. In particular, work described in this deliverable has led to an understanding, and then translation, of EU BON's intended outputs in meaningful language/formats suited to a broad range of end-users, from the policy and conservation spheres, but also decision-makers more broadly. This has meant experimenting with non-traditional ways of packaging and promoting scientific outputs, e.g. the use of infographics being one example. A high-level narrative description of the work carried out is followed by a total of 13 annexes providing full details of the various outputs.

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List of acronyms

CBD	Convention on Biological Diversity
CMS	Convention on Migratory Species
CNRS	Centre National de Recherche Scientifique
CSIC	Agencia Estatal Consejo Superior de Investigaciones Científicas
EBV	Essential Biodiversity Variables
EC	European Commission
ECSA	European Citizen Science Association
EEA	European Environmental Agency
EPAD	European Public Affairs Directory
EU	European Union
EU BON	European Biodiversity Observation Network
EuMon	EU-wide Monitoring methods and systems of surveillance for species and habitats of community interest
FEM	Fondazione Edmund Mach
FIN	Fishbase Information and Research Group Inc.
GBO	Global Biodiversity Outlook
GEO BON	Group on Earth Observations Biodiversity Observation Network
GBIF	Global Biodiversity Information Facility
IEEP	Institute for European Environmental Policy
IMCC	International Marine Conservation Congress
IPBES	Intergovernmental Platform on Biodiversity & Ecosystem Services
LTER	Long Term Ecological Research Network
M40	Month 40 (March 2016)
M46	Month 46 (September 2016)
M50	Month 50 (January 2017)
MRAC	Musée Royal de l’Afrique Centrale
MSFD	Marine Strategy Framework Directive
MfN	Museum für Naturkunde
REDIAM	Red de Información Ambiental de Andalucía
RIO	Research Ideas and Outcomes journal
SDM	Species Distribution Modelling
SGN	Senckenberg Gesellschaft für Naturforschung
SMEs	Small and Medium sized Enterprises
UCAM	University of Cambridge
UEF	(Ita-Suomen Yliopisto)
UFZ	Helmholtz-Zentrum für Umweltforschung GMBH
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
WCMC	World Conservation Monitoring Centre
WFD	Water Framework Directive
WOA	World Oceans Assessments
WP	Work Package

Introduction

This deliverable fits under EU BON Work Package (WP) 6 "*Stakeholder engagement and science-policy dialogue*", led by the World Conservation Monitoring Centre (WCMC). This deliverable provides an overview of the outputs resulting from three WP6 Tasks:

- Task 6.1 "*Review policy and stakeholder requirements for biodiversity data"* (led by WCMC),
- Task 6.2 "*EU BON stakeholder roundtable"* (led by MfN), and
- Task 6.4 "*Sector specific stakeholder engagement with user communities*" (led by IEEP).

Much of the work presented here is, however, also directly relevant to WP7 ("*Implementation of GEO BON: strategies and solutions at European and global levels*") and indeed many, if not most, outputs were produced jointly with WP7. Finally, due to WP6's integrative role in EU BON, a number of outputs is of relevance to other EU BON WPs, and was produced jointly with these, as reflected in the list of contributors to this deliverable.

Progress towards objectives

The objectives of this deliverable were to

1. review policy requirements for biodiversity data at European and national levels,
2. carry out regular engagement with relevant political authorities and other stakeholders at European and national levels in support of EU BON delivery, and
3. build up stakeholder dialogue with sector-specific user communities.

Based on the work carried out to date, and as demonstrated by the outputs presented in this document, the objectives of this deliverable have been met. The deliverable is structured as follows:

- task-specific outputs are presented for Tasks 6.1, 6.2 and 6.4, in this order; and
- additional information, and/or copies of self-standing outputs such as reports, scientific articles or other output types are provided in the annexes (13 in total).

Achievements

Funded under the European Commission's 7th Framework Programme, EU BON is a *research* project and, indeed, WP6 can be linked to a total of six peer-reviewed published articles (plus one recently accepted); the large majority of these articles was produced in collaboration with other EU BON WPs.

There were high expectations placed on WP6 in terms of integrating EU BON's work across WPs; this integration has been achieved. The EU BON consortium has clear technical strengths in biodiversity data *collection*, *management*, *collation*, *documentation*, *standardisation*, *licensing*, *analysis*, *modelling*, *publication*, *sharing*, and much more. Although a number of WP6 partners also belonged to WPs related to these very technical and specialised activities, many others understood better (or belonged to) the sphere of users of biodiversity *information* and *knowledge*, rather than that of users of (raw) *data*. This "barrier" was brought down via extensive cross-WP consultation and engagement as part of project meetings, stakeholder roundtables, workshops, conferences and team meetings, leading to a mutual understanding of the two groups.

Delaying the delivery of this document by 6 months helped significantly in this regard, by providing more consultation time. This has allowed WP6 to better understand, and then translate EU BON's intended outputs in meaningful language/formats suited to a broad range of end-users, from the policy and conservation spheres, but also decision-makers more broadly. This has meant experimenting with non-traditional ways of packaging and promoting scientific outputs, e.g. the use of infographics being one in particular. Visualisations and decision-support tools are another very effective way to convey a data-based message to a non-technical audience, and this work will be presented in deliverable D6.3 *Biodiversity visualisation and public interface software operational* (due M50).

Future developments

At the time of writing, WP6 and collaborators are capitalising on the extensive cross-WP consultation and engagement discussed above. This is taking the form of a number of joint outputs (e.g. infographics, workshop/roundtable reports, manuscripts), which are being prepared for delivery before the end of the funded phase (May 2017). Further details on this on-going work are provided in relevant sections below.

Review policy and stakeholder requirements for biodiversity data (Task 6.1)

During this Task, a review of existing and emerging policy requirements for biodiversity data was conducted, to ensure policy relevance of EU BON's outputs. This was carried out by:

1. examining the outputs of previous European projects,
2. reviewing reporting requirements for a number of biodiversity-related instruments, and
3. engaging with policy-makers at various scales (national, European and global).

Beyond the policy sphere, a range of other decision-makers and data users was identified, along with their biodiversity data needs. The results of this Task are presented underneath in the form of a narrative summary, supported by a collection of annexes that provide further information.

Policy requirements for biodiversity data

There are many and diverse requirements by policies for biodiversity data on status and trends of species and habitats. Wetzel et al. (2015) (**Annex 1**) produced an Euro-centric overview of the biodiversity policy landscape (**Figure 1**), which is particularly complex as national governments can be parties to a number of regional instruments (e.g. European Union Directives, Regional Seas Conventions), and global ones (e.g. Convention on Biological Diversity CBD, Convention on Migratory Species CMS). Countries are also committed to take part in global processes such as the Intergovernmental Platform on Biodiversity & Ecosystem Services (IPBES) or the World Oceans Assessments (WOA). In this context, an European Biodiversity Observation Network has an essential role in bringing down barriers that prevent existing data from being *discoverable*, *accessible* and *digestible*, and hence used to support the needs of the biodiversity policy sphere; for example the tracking of progress against biodiversity targets.

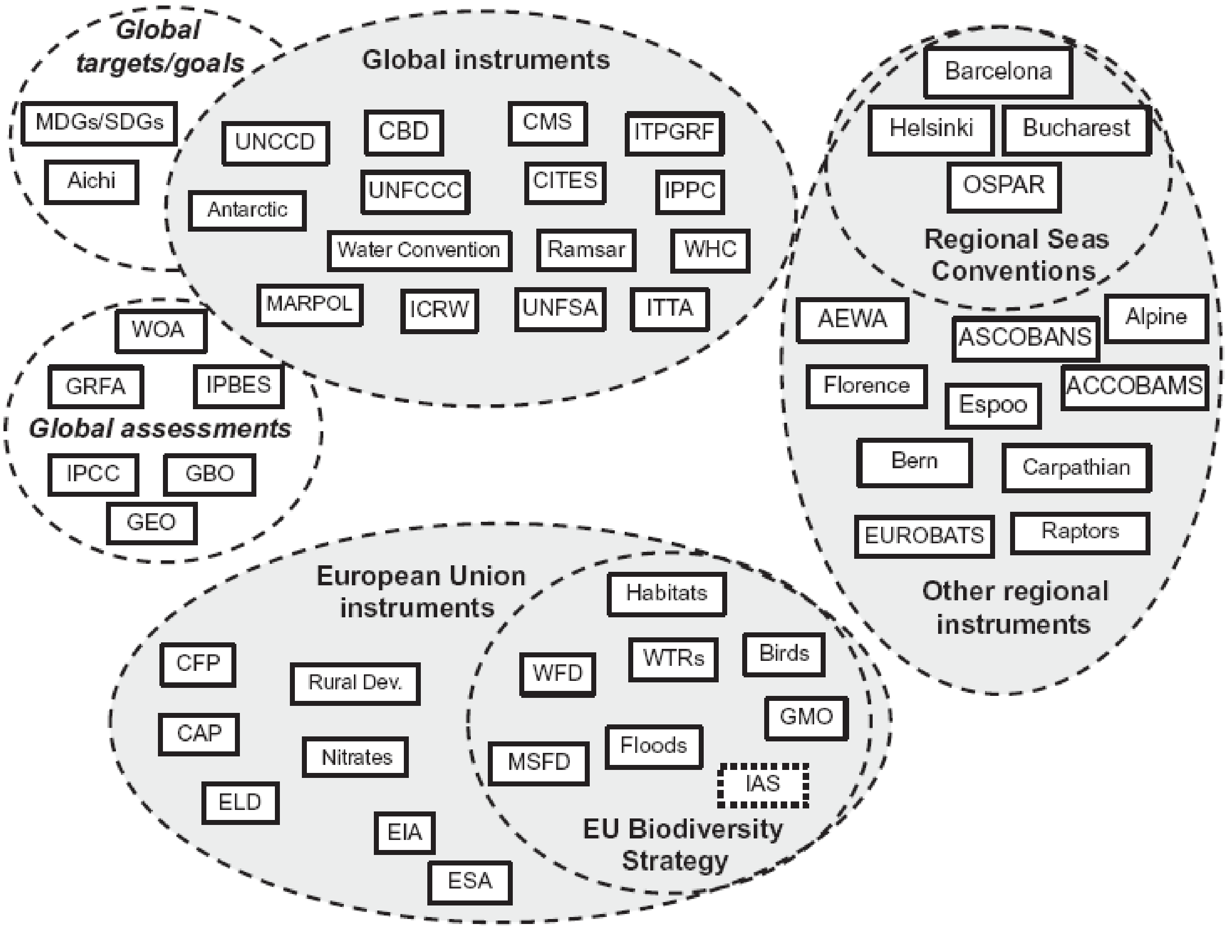


Figure 1. Euro-centric overview of the biodiversity policy landscape (Wetzel et al., 2015) (**Annex 1**).

To better understand policy-level data needs, Geijzendorffer et al. (2015) (**Annex 2**) examined in detail the reporting requirements for seven European and global policy instruments: CBD, Ramsar, CMS, the Nature Directives (Birds and Habitats), the Marine Strategy Framework Directive (MSFD), and the Water Framework Directive (WFD). The authors found that taking an ‘Essential Biodiversity Variables’ (EBV) (Pereira et al., 2013) approach is useful to bridge the gap between biodiversity data and policy reporting needs, with EBVs playing an “adaptor” role between the two. However, and so as to clarify the relationship between EBVs and indicators of biodiversity change, Brummitt et al. (in press, **Annex 3**) explained this relationship with a stock market analogy (**Figure 2**).

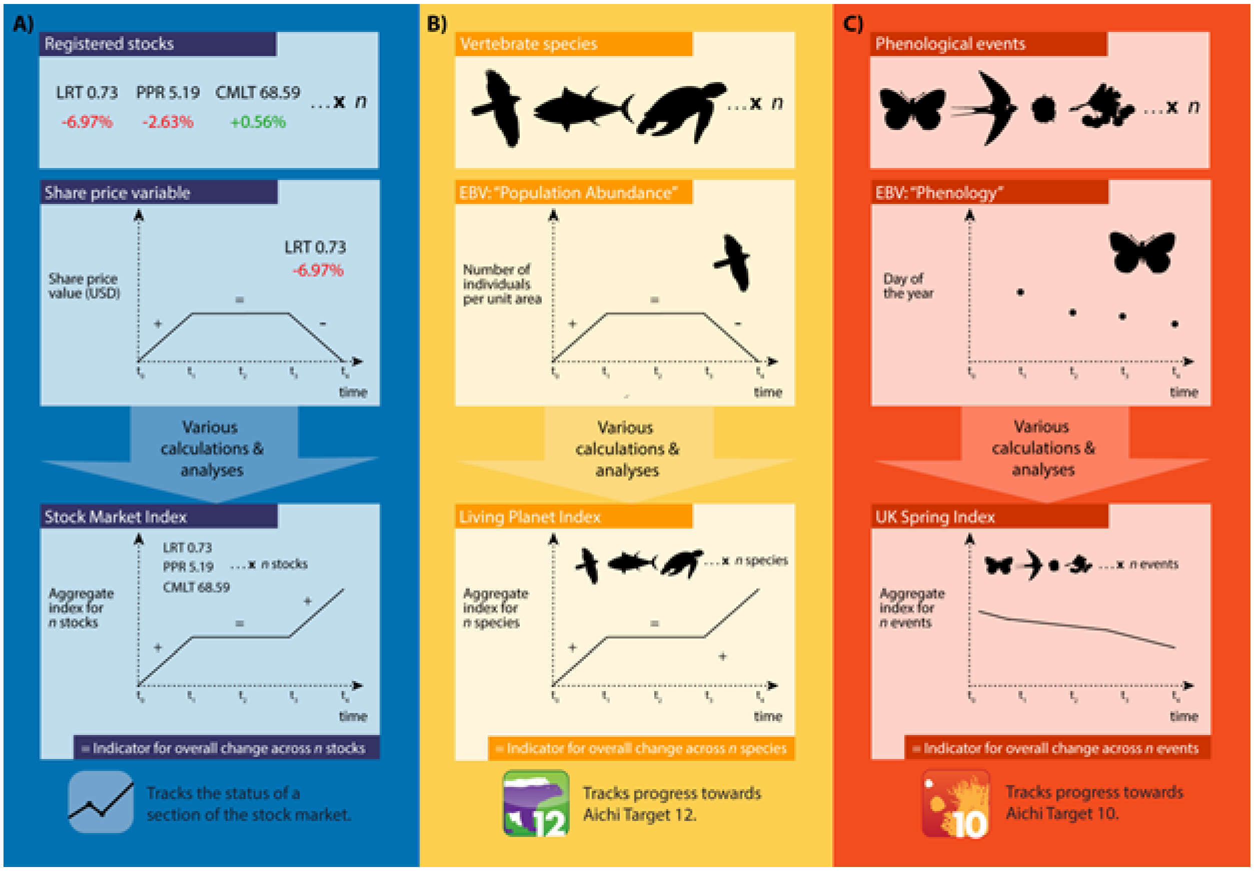
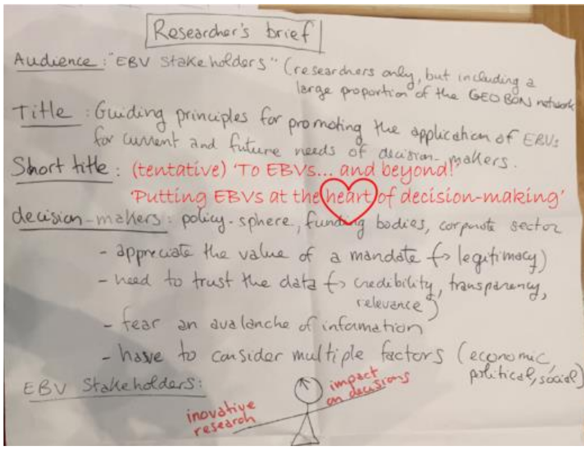


Figure 2. Hypothetical scenarios to reflect analogy between (A) the Stock Market Index, (B) the Living Planet Index, or LPI, and (C) the UK Phenology Network's UK Spring Index (Brummitt et al., in press, **Annex 3**).

Whilst EBVs appear to be a promising framework for looking at biodiversity change, policy-makers and other decision-makers may find it a difficult framework to use in practice. As part of a joint EKLIPSE and EU BON workshop ("*Identifying joint pathways to address the challenges of 'biodiversity data provision' and 'decision-making*"), a "Researcher's brief" was drafted, aimed at scientists and researchers, notably those of GEO BON[1] who work on EBVs. The brief provides guiding principles for promoting the application of EBVs for current and future needs of decision-makers (**Annex 4**). A tentative list of 'what to do', and 'what not to do' is shown in **Figure 3**, and a manuscript is in preparation.

[1] Group on Earth Observation Biodiversity Observation Network, http://geobon.org/



Do do	Don't do
Speak with a **common voice** (to non-specialists) (*no in-fighting please*)	Put an EBV "skin" on everything you do
Clearly **define** what is an EBV and how it relates to indicators	Create too many EBVs (*no longer 'essential', see ECVs example*)
Engage beyond the research world, seek **mandate**, be **inclusive** (language, gender, origin, capacity)	Work in isolation without standards
Be **realistic** for what can be done now and later	Reduce EBVs to 'building blocks of indicators'
Define criteria for good EBVs	
Use EBVs as a clearing house	
Convey the limitations of EBVs and their data in a way that is **understandable** by non-specialists	
Clarify what **impact** EBVs should have	
Be salient, **credible**, legitimate, **iterative**	

Figure 3. "Researcher's brief" produced during the joint EKLIPSE and EU BON workshop (GEO BON Open Science Conference and All Hands Meeting, Leipzig, Germany, 04-08 July 2016). See **Annex 4** for details.

Catering for "other" users of biodiversity data

There were relatively high expectations placed on WP6 by the EU BON partners, and the project's Advisory Board, in terms of WP6 providing integration and direction to EU BON's work, specifically in relation to what the policy sphere was expecting the project to deliver. In short, WP6 partners were often asked what the policy sphere, and hence policy-makers, "wanted" from EU BON, and how the project outputs they were preparing could be made more relevant to policy-level end-users. In collaboration with WP7, WP6 liaised extensively with other WPs, to better understand the work they were doing and, above all, to help them express in non-specialist language what question their "product" was aiming to help answer, and who could use the product and/or the results of its use.

One such engagement, which represented a significant milestone for the EU BON project, was the cross-WP workshop held in Cambridge in November 2015, and entitled "*Packaging EU BON's outputs into solutions for decision-makers*" (see full report in **Annex 5**). During the workshop, there was a realisation that whilst a number of EU BON products is indeed relevant to policy-level end-users, many more are actually relevant to other users of biodiversity data, in particular specialised users such as scientists and researchers, but also conservation/environmental managers, citizen-scientists, spatial planners, data managers/curators/creators, and the wider public. Who the direct user is of a given product is closely linked to the level of technical input/processing needed to produce a result. Whilst a scientist may be able to use e.g. a R package, a conservation manager is more likely to prefer using a Web-based decision-support tool that requires limited technical skills. The workshop successfully led to an improved vision of how to 'market' EU BON's products for end-users, and to an improved understanding of the end-users and the barriers they face in accessing, and using, biodiversity data and tools.

It was during this workshop that a first list of EU BON products was drafted (**Annex 6**). Products (30+ at the time of writing) are categorised as follows:

- Data analysis (e.g. R package for Species Distribution Modelling),
- Decision-support (i.e. tackling a specific question, database providing digested information/metadata),
- Data management/collection (e.g. for handling, curating, accessing, publishing, managing, sharing, training).

The list has already been shared externally, for instance with the European Environmental Agency (EEA), and is in the process of being transferred to the European Biodiversity Portal[2] where it will continue to be updated as new products are released.

[2] At the time of writing, this can be found at: http://beta.eubon.ebd.csic.es/products.

For a number of products, 19 factsheets (**Annex 7**) provide further detail about the products, using a high-level non-technical language. This approach has generated interest from the Oppla platform[3], a new virtual hub where the latest thinking on nature-based solutions is brought together from across Europe. It is likely that a selection of EU BON products will be submitted for listing on this platform, further increasing the reach of EU BON's work to new audiences.

Communicating the value of EU BON products to potential end-users

Beyond the product list and associated factsheets, show-cases (i.e. demonstrations) of "what a particular product, or group of products, can do" can be helpful to communicate its/their value to potential end-users. Infographics are being used in EU BON for this purpose, beginning with one published in the "green week" issue of *The Parliament Magazine* (Weatherdon, 2015; **Figure 4**; **Annex 8**), aiming to answer a clear question of policy relevance. This infographic is based on an online decision-support tool[4] that uses the AquaMaps database[5]: it shows how fish community composition in the North Sea may change as a result of climate change, highlighting how many species would be gained and/or lost. The issue containing the infographic was distributed to over 4,000 delegates in attendance. Furthermore, as the magazine for the European Parliament and European Commission, this issue was also distributed to members of these institutions, the Presidency Office, party political groups and various other EU institutions. Additionally, a digital version of the magazine was distributed to over 50,000 contacts globally, including journalists, the public affairs contacts from EPAD (European Public Affairs Directory), bulletin subscribers, from EU officials/Commission staff to public affairs consultants. Two related infographics are in the planning for the Baltic and Mediterranean Seas, as well as updating the North Sea one with the most up to date AquaMaps data.

[3] http://oppla.eu
[4] http://www.aquamaps.org/eubon/home.php
[5] http://www.aquamaps.org

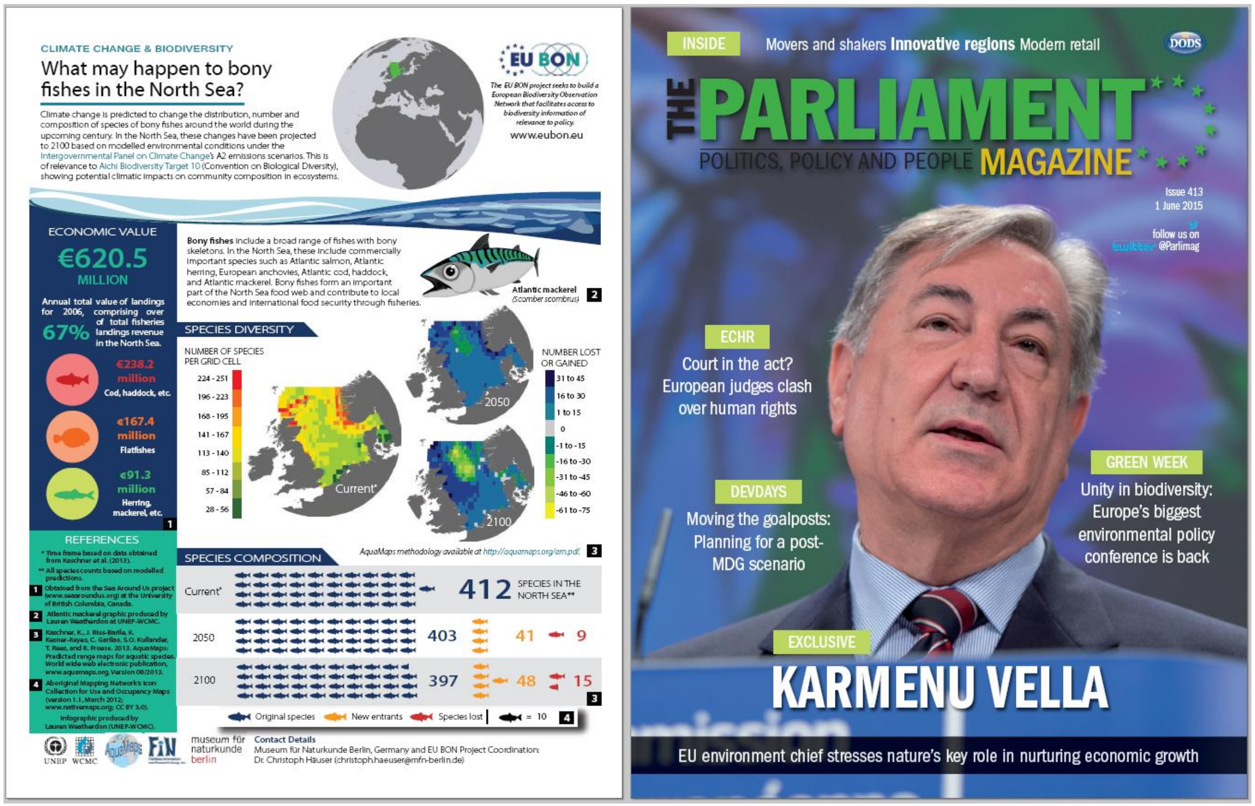


Figure 4. Infographic on the possible impacts of climate change on community composition of bony fishes in the North Sea, which was published in the 'Green Week' issue of The Parliament Magazine (Weatherdon, 2015) (**Annex 8**).

Other infographics, to be published in EU BON's "RIO collection"[6], are in the planning, notably in relation to explaining the value of Species Distribution Modelling (SDM) to policy and decision-makers, including those in the policy sphere. SDM happen to be a scientific strength of the EU BON consortium, particularly in WP3 and 4, and more needs to be done to communicate the value of this work to decision-makers. The SDM infographic will aim to communicate how SDM work, their applications, and will showcase an EU BON example. The final output will include a dissemination strategy to ensure the value of the SDM approach in conservation decision-making is communicated widely to relevant target audiences. The reach of the infographic will be monitored e.g. through download statistics.

Another infographic in planning aims to explain EU BON's contribution to a global biodiversity policy process, specifically EU BON's work towards achieving Aichi Biodiversity Target 19[7]. The infographic (**Figure 5** below) illustrates how biodiversity data flow from collection to a global biodiversity assessment, and highlights the data work done across EU BON work packages.

[6] Research Ideas and Outcomes, http://riojournal.com/browse_user_collection_documents.php?collection_id=2&journal_id=17.

[7] Aichi Target 19: *By 2020, knowledge, the science base and technologies relating to biodiversity, its values, functioning, status and trends, and the consequences of its loss, are improved, widely shared and transferred, and applied*. https://www.cbd.int/sp/targets/rationale/target-19/

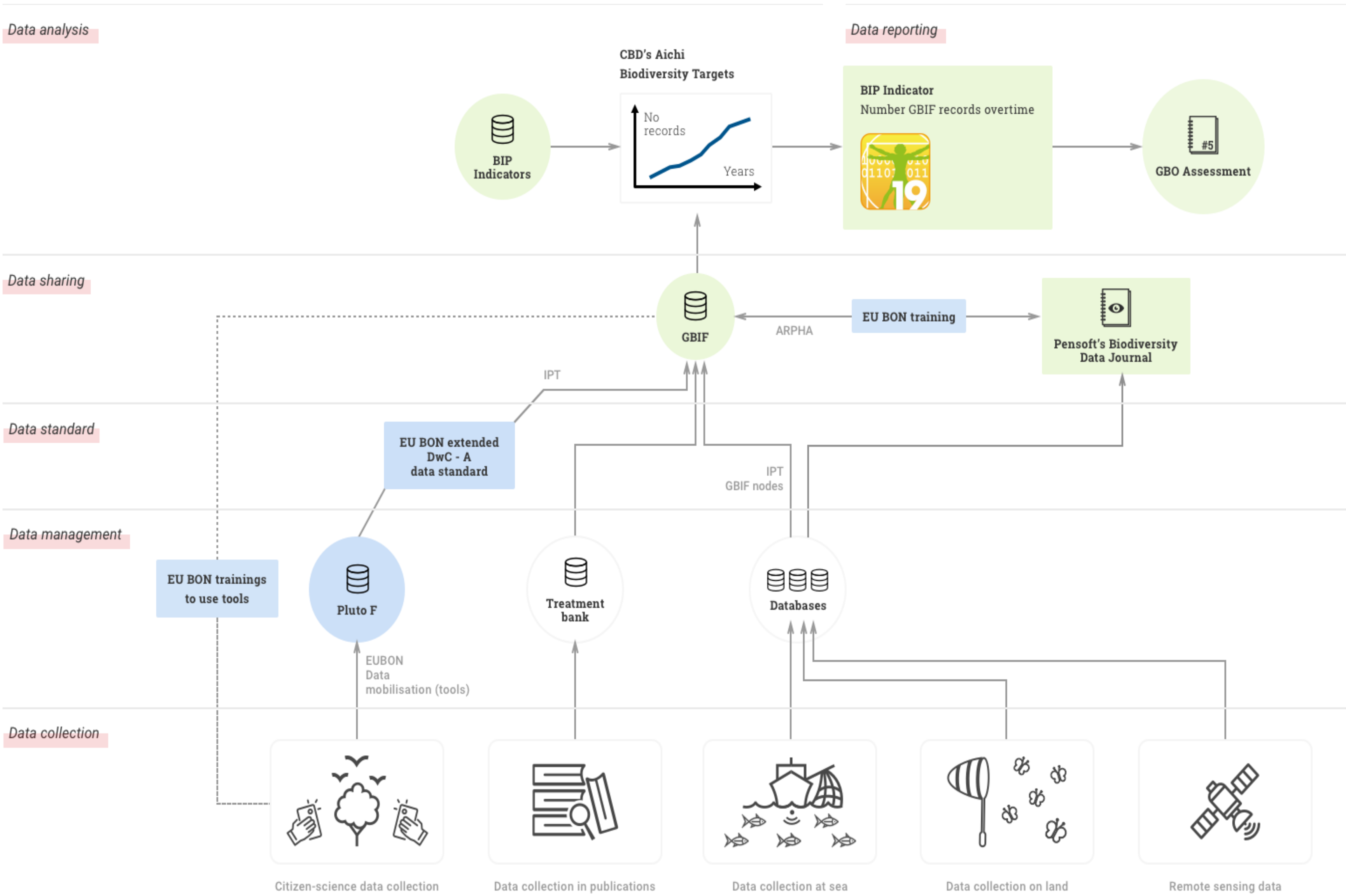


Figure 5. Draft version of a cross-WP infographic tentatively entitled "EU BON's contribution to Aichi Target 19 via the Global Biodiversity Information Facility (GBIF)".

Other infographics may also be produced before the end of the project, including an infographic that would complement a manuscript led by the Senckenberg Institute, titled "*How many barriers are too many for freshwater fish?*" The manuscript demonstrates optimal locations for removing barriers that affect the movement of threatened species, helping to (a) identify which species are negatively affected, (b) which segments of the river network are most detrimentally affected by barriers, and (c) a precise number of barriers that should be removed to improve habitat suitability.

With regards to the added value of EU BON to regional biodiversity networks, a pilot case is being carried out together with the Regional Environmental Information Network of Andalusia (REDIAM, Spain). By means of the tools developed by EU BON, further exploitation of the regional information existing on land uses and the *Quercus rotundifolia* and *Quercus suber* (oak) species is made in order to provide a useful product for managers and the general public, and to strengthen understanding of the existing information. Potential products that are envisaged by the use-case include (a) support in the evaluation of pressures of the mentioned species, and (b) assessment of the conservation status of the forest, including the possibility to visually assess compliance to the Habitats Directive.

Finally, a manuscript titled "Mobilising marine biodiversity data and information to support decision-making," is currently in preparation, focusing on case studies that illustrate the enabling and inhibiting factors that influence the use of data collated in marine biodiversity databases towards marine policy implementation. Drawing from these findings, the authors will highlight approaches that could be used to better meet the needs of decision-makers, and to thereby inform conservation-based policies and support efforts to meet international and national conservation targets. A preliminary version of the manuscript was presented as a poster at an international conference (see **Annex 9**). The manuscript will be reviewed for publication in an upcoming special issue of *Frontiers in Marine Science*.

EU BON stakeholder roundtable (Task 6.2)

The EU BON roundtables aim to strengthen stakeholder engagement and exchange ideas with key institutions and organizations during the course of the project. The main purpose of these roundtables is to carry out regular engagement with relevant political authorities and other stakeholders at European and national level, in support of the delivery of the EU BON project.

Relevant political authorities from the field of European policy and agencies have been, for example, the European Commission (based in Brussels), the European Environment Agency (based in Copenhagen) and the Joint Research Center (based in Ispra). The roundtables have sought to build up a stakeholder dialogue with exemplar sector-specific user communities, such as members of citizen science projects and researchers from field sites and regional biodiversity networks. The work of the EU BON roundtables has also focused on improving the European science-policy interface, e.g. by supporting international policy-relevant processes and intergovernmental organizations, such as IPBES or the CBD, by providing expertise and knowledge to such intergovernmental political processes.

Task 6.2 includes the planning, organisation and facilitation of a total of four stakeholder roundtables, addressing different communities and exchanging views and ideas with the invited partners in order to improve existing approaches and EU BON products. To date, three roundtables have taken place, and a fourth one is planned for November 2016 (see **Table 1**). The exchanges with user communities have helped to further develop products such as tools and models, update existing data and information, and refine existing biodiversity data workflows (e.g. from collecting data in the field to the processing and analysis the data).

Stakeholder roundtables are also an important feedback and quality control mechanism for the project as a whole. It has provided opportunities for adaptive management to tackle unforeseen requirements and shifting priorities (the project proposal was indeed written a while back).

Table 1. Overview of the EU BON stakeholder roundtables.

Year	Title	Main stakeholder targeted	Host and location	Full details
2013	Biodiversity and Requirements for Policy	European policy (Commission, agencies, researchers), International Networks (Group on Earth Observations), EU funded projects with linkage to biodiversity data.	Leibniz Association, Brussels, Belgium	Vohland et al. 2016a, see **Annex 10**
2014	How can EU BON support citizen science?	Citizen Science projects, citizen science networks such as the European Citizen Science Association (ECSA), researchers and biodiversity networks.	Museum für Naturkunde, Berlin, Germany	Vohland et al. 2016b, see **Annex 11**
2015	Workflow from data mobilization to practice	European, national and regional networks (biodiversity data, Group on Earth Observations, ecological research), researchers from the field / sites, EU BON test site partners, political administration	University of Granada, Granada, Spain	Wetzel et al. 2016, see **Annex 12**
Planned for 2016	Pathways to sustainability for EU BON's network of collaborators and technical infrastructure *(to be held in November 2016)*	European funded projects, networks (LTER-Europe, ECOPOTENTIAL, EKLIPSE, OPPLA), "European customers" (EC, EEA), and global initiatives (GEO BON, UNEP, LifeWatch).	Museum für Naturkunde, Berlin, Germany	

To date, the roundtables stimulated a lot of discussions from which important recommendations were drafted, for future and current approaches of biodiversity observation networks and the provision of knowledge for environmental and conservation policy. Here, we provide key findings as outcomes of the discussions, task and interactive world cafe sessions.

The main outcomes and results from the *first stakeholder roundtable* (**Figure 6**) include the following aspects and points:

- The discussion at the roundtable highlighted that what biodiversity policy needs are indicators and measurements to answer burning policy questions. A crucial contribution of the EU BON consortium would be the work on Essential Biodiversity Variables to develop a framework for policy reporting and structuring of biodiversity data. This task was followed for example in the paper of Geijzendorffer and colleagues (2015; **Annex 2**).
- A key challenge of the future will be to develop sustainable solutions for the integration of biodiversity and earth observation data, also including metadata and data from EU projects and initiatives.
- Another important discussion was around how public stakeholders could be involved in the EU BON project, e.g. citizen scientists in order to provide useful information for scientists and researchers. This engagement was perceived to be an important part of the European Citizen Science Gateway and it was decided to organize the second roundtable with partners from the field of citizen science.

- To formalize the relationships with other key biodiversity projects, it was decided that a template for a Memorandum of Understanding should be drafted to establish a network of EU BON associates to foster ongoing exchange with other biodiversity projects and political stakeholders.

Figure 6. Participants from science, policy and international networks at the EU BON stakeholder roundtable in Brussels (credit: EU office of the Leibniz Association).

The *second stakeholder roundtable* (**Figure 7**) targeted citizen scientists and related networks, some of the key recommendations that were drafted are summarised below:

- The discussions and breakout groups generated momentum for the development of the EU BON portal and citizen science gateway, in order to foster data mobilization from different communities, and to connect with an important partner, the European Citizen Science Association (ECSA).
- Key success factors for citizen science and species occurrence data in Europe were discussed. There are many key success factors for citizen science initiatives (e.g. effective user interfaces, rich user services, open and licensed data, reporting, and quality control).
- Citizen Science is important for biodiversity data collection, for example the EuMon project documented 395 monitoring schemes, overall it was recorded that more than 46,000 citizen scientists devote over 148,000 person-days/year to biodiversity monitoring activities.
- Valuable input was given, such as the need to provide incentives for citizen scientists, the need to make data citable and traceable by Digital Query Identifiers (DOI), and the provision of visualization opportunities for the development of the EU BON biodiversity portal.

In complement to the second stakeholder roundtable, a peer-reviewed manuscript titled “Is citizen science an open science in the case of biodiversity observations?” was developed and published in the *Journal of Applied Ecology* by Groom et al. (2016). The manuscript explored the varieties of licenses attributed to data contributed to the Global Biodiversity Information Facility (GBIF) to understand how the “openness” of data differs by data provider.

Figure 7. Participants at the 2nd EU BON stakeholder roundtable (credits: Carola Radtke, MfN)

Some of the key findings from the *third stakeholder roundtable* (**Figure 8**) are summarised below:

- The discussions with the participants from the consortium and regional biodiversity networks as well as researchers from research-sites showed that a clarification of the targeted users of EU BON tools and products are needed. Hence, on the EU BON biodiversity portal, a clear guidance is key for the different user groups, such as "professional" users (e.g. researchers, data managers, data analysts), and interested users with limited technical skills or scientific background knowledge.
- It was determined that EU BON tools should be demand driven. Many tools and products within EU BON result from the ideas of the involved scientists, based on what they believe stakeholders might need (e.g. for local park managers or policy reporting). However, it was acknowledged the need for a tighter link between stakeholders, end users, and developers.
- Small- and medium-sized enterprises might (SMEs) support the interface between science and practice, as they could develop tools and products (e.g. for visualization of data) that could help in translating scientific knowledge in usable knowledge in the political process.
- Finally, EU BON is output-oriented. However, more time, skills, and capacity needs to be placed on users and their needs for the ongoing improvement of biodiversity data and information workflows. Funding schemes need to be shifted to allow for more opportunities to talk with targeted stakeholders.

Figure 8. 3rd Stakeholder Roundtable: Discussion at the second day of the roundtable (credits: Dirk Schmeller).

In addition to these specific outcomes, the stakeholder roundtables also resulted in more general recommendations for biodiversity projects on a European scale.

The upcoming *fourth stakeholder roundtable* ("Experiences shared from policy/stakeholder roundtable process") aims to present current achievements and products of the EU BON project, which can be assigned to three categories: 1) tools and infrastructure, 2) consortium and its collaborative network, and 3) biodiversity monitoring and scientific forecasting. As the final stakeholder roundtable, this session aims to examine sustainability issues after the funding phase of EU BON.

Sector specific stakeholder engagement with user communities (Task 6.4)

The aim of this task was to explore the role of users of natural resources in data collection, mobilisation and use, and to explore the use of biodiversity data in policy making and implementation in the EU. We conducted a review of the bottom-up biodiversity data gathering activities of different stakeholder sectors, and whether they could be enhanced by the types of tools and services that EU BON is developing (Underwood et al. 2015, **Annex 13**). Four sectors were prioritised because of their current use of biodiversity data and their potential to contribute to data provision and monitoring, these were i) farmers and agricultural organisations, ii) hunters and hunter groups, iii) anglers and angler groups, and iv) planning authorities and developers (e.g. the construction industry). The review examined the extent to which biodiversity data is already curated and made available by the sector due to policy reporting obligations or own initiatives, it also highlighted the key factors that influence their capacity to do so (see **Box 1** below), and finally, it provided an indication of the extent of the likely motivation of these sectors to engage in biodiversity data mobilisation and collection.

Box 1. Key factors that influence the potential of stakeholder groups to contribute to biodiversity data collation

1. *Relevance of data*: Stakeholder groups usually gather data either because they are required to do so by legislation, for example EU fishermen who are already subject, at least in theory, to quite extensive data reporting, or because the data are important for management of the common resource like for hunting groups. Few stakeholder groups run data gathering networks that respond directly to policy-relevant questions or problems. However, data brokers could establish joint ventures with stakeholder groups interested in developing particular indicators or products relating to biodiversity assets and risks relevant to them.
2. *Quality of data collection and curation*: Biodiversity policy needs to be informed by data collected using standard methods with known accuracy and precision, using determinable baselines and targets for the assessment of improvements and declines. Data collection must also be efficient and affordable so that it can be sustained over the long term. This generally requires collaboration between researchers and stakeholders.
3. *Data ownership and recognition of effort*: it is important to recognise the significant effort invested by the providers of good quality data, for example through citation using the DOI system, or feedback and interaction through citizen science organisations. Data suppliers often require a legal basis for the protection of certain data and assurance that data governance and dissemination will protect their data rights and their interests.

To gain a more in-depth understanding of how biodiversity data are being used for policy making in the EU, we examined the use of biodiversity data and biodiversity data portals in the implementation of several EU policies relating to natural resources, such as: marine spatial planning, environmental impact assessment, river basin management planning, and rural development programming.

We identified a number of opportunities to improve policy planning, implementation and monitoring using biodiversity data, that are being developed by individual projects but not implemented more widely (see box on river basin management planning).

Use of biodiversity data in river basin management planning
The Water Framework Directive (WFD) requires Member States to monitor and assess the ecological status of all surface waters and groundwater, and to achieve good water status for all these water bodies. This includes the restoration of biological parameters, such as aquatic macrophyte vegetation and the connectivity of rivers for fish. The water status of each water body has to be judged against reference conditions for similar water bodies which are of 'high status'. All these tasks require access to high quality biodiversity data on the key flora and fauna, including historical records. The European Commission evaluation of the first round of plans identified significant gaps in the assessment of ecological status. There appear to be various opportunities for biodiversity data to help improve river basin management, that are not being taken. For example, maps have been created of fish connectivity measures on German rivers[8] and fish barriers in the Danube basin[9], but neither platform includes data on fish populations and distribution. In Poland, river maintenance plans pose a strong threat to biodiversity, and there is an urgent need for better biodiversity data to assess and monitor the possible impacts. The greatest challenge to civil society monitoring of policy planning is that there is no unified biodiversity database which collects all existing knowledge on freshwater biodiversity. The Polish government authorities responsible for river basin management use two different incompatible mapping systems and so cannot share or exchange spatial information. An NGO is currently attempting to map existing and planned river hydromorphological alterations together with available fish distribution data.

Use of biodiversity data portals for marine spatial planning
The European Marine Observation and Data Network (EMODnet) is a long term initiative led by the European Commission Directorate-General for Maritime Affairs and Fisheries. The aim of EMODnet is to provide European marine biodiversity data and products in a single access point. EMODnet consists of more than 100 organisations assembling marine data, products and metadata providing more readily available data to the public and private users[10]. Data are provided as species distribution maps, species occurrence records and species abundance. EMODnet monitored the purpose of data downloads over a one year period and found that the main purpose of data downloads was for research (40 per cent), including student theses and researchers testing community structure and validation models. Planners and policy makers in contrast did not appear to be using the resource to any great extent. In contrast, in the UK, the government provides access to environmental and biodiversity data sets on a joint online platform. Surveys found the biggest users of the portal were environmental consultants[11], and that protected areas was the most frequently used theme followed by the habitat and species layers.

[8] Ecologic Institut 2016: Atlas Fischschutz & Fischabstieg. URL: http://forum-fischschutz.de/atlas-standorte
[9] http://atlas.freshwaterbiodiversity.eu/index.php/explore/freshwater-conservation-and-management/item/82-danube-barriers-longitudinal-connectivity
[10] http://www.emodnet.eu/biology
[11] Personal communication, Andrea Ryder, Natural England, 8 March 2016

An interesting example is the use of biodiversity data on species affected by farming practices to target agri-environment contracts under rural development programmes. The UK countries have developed targeting frameworks using biodiversity distribution data on farmland birds and bumblebees to identify target areas in which farmers are encouraged to sign up to a farmland wildlife package scheme that provides wild bird food crops and pollinator margins to boost species populations. The biodiversity data are integrated into the database used to administer farm payments and contracts.

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Annexes

Most of the annexes listed below can be accessed online and, as such, only the contents of the ones that cannot be found online (e.g. Annexes 4, 5, 6 and 13) are included below. To access the contents of other annexes, please follow the hyperlinks provided. Note that the page http://www.eubon.eu/documents/1/ on the EU BON web site also provide access to online outputs. Finally, it is possible to download all D6.1 annexes in PDF format at the address: http://wcmc.io/DeliverableD61.

Annex 1. Scientific article: *The roles and contributions of Biodiversity Observation Networks.*

This article by Wetzel et al. (2015) can be accessed online at http://www.tandfonline.com/doi/pdf/10.1080/14888386.2015.1075902.

BIODIVERSITY, 2015
http://dx.doi.org/10.1080/14888386.2015.1075902

The roles and contributions of Biodiversity Observation Networks (BONs) in better tracking progress to 2020 biodiversity targets: a European case study

Florian T. Wetzel[a]*, Hannu Saarenmaa[b], Eugenie Regan[c], Corinne S. Martin[c], Patricia Mergen[d], Larissa Smirnova[d], Éamonn Ó Tuama[e], Francisco A. García Camacho[f], Anke Hoffmann[a], Katrin Vohland[a] and Christoph L. Häuser[a]

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(*Received 5 April 2015; final version received 21 July 2015*)

The Aichi Biodiversity Targets of the United Nations' Strategic Plan for Biodiversity set ambitious goals for protecting biodiversity from further decline. Increased efforts are urgently needed to achieve these targets by 2020. The availability of comprehensive, sound and up-to-date biodiversity data is a key requirement to implement policies, strategies and actions to address biodiversity loss, monitor progress towards biodiversity targets, as well as to assess the current status and future trends of biodiversity. Key gaps, however, remain in our knowledge of biodiversity and associated ecosystem services. These are mostly a result of barriers preventing existing data from being discoverable, accessible and digestible. In this paper, we describe what regional Biodiversity Observation Networks (BONs) can do to address these barriers using the European Biodiversity Observation Network (EU BON) as an example. We conclude that there is an urgent need for a paradigm shift in how biodiversity data are collected, stored, shared and streamlined in order to tackle the many sustainable development challenges ahead. We need a shift towards an integrative biodiversity information framework, starting from collection to the final interpretation and packaging of data. This is a major objective of the EU BON project, towards which progress is being made.

Keywords: Biodiversity; Convention on Biological Diversity; Biodiversity Observation Networks; GEOSS; Aichi Biodiversity Targets; informatics; biodiversity portal

Introduction

Biodiversity supports essential ecosystem functions and, consequently, many ecosystem services that are key to human well-being (Cardinale et al. 2012). The ongoing global biodiversity decline is a threat to human well-being, particularly in developing countries (MEA 2005). And yet, mankind contributes directly to the many factors that drive this decline (CBD 2014; EEA 2010, 2015). There is, however, a high potential for mitigation measures aimed at reducing human pressure and impact on biodiversity (Pereira et al. 2010) and this represents an important field of action for environmental policy.

One central political and international instrument aimed at halting biodiversity loss is the Convention on Biological Diversity (CBD), which sets ambitious goals to protect various levels of life forms and to implement sustainable use of natural resources (CBD 2005). The goals were formalised in the UN Strategic Plan for Biodiversity 2011–2020 along with 20 specific targets, called Aichi Biodiversity Targets (CBD 2010). However, as shown by a recently published mid-term review of progress (CBD 2014; Tittensor et al. 2014), many of these global targets are unlikely to be met unless efforts are increased. Indeed, the situation at European level is not much better (EEA 2015).

In order to more effectively inform and implement environmental policies, including tracking progress towards regional and global biodiversity targets, there is an increasing demand for comprehensive, sound and up-to-date biodiversity data. Key gaps, however, remain in our knowledge of the status and trends of biodiversity and associated ecosystem services, mostly as a result of barriers preventing existing data from being discoverable, accessible and digestible. Existing data are often not *discoverable*, i.e. it is not easy to locate them, because they are not uploaded in a well-known public repository (portal) or they have poorly documented/structured, or even absent, metadata. Existing data are also often not *accessible*, making them unavailable for use, for instance because of usage restrictions (licensing) and confidentiality. Finally, existing data are often not *digestible* (i.e. interoperable), for instance because they do not follow agreed standards, and it makes it difficult to integrate/combine them with other similar data. Besides these three main issues, certain expertise is often required to use data, which must be packaged into 'data

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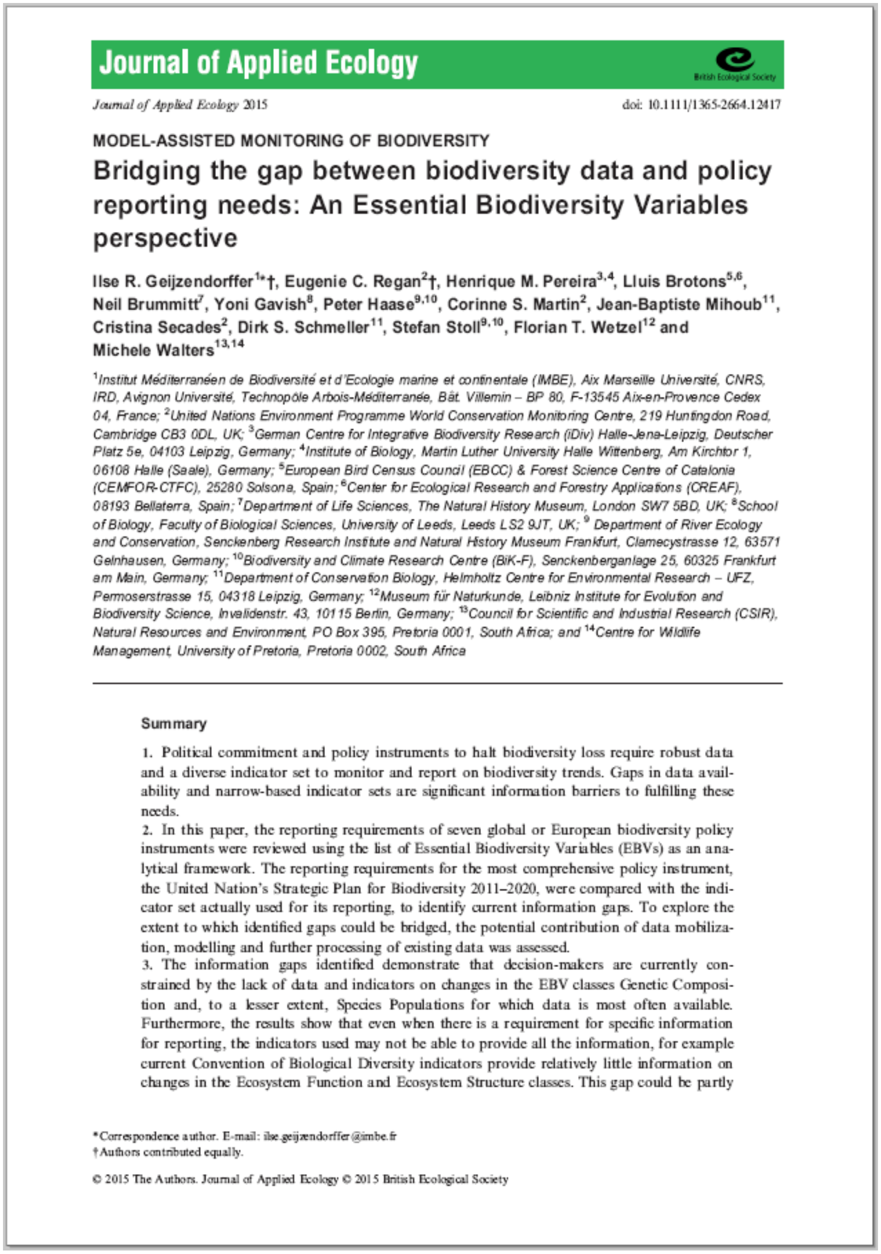
Annex 2. Scientific article: Bridging the gap between biodiversity data and policy reporting needs.

This article by Geijzendorffer et al. (2015) can be accessed online at http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12417/abstract.



Journal of Applied Ecology

British Ecological Society

Journal of Applied Ecology 2015 doi: 10.1111/1365-2664.12417

MODEL-ASSISTED MONITORING OF BIODIVERSITY

Bridging the gap between biodiversity data and policy reporting needs: An Essential Biodiversity Variables perspective

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Summary

1. Political commitment and policy instruments to halt biodiversity loss require robust data and a diverse indicator set to monitor and report on biodiversity trends. Gaps in data availability and narrow-based indicator sets are significant information barriers to fulfilling these needs.
2. In this paper, the reporting requirements of seven global or European biodiversity policy instruments were reviewed using the list of Essential Biodiversity Variables (EBVs) as an analytical framework. The reporting requirements for the most comprehensive policy instrument, the United Nation's Strategic Plan for Biodiversity 2011–2020, were compared with the indicator set actually used for its reporting, to identify current information gaps. To explore the extent to which identified gaps could be bridged, the potential contribution of data mobilization, modelling and further processing of existing data was assessed.
3. The information gaps identified demonstrate that decision-makers are currently constrained by the lack of data and indicators on changes in the EBV classes Genetic Composition and, to a lesser extent, Species Populations for which data is most often available. Furthermore, the results show that even when there is a requirement for specific information for reporting, the indicators used may not be able to provide all the information, for example current Convention of Biological Diversity indicators provide relatively little information on changes in the Ecosystem Function and Ecosystem Structure classes. This gap could be partly

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†Authors contributed equally.

Annex 3. Scientific article: *Taking stock of nature: Essential biodiversity variables explained.*

This article by Brummitt et al. (2016) will soon be accessible online via http://dx.doi.org/10.1016/j.biocon.2016.09.006.

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Taking stock of nature: Essential biodiversity variables explained

Neil Brummitt [a,*], Eugenie C. Regan [b,c], Lauren V. Weatherdon [b], Corinne S. Martin [b], Ilse R. Geijzendorffer [d,e], Duccio Rocchini [f], Yoni Gavish [g], Peter Haase [h,i], Charles J. Marsh [j], Dirk S. Schmeller [j,k,**]

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UK spring index

ABSTRACT

In 2013, the Group on Earth Observations Biodiversity Observation Network (GEO BON) developed the framework of Essential Biodiversity Variables (EBVs), inspired by the Essential Climate Variables (ECVs). The EBV framework was developed to distill the complexity of biodiversity into a manageable list of priorities and to bring a more coordinated approach to observing biodiversity on a global scale. However, efforts to address the scientific challenges associated with this task have been hindered by diverse interpretations of the definition of an EBV. Here, the authors define an EBV as a critical biological variable that characterizes an aspect of biodiversity, functioning as the interface between raw data and indicators. This relationship is clarified through a multifaceted stock market analogy, drawing from relevant examples of biodiversity indicators that use EBVs, such as the Living Planet Index and the UK Spring Index. Through this analogy, the authors seek to make the EBV concept accessible to a wider audience, especially to non-specialists and those in the policy sector, and to more clearly define the roles of EBVs and their relationship with biodiversity indicators. From this we expect to support advancement towards globally coordinated measurements of biodiversity.

Much has changed since 1990, when biodiversity was only a minor consideration in environmental policy (Noss, 1990). The establishment of the Convention on Biological Diversity (CBD) at the Rio Earth Summit in 1992 brought biodiversity centre-stage. However, despite Contracting Parties' agreement on the UN Strategic Plan for Biodiversity 2011–2010, and associated Aichi Biodiversity Targets (Decision X/2), biodiversity has been and is still declining globally (Butchart et al., 2010; Tittensor et al., 2014). There are many reasons why international efforts are failing to halt biodiversity loss. One major obstacle is that the complexity of biodiversity (considerable species diversity, complex ecological interactions, numerous pressures interacting synergistically to impact multiple aspects of biodiversity, etc.) often makes it difficult to track trends in the state of biodiversity against tractable and easily achievable conservation goals (Brooks et al., 2014; Noss, 1990).

In 2013, the Group on Earth Observations Biodiversity Observation Network (GEO BON) developed the framework of Essential Biodiversity Variables (EBVs) (Pereira et al., 2013), inspired by the Essential Climate Variables (ECVs) (Doherty et al., 2009; GCOS, 2004). Similar to the ECVs, the EBV framework was developed to distill the complexity of biodiversity into a manageable list of priority measurements and to bring a more coordinated approach to observing biodiversity on a global scale. Major scientific challenges are faced when distilling biodiversity into a limited number of essential variables, including i) the identification of a single variable for a critical aspect of biodiversity, ii) the translation of information between different biological and geographical realms (e.g., terrestrial and marine), iii) the heterogeneity of methods and data for measuring and recording different components of biodiversity, and iv)

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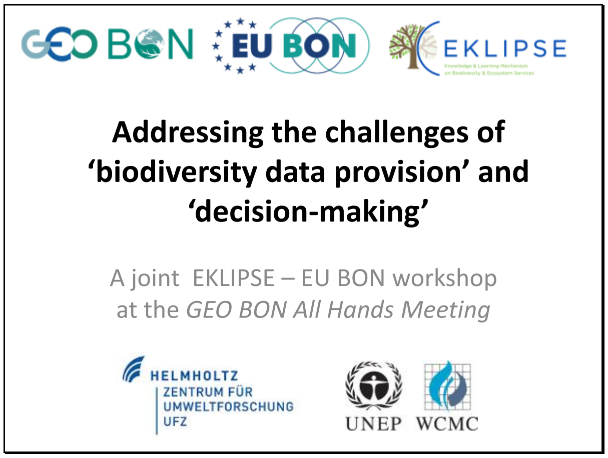
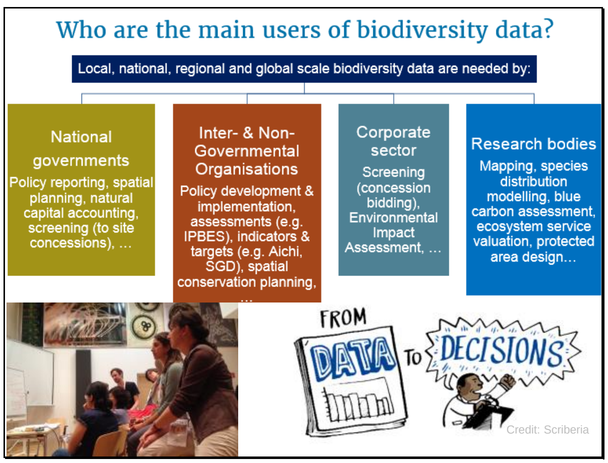
Annex 4. Workshop report: *The challenges of 'biodiversity data provision' and 'decision-making' (Leipzig, Germany, 04-08 July 2016).*

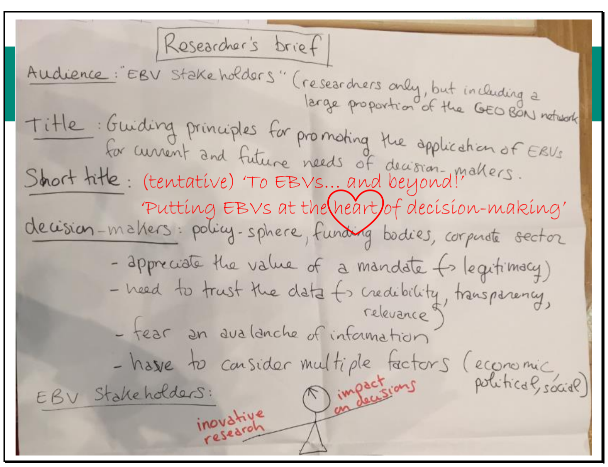
The slides were presented at the final plenary of the GEO BON Open Science Conference and All Hands Meeting.



- Thank you for the opportunity to report back on the workshop that took place yesterday.
- This workshop sits a little in parallel to the GEO BON working groups as they are currently structured.
- The issues, challenges and possible solutions we discussed and identified are, however, very relevant to the GEO BON network, at this particular time when GEO BON as a whole is evolving to make itself (even?) more relevant to decision-makers in the broadest send of the term. I see this workshop as very cross-cutting.
- What I will present now, on behalf of a total of 17 workshop participants, is based on the very varied expertise we had in the room that day. It's the combined view of the participants.



- Decision-makers fall broadly into these 4 categories, and they use varying spatial scales of data to make decisions.
- Decision-makers use data in various forms, e.g. the research bodies tend to use data in raw form, whilst other decision-makers will prefer the data to be processed into data products (e.g. traffic light maps, trends, databases, via decision-support tools), e.g. the case of a national government official carrying out reporting for his country under a policy instrument.
- A lot of the GEO BON network falls in the "research bodies" category, but the workshop mainly focused on the other three categories of decision-makers.



- To cut a long story short, we decided to produce two researcher's briefs, instead of a policy brief (as originally envisaged).
- Around two case studies: one on the **IUCN Red List of threatened species**, based on a real life story in Brazil, and **another around EBVs**, which is of interest to many in the GEO BON network.
- Given the time limitations, I will cover the results from the EBV case study.
- The researcher's brief would be addressed to "EBV stakeholders", [read]
- The long/boring title would be…, and the short title is still to be confirmed (any suggestion welcome).
- The typical decision-maker we had in mind in this exercise, and the thoughts of whom are reported here, and from the policy sphere, funding bodies and the corporate sector, the last two have

something that a lot of us in GEO BON want – funding! So it's important to communicate EBVs well to them. Here is what they care about… [read]

- The diagram at the bottom illustrates that the EBV stakeholders need to strike a balance between doing **innovative research** (a lot of that is taking place under the GEO BON umbrella), and having **impact on decisions**

***Do* do**	***Don't* do**
Speak with a **common voice** (to non-specialists) (*no in-fighting please*)	Put an EBV "skin" on everything you do
Clearly **define** what is an EBV and how it relates to indicators	Create too many EBVs (*no longer 'essential', see ECVs example*)
Engage beyond the research world, seek **mandate**, be **inclusive** (language, gender, origin, capacity)	Work in isolation without standards
Be **realistic** for what can be done now and later	Reduce EBVs to 'building blocks of indicators'
Define criteria for good EBVs	
Use EBVs as a clearing house	
Convey the limitations of EBVs and their data in a way that is **understandable** by non-specialists	
Clarify what **impact** EBVs should have	
Be salient, **credible**, legitimate, **iterative**	

- In terms of guiding principles, this table lists some of the Do's and Don't's that our group came up with, that might help the EBV stakeholders in the wider GEO BON network in striking the balance between doing **innovative research** and having actual **impact on decisions**.
- [read]
- This is obviously tentative and preliminary, but a good starting point and really informative, we think

GEO BON

What other parts of GEO BON does this workplan connect to? How?

- "80% of knowledge used in environmental policy in the European Union comes from consultancy service contract" (quote from EU official)
- GEO BON can have a role in supporting a broad range of decision-makers
- ... and not just those of the EU and the policy sphere
- The workshop outputs clearly align with the outputs from the workshop on "indicators for policy"
- ... let's join forces and broaden the scope of that WG?

Annex 5. Cross-WP workshop report: *Packaging EU BON's outputs into solutions for decision-makers (Cambridge, UK, 23-24 November 2016).*

Contents

1. Workshop logistics

Venue:
Both days at UNEP-WCMC offices:

UNEP World Conservation Monitoring Centre
219 Huntingdon Road, Cambridge CB3 0DL, UK
Reception: +44 (0)1223 277314
http://www.unep-wcmc.org/about-us/contact#contact-page

2. Workshop background, objectives, outputs and outcomes

Background:
The idea of a small, focused workshop arose out of (a) the steer from the external Advisory Board that more cross-WP communication was needed, and (b) the appreciation at the third EU BON general meeting in Cambridge of how much traction the "Aquamaps North sea fish" infographic (http://wcmc.io/North-Sea; developed under WP6) achieved. This infographic has demonstrated how a modelling tool can help answer a clear policy (or decision-maker)-relevant question.

Under EU BON, WP3 has developed some powerful tools (Tasks 3.1 and 3.2), and more tools are in the planning/development under Task 3.3. WP4 is in a similar position. The external Advisory Board has set us the challenge of bringing those tools to bear on policy-relevant issues/questions**,** i.e. linking EU-BON modelling capacity to policy need(s). There is a real opportunity here to raise the profile of EU BON's science, to have an impact in the policy sphere, drawing from the available datasets (WP1/2), tools (WP3/4) and identified policy-level and other decision makers' needs (WP6/7).

While WP3/4 have good ideas of the tools available, they have only hazy notions of European and global policy needs… conversely, those in WP6/7 know the policy agenda well (and the needs of a range of other decision-makers), but only have vague notions of the tools available under EU BON.

Objective(s) of the meeting:
The overall goal of the workshop is to identify the "overlapping bits" across WP3/4 and 6/7 (but not exclusively), so as to identify applications of EU BON's tools for decision-making, including at policy-level. Through short presentations and brainstorming, we will identify questions relevant to policy and decision-makers more broadly, that can be answered using WP3/4's and other WPs' tools.

Proposed output(s) for the meeting:

- A list of 5-10 EU BON products. Inspired by the "Aquamaps North sea fish" infographic approach, we aim to come up with a list of "products" derived from the work of WP3/4 (and WP(1)/2) that can answer clear questions relevant to policy, and to decision-makers more broadly. These products, which could be infographics, online tools for decision-support, or else (e.g. R packages supported by technical briefs; policy briefs, etc), will be used to showcase WP3/4's tools in the policy-sphere (e.g. European Commission, EEA, CBD, etc) and to other decision-makers, notably at the local and national-scales.
- This list will be delivered as a "products table" for use by EU BON Project Coordination (MfN).
- Along with the "products table", we will provide implementation plans (including timeline, and "who is doing what?") for developing and then showcasing selected (prioritised) EU BON products.

Outcomes of the meeting:

- A better understanding of how to 'market' EU BON's products for end-users. [*outcome met*]
- A better understanding of the end-users and the barriers that they face in accessing and using biodiversity data tools. [*we have gone some way - we realise there are barriers*]
- Improved collaboration between EU BON Work Packages [*double-yes!*], and a coherent vision for collaboration [*getting there - we have implementation plans for some of these tools*].

3. Workshop agenda

DAY 1

11:00 Welcome (Eugenie and Bill K) and introductions.

11:15 UNEP-WCMC (Lauren): examples of where data/models/tools have successfully been used into policy and decision-making processes (10' + questions)

11:35 Vizzuality/Symbiotica (Simao): presentation of data visualisations, relevant to policy but not exclusively (e.g. Global Forest Watch) (5' + questions)

11:50 Discussion: packaging EU BON's outputs into solutions for decision-makers. What are the key aspects of a data tool for decision-makers? What lessons can EU BON learn from others' experiences? Output**:** list of key aspects/criteria of a good decision-support tool.


Key aspects/criteria of a good
decision-support tool

13:00-14:00 LUNCH

14:00: Short 5' presentations on each "tool". Chair: Bill K.
Slides: https://www.dropbox.com/sh/qvz72v37f4l3y1d/AAB4I8qntiF6F9_gbytojYyTa?dl=0

Approximate guidelines:

A. (1 slide): Name of the tool or method, and a brief user-friendly description of the what it's for (and why it was needed).

B. (1 slide): inputs and outputs: (i) what sort of data or resources are needed to run the method, and (ii) what does it produce (e.g. Population estimates? Suitability maps?)

C. (1 slide): A *very simple* explanation of how the tool/method works – in very general non-technical terms (with pictures or diagrams if possible)!

D. (1 slide – or combine with next): Is the method operational yet? And if so: has it been tested? How well does it work? If it's NOT operational, how soon will it be ready?

E. (1 slide): What analyses/applications have you already done with it? Any particularly interesting findings? And/or: what analyses/applications are already planned (e.g. in the DoW)?
F. (1 slide): what are some other topics/applications you think the tool method MIGHT be used for – especially ones you think might be of interest to policy-makers or the general public?
Remember: the idea is to communicate the excitement and value of your tool/method to a NON-SPECIALIST audience. The focus should not be so much on technical innovation of HOW it works, and much more on the WHY it's needed and WHAT we can potentially use it for. **Keep in mind:** Who is the key customer for the tool? What problem does the tool solve?

1. **Bill -** Overview of work package 3 tools.
2. **Guy** (remote) - Virtual Ecologist, a tool for optimising monitoring.
   Testing and demonstrating the cost-efficiency of voluntary monitoring toward greater trust and support.
   User: scientist wishing to demonstrate the value of voluntary monitoring.
3. **Duccio/Carol** (remote): Fourier transforms and the Land Surface Temperature (LST) derived set
4. **Yoni** - Hierarchical habitat classification.
5. **Simao**: GeoCAT, an online tool that supports threat assessment of plant species under the IUCN Red List.`

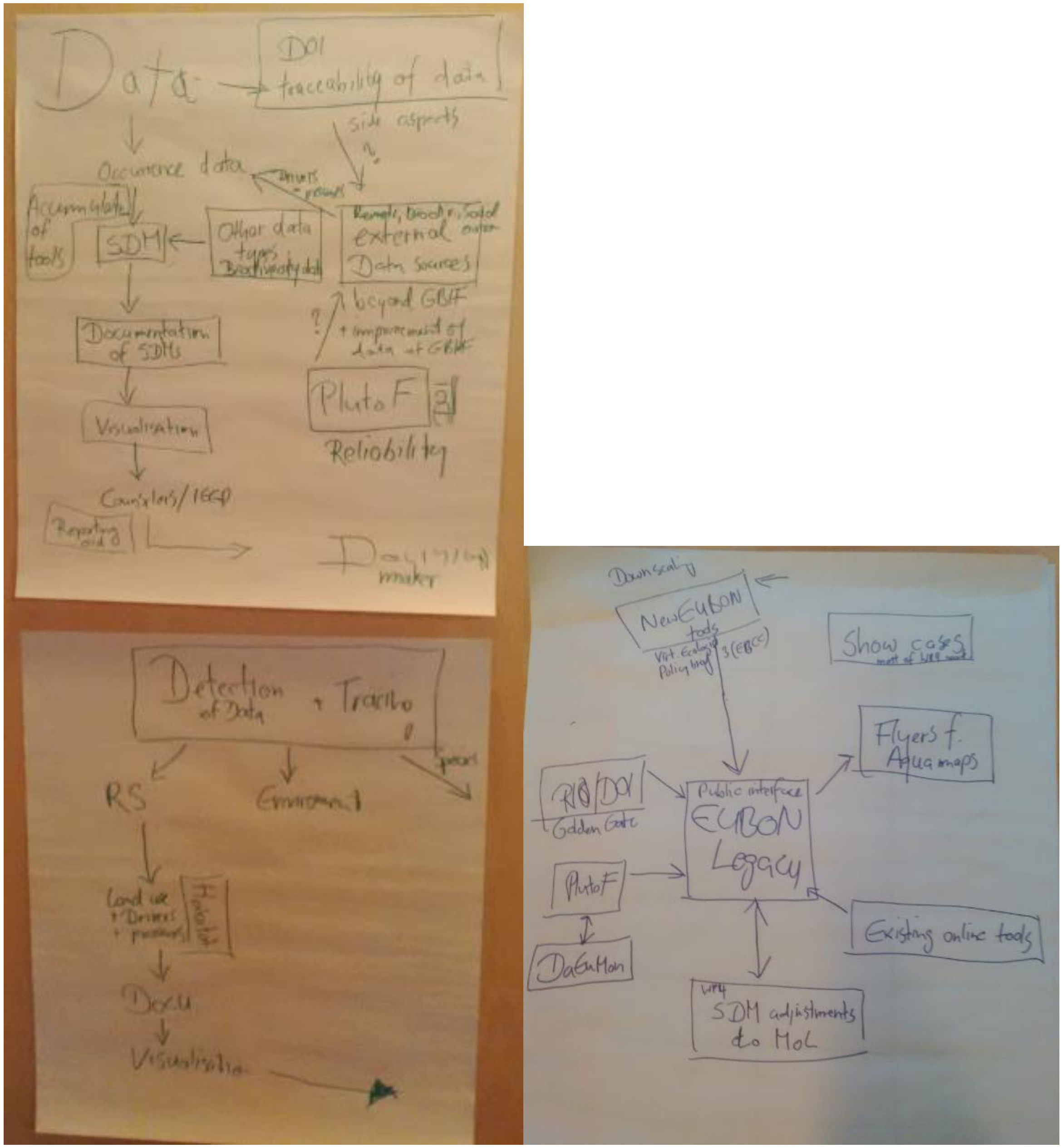
15:30-16:00 COFFEE

6. **Charlie**- Downscaling models and IUCN red listing
7. **Mathias (remote)**: Freshwater Species Distribution Models (SDMs): distribution predictions for catchment management and conservation
8. **Cristina (remote)**: AquaMaps, an online tool to explore/download modelled species distributions of marine and freshwater species.
9. **Yoni** - Adjusting species distributions for local diversity - the Alpha adjusted model
10. **Johannes [presented by Yoni]**: Diversity calculator, a tool that allows calculations of alpha and beta diversity for large raster datasets (large in extent and large in terms of stacked raster)
11. **Donat**: GoldenGate Imagine, a tool that allows to harvest observation data from the published record for further use.
12. **Donat**: TaxPub, a schema that allows publishing structured observation data for direct harvest GBIF, and implemented in Pensoft publications.
13. **Urmas**: EU BON Dataset mobilisation, editing and publishing toolkit
14. **Pavel (presented by Urmas)**: New tools for importing content from GBIF, DataONE, iDigBio, BOLD and UNITE/PlutoF into scholarly manuscripts, as important elements of EU BON's Data Publishing Toolkit.
15. **Christos** - An online graphic user interface to dynamically explore model results and ecological indices.

DAY 2

09:00 - 10:00: 4 groups including 1 person from WP6/7. Brainstorm which of the tools presented on Day 1 have the strongest potential for a storyline (e.g. from Data to Decision). Criteria for inclusion in the "products table" (see section 4): *attractive* and *feasible* and r*elevant to a decision-maker*.


LST
Attractive
Feasible
Freshwater SDM
Tool
SON as Case Study
Germany
Find Application
much of North Europe?
Computational limits?
GeoCAT
Help update Red Listing
AOO calculator
Downscaling
Link into GeoCAT?
Goldengate
but time consuming
not Really policy
Fourier Transf.
Reflectance Diversity
Ecosystem Condition?
Cartograms
Hierarch. Random For
AquaMaps
Marine Invasives
Alien Spp
Credible


Data
DOI
traceability of data
side aspects
Occurrence data
SDM
Other data types
external Data sources
beyond GBIF
Documentation of SDMs
Visualisation
PlutoF
Reliability
Detection of Data
RS
Docu
Visualisation
Downscaling
New EUBON tools
Show cases
Flyers f. Aquamaps
Public interface
EUBON Legacy
Golden Gate
PlutoF
Existing online tools
SDM adjustments to MoL

10:00-10:30: UCAM (David) and Evelyn (IEEP): “removing the blockades”. A discussion of how WP6 (tasks 6.3 and 6.4) are working towards a better understanding of the barriers faced by decision-makers (of the policy sphere) in accessing/using biodiversity data.

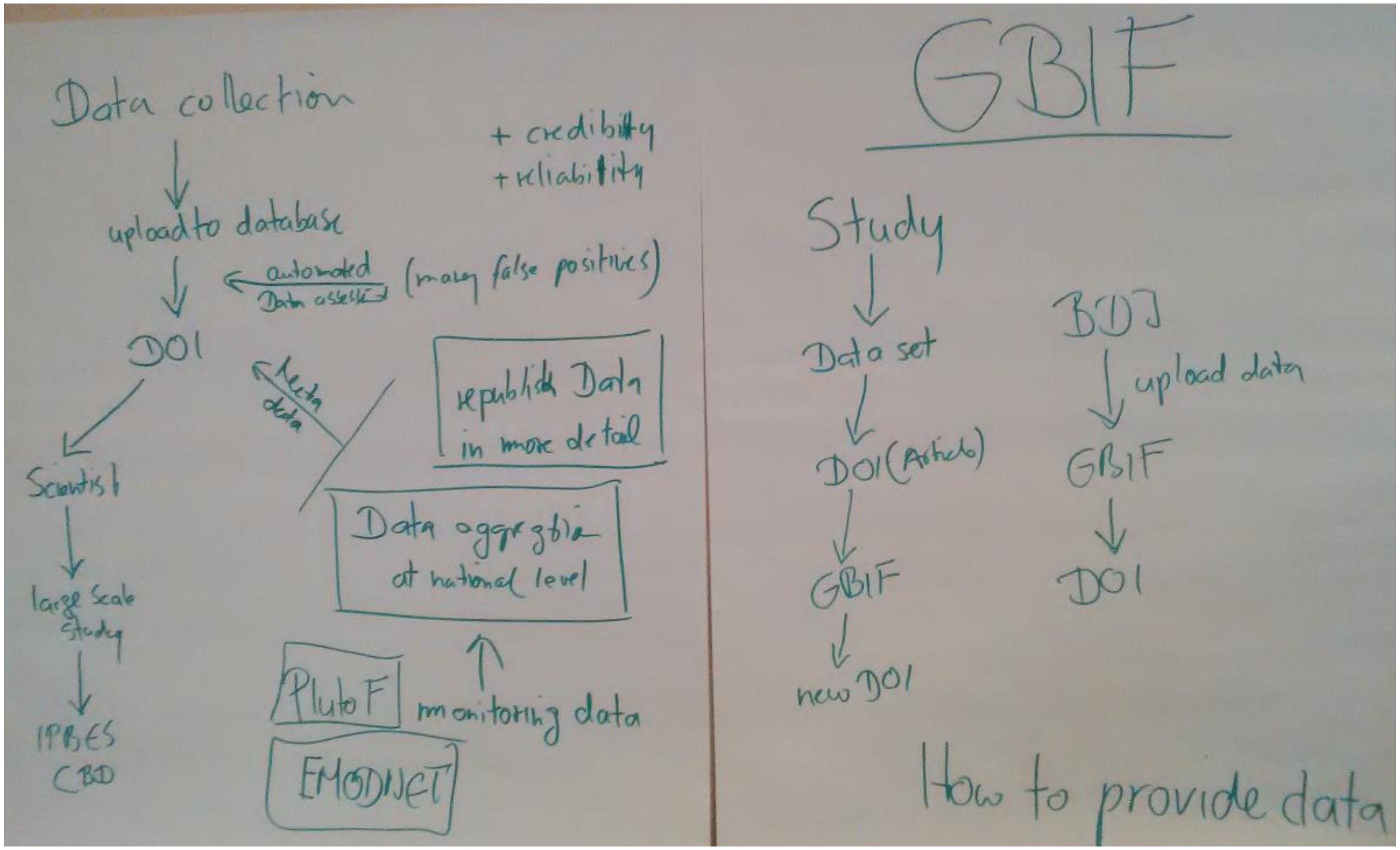
> *Policy-makers do not have time to consult experts on a day to day basis. They need to be able to find relevant information themselves.*

10:30-11:45: Report back from the breakout groups.

> *EU BON = an independent platform where the data users/experts can access previously fragmented information and tools. This vision will only if Member States can access better information in EU BON than they already have access to at national-level.*
> *EU BON should push accumulation of data* ***products****, not the raw data.*

11:45-12:00 COFFEE

12:00: 4 break-out groups. For each of the products (or a selection), finalise the aims, and make an implementation plan (including timeline, and “who is doing what?”). Report back at 12:50pm.



13:30-13:45 LUNCH

13:45-15:00: Finalise products table.

15:30 FINISH!

4. Workshop recommendations

Recommendations that arose from the workshop:

- EU BON products and tools should be featured in the European Biodiversity Portal. To make this happen, targeted discussions with the Portal team need to be held.
- For selected tools, it is important to showcase (on the portal) how they can be used at the site level (e.g. by protected area managers, etc).
- Continue this workshop's work in person (e.g. at the Granada meeting) or via email/"Skype" calls. Use the "products table" (below, in this section) as recording medium. We expect significant input in the table by 03 December (close of business), so that it can be used efficiently in Granada, as supporting material for the third stakeholder roundtable.
- The "products table" will then be shared by WCMC (on 08 December) with EU BON's Project Coordination, and all the other work packages, for their input/feedback, and to help reaching out further and picking-up more product nominations.
- Implementation plans will be taken forward by their leads. This will include reaching out to targeted users/audience.
- Where/if relevant, a meeting (in person or "Skype") with the EEA and European Topic Centre will be organised, to present relevant outputs of the workshop, and gain policy feedback.

5. EU BON "products table"

A EU BON "product" is an item or service that most closely meets the requirements of a particular user.

A good EU BON product:

- Is designed around a well-defined end user (i.e. this is different from a report detailing what work has been done). It should address a user need, i.e. answer a clear specific question.
- Delivers on a singular value proposition - it does one thing, and does it well (preferably exceptionally well!).
- Is simple to use, intuitive, visual (e.g. uncluttered interface.)
- Addresses/anticipates user needs.
- Has a clearly defined audience, usually small, e.g. policy sphere (via alignment with policy agenda, EU directives) or scientists, but not both.
- Has a name that people (including your mum!) remember and relate to, i.e. the intended user knows straight away what the product is supposed to do.
- Is well communicated, e.g. it answers a simple question and is in an attractive/user-friendly format. E.g., an infographic. Users and potential users must know why they need to use it, what benefits they can derive from it, and what it does difference it does to their lives.
- Is flexible for different questions? Responsive to user need? Universal?
- Is scalable - different answers/solutions for different scales.
- Is credible - e.g. data driven, data used have metadata, uncertainty is explained/can be visualised, uses relevant data, fit for purpose
- Is likely to have direct (specialist) and indirect (non-specialist) users
- Provides user support, e.g. webinars
- Is remarkable!

+

The “products table” below is used to collectively gather our many ideas into a standardised format. Criteria for shortlisting products:

1. Relevant (this could be separated into "relevant to whom" and "relevant to what")

2. Credible
3. Feasible
4. Attractive (e.g. it has a clear storyline)

Tool name (scientific)	Question(s) it answer(s) / helps answer. Decision(s) it supports.	Product format, and proposed showcase	Direct audience/user	Indirect audience/user	Lead person	Partners	Comments
(1) LST (Land Surface Temperature maps)	Finer-scale Land Surface Temperature maps allow to create spatially more accurate Species Distribution Models	(1) Continental maps as raster files (delivered) (2) Time visualisation of yearly averaged maps. Could be created using CartoDB. Would be possible to overlay sampling effort over time from GBIF, displayed).	(1) SDM researchers unaware of this great new resource (2) Scientists, general public	N/A	Duccio/Carol	Simao	Seems to have applications beyond biodiversity, e.g. climate (seasonality, extreme weather events, heat waves, unusually cold winters).
(2) Roadmap to species distribution modelling	Provides guidance regarding appropriate models to use for different levels of inputs, offering a workflow (assumptions, limitations, required data, scale, etc.).	Infographic (/ policy briefing?)	Scientists/ researchers	Policy-makers	Duccio/Carol	Lauren, [Simao]	Perhaps a way to tie together and showcase all products of EU BON (e.g. R packages and methodologies).
(3) Freshwater ensemble SDM	How many river barriers can Lamprey (or other threatened spp) handle? How many river barriers are too many?	Case-study for one catchment in Germany. Infographic	River basin managers [Freshwater] Conservation Biologists	Habitat Directive and Water Framework Directive secretariats	Mathias / Stefan	Lauren (infographic), Evelyn	European-wide scale could be a next step if suitable data are available (e.g. on barriers). Can serve as a reference for conservation/management/policy making elsewhere
(4) GeoCAT	How can I incorporate supporting spatial data such as Species Distribution Models in the GeoCAT tool, to	Online tool plus illustrated technical brief to entice IUCN expert groups to make use of it	IUCN expert groups (including non-technical members)	CBD Secretariat (as Red List assessment are fed in indicators to track	Simao/Corinne/Lauren		http://geocat.kew.org/ SDM data could come from AquaMaps.

Tool name (scientific)	Question(s) it answer(s) / helps answer. Decision(s) it supports.	Product format, and proposed showcase	Direct audience/user	Indirect audience/user	Lead person	Partners	Comments
	support my Red List assessment work?			Aichi targets)			
(5) "Area of occupancy calculator" (= downscaling models)	How can coarse "atlas data" be made finer (i.e. downscaled) so that Criterion B2 is more widely used in Red List assessments?	R package and technical brief. Infographic?	Scientists who is undertaking a Red List assessment (user needs to be an R expert)	IUCN expert groups, e.g. Neil B. and his global sampled RLI of plants.	Charlie/Neil/ Bill K/Yoni G	Corinne/ Lauren/ Simao	Criterion B2 has proved impractical to apply; using downscaling to 2 km scale, or a multi-scale approach could make it operational. Could this be integrated in GeoCAT through a plug-in? *See Milestone MS653 for latest version of this text*
(6) Fourier transform	Using remotely-sensed landscape fragmentation data to monitoring ecosystem condition (e.g. extent of deforestation, forest degradation)	Provides some of the materials needed to create an indicator of the degree of fragmentation of forests. It would need to be informed using contextual data (i.e." this fragmentation in this specific habitat means…")	EEA: "we need to assess ecosystem condition using spatial data". In the context of the European biodiversity strategy.	Relevance to UN-REDD/REDD+ needs to be investigated [*are these aggregate measures across habitats?*] Policy makers & analysts	Duccio/Carol	Corinne/Lauren	Note: works well at the small-scale Linked to EBVs.Could be applied to assessing "Ecosystem condition". Link to the "Global Human Footprint" ?
(7) AquaMaps for EU BON Interface	Explore and download data for modelled species distributions of European marine and freshwater species	Online tool	Students, researchers, conservation planners, NGOs	NGOs	Cristina/Kathleen		http://www.aquamaps.org/am_eubon/ (marine) http://www.aquamaps.org/am_europe/ (freshwater)
(8) Predicted distributional changes to known marine protected species	How may climate change affect the spatial distribution of a particular threatened species in Europe?	Online tool	General public, policymakers		Cristina/Kathleen		http://www.aquamaps.org/am_eubon/otherspecieslist.php?type=threatened

Tool name (scientific)	Question(s) it answer(s) / helps answer. Decision(s) it supports.	Product format, and proposed showcase	Direct audience/user	Indirect audience/user	Lead person	Partners	Comments
(9) Predicted Climatic Impact on Future Community Composition in Large Marine Ecosystems	How may climate change affect species diversity in the North sea?	Online tool and Infographic	General public, policymakers		Cristina/Kathleen/Lauren (infographic)		North Sea infographic delivered (http://wcmc.io/North-Sea). Species counts and maps need to be updated with the latest dataset (version 08/2015) http://www.aquamaps.org/am_eubon/SpecRichLME.php
(10) GoldenGATE Imagine	How can I mine data about a particular species from the published scientific literature and harvest them in GBIF? What is a scientists understanding of a particular species?	Illustrated technical brief.	Scientists, citizen scientists		Donat		
(11) Hierarchical RandomForest Habitat classification	A habitat classification map. Developing higher thematic resolution habitat maps using remote sensing imagery.	R package and technical brief	Protected area/Natura 200 sites manager, river basin manager	EEA?	Yoni	Evelyn	Compatibility with EUNIS? Rate limiting variable is probably availability of good ground truth data.
(12) Data publishing and dissemination toolbox	The EU BON's Data Publishing and Dissemination Toolbox (DPDT) is a set of standards, guidelines, recommendations, workflows and tools designed to ease scholarly publishing of biodiversity-related data, which are of primary interest to EU BON	Online tool	Scientists, data owners	Data managers	Lyubomir Penev		Compatible with GBIF IPT, DataONE, iDigBio, PlutoF, BOLD and any other platform supporting EML and Darwin Core standards

Tool name (scientific)	Question(s) it answer(s) / helps answer. Decision(s) it supports.	Product format, and proposed showcase	Direct audience/user	Indirect audience/user	Lead person	Partners	Comments
	and GEO BON network.						
(13) Alpha-adjusted SDM	Predict future species richness and species distributions under climate/land-use change	R package leading to maps	Scientists	Conservation planners	Yoni/Charlie/Bill		Currently people use stacked single-spp SDMs -- but they tend to predict higher local richness than is actually found as SDMs overpredict species distributions Note: Alpha adjusting may predict less dire consequences of CC in Northern Europe, and more extreme effects in south...
(14) Mapping species trends in relation with environmental drivers of change	What are species temporal trends (either decline or growth or stable)? How do these trends structure in space? Where species trends are critical? and why?	product: R codes available+maps showcases: birds from Cataloña (EBCC data) + marine fish in North Sea (ICES open data)	Experts/conservation planners (method) Decision makers (maps)	Scientists (for method feedbacks and improvements)	Jean-Baptiste Mihoub	Lluis Brotons Nicolas Titeux Aliénor Jeliazkov	
(15) Biodiversity upscaling toolkits	What is the species richness of poorly recorded taxa (e.g. soil microbes or nematodes) How is species richness changing at multiple spatial scales -- e.g. is biotic homogenisation taking place?	R library already published	General public, policymakers		Charlie/Yoni/Bill		Could be applied where there are good standardised "point" records collected across a wide area.
(16) Marine Ecological Modelling virtual laboratory: "*ecosystem modelling*" option	What is the ecological status of water bodies? Assessment based on various indices related to the implementation of the Water	Graphic User Interface (GUI) with visualization maps providing information on prognosis of concentration of environmental variables and ecosystem components measures (e.g. biomass, productivity).	Environmental managers (management authorities), policy makers, scientists, students.	Administrators at all levels, fishermen, citizen scientists.	Alkis Kalabokis , Manolis Potiris , George Petihakis (HCMR)		Needs to be set up for each marine body. Product in its final testing

Tool name (scientific)	Question(s) it answer(s) / helps answer. Decision(s) it supports.	Product format, and proposed showcase	Direct audience/user	Indirect audience/user	Lead person	Partners	Comments
	Framework Directive and the Marine Strategy Framework Directive	Four showcases in Greece and Cyprus, including the study site of the Amvrakikos Gulf lagoons.	Assists decisions to be taken such as when to open channels of communication between lagoons and open sea based on predicted oxygen depletion rates				
(17) Marine Ecological Modelling virtual laboratory: "*introduction of Invasive and Alien Species of Indo-Pacific origin in the Mediterranean*" option	Where are Invasive and Alien Species of Indo-Pacific origin found in the Mediterranean sea? Where will they establish themselves and spread to under climate change and maritime traffic scenarios?	Species distribution probability maps	Environmental managers (management authorities), policy makers, scientists, students.	Administrators at all levels, fishermen. Relevant to the EC's Marine Strategy Framework Directive Descriptor 2: Non-indigenous species	Matthias Obst, Nicolas Bailly, Arvanitidis Christos	HCMR, FIN, University of Gothenburg (not EU BON)	Product in its final testing stage
(18) SDM Profiling	How good is my monitoring scheme? Which points could be moved and where to (if they are not providing much information where they currently are)?	R package	Scientists, monitoring programme managers		Charlie\Yoni\Bill, Mathias		
(19) MPA Planning Tool	Where should I set up my marine protected area?	Online tool	Conservation planners		Cristina/Kathleen	WCMC?	Based on your selected area of interest (as part of a large marine ecosystem, an exclusive economic zone, or an FAO area), a user can then select species of interest with regard to status of threat, resilience, dependence on the ecosystem, fishing and other importance. The tool then produces a map of your area color-coded as to the

Tool name (scientific)	Question(s) it answer(s) / helps answer. Decision(s) it supports.	Product format, and proposed showcase	Direct audience/user	Indirect audience/user	Lead person	Partners	Comments
							number of the selected species occurring at a certain locality. If of interest to EU BON we can work with WCMC to see how to improve this tool for conservation planners. http://www.aquamaps.org/eubon/MPAs.php
(20) integration of all the developed R scripts to be made available under the online R_vLab	Virtual laboratory	An online platform that allows access to all the tools that can be used as web services (as opposed to self-standing R scripts run on a PC), so that users can use them simultaneously.	Scientists		Christos Arvanitidis		E.g. R_vLab of LifeWatchGreece (https://rvlab.portal.lifewatchgreece.eu/), which is also available as a mobile app.
(21) Tailored Specify database platform and tutorial	Specify is a database platform for museum and herbarium research data, developed by the Biodiversity Institute of the University of Kansas (USA). It manages species and specimen information for computerizing biological collections, tracking museum specimen transactions, linking images to specimen records and publishing catalog data to the Internet.	Tailored Specify software plus EU BON-supported online tutorial (http://danbif.dk/biodiversitetsdata/specify/ - under development).	The tutorial contains pages explaining about the Specify forms and functions, and user-stories for museum curators and collection managers.	Other users of Specify	Karin / Markus Skyttner Martin Stein/Lotte Endsleff/Isabel Calabuig		A link to the online tutorial should be implemented on the EU BON portal.
(22) raquamaps	Web-enables the R package raquamaps to make it easy to use and	raquamaps is an R package providing some core functionality of the AquaMaps modelling, with	Scientists		Markus Skyttner		https://github.com/raquamaps/mirroreum

Tool name (scientific)	Question(s) it answer(s) / helps answer. Decision(s) it supports.	Product format, and proposed showcase	Direct audience/user	Indirect audience/user	Lead person	Partners	Comments
	convenient to access	the intent to speed it up and make it easier to automate etc and also provide it in an open source format, following these best practice guidelines: http://r-pkgs.had.co.nz/					
(23) PlutoF	PlutoF provides cloud database and computing services for the biology and related disciplines. The purpose of the platform is to provide synergy through common modules for the taxon occurrences, classifications, geography, projects, agents, analytical tools, etc.	Database, workbench, public API for custom applications Citizen science module example of a project public output https://plutof.ut.ee/#/citizen-science-projects/loodusheli	Researchers	Citizen scientists,	Urmas Kõljalg		
Tool name (scientific)	Question(s) it answer(s) / helps answer. Decision(s) it supports.	Product format, and proposed showcase	Direct audience/user	Indirect audience/user	Lead person	Partners	Comments

Other tools to be considered for inclusion in the "products table":

- the **European Biodiversity Portal** (EBP) - WP2. Focal point: Hannu Saarenmaa.
- **PlutoF**. Focal point: Veljo Runnel. Citizen science content mobilised through the PlutoF platform by the University of Tartu, registered and then indexed (in near real time) in GBIF (operational: http://www.gbif.org/dataset/169fa761-2fb9-4022-93bd-e22b7a062efd)
- **GBIF IPT 2.3 and revised data standard (extended Darwin core data standard** for (time-series) monitoring data). Could be promoted to the EEA as a means to mobilise data collected by Member States under the Birds and Habitats directives. Seems relevant to WWF's Living Planet Index (which is used as indicator for tracking progress of Aichi target 12). Focal point: Tim Robertson.
- **Virtual ecologist**, an R package to optimise monitoring schemes using the right balance of volunteer/paid observers. Focal point: Guy Peer.
- **Cartogram**, a tool to visualize and communicate surveying effort and available data across the EU. Focal point: Duccio/Carol.

- An index of species richness (i.e. biotic diversity), based on remotely-sensed data ("Reflectance: **diversity measures of heterogeneity**"), a tool that Provides a remotely-sensed correlate of biotic diversity [It calculates local (alpha) diversity and spatial turnover (beta diversity) in reflectance data]. Focal point: Duccio/Carol.

Product list for WP1/2 (as prepared for the Granada third stakeholder roundtable, December 2015):

EU BON products (WP1-2)

	Data mobilization (WP1)	**Data integration and interoperability (WP2)**
Guidelines, best practices, reports	• Gap analysis and priorities for filling identified gaps in data coverage and quality • Summary report and strategy recommendations for EU citizen science gateway for biodiversity data • Summary report of operational EU BON services and data provision for the European taxonomic backbone	• Architectural design, review and guidelines for using standard • Review and specification of data sharing tools • EU BON / GBIF primer for sample based data
Development and updates	• EU BON taxonomic backbone and services prototype integrated in EU BON portal • Prototype (alpha version) of citizen science gateway	• Five new Darwin Core terms for sample based data • EBV data flow visualisation
Sustainable infrastructure	• DINA – Specify. Collection Management Software and technological infrastructure • PlutoF- Platform for biodiversity data management • Pan-European Species directories Infrastructure, Euro+Med Plantbase, Fauna Europaea	• EU BON / GBIF data hosting service • EU BON / GBIF registry system • EU BON helpdesk
Software and tools	• DINA web system • Unified Taxonomic Information Service • JACQ staging area • PlutoF citizen science module	• GBIF Integrated Publishing Toolkit for quantitative data • European Biodiversity Portal • GoldenGate Imagine tool for text mining
Datasets	• Global DNA reference datasets for fungi - UNITE • Collection datasets through PlutoF platform. • PESI database update in April 2015 • Taxonomic source databases updated • Fauna Europaea: Update vernaculars (> 35 000) • Specimen records via Specifiy	• EuMon extended metadata catalogue • Datasets on the hosting service of EuMon and other sources • Plazi treatment server for published observation records

Product list for WP1/2 (as prepared for the Granada third stakeholder roundtable, December 2015):

Product list (WP4-7)

Analyses of patterns, processes and trends (WP4)

- Guidelines for improving existing monitoring schemes
- Report on biodiversity changes using improved EU data sources
- Road map for the Development of Species Distribution models
- Framework for quantifying and communicating uncertainty in range and trend assessments
- Online guideline for trend analysis (occupancy and abundance)

Testing and validation of concepts, tools, services (WP5)

- Guidelines for establishing BON's
- 'Certificate' for biodiversity observation sites
- D5.3: Evaluation of EU BON information services and the potential to support decision makers

Stakeholder engagement & science-policy dialogue (WP6)

- GeoCAT, an online tool to support IUCN Red List Threat assessments
- Infographic: "What may happen to bony fished in the North Sea"
- Further Infographics e.g. "Roadmap of models"
- AquaMaps visualisation and decision-support tools

Implementation of GEO BON: strategies and solutions at European and global levels (WP7)

- Recommendations for integrated national / regional biodiversity recording/monitoring schemes and information infrastructures (BIFS / BONS), including business plan – at least for Europe
- Blueprint for a global biodiversity monitoring scheme / infrastructure (GEO BON)

6. Products implementation plans

(3) Implementation plan for freshwater SDMs product: "How many Barriers are too many for freshwater fish?"

Actions:

- Build a team for implementation (maybe Mathias, Stefan, Evelyn, Corinne, Lauren, Simao… etc.?) Any volunteers?
- Define scope of the product. Currently predictions focus on fish species modelled in the RMO LTER (EU BON test site)
- Identify targeted users: conservationists/managers/policy makers.
- Condense the main story
- Prepare and present results (e.g. similar to previous infographic?)

Aim by end of EU BON:

1. Produce recommendations on barrier quantity and position for all relevant species (Red List + Habitat Directive Annex II & V)
2. Publish results (scientific publication)
3. Scope additional ways of spreading the lessons learnt. How to reach conservationists/managers/policy makers? Help!

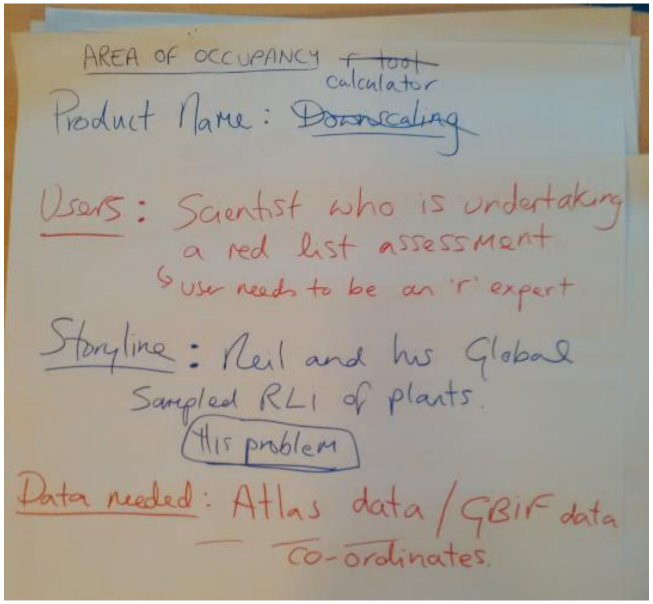
(5) Implementation plan for the AOO [area of occupancy] Calculator:

See Milestone MS653 for latest version of this text

Help them do an EU level assessment based → comparison with the national assessment (serving experts): what the data sources are, what the data limitations are.

SMART actions:

- Simao talk to Kew about the AOO Calculator and about bringing it into GEOCAT in February 2016.
- Bill\Charlie - create 1 page flyer for Kew but that could also be used as a general communication tool for the AOO Calculator. Timeframe: By end of May 2016.
- Bill/Charlie/Neil/ Quentin to create a set of criteria for choosing suitable models for downscaling. This will be done in preparation for the meeting with Kew.
- User survey? Bill/Charlie/Simao to talk to potential users, i.e. Red List assessors. about GEOCAT and the AOO Calculator and make a list of improvements.
- A meeting with Kew, et al. in mid-2016. Bill and Charlie to propose concrete recommendations on best practices…?



Aim by end of EU BON:

1. to have applied criterion B2 to case studies as a showcase of the added value of the AOO Calculator.
2. To have the revised AOO Calculator operational within GEOCAT.
3. (Integration of Aquamaps into GeoCAT with a showcase of a CITES case study. Thereby showing the policy relevance of GEOCAT) - *this is an independant improvement of GeoCAT (see product 4).*

Recommendation: a one-page flyer of each product taking into account attractiveness, feasibility and relevance (to whom and for what).

Improving GeoCat:

- mask out sea
- Time filter

(8) Implementation plan for the AquaMaps Tool - Predicted Distributional Changes to Known Marine Protected Species

Actions:

- Ask for design/usability feedback (internally from WP6 partners) of tool and implement changes and improvements as necessary
- Update species predictions with the latest dataset as it becomes available
- Select a threatened species that could be of specific interest in the near future and publish an infographic that could serve as a showcase for the tool

Aim by end of EU BON:

1. Online tool available (via deep link) through the EU BON portal

(9) Implementation plan for the AquaMaps Tool - Predicted Climatic Impact on Future Community Composition in Large Marine Ecosystems

Actions:

- Update North Sea species counts and maps with the latest dataset as it becomes available (online tool and infographic)
- Review Mediterranean Sea predictions, species counts and maps and produce a similar infographic

Aim by end of EU BON:

1. Online tool available (via deep link) through the EU BON portal

2. Infographics updated and made available through the EU BON portal

(17) Marine Ecological Modelling virtual laboratory: "*introduction of Invasive and Alien Species of Indo-Pacific origin in the Mediterranean*" option

Actions:

- Finalize last details for the set up of the two options of the Ecological Modelling virtual laboratory (v_Lab) (ecosystem modelling, IAS introduction in the Mediterranean)
- Add a showcase narrative under each option

Aim by end of EU BON:

4. Develop the user manuals
5. Make it available through the EU BON portal (develop the appropriate links)
6. Publish results (scientific documents)

(19) Implementation plan for the AquaMaps Tool - MPA Planning Tool

Actions:

- Discuss with WCMC and other partners whether there is interest in this tool and if we should develop/improve it further
- If yes, revisit tool, see where improvements can/should be made, and make necessary changes
- Test tool with intended users

Aim by end of EU BON:

1. An improved MPA Planning Tool available (via deep link) through the EU BON Portal

(20) Implementation plan for the integration of all the developed R scripts to be made available under the online R_vLab

Actions:

- Ask developers for the accreditation they need for their establishments and themselves
- Modify the current policy documents to embrace all desires from the developers so that all terms of use to be clear on the platform
- Parallelize/optimize the R libraries needed for the running of the tools (e.g. SDMs)
- Integrate the new R scripts in the R_vLab
- Debug, where appropriate, and test the speed of the performance

Aim by end of EU BON:

7. Platform available to all potential users, along with the policy document, identifying the terms of its free use
8. Make the online platform available the way it suits EU BON users.

Annex 6. EU BON product list.

The EU BON product list is available below, and is accessible via the beta version of the European Biodiversity Portal at http://beta.eubon.ebd.csic.es/products. This is a list of tools and products produced or improved as part of the European Biodiversity Observation Network (EU BON) project. Products are organised in the following broad categories:

- Data analysis (e.g. R package for SDM)
- Decision-support (i.e. tackling a specific question, database providing digested information/metadata)
- Data management/collection (e.g. for handling, curating, accessing, publishing, managing, sharing, training)

Product name	High-level description	Product format and showcase(s)	Audience / user(s)	Contact(s)	Factsheet included (#)	Status
EuroLST	Fine-scale (250 m) Land Surface Temperature maps allow to create spatially more accurate species distribution models.	**Format:** European-wide continental maps in GIS-ready formats: http://www.geodati.fmach.it/eurolst, http://www.mdpi.com/2072-4292/6/5/3822	**Direct:** Species distribution modelling scientists; GIS analysts. **Indirect:** Other scientists; general public.	Duccio Rocchini (ducciorocchini@gmail.com)	No	Ready
Fourier Transform	Uses remotely-sensed landscape fragmentation data for monitoring ecosystem condition (e.g., extent of deforestation, forest degradation).	**Format:** Methodology	**Direct:** Scientists. **Indirect:** Agencies (e.g., EEA) needing to assess ecosystem condition in the context of the EU Biodiversity Strategy.	Duccio Rocchini (ducciorocchini@gmail.com)	No	Ready
Freshwater Species Distribution Model Ensemble	Supports decision-making on where river barriers should be removed to reduce impacts to threatened species (e.g., lamprey).	**Format:** Methodology **Showcase:** Case study for one catchment in Germany.	**Direct:** River basin managers; freshwater conservation biologists. **Indirect:** Habitat Directive or Water Framework Directive Secretariats.	Mathias Kuemmerlen (mathias.kuemmerlen@senckenberg.de)	No	Ready but not stand-alone
Hierarchical RandomForest Habitat Classification	Machine-learning classification that accounts for the hierarchical structure of habitats, providing a cost-effective way to improve the classification accuracy.	**Format:** R package (*HieRanFor*)	**Direct:** Scientists working on national or international habitat classification schemes (e.g., EUNIS). **Indirect:** Government agencies and policy-level users (e.g., EEA) dealing with habitat classification.	Yoni Gavish (Gavish.Yoni@gmail.com)	Yes (9)	Ready
Alpha-adjusted Species Distribution Model	Model that accounts for the number of species a site can support (alpha diversity) and the suitability of the sites to the focal species, relative to its suitability to other species.	**Format:** R script	**Direct:** Species distribution modelling scientists. **Indirect:** Conservation planners using output maps.	Yoni Gavish (Gavish.Yoni@gmail.com)	Yes (11)	Ready

Product name	High-level description	Product format and showcase(s)	Audience / user(s)	Contact(s)	Factsheet included (#)	Status
Species Distribution Model Profiling	Spatially-explicit evaluation tool for species distribution modelling that helps identify new monitoring sites that are most likely to increase the accuracy of predicted distributions for a species of interest.	**Format:** R package	**Direct:** Scientists; monitoring programme managers.	Yoni Gavish (Gavish.Yoni @gmail.com)	Yes (4)	Ready
Hybrid Species Distribution Models	A set of four hybrid species distribution models—each with different assumptions, emphasis, and data requirements—that account for environmental heterogeneity and spatial aspects (e.g., dispersal limitation, spatial autocorrelation) to increase the accuracy of predicting species distributions and operate at various spatial resolutions.	**Format:** R package (*downscale*)	**Direct:** Scientists **Indirect**: Policy-level audience needing to report on species occurrence in the absence of observed data.	Yoni Gavish (Gavish.Yoni @gmail.com)	Yes (3)	Ready, but requires testing
Population downscaling tools	Set of 10 models that predict the number of occupied sites at fine resolution from coarse-scale atlas data.	**Format:** R package	**Direct:** Scientists **Indirect** Policy-level audience needing to report on status and trend of the area of occupancy of species.	Charlie Marsh (charliem2003 @gmail.com)	No	Ready
Diversity upscaling tools	Advanced methods to predict the number of species in a large area of interest from a limited number of fine-scale samples taken from within the area.	**Format:** R package	**Direct:** Scientists **Indirect:** Policy-level audience needing to report on species richness at landscape and regional scales.	Yoni Gavish (Gavish.Yoni @gmail.com)	No	Some methods ready; some require further work

Product name	High-level description	Product format and showcase(s)	Audience / user(s)	Contact(s)	Factsheet included (#)	Status
VirSysMon (Virtual Systematic Monitoring)	VirSysMon is a cost-efficient tool for optimizing systematic monitoring schemes based on a Virtual Ecologist approach. It allows testing, optimizing, and demonstrating the cost-efficiency of voluntary versus paid-expert monitoring toward higher quality, greater trust and support. The idea is to mimic the sampling behaviour of alternative observers, and thereby assess the potential influence of observers on monitoring outcomes (e.g. data quality, abundance estimates, or chances of identifying the status and trends of species and communities). Spatially explicit, individual-based simulation models are used to create 'virtual reality' as a baseline to which model results are compared. We consider two types of observers: volunteers versus paid observers. Key parameters explored are sampling area, detection probability, identification error, habitat preferences (of observers), sampling frequencies within and between years, missed visits, and costs.	**Format:** R package **Showcase:** A set of virtual species simulated over 50 years (using RangeShifter) and re-sampled by volunteers versus paid experts.	Scientists wishing to assess alternative sampling designs and intensity, optimise or improve scheme designs, or demonstrate the value of voluntary monitoring.	Guy Pe'er (guy.peer@ufz.de), Ferdinand Schirrmeister	No	Ready
R virtual laboratory (R vLab)	Supports and integrated and optimized (with respect to computational speed and data manipulation) online R environment. vLab allows for a predefined, commonly used set of R functions to run on the LifeWatch Infrastructure in order to support large-scale computational and modelling activities.	**Formats:** Online platform allowing users to run R scripts (R_vLab of LifeWatchGreece at https://rvlab.portal.lifewatchgreece.eu/). Also available as a mobile app.	**Direct:** Scientists	Christos Arvanitidis; Anastasis Oulas	Yes (19)	Ready
rAquaMaps	A set of tools that make it easier to produce AquaMaps outputs (model-based, large-scale predictions of natural occurrences of marine species).	**Format:** R package available at: https://github.com/raquamaps/raquamaps	**Direct:** Species distribution modelling scientists.	Markus Skyttner	No	Ready
AquaMaps' Create-Your-Own-Map tool	A web-interface tool linked to an AquaMaps species distribution map that allow species experts to edit an erroneous map, and re-generate and publish an improved version of it. Pop-up user guide included.	**Online tool:** http://www.aquamaps.org/eubon/home.php, and http://www.aquamaps.org	**Direct:** Scientists; graduate students with expertise on a species or group of species.	Kathleen Reyes; Cristina Garilao	Yes (12)	Ready

Product name	High-level description	Product format and showcase(s)	Audience / user(s)	Contact(s)	Factsheet included (#)	Status
Diversity calculator	A tool for calculating alpha and beta diversity from a large stack of gridded maps (large in extent and high in resolution, resulting in a high number of grid cells).	Currently available as stand-alone software, but transformation into an R package to be used in the Rvlab is under way.	**Direct:** Scientists (species distribution modelling; macroecology; biogeography).	Johannes Penner	No	Beta version – still being refined
SDM Communication Toolbox	This toolbox includes three resources that explain the value of species distribution models (SDMs) to different audiences: • "Roadmap to SDMs"; • "Value of SDMs to decision/policy-makers; • "From SDMs to policy (applications of SDMs to EU relevant policy)."	**Formats:** PDF document and infographics.	**"Roadmap to SDMs":** Scientists (species distribution modellers; macroecologists; biogeographers). **"Value of SDMs to decision- and policy-makers"** and **"From SDMs to policy":** Policy- and decision-makers, or scientists seeking to communicate the value of their SDMs to these audiences.	**"Roadmap to SDMs":** Duccio Rocchini; Carol Garzon **"Value of SDMs"/"From SDMs to policy":** Sarah Darrah; Corinne Martin	In preparation	In preparation
GeoCAT	Browser-based tool that performs rapid geospatial analysis to ease the process of Red Listing taxa (threat assessments).	**Online tool:** Geospatial tool (http://geocat.kew.org)	**Direct:** IUCN expert groups (particularly non-technical members). **Indirect:** Convention on Biological Diversity Secretariat.	Simão Belchior	Yes (2)	Ready, but being improved
AquaMaps for EU BON Interface	Explore and download data for modelled species distributions of European marine and freshwater species.	**Online tool:** http://www.aquamaps.org/am_eubon/ (marine) and http://www.aquamaps.org/am_europe / (freshwater)	**Direct:** Students, scientists, conservation planners, and NGOs.	Kathleen Reyes; Cristina Garilao	Yes (5)	Ready
Possible climate change impact on the spatial distributions of threatened species	This tool illustrates how the (modelled) spatial distributions of IUCN red listed species may change, based on IPCC A2 emissions scenario.	**Online tool:** http://www.aquamaps.org/am_eubon/otherspecieslist.php?type=threatened	Policy-level users; general public.	Kathleen Reyes; Cristina Garilao	Yes (6)	Ready
Possible climate change impact on bony fish diversity in Large Marine Ecosystems	This tool illustrate the possible climate change impact on bony fish community composition, for a number of EU-relevant LMEs.	**Online tool:** http://www.aquamaps.org/am_eubon/SpecRichLME.php **Infographic**: http://wcmc.io/North-Sea.	Policy-level users; general public.	Kathleen Reyes; Cristina Garilao	Yes (7)	Ready

Product name	High-level description	Product format and showcase(s)	Audience / user(s)	Contact(s)	Factsheet included (#)	Status
Marine Ecological Modelling virtual laboratory: ecosystem modelling	Provides information on the ecological status of water bodies, based on various indices related to the implementation of the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD). Provides decision-support for when to open channels of communication between lagoons and open sea based on predicted oxygen depletion rates.	**Format:** Graphic User Interface (GUI) with visualization maps **Showcases:** four in total (Greece and Cyprus), including the study site of the Amvrakikos Gulf lagoons.	Environmental managers (management authorities), policy-level users, scientists, students, citizen-scientists.	Christos Arvanitidis (on behalf of Alkis Kalabokis, Manolis Potiris, and George Petihakis)	Yes (18)	Ready
Marine Ecological Modelling virtual laboratory: alien and invasive species	Provides information on the geographic location of alien and invasive species of Indo-Pacific origin found in the Mediterranean sea, along with likely spread under climate change and maritime traffic scenarios. It is based on the BioVel Workflows.	**Format:** Maps of probability of occurrence.	Environmental managers (management authorities), policy-level users (MSFD Descriptor 2), scientists, students, citizen-scientists	Christos Arvanitidis (on behalf of HCMR, FIN, and the University of Gothenburg). Not a direct EU BON product.	No	Workflow in preparation
DaEuMon, BioMAT, and PMN: Toolbox on biodiversity monitoring in Europe	**DaEuMon** provides metadata of habitat and species monitoring schemes in Europe covering the terrestrial, freshwater and marine realms (the later added only recently). Currently more than 600 schemes are included. Among other information, data on habitat/taxa coverage, spatial and temporal coverage, effort, design and costs are provided. **BioMAT** is a search and graphical display tool that provides an overview of monitoring schemes in Europe and their characteristics. Search options are available to extract schemes that fulfil particular criteria, e.g. launching reason and coverage of Natura 2000 issues. The **Participatory Monitoring Networks (PMN) database** is comprised of monitoring organisations and their characteristics (e.g., organisation structure, recruitment and maintenance of members, data sharing).	**DaEuMon:** Online portal accessible via http://eumon.ckff.si/about_daeumon.php. **BioMAT:** http://eubon.ckff.si/biomat. **PMN-database:** http://eumon.ckff.si/wp1/wp1.php	**Direct:** Coordinators of monitoring schemes, nature conservation administrations, conservation biologists, and any person interested in finding out what is done in biodiversity monitoring within Europe. **Indirect:** European agencies involved in implementing Marine Strategy Framework Directive and Habitats Directive.	Klaus Henle, Dirk Schmeller	Yes (15, 16)	Ready

Product name	High-level description	Product format and showcase(s)	Audience / user(s)	Contact(s)	Factsheet included (#)	Status
Cartograms to represent spatial uncertainty in species distribution	Provides guidance regarding appropriate models to use for different levels of inputs, offering a workflow (assumptions, limitations, required data, scale, etc.).	**Format:** Methodology. **Showcase:** infographic (/ policy briefing?)	**Direct:** Scientists/ researchers **Indirect:** Policy-makers	Duccio Rocchini (ducciorocchini@gmail.com)	Yes (10)	Ready
List of research infrastructures, portals and data providers	Lists and provides high-level information (brief description, datasets provided, type, user groups, institution/location, partners, hyperlink) on research infrastructures, initiatives, portals and data providers from the global, regional and national levels. Linking and mapping networks and initiatives with metadata.	Format: metadata list, and possible showcase.	**Direct:** Data users in various forms (creators, curators, managers, scientists, etc.) **Indirect**: Policy-level users wishing to gain an understanding of the biodiversity informatics landscape.	Florian Wetzel, Corinne Martin, Heather Bingham, Katherine Despot-Belmonte, Lauren Weatherdon	In progress	In preparation
EU BON Biodiversity Portal	Links to relevant databases and information systems, and structured advice for assessing relevant distributed information/datasets for different user groups, including contributions from citizen science data gathering gateways. Technically integrates various data sources under one search facility and spatially/temporally oriented user interface. The portal will also act as showcase for the various EU BON products.	Online platform (in development, http://test-eubon.ebd.csic.es).	**Direct:** Scientists, citizen-scientists, data creators/managers/curators. **Indirect**: Environmental managers, policy-level users.	Hannu Saarenmaa; Antonio Garcia Camacho	No	Beta version
Data mobilisation and curation with PlutoF	Allows users to create, manage, share, analyse and publish biology-related databases and projects, in a cloud environment.	**Online platform**: https://plutof.ut.ee	Data owners, managers, or curators.	Urmas Koljalg	Yes (1)	Ready
Mobilisation of specimen data	Easy-to-use import tool for the mobilisation of specimen data (e.g. middle sized and private collection data). Data can be imported using custom template files (https://plutof.ut.ee/#/import), and are fully manageable through the PlutoF cloud after upload. Uploaded specimen data can be automatically released to GBIF, published with DOI, or sent to the Pensoft journal manuscript editing tool	**Online platform**: https://plutof.ut.ee	Collection owners, such as institutions, researchers and citizen scientists.	Urmas Koljalg	No	Ready

Product name	High-level description	Product format and showcase(s)	Audience / user(s)	Contact(s)	Factsheet included (#)	Status
Taxonomy module	Provides an online workbench for managing multiple biological classifications in the same system. Fully implemented on the PlutoF platform. Taxon occurrences may be identified and linked to taxon names in several classifications. Additional functionalities include taxon name search, RESTful API, and importing taxon names from GBIF	Online service provided by PlutoF platform. Stand-alone version with base support (database and web services) also available as a separate package at https://github.com/TU-NHM/plutof-taxonomy-module.	Scientists, workgroups developing classifications and taxonomic databases. Database developers who need taxon names and classifications as data anchors.	Urmas Koljalg	No	Ready
GoldenGate Imagine	Allows semiautomatic, interactive extraction (text mining) of taxonomic treatments, scientific names, named entities, bibliographic references, and observation data from taxonomic publications (example of an article on dragonflies)	**Open source desktop software:** http://plazi.org/resources/treatmentbank. Online version in preparation. **Showcase:** extracted research data can be visualised as a dashboard.	Scientists; citizen scientists.	Donat Agosti	Yes (8)	**Software:** Ready. **Online:** In progress.
DNA based species hypotheses	Provides access to datasets for the identification of eukaryotic species from any biological samples based on rDNA ITS sequences. These can be utilised in Sanger-based, as well as in High Throughput Sequencing (HTS), projects. Datasets are available through the HTS pipelines like QIIME, mothur, CREST, UCHIME, etc. or can be downloaded for the in-house analyses.	**Online platform:** https://unite.ut.ee/repository.php	Scientists and stakeholders whom identify species from environmental samples.	Urmas Koljalg	No	Ready
PlutoF/Pensoft automated workflow	Provides a direct connection between PlutoF's databases and Pensoft's ARPHA writing tool. It allows users to import their data from PlutoF's databases directly into online Pensoft journal article in a dynamic and seamless way.	Online solution available through https://plutof.ut.ee and http://arpha.pensoft.net/	PlutoF users whom would like to publish their data and datasets in Pensoft journals.	Urmas Koljalg	No	Ready
Citizen Science project management tool	Allows users to manage and optimize citizen science workflow by working with contributors who collect, analyse and publish data. PlutoF's workbench provides an integrated solution for creating data forms, reaching out for contributors and moderating observation data. The tool also allows to work with specimen data, e.g. digitising specimen information from labels.	**Format**: Citizen science module. **Showcase:** Example of a project public output https://plutof.ut.ee/#/citizen-science-projects/loodusheli	**Direct:** Citizen scientists; scientists who collaborate with citizen scientists in order to collect data and samples. **Indirect:** General public; government agencies.	Veljo Runnel (Veljo.Runnel@ut.ee)	No	Ready

Product name	High-level description	Product format and showcase(s)	Audience / user(s)	Contact(s)	Factsheet included (#)	Status
Training packs	Provides detailed, practical information on how to use and implement data tools designed by EU BON and its associated partners.	Accessible online as PowerPoint presentations and complementary training content, such as videos via the EU BON Helpdesk: http://eubon.cybertaxonomy.africamuseum.be/past-trainings.	All scientists, IT professionals, students and other people working with biodiversity data.	Patricia Mergen (patricia.mergen@africamuseum.be)	Yes (17)	Ready
Mirroreum	A platform for authoring and publishing “Reproducible Open Research”, so that researchers are able to share and collaborate at all steps in the research chain, i.e., from raw data to scientific knowledge dissemination, using R packages produced within EUBON. Reproducibility allows for researchers and users of the outputs to focus on the actual content of a data analysis, rather than on superficial details reported in a written summary. In addition, reproducibility makes an analysis more useful to others because the data and code that actually conducted the analysis are available.	Docker-Compose app available at: https://github.com/raquamaps/mirroreum.	**Direct:** Scientists wishing to make their research more transparent. **Indirect:** Policy-level audience (e.g., IPBES Task Forces) wishing to ensure that scientific work used in policy is transparent and reproducible.	Markus Skyttner	Yes (13)	Ready
Extended Darwin Core for sample data	Extension of an existing and widely used data standard so as to handle sample-based datasets and hence trends, e.g. time series collected using standardised protocols, abundance data from monitoring activities.	**Format:** Extended data standard. **Showcase:** Online discovery tool for datasets of interest for developing Essential Biodiversity Variables (EBVs) - species distribution and population abundance (http://eubon-ebv.gbif.org, http://geobon.org/essential-biodiversity-variables/what-are-ebvs/, http://test-eubon.ebd.csic.es/web/eu-bon-biodiversity-portal/ebv-population-browser).	**Direct:** Scientists; data creators, managers or curators. **Indirect:** Policy-level users (as essential biodiversity variables can form the basis of indicators).	Tim Robertson	No	Ready

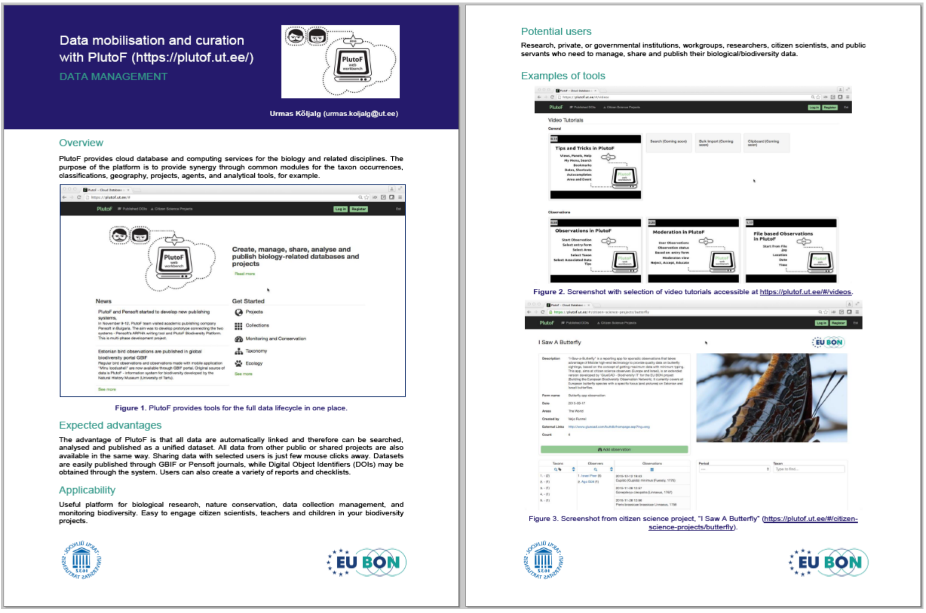
Product name	High-level description	Product format and showcase(s)	Audience / user(s)	Contact(s)	Factsheet included (#)	Status
Data publishing and dissemination toolbox	Set of standards, guidelines, recommendations, workflows and tools designed to ease scholarly publishing of biodiversity-related data, which are of primary interest to EU BON and GEO BON network. Compatible with GBIF IPT, DataONE, iDigBio, PlutoF, BOLD and any other platform supporting EML and Darwin Core standards.	Online tool (in development).	Scientists; data owners, managers, or curators.	Lyubomir Penev (penev@pensoft.net)	Yes (14)	In preparation
ARPHA DwC Archive export plugin	Articles published via the ARPHA platform and associated Biodiversity Data Journal (BDJ) have a Darwin Core Archive export functionality, which allows for direct import of an article's underlying specimen records in GBIF.	**Showcase:** http://bdj.pensoft.net/articles.php?id=7975&display_type=list&element_type=5		Lyubomir Penev (penev@pensoft.net)	Yes (14)	Ready
Create a data paper from metadata "at the click of a button"	Articles published via the ARPHA platform benefit from an easy creation of data paper manuscripts from EML metadata stored in GBIF IPT, LTER and DataONE.	**Format and showcase:** http://arpha.pensoft.net/tips/?tip=24 http://arpha.pensoft.net/tips/?tip=25 http://arpha.pensoft.net/tips/?tip=26 http://blog.pensoft.net/2015/10/13/a-data-paper-at-the-click-of-a-button-streamlining-metadata-conversion-into-scholarly-manuscripts-for-gbif-and-dataone-data/		Lyubomir Penev (penev@pensoft.net)	Yes (14)	Ready
Plugin for direct online import of specimen records into manuscripts from GBIF, BOLD, iDigBio and PlutoF.	Authors can import occurrence records in articles created in ARPHA via Excel spreadsheets or directly from GBIF, BOLD, iDigBio and PlutoF.	Format and showcase: http://arpha.pensoft.net/tips/?tip=28 http://arpha.pensoft.net/tips/?tip=30 http://arpha.pensoft.net/tips/?tip=31 http://arpha.pensoft.net/tips/?tip=32 http://arpha.pensoft.net/tips/?tip=33 http://blog.pensoft.net/2015/10/20/streamlining-the-import-of-specimen-or-occurrence-records-into-taxonomic-manuscripts/		Lyubomir Penev (penev@pensoft.net)	Yes (14)	Ready

Product name	High-level description	Product format and showcase(s)	Audience / user(s)	Contact(s)	Factsheet included (#)	Status
Novel IUCN-compliant article templates: Species Conservation Profiles (SCP) and Alien Species Profile (ASP)	Authors using the ARPHA Writing Tool can work collaboratively on their Species Conservation Profiles (SCP) and Alien Species Profiles (ASP), peer-review and publish them as citable scholarly articles.	http://bdj.pensoft.net		Lyubomir Penev (penev@pensoft.net)	Yes (14)	Ready
TreatmentBank	Treatment Bank is a resource that stores and provides access to the taxonomic treatments, observation records, and data therein provided from taxonomic publications using, among other tools, Golden Gate.	**Format:** Online (http://TreatmentBank.org)	All with interest in taxonomic treatments of a particular name usage. GBIF, NCBI, EU BON taxonomic backbone. Contributes to audiences interested in new names and observation records from published records.	Donat Agosti (agosti@plazi.org)	Yes (8)	Ready
EU BON Taxonomic Backbone	The EU BON Taxonomic Backbone allows federated searches on multiple European checklists, returning a unified set of individual responses of various checklists. UTIS connects to the web services of the Pan-European Species Directories Infrastructure (EU-Nomen), EUNIS, which fully covers Natura 2000. Therefore, UTIS can be used in full compliance with Appendix 3 of the INSPIRE directive. Furthermore, it connects to the Catalogue of Life (CoL) and the World Register of Marine Species (WoRMS).	http://cybertaxonomy.eu/eu-bon/utis/1.2/ http://cybertaxonomy.eu/eu-bon/utis/1.0/		Andreas Kohlbecker (a.kohlbecker@bgbm.org)	No	Ready

Product name	High-level description	Product format and showcase(s)	Audience / user(s)	Contact(s)	Factsheet included (#)	Status
Mobile App tools for citizen science butterfly sightings, which implement PlutoF's API for observation reporting.	"I-Saw-a-Butterfly" is a reporting app for **sporadic observations** that takes advantage of Mobilehigh-end technology to provide quality data on butterfly sightings, based on the concept of getting maximum data with minimum typing. Developed by GlueCAD the app aims at citizen science observers (Europe and Israel). It currently covers all European day butterfly species with a specific focus (and pictures) on Estonian and Israeli butterflies. A second recording app by GlueCAD for **systematic observations** along fix transects ("BMapp") is currently being tested by INPA with Amazon's frog list and by volunteers of the Israeli National Butterflies Monitoring Scheme.	**Format:** Mobile application packages. "I-Saw-a-Butterfly" is freely available for the public on Google Play.	Scientists; citizen scientists; data creators.	Israel Peer (Israel@gluecad.com)	Yes (1)	The first mobile app is ready, while the second is in testing.

Annex 7. EU BON product factsheets.

Factsheets are accessible via the beta version of the European Biodiversity Portal at http://beta.eubon.ebd.csic.es/products.



Data mobilisation and curation with PlutoF (https://plutof.ut.ee/)

DATA MANAGEMENT

Urmas Kõljalg (urmas.koljalg@ut.ee)

Overview

PlutoF provides cloud database and computing services for the biology and related disciplines. The purpose of the platform is to provide synergy through common modules for the taxon occurrences, classifications, geography, projects, agents, and analytical tools, for example.

Figure 1. PlutoF provides tools for the full data lifecycle in one place.

Expected advantages

The advantage of PlutoF is that all data are automatically linked and therefore can be searched, analysed and published as a unified dataset. All data from other public or shared projects are also available in the same way. Sharing data with selected users is just few mouse clicks away. Datasets are easily published through GBIF or Pensoft journals, while Digital Object Identifiers (DOIs) may be obtained through the system. Users can also create a variety of reports and checklists.

Applicability

Useful platform for biological research, nature conservation, data collection management, and monitoring biodiversity. Easy to engage citizen scientists, teachers and children in your biodiversity projects.

Potential users

Research, private, or governmental institutions, workgroups, researchers, citizen scientists, and public servants who need to manage, share and publish their biological/biodiversity data.

Examples of tools

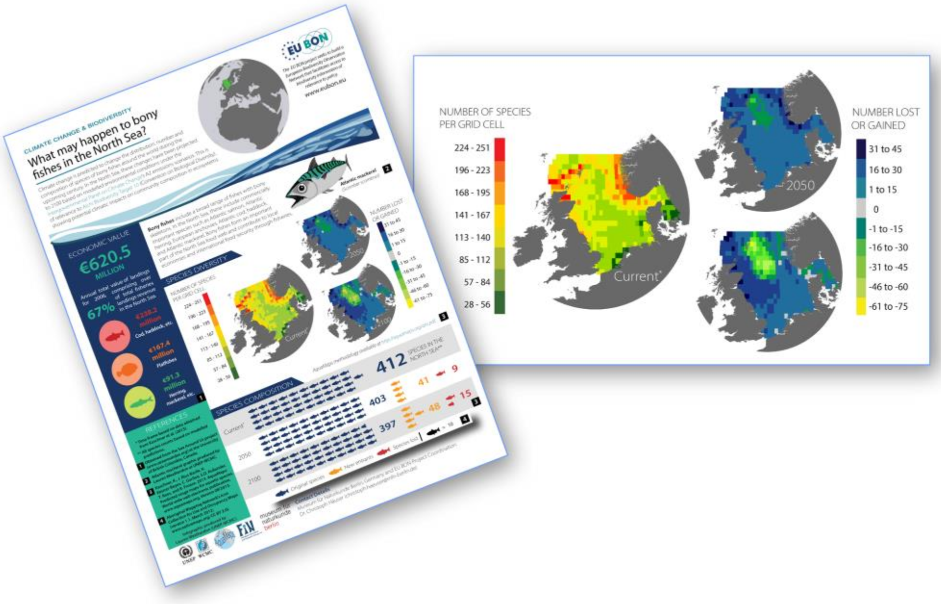
Figure 2. Screenshot with selection of video tutorials accessible at https://plutof.ut.ee/#/videos.

Figure 3. Screenshot from citizen science project, "I Saw A Butterfly" (https://plutof.ut.ee/#/citizen-science-projects/butterfly).

Example factsheet, providing high-level non-technical information on one of EU BON's products.

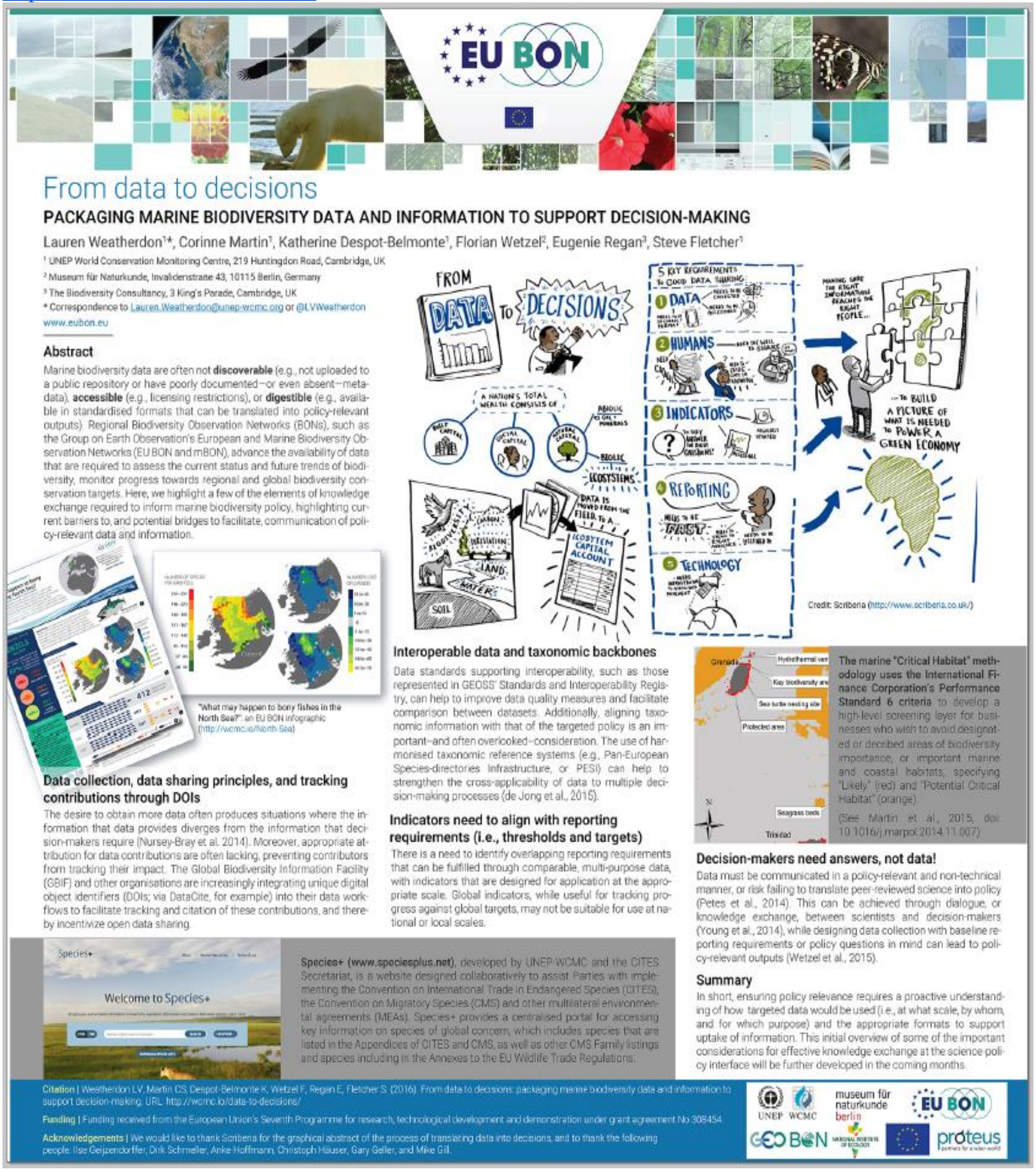
Annex 8. Infographic: *Climate change and biodiversity: What may happen to bony fishes in the North Sea?*

The infographic by Weatherdon (2015), previewed below, can be accessed online at http://wcmc.io/North_Sea_Fishes, and on the Web site of The Parliament Magazine at https://www.theparliamentmagazine.eu/articles/magazines/issue-413-1-june-2015.



Annex 9. Conference poster: *From data to decisions*

The poster by Weatherdon et al. (2016), previewed below, can be accessed online at http://wcmc.io/data-to-decisions.



Annex 10. Report of the first stakeholder roundtable *(Policy requirements)*.

This article by Wetzel et al. (2016) can be accessed online at http://riojournal.com/articles.php?id=8600.

RIO Research Ideas and Outcomes 2: e8600
doi: 10.3897/rio.2.e8600

OPEN ACCESS

Workshop Report

1st EU BON Stakeholder Roundtable (Brussels, Belgium): Biodiversity and Requirements for Policy

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Abstract

The first EU BON Stakeholder Roundtable was held on 18 June 2013 at the Leibniz Association in Brussels, under the motto "Biodiversity and Requirements for Policy". Important topics regarding biodiversity information were discussed with political stakeholders and a variety of valuable recommendations were given for the future process of EU BON in order to improve biodiversity knowledge availability and usability. Among the participants were members of the European policy, representatives of recent European biodiversity projects and EU BON members. At the roundtable, intensive discussions took place regarding what biodiversity policy needs, for example which indicators and measurements are needed to answer policy questions that are related to biodiversity and ecosystems. Suggestions were made to formalize Essential Biodiversity Variables (EBV's) and Aichi targets. A future approach was set towards producing a guideline and timeline for the work on EBVs that should be established within EU BON.

The challenges of future research policy were also discussed and the collaboration of EU BON with the Group on Earth Observations (GEO) will be a substantial part of the continuous contributions to the global process. EU BON should also serve as a showcase for the European Commission in this respect. EU BON also aims to answer crucial questions regarding data policy, e.g. how to establish a general repository for a long-lasting

Annex 11. Report of the second stakeholder roundtable *(Data workflows).*

This article by Vohland et al. (2016a) can be accessed online at http://riojournal.com/articles.php?id=8616.

RIO Research Ideas and Outcomes 2: e8616
doi: 10.3897/rio.2.e8616

OPEN ACCESS

Workshop Report

2nd EU BON Stakeholder Roundtable (Berlin, Germany): How can a European biodiversity network support citizen science?

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Abstract

The second EU BON Stakeholder Roundtable took place on 27 November 2014 at the Museum für Naturkunde in Berlin. The roundtable was dedicated to explore ways in which EU BON can support citizen science (CS) activities. EU BON is building an integrated biodiversity information platform in order to serve science, policy and administration. Also citizen scientists and related projects and networks are important stakeholders. Moreover, citizen scientists can play an essential role for biodiversity networks, as they support the increase of knowledge in the field of biodiversity in various aspects: they may debate research questions, most often they collect data in the field, and they may interpret data and publish their results.

At the stakeholder roundtable in Berlin, various stakeholders from the field of citizen science were invited to discuss possibilities of interactions and the role of EU BON for supporting citizen science on a European scale. EU BON products could help CS stakeholders in various ways, e.g. with tools for the standardization of data and training on widely used and accepted data collection standards, as well as tools for the visualization/

Annex 12. Report of the third stakeholder roundtable *(Citizen science).*

This article by Vohland et al. (2016b) can be accessed online at
http://riojournal.com/articles.php?id=8622.

RIO Research Ideas and Outcomes 2: e8622
doi: 10.3897/rio.2.e8622

OPEN ACCESS

Workshop Reports

3rd EU BON Stakeholder Roundtable (Granada, Spain): Biodiversity data workflow from data mobilization to practice

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Abstract

At the third EU BON roundtable, participants from global, European and regional projects, institutions, governmental organizations and universities met to discuss biodiversity data workflows across different scales and their current limitations. Furthermore, the roundtable focused on tools and products from EU BON and other projects that may help to improve data collection and evaluation. The roundtable, that took place from 10 to 11 December 2015 in Granada, Spain, particularly addressed the EU BON test sites to discuss data mobilization at the site level, workflows of data/information and the further usage for policy reporting and political processes. These issues were discussed with partners from EU BON and related biodiversity projects (LTER, GEO BON, LifeWatch, Ecoscope) and stakeholders of biodiversity data (regional biodiversity networks: the environmental information network of Andalusia (Rediam), the Center for Monitoring and Assessment of Global Change (CAESCG), the Life project ADAPTAMED as well as local scientists).

Annex 13. Project milestone report: *Sectors that benefit from and/or impact on ecosystem services and biodiversity.*

This project milestone report is by Underwood et al. (2016).

Milestone MS641/MS642

Version: 4
Date: 2015-10-26
Author: E. Underwood, R. Ashcroft; A.J. McConville; S. Newman
Document reference: MS641/MS642

Sectors that benefit from and/or impact on ecosystem services and biodiversity: potential contribution to biodiversity data provision and monitoring (M16)

STATUS: FINAL

Project acronym:	EU BON
Project name:	EU BON: Building the European Biodiversity Observation Network
Call:	ENV.2012.6.2-2
Grant agreement:	308454
Project Duration:	01/12/2012 – 31/05/2017 (54 months)
Co-ordinator:	MfN, Museum für Naturkunde - Leibniz Institute for Research on Evolution and Biodiversity, Germany
Partners:	UTARTU, University of Tartu, Natural History Museum , Estonia
	UEF, University of Eastern Finland, Digitisation Centre, Finland
	GBIF, Global Biodiversity Information Facility, Denmark
	UnivLeeds, University of Leeds, School of Biology, UK
	UFZ, Helmholtz Centre for Environmental Research, Germany
	CSIC, The Spanish National Research Council, Doñana Biological Station, Spain
	UCAM, University of Cambridge, Centre for Science and Policy, UK
	CNRS-IMBE, Mediterranean Institute of marine and terrestrial Biodiversity and Ecology, France
	Pensoft, Pensoft Publishers Ltd, Bulgaria
	SGN, Senckenberg Gesellschaft für Naturforschung, Germany
	SIMBIOTICA, Simbiotica S.L., Spain
	FIN, FishBase Information and Research Group, Inc., Philippines
	HCMR, Hellenic Centre for Marine Research, Greece
	NHM, The Natural History Museum, London
	BGBM, Botanic Garden and Botanical Museum Berlin-Dahlem, Germany
	UCPH, University of Copenhagen: Natural History Museum of Denmark, Denmark
	RMCA, Royal Museum of Central Africa, Belgium
	PLAZI, Plazi GmbH, Switzerland
	GlueCAD, GlueCAD Ltd. – Engineering IT, Israel
	IEEP, Institute for European Environmental Policy, UK
	INPA, National Institute of Amazonian Research, Brazil
	NRM, Swedish Museum of Natural History, Sweden
	IBSAS, Slovak Academy of Sciences, Institute of Botany, Slovakia
	EBCC-CTFC, Forest Technology Centre of Catalonia, Spain
	NBIC, Norwegian Biodiversity Information Centre, Norway

FEM, Fondazione Edmund Mach, Italy
TerraData, TerraData environmetrics, Monterotondo Marittimo, Italy
EURAC, European Academy of Bozen/Bolzano, Italy
WCMC, UNEP World Conservation Monitoring Centre, UK
UGR, University of Granada, Spain

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EU BON

EU BON: Building the European Biodiversity Observation Network
Project no. 308454

Large scale collaborative project

MS641/MS642
Sectors that benefit from and/or impact on ecosystem services and biodiversity: potential contribution to biodiversity data provision and monitoring

Milestone number	MS641/MS642
Milestone name	Sectors that benefit from and/or impact on ecosystem services and biodiversity: potential contribution to biodiversity data provision and monitoring
WP no.	WP6 (task 6.4)
Lead Beneficiary (full name and Acronym)	IEEP
Nature	Written report
Delivery date from Annex I (proj. month)	2014-03-31 (M16)
Delivered	Yes
Actual forecast delivery date	2015-08-20
Comments	**MS641** (Sectors for specific stakeholder engagement Identified; M8) and **MS642** (Summary of literature review of monitoring input by user groups to date; M16) were merged to one Milestone (heading see above)

Name of the Authors	**Name of the Partner**	**Logo of the Partner**
Rob Ashcroft; A.J. McConville; S Newman; E Underwood	Institute for European Environmental Policy (IEEP)	
Acknowledgements of reviews and improvements from:	Ilse Geijzendorffer Corinne Martin Dirk Schmeller	

In case the report consists of the delivery of materials (guidelines, manuscripts, etc)

Delivery name	**Delivery name**	**From Partner**	**To Partner**

MS641/642 Sectors that benefit from and/or impact on ecosystem services and biodiversity: potential contribution to biodiversity data provision and monitoring

Summary of the Milestone

The EU BON project has identified a need to improve the coverage and integration of biodiversity observation systems and environmental datasets in the EU, in order to strengthen the implementation and analysis of environmental policies (Hoffmann et al., 2014). In order for the EU environmental policy framework to be effective, policy-makers require information on the progress towards policy objectives related to biodiversity.

EU BON aims to improve knowledge and methods for linking biodiversity and environmental data, provide mechanisms for delivering integrated biodiversity information needed to meet specific tasks, develop frameworks and strategies for next generation management and use of biodiversity information at national and regional levels, and design concepts for sustaining integrated environmental information systems with the active participation of scientists, citizens, business and industry. This milestone contains a scoping study of some beneficiaries of ecosystem services within the EU in order to investigate their potential role in the mobilization, collation and use of biodiversity data to inform policy in the EU. It combines both **MS641** and **MS642** milestones as the document contains both the analysis of the main beneficiaries of ecosystem services and biodiversity (MS642) (see Chapter 3) and the identification of sectors for specific stakeholder engagement (MS641) (see Chapter 4 part 1). As the sector identification was carried out on the basis of the analysis, it did not make sense to separate them into two documents. .

Introduction

This work contributes towards the deliverable D6.2 which is to be produced by month 46 as a policy paper on strategies to overcome the barriers for data mobilisation and use in conservation policy. The objective of the literature review and scoping study is to identify which beneficiaries of ecosystem services have the greatest potential to input and deliver monitoring of biodiversity. The next phase of the work will investigate a limited number of sectors in more detail.

Progress towards objectives

A literature review provides the basis on which to identify the sectors with the highest potential to contribute to biodiversity data provision and monitoring, by providing data and/or by financial contributions to facilitate biodiversity data provision. We examined the scale and nature of the sector dependency in relation to the motivation of the sector to contribute to conservation of the ecosystem service and its underlying biodiversity, the species and habitats on which the ecosystem service relies, any negative impacts of the sector on species and habitats, and any existing data collection and monitoring carried out by the sector in this area. The review examines the extent to which biodiversity data is already curated and made available by the sector due to policy reporting obligations or own initiatives, and also provides an indication of the extent of the likely motivation of the sector to engage in biodiversity data mobilisation and collection. We prioritize **four sectors** on their use of biodiversity data and their potential to contribute to biodiversity data provision and monitoring. These are **i)** farmers and agricultural organizations, **ii)** hunters and hunter groups, **iii)** anglers and angling groups, and **iv)** planning authorities and developers (e.g. the construction industry). The review also identifies some key barriers and opportunities to increased biodiversity data mobilization from these sectors, as well as the increased involvement of the sectors in the utilization of biodiversity data.

Conclusions and further developments

The next stage of the work will focus on policy-makers as key users of the EU BON data portal. The policy-makers are defined as public authorities who use biodiversity data to design, target, implement and assess policy at the regional and national level. The analysis will build on the current review by focusing on the agricultural sector, the development sector, and the freshwater sector, with focus on biodiversity data use by the following **policy groups**:

- Agricultural rural development programming agencies
- Local planning authorities and developers
- River basin management committees

Contents

1. Overall aim and context

The EU BON project has identified a need to improve the coverage and integration of biodiversity observation systems and environmental datasets in the EU, in order to strengthen the implementation and analysis of environmental policies (Hoffmann et al., 2014). EU policy has played an important role over the past 30 years in requiring Member States to take stronger measures to protect their habitats and species. In order for this policy framework to be effective, policy-makers require information on what progress has been made towards policy objectives. Information on biodiversity is required to assess the effectiveness of specific policy interventions and improve their design and targeting. Information on biodiversity is also required to assess the baseline situation, existing pressures, and emerging threats, and to build the evidence base for new policy interventions.

EU BON aims to improve knowledge and methods for linking of biodiversity and environmental data, provide mechanisms for delivering integrated biodiversity information needed to meet specific tasks, develop frameworks and strategies for next generation management and use of biodiversity information at national and regional levels, and design concepts for sustaining integrated environmental information systems with active participation of citizens, business and industry.

Opportunities exist to enhance the collection and mobilization of data on biodiversity and ecosystem services from stakeholders who benefit directly because they have a high dependency on ecosystem services and/or biodiversity to maintain their business model. This component of the EU BON project aims to identify those users of biodiversity and ecosystem services with the most potential for provision of biodiversity data, on the basis of the scale and nature of their dependency, the species and habitats on which the dependency relies, and the existing monitoring carried out by the sector in this area. The review also identifies the existing and emerging policy processes that stakeholder groups are most likely to be able to feed into. Some stakeholders are already contributing to monitoring and data provision at the EU level because of legal obligations, whilst others could provide added value through integration into the EU BON portal. The motivation of stakeholder groups as biodiversity information users to financially contribute to the provision of biodiversity data is also considered.

Dependency is interpreted broadly as the benefits obtained from the ecosystem service or services and associated biodiversity, and includes not only financial benefits but also other societal benefits such as recreational values. The interests and incentives of different sectors with regard to biodiversity data will differ according to which ecosystem services they depend on. The review assumes that it is in the interests of beneficiaries of ecosystem services to adopt a long term sustainable business model that conserves the natural resources from which the services are derived, including an interest in better knowledge and data on the natural resources and/or services. This assumption is supported by the increasing business interest in ecosystem services (Waage and Kester, 2014). However, it is recognized that some businesses are still interested in 'hiding' unsustainable environmental practices by not participating in knowledge or data sharing, or regard biodiversity only as an external constraint on business activities (Houdet et al., 2012). There is an expectation that those who benefit from biodiversity should be contributing to monitoring and policy implementation, but this is not always happening. More importantly, beneficiaries of ecosystem services may adopt practices that boost the service provision whilst having negative impacts on other ecosystem functions and biodiversity, such as the practice of stocking non-native fish. These practices and impacts are also considered in the review.

It is also important to note that the relationship between ecosystem services and biodiversity is multi-layered (Mace et al., 2012), and still a subject of scientific debate (Harrison et al., 2014). Some ecosystem services are inherently less dependent on particular species and rely more broadly on ecosystem structure and functions, whilst for some ecosystem services, the role of biodiversity is yet not clearly defined. As a general rule, ecosystem services rely on ecosystem functions and/or a core group of more common species, whilst rare and threatened species only contribute to ecosystem services in very localised areas and situations, so conserving ecosystem services does not necesarily correspond to conserving biodiversity. We therefore reviewed for each sector both the key species linked to beneficial and negative impacts, and the importance for the sector of information about key habitats and environmental information more widely.

2. Methodology

This report is based on a literature review to identify the sectors with the greatest potential to provide policy-relevant biodiversity data in Europe because of the impacts of biodiversity on their business or interests. The following steps were carried out:

1. *Selection of an ecosystem service categorisation most appropriate for the identification of stakeholder dependencies on ecosystem services*. The CICES classification (EEA, 2014) was selected because it was developed for use in natural capital accounting and is designed to avoid double counting by avoiding overlapping ecosystem service categories. As argued by Mace et al. (2012), biodiversity indicator development can benefit from being informed by natural capital accounting. Ecosystem services are defined so as to exclude the production and/or use of domesticated or non-native resources (e.g. crops, livestock and domesticated bees, aquaculture, plantations, mass-released predators) in order to focus on those services that directly depend on native biodiversity and ecosystems. Therefore some ecosystem services in the CICES classification were excluded from the analysis, and some ecosystem services are defined so as to exclude certain resources. The final list of ecosystem services is in the table in **Annex 1**.

2. *Identification of the beneficiaries of ecosystem services and/or the sectors with the greatest dependency and/or impacts on ecosystem services*. The beneficiaries/sectors are identified and scored according to their degree of dependency and/or their degree of impact on the ecosystem service as low, medium or high, based on a review of the key literature (Bishop, 2011; EASAC, 2009; Ecosystem Markets Task Force, 2013), and an internet search using keywords such as "business and biodiversity", "industry impacts on biodiversity", "biodiversity offsetting". The ecosystem services and benefiting sectors and associated ecosystems are listed in Annex 1. The following seven sectors were selected as having a relatively high dependency on ecosystem services and the associated biodiversity: the crop breeding sector; agriculture (for three different ecosystem services, see Annex I); the recreational wild capture sectors hunting and angling; commercial marine fisheries; water supply companies; the insurance industry; and the tourism sector (see Annex I). In addition, the infrastructure and urban development sector was included because, although not dependent on ecosystem services, it has adverse impacts on habitats and species of which some may have statutory protection from destruction or disturbance. This suggests a high dependence on biodiversity data for environmental impact assessment and possible mitigation and compensation. In conclusion, eight sectors with a relatively high dependency and/or impact on ecosystem services were selected for analysis.

3. *Review sectors to determine which sectors have the greatest potential to contribute to biodiversity data provision and use*. We reviewed the nature of the dependency on biodiversity and ecosystem services of each sector using the assumptions in literature on the relation between the relevant ecosystem service(s) and the key species and habitats. The review also considered which sectors are likely to be able to provide most policy-relevant biodiversity data, for example by reviewing existing policy-related mandatory monitoring and reporting, and contributions to biodiversity data collection and EU biodiversity policy indicators. This includes EU policy requirements such as the Habitats and Birds Directives, the Common Agricultural Policy, Water Framework Directive, Marine Strategy Framework Directive, the EU Biodiversity Strategy 2020 and associated policies.

4. *Rank the sectors on their potential to contribute to biodiversity data provision and use*. The sectors were ranked for their potential contribution to EU BON according to three criteria:

How strong is the incentive for the sector to manage the resource sustainably & hence to support monitoring and data provision? How strong is the potential capacity of the sector for data mobilization and collection?

How high is the EU policy relevance of the habitats and species connected to the sector? To rank the degree of the incentive to support monitoring and data provision, we analysed the dependency of the sectors in more detail as to whether the stakeholders are actually directly benefiting from biodiversity (species and habitats) or whether there is a chain involving others. For example, crop breeders very rarely use plant genetic material directly from wild populations; they rely on material that has already been collected and characterised for its genetic and phenotypic attributes, and therefor rank low for incentive. Sectors also differ in the degree to which they are dependent on receiving biodiversity data and thus their incentive to pay for the organization of data via a data portal. The EU policy relevance of the species and habitats linked to each sector was analysed by looking for their relevance to current policies in the EU. Species and habitats of EU conservation importance under the Birds and Habitats Directives were ranked highly, as well as emerging policy fields such as wild pollinators or natural biological control as a component of integrated pest management and pesticide reduction strategies under the Sustainable Use of Pesticides Directive. The sectors were also ranked according to whether stakeholders are already contributing to monitoring and data provision, or whether they could provide added value through integration into the EU BON data portal. Each sector was ranked for each question as high, potentially high, medium, or low. The ranks were then combined to an overall rank, from which the highest ranked sectors can be prioritized for focus in the EU BON project.

3. Sectors that benefit from or impact ecosystem services: their potential contribution to biodiversity data provision and monitoring

3.1. Farmers and agricultural organizations

Ecosystem service: Agricultural genetic materials from all biota - Provisioning

The ecosystem service(s) and beneficiaries

Genetic materials from biota represent a provisioning service which is of significance to numerous economic sectors, including agriculture. In order to develop crops and livestock that meet changing consumer demands, environmental and agronomic conditions, breeders need access to a diverse pool of genetic material. The main types of genetic diversity provided by ecosystems to the agricultural sector are diverse crop genotypes and races, crop wild relatives, and native or traditional breeds of livestock. This review for practical reasons focuses on crop wild relatives. Crop wild relatives are defined as wild species, closely related to crops, which have the potential ability to contribute beneficial traits for crop improvement (Maxted et al., 2006). Pimentel et al. (1997) have estimated that crop breeding through crossing with wild relatives contributes approximately US$115 billion towards increased yields worldwide per year. A number of crops and their wild relatives are native to Europe (Bilz et al., 2011), and native and endemic European crop wild relatives offer a potential insurance against the threats to crop production from climate change, disease and pests, and other environmental change (Planta Europa, 2008).

The nature of the dependency

Plant breeders have the most direct dependency on crop wild relatives, as plant breeding depends on the ability of breeders to access genetic diversity, including crop wild relatives, and use it in new varieties (Maxted and Kell, 2009). In this way, they can produce varieties with desired properties, such as better disease resistance, increased yield, adaption to environmental conditions, and improved taste, shelf-life or nutritional value (EASAC, 2009; EASAC, 2011; Underwood et al., 2013). Thus, there is an economic incentive to conserve this genetic resource, as future food production may depend on the availability of genetic diversity within crop wild relatives to breeders. Plant breeders include public and private plant breeding research institutes, private seed companies, seed associations and cooperatives, and agriculture-related NGOs. Europe has relatively well advanced public breeding institutions and programmes, but access to useable genetic diversity is regarded as a limiting factor on further cultivar development. Organic producers may particularly stand to benefit from the exploitation of genetic diversity offered by crop wild relatives. It is estimated that more than 95% of organic production is based on crop varieties that were bred for the conventional high-input sector and as a consequence lack key traits required under organic and low-nutrient conditions (Lammerts van Bueren et al., 2011).

Recent advances in plant breeding techniques have improved the ease of transfer of traits between distantly related species and expanded the value of crop wild relatives that are more distantly related to modern crop varieties (EASAC, 2013). The crop breeding sector is increasingly using crop wild relatives for crop improvement (Feuillet et al., 2008; Hajjar and Hodgkin, 2007; Maxted et al., 2012a), though there are still key barriers to plant breeders' use of *in situ* resources, particularly the lack of information about germplasm characteristics and availability.

Crop breeders generally rely on materials from *ex situ* collections including gene banks in which the germplasm is already characterized and subjected to pre-breeding and genetic enhancement (Stevanato et al., 2013). However, only 6 per cent of European crop wild relative species have any collections in seed gene banks (Maxted et al., 2012b). Crop breeding therefore has an indirect dependency on *in situ* crop wild relative conservation. There is growing recognition of the importance of *in situ* conservation of crop wild relatives; however, these initiatives are currently being driven by conservation and research interests, with very little involvement of the plant breeding sector (Kell et al., 2011).

Species on which the services provided rely

It has been estimated that more than 15,000 species of crop wild relative are native to Europe, of which at least half are endemic (Maxted et al., 2007). Some of the wild relatives of crops of major socio-economic importance which are endemic to Europe are listed in **Box 1**. Gene pools of numerous other minor crops, herbs, aromatic and ornamental plants, and forestry species are also present in Europe, and also form valuable genetic resources. The first assessment of the status of European crop wild relatives concluded that at least 11.5% of 572 high priority European crop wild relative species are threatened, primarily from unsustainable farming practices, urbanisation, and other infrastructure developments (Bilz et al., 2011; Kell et al., 2012); in addition many are affected by gene flow and hybridization with crops (Underwood et al., 2013).

Box 1. Wild relatives (CWR) of some crops of major socio-economic importance which are native to Europe and the near East, and their IUCN Red List threat status in Europe (Bilz et al., 2011)(Underwood et al., 2013) (CR critically endangered, EN endangered, VU vulnerable, DD data deficient)

Crop wild relatives of Wheat (*Triticum aestivum ssp aestivum*) – 33 CWR spp., e.g. *Triticum monococcum* subsp. *aegilopoides* (wild einkorn), *Aegilops cylindrica, Ae. geniculata, Ae.neglecta, Ae.triuncialis, Ae.ventricosa, Ae.tauschii* (EN), *Ae. bicornis* (VU) - 12.1% of CWR are threatened
Crop wild relatives of Barley (*Hordeum vulgare*) – 7 CWR spp., e.g. *Hordeum vulgare* subsp. *agiocrithon, H.vulgare* subsp. *spontaneum, H.bulbosum, H.marinum, H.murinum* (5 subsp), *H.secalinum*

Crop wild relatives of Oats (*Avena sativa*) – 13 CWR spp., *e.g. Avena insularis* (EN), *Avena sterilis* (5 subsp.), *Avena fatua, Avena murphyi* - 15.4% of CWR are threatened
Crop wild relatives of Sugarbeet (*Beta vulgaris ssp vulgaris*) - 10 CWR spp., e.g. *Beta vulgaris* subsp. *maritima, Beta patula* (CR), *Beta nana* (VU) , *Patellifolia webbiana* (CR) - 50% of CWR are threatened
Crop wild relatives of Carrot (*Daucus carota*) – 13 wild subspecies e.g. *Daucus carota* subsp.*azoricus, Daucus carota* subsp.*cantabricus* (mostly DD as threats are unknown)

Crop wild relatives of Cabbage (*Brassica oleracea*) – 137 CWR species in the wider *Brassica* gene pool e.g. *Brassica oleracea* ssp *oleracea, B. oleracea* ssp. *Bourgeaui, B. macrocarpa* (CR), *B. hilarionis* (EN), *B. glabrescens* (VU), *Crambe maritima*
Crop wild relatives of Olive (*Olea europaea*) – 5 wild subspecies and 1 CWR species - *O.eu. subsp. cerasiformis, O eu. subsp. europaea, O.eu. subsp. guanchica, O.eu. subsp. oleaster, O.eu. var. Sylvestris, Olea maderensis (DD)*
Crop wild relatives of Apple (*Malus x domestica*) – 5 CWR spp., e.g. *Malus sylvestris* (crab apple) (DD)

Crop wild relatives of Asparagus (*Asparagus officinalis)* - 19 CWR species, e.g. *Asparagus maritimus, A.o.* ssp.*prostratus* (26.3% of CWR are threatened)

Habitats on which the services provided rely

Certain regions in Europe have a high concentration of crop wild relative diversity, where efforts could perhaps be focused. For example, the eastern Mediterranean region has particularly high crop wild relatives diversity, and is the centre of diversity for the wild relatives of numerous economically important crops including wheat, barley, oats, lentil and olive (Bilz et al., 2011). The EU's oceanic islands such as the Canaries and Azores, as well as Sicily, Malta and Corsica, are host to a high percentage of European crop wild relative species, as islands tend to be centres of endemism due to their geographic isolation (Bilz et al., 2011). There are very few protected areas that meet minimum internationally recognised quality standards for genetic reserves (Iriondo et al., 2012); however, some sites are now being set up.[12]

Existing policy targets and indicators that require data

There is currently no EU legislation with a focus on crop wild relative conservation, and no coordinated or systematic attempt to monitor or conserve crop wild relatives at the European level (Maxted et al., 2012a). The EU Biodiversity Strategy 2020 includes the vaguely worded Action 10 (under Target 3A on agriculture) to conserve Europe's agricultural genetic diversity: '*The Commission and Member States will encourage the uptake of agri-environmental measures to support genetic diversity in agriculture and explore the scope for developing a strategy for the conservation of genetic diversity*' (European Commission, COM(2011)244 Final). There is currently no EU-level indicator for plant genetic resources.

[12] http://www.agrobiodiversidad.org/aegro/

The Convention on Biological Diversity Aichi Target 13 more specifically states that '*By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversit*y' (CBD, 2011). The associated global indicator is the genetic diversity of domesticated animals and ex situ crop collections, based on the State of the World Report on Plant Genetic Resources for Food and Agriculture (PGRFA), which does not cover crop wild relatives, although further indicators are being developed.

Several Member States, funded by an EU research project, have recently published national conservation strategies for crop wild relatives, including Spain,[13] Finland,[14] and Italy[15], and are developing national inventories of crop wild relatives, for example the regions in the UK.

Existing data collections and monitoring

Several EU research collaborations have set up EU-wide data sources on crop wild relatives. The Crop Wild Relative Information System was a database set up by the PGR Secure project,[16] with a list of the 25,000 crop wild relatives present in Europe (Kell et al., 2007). The European Cooperative Programme for Genetic Resources (ECPGR), a collaboration of national networks of gene banks and conservation initiatives, aims to contribute to the conservation of genetic resources both in situ and ex situ and to increase the utilisation of these resources, including a working group on crop wild relative conservation.[17]

Potential contribution to EU BON

How strong is the incentive for the sector to manage the resource sustainably & hence to support monitoring and data provision?

MEDIUM – There is growing recognition of the importance of *in situ* conservation of crop wild relatives; however, these initiatives are currently being driven by conservation and research interests, with very little involvement of the plant breeding sector (Kell et al., 2011). It is possible that the crop breeding sector may be willing to finance access to data on crop wild relative populations as they become increasingly relevant to crop breeding programmes.

How strong is the potential capacity for data mobilisation and collection?

LOW – Crop breeders do not directly use *in situ* crop wild relative populations, as explained above, and rarely survey or collect materials from the wild, so do not have substantial data collections to share. However, national inventories and collaborative networks for the sharing of information about crop wild relatives in Europe are growing and there are several EU-wide database initiatives (Maxted et al., 2013).

How high is the EU policy relevance of the habitats and species?

POTENTIALLY HIGH - There is currently no EU policy framework that explicitly includes crop wild relative conservation. However, there is increasing momentum at the international and EU level to target policies more specifically to crop wild relative conservation. This is an emerging policy area.

[13] http://www.pgrsecure.bham.ac.uk/sites/default/files/documents/public/National_CWR_Conservation_Strategy_Spain.pdf

[14] http://jukuri.mtt.fi/bitstream/handle/10024/481549/mttraportti121.pdf

[15] http://www.pgrsecure.bham.ac.uk/sites/default/files/documents/public/National_CWR_Conservation_Strategy_Italy.pdf

[16] http://www.pgrsecure.org/helpdesk_cwr

[17] http://www.ecpgr.cgiar.org/working-groups/wild-species-conservation/

Ecosystem service: Pollination - Regulation & maintenance

The ecosystem service(s) and beneficiaries

Biotic pollination (by animals, primarily insects) is an ecosystem service with well documented importance for agricultural production (EASAC, 2009). Insect pollination is necessary for (or contributes to) production of a third of all the crop types that are used directly for human food globally (Klein et al., 2007). Although many of the highest volume crops, namely cereals such as rice and wheat, are wind pollinated, a large proportion of other crops are vulnerable to yield loss or yield reduction in the absence of pollination (Potts et al., 2010) (see **Box 2**). For example, it has been shown that pollination increases strawberry crop quality and shelf life (Klatt et al., 2013), and enhances seed yield, quality, and market value in oilseed rape (Bommarco et al., 2012), though pollination requirements differ between varieties (Hudewenz et al., 2014). It is suggested that the human diet could become greatly impoverished with further decline in pollination services (Klein et al., 2007) as many pollinated crops are high in important micro-nutrients (Eilers et al., 2013).

Demand for pollination services is generated by the decision of farmers to plant crops which profit from pollination. The overall economic value of pollinators can be estimated either by assessing the contribution of pollination to crop yields or by estimating the cost of replacing insect pollination with a human manipulation (Hanley et al., 2014). A study estimated that at aggregated EU level, the absence of insect pollination would result in a reduction in total production of pollinator-dependent crops in the region of 25-30% (Zulian et al., 2013). One frequently quoted study has estimated that the annual value of insect pollination (using the commodity values of the 100 most important commodity crops and a pollinator dependency ratio) is €22 billion for European agriculture, and €14.2 billion for EU member states (Gallai et al., 2009). However, no robust estimates exist yet for the marginal value of pollination services on a particular crop, i.e. the effect that changes in the abundance of pollinator species have on crop economic value, which is different for each crop and pollinator species community, and varies over time and among locations (Vanbergen and Insect Pollinators Initiative, 2013).

It is worth noting that for certain crops, pollination is necessary for seed production but not for fruit production, and there can therefore be an economic incentive to reduce pollination rather than increase it, if seedless fruit are more likely to meet customer demands. These crops include fig (*Ficus carica*) and some cucumber, eggplant/aubergine and citrus varieties; although some tangelos and tangerines are self-incompatible and so require pollination for fruit production.

Box 2. Crops that benefit from insect pollination

- Fruits – apple, orange, tomato, pear, peach, melons, lemon, strawberry, raspberry, plum, apricot, cherry, kiwifruit, mango, currants
- Vegetables – carrot, onion, peppers, pumpkins/squash, field bean, courgette, French bean, eggplant/aubergine, cucumber
- Industrial & biofuel crops – cotton, oilseed rape, soy bean, white mustard, buckwheat
- Seeds and nuts – sunflower, almond and chestnut
- Herbs – basil, sage, rosemary, thyme, coriander, cumin and dill
- Forage crops for animals – soy bean, field bean, field pea, alfalfa, clover, sweet clover
- Essential oils – chamomile, lavender, and evening primrose.

Source: STEP-project Fact Sheet[18]

[18] Available at: http://www.step-project.net/img/uplf/STEP_factsheet_ENG.pdf

The nature of the dependency

Some high value crops that require insect pollination, such as tomato and strawberries, are now grown in greenhouses and pollinated with commercially reared bumblebee species (Goulson et al., 2008a), and honeybees *Apis mellifera* are managed for pollination service provision in much of the world (Breeze et al., 2011). However, studies show that in open field crops diverse wild pollinator communities provide equal, superior or complementary service levels to managed honeybees, except in very large-scale intensive agricultural landscapes where there is no habitat for wild pollinators (Garibaldi et al., 2013; Rader et al., 2012; Winfree et al., 2008). Garibaldi et al. (2013) found a universally positive relationship between fruit set and flower visitation by wild insects in a study of 41 crop systems worldwide. Kleijn et al. (2015) found wild pollinators contributed the same economic value as honeybees in a review of 90 studies. A higher diversity of pollinator species can increase crop yield as a result of complementary or synergistic behaviour of the functional groups independently of the absolute numbers of pollinators (Albrecht et al., 2012; Brittain et al., 2013). Native wild pollinators also have a value as an insurance against on-going or sudden losses of domestic honey bees due to outbreaks of pests and diseases (Vanbergen & Insect Pollinators Initiative, 2013; Winfree et al., 2007). It is estimated that in the UK, honeybees are only providing at most a third of crop pollination, with wild pollinators providing the rest (Breeze et al., 2011).

There is increasing evidence to suggest that key agricultural sectors in Europe should have an economic interest in the maintenance of healthy populations of wild pollinators (Potts et al., 2010). With the substantial growth in the area of insect pollinated crops such as oilseed rape in Europe in the last two decades, the demand for pollinator services is increasing (Garratt et al., 2014a). As pollinator dependency is increasing however, there is clear evidence of a decline in wild pollinator abundance and diversity (Garibaldi et al., 2013), as well as the decline in honeybee stocks (Potts et al., 2010), which are estimated to be inadequate to meet the pollination demand in at least half of the countries in Europe (Breeze et al., 2014). The decline in wild pollinators therefore represents a threat to biotic pollination service provision, and thus possibly direct economic losses for the agriculture sector (Deguines et al., 2014), most significantly in the Mediterranean region, where the economic benefits from pollination are greatest (Leonhardt et al., 2014).

Apples are the most economically important insect-pollinated crop in the EU, and a study in UK apple orchards found that fruit set and apple seed number were found to be suffering potential pollination deficits, although these were not reflected in apple size or weight (Garratt et al., 2014b). A high level of solitary bee activity was found, indicating that they could be making a valuable contribution to pollination. More blossoms developed into fruit in North American apple orchards with a higher diversity of wild bee species, whilst the presence or absence of honeybees was not significant (Mallinger and Gratton, 2014). However, there is still a severe lack of basic information on how the diversity and abundance of wild pollinating insects contribute to seed/fruit yield and quality and how climate change will affect pollination service need and provision.

It is important to note that some agricultural practices and the loss of semi-natural habitats and legume crops are key factors in the decline of wild pollinator populations on farmland (Goulson et al., 2008b; Kosior et al., 2007; Le Féon et al., 2010). A number of insecticides have lethal or sublethal effects on wild bees (Godfray et al., 2014; Sandrock et al., 2014). The intensive use of herbicides and fertilizer and the loss of fallow and set-aside have contributed to declines in weed populations and a decrease in pollen and nectar sources (Carvell et al., 2006; Kovács-Hostyánszki et al., 2011).

Wild pollinators are essential for the maintenance of many wild plant species, and there is evidence that the decline of wild pollinators is having a negative impact on wild plant populations in and around farmland (Biesmeijer et al., 2006; Jacobs et al., 2009). The increasing public concern about the loss of wild pollinators is motivated by appreciation of both their importance for maintaining crop yields and for wild plant populations, and by the pleasure people derive from seeing bees and the intrinsic value associated with them. The food industry, pesticide companies, and farmers are under increasing pressure to show that they are taking action to benefit wild pollinators rather than harming them, independently of their economic contribution to crop production.

Species on which the service provided relies

Bee species (Hymenoptera: Apoidea) are generally considered the most important pollinators of crops in temperate regions, but wasps (Hymenoptera: Apocrita), hoverflies (Diptera: Syrphidae), beetles e.g. pollen beetles (Coleoptera: Melyridae), and moths (Lepidoptera) can also play a role for particular crops. Other flies can more important than hoverflies because they are more abundant and diverse and carry more pollen (Orford et al., 2015). Butterflies (Lepidoptera) are generally not very effective pollinators. Bumblebees (*Bombus* spp) and some solitary bee species specialise in 'buzz' pollination or sonication, which is particularly effective at pollinating *Solanum* species (including eggplants, tomatoes) and *Vaccinium* species (including cranberries and blueberries). The long-tongued bumblebees are effective pollinators of legume flowers including clover, field beans and peas (Garratt et al., 2014a). *Osmium* bee species are particularly effective at pollinating apple trees. Other animals, such as bats and birds, are not generally regarded as important pollinators in Europe, though at the global scale their decline may be affecting pollination services (Regan et al., 2015).
Crop pollination is generally provided by a relatively small number of pollinator species that prefer to forage on crops and that are tolerant of agricultural intensification (Kleijn et al., 2015); however, many rare and threatened pollinator species used to be more common in agricultural landscapes and contributed to crop pollination (Bommarco et al., 2011), and have an insurance value in case the currently common species are affected.

Habitats on which the service provided relies

Semi-natural habitats with abundant dicotyledonous floral resources are essential for sustaining wild bee populations in farmland, including grasslands, fallows, woodland, hedgerows, field margins, and gardens (Osgathorpe et al., 2012; Rollin et al., 2013). Pollinator species in Europe have been severely affected by the loss of semi-natural grasslands and heathlands, as well as other pressures (Le Féon et al., 2010). Loss of semi-natural habitat tends to change pollinator communities on farmland to communities dominated by common taxa. Pollination in intensively managed agricultural land that has lost suitable bee habitat benefits from rotational fallows (Kuussaari et al., 2011) and from proximity to wild bee populations from gardens (Samnegard et al., 2011). Long-tongued bumblebee species have declined more rapidly and are more threatened than short-tongued species, and this is related to the decline in plant species that can only be accessed by long-tongued bees (Fabaceae, Scrophulariaceae, Lamiaceae etc).
Small-scale pollinator habitat creation measures in intensively farmed landscapes can successfully enhance the abundance of the more common crop-visiting pollinators (Scheper et al., 2013; Wood et al., 2015b), and measures targeted at their ecological requirements can enhance rare pollinators (Pywell et al., 2012). However, many wild pollinators other than bumblebees prefer wild flower species that are generally not included in seed mixes available to farmers (Wood et al., 2015a).

Existing policy targets and indicators that require data

No bee or hoverfly species are protected at EU level through being listed in the annexes of the Habitats Directive. The only European level indicator for a group that includes pollinating species is the European Butterfly Indicator for Grassland, which is based on population trends of 17 butterfly species in 19 countries (van Swaay et al., 2010). Wild bees and wasps, sawflies and sand wasps (Apoidea, Bembix, Cimbex) are legally protected in Germany[19], in Poland and in other regions, but this has few practical consequences.

However, awareness of the decline in pollinator populations is increasing. Several Member States or regions, including England and Wales in the UK, have published national pollinator conservation strategies.

Existing data collection and monitoring

Little information exists on the stocks and flows of wild pollinators in Europe as no dedicated monitoring schemes are in place at the EU level to accurately detect changes in abundance of wild insect pollinators. Data on European bee species are currently fragmented in national and local databases. The Atlas of European Bees, compiled in the framework of the STEP FP7 project, is collating data contributed by researchers across Europe for over 40 bee and wasp genera, for example the bumblebee and cuckoo bee (*Bombus*) database (Rasmont and Iserbyt, 2014). The recently published Red List of bee species for Europe assembled an impressive evidence base of published records, databases, maps, taxonomic frameworks and expert knowledge, but was still forced to conclude that for 56.7% of bee species in Europe, there is insufficient data to draw any conclusions about their population status (Nieto et al., 2014). The European bee data in GBIF (Global Biodiversity Information Facility) is heavily biased towards two countries[20] with very few or no occurrence records from Mediterranean countries, and existing datasets on pollinator abundance at field level are insufficient to scale up to relative pollinator abundance at the regional scale (Zulian et al., 2013).

Monitoring of bees in the EU currently relies heavily on academic experts and volunteer networks such as the Bees, Wasps & Ants Recording Society in Britain and Ireland, but in many areas there is little monitoring or data, particularly in Mediterranean countries. The BioBio project (Targetti et al., 2014) proposes an EU-wide farm-scale monitoring scheme to measure six biodiversity parameters including wild bees with cost ranging between €2700 and €8200 per farm depending on the degree to which the monitoring relies on volunteer involvement. According to Lebuhn et al. (2013), a monitoring program with 200–250 sampling locations each sampled twice over 5 years would provide sufficient power to detect annual declines of 2–5% in the number of species and in total abundance and would cost US$ 2,000,000.

Because of the gaps in data about pollinator populations at the national and EU level, crop pollination services are being estimated by matching semi-natural habitat distribution (derived from land cover data at 100m resolution) and crop distribution data (Zulian et al., 2013). However, land cover data cannot distinguish between plant species rich or poor grassland, forest or mixed farmland areas, and therefore cannot distinguish their relative value as pollinator habitat.

Potential contribution to EU BON

How strong is the incentive for the sector to manage the resource sustainably & hence to support monitoring and data provision?

HIGH (PARTIAL) - Growers of outdoor fruit and vegetables, oilseed rape, sunflower, and the other crop types listed in **Box 1**, should have an incentive to invest in measures to ensure the maintenance of this service from wild pollinators, which might include better information about what pollinators contribute what where. Agricultural advisory services can also be expected to have an interest. However, the awareness of the crop production benefits provided by wild pollinators, as opposed to honeybees, is generally quite low. The most common pollinators can be relatively easily encouraged with simple habitat creation measures, and interest in the presence of rarer species may be limited. Pesticide companies and some farmers are currently motivated to invest in pollinator conservation to compensate for the negative impacts of pesticide use on bees, partly in an attempt to avert further

[19] http://www.wildbienen.de/wbs-gese.htm

[20] Great Britain (45% of occurrences) and Sweden (25% of occurrences)

restrictions on pesticide availability. This is contributing to an increasing interest in access to better information on wild pollinators. Better data on pollinator species distributions, ecology and populations makes it possible to assess the contribution of pesticides to pollinator population declines (Ollerton et al., 2014).

How strong is the potential capacity for data mobilisation and collection?

MEDIUM – Bumblebees (*Bombus* spp) are relatively easy to identify and monitor using standardized surveying methods, and there is a high potential for greater data collection on abundance and species presence on farmland using volunteers including farmers (Herzog et al., 2012). Solitary bees, hover flies, and other groups require specialist identification skills and therefore need to be surveyed by experts. Pollinators in agricultural habitats are likely to belong to relatively abundant and ubiquitous species, whilst the most highly threatened pollinator species are restricted to natural and semi-natural habitats and are less likely to be contributing to the pollination of economically important crops. However, monitoring on farmland could provide valuable data on population trends of widespread species, and the pressures affecting pollinator populations.

How high is the EU policy relevance of the habitats and species?

POTENTIALLY HIGH – Although there are no bee species protected under the Habitats Directive and no EU wide pollinator monitoring strategy, this is an emerging policy area. Pollinators are one of the key target groups of agri-environment funding in many rural development programmes under the CAP, and objective evidence of the presence and abundance of pollinator species is essential for the efficient targeting and monitoring of these subsidies. There is also increasing focus on monitoring the impact of pesticide use on bees and other wild pollinators, currently partly motivated by the temporary ban on the neonicotinoid pesticides and fipronil. An increasing number of Member States are developing national pollinator strategies and plans, which include programmes for monitoring, research and assessment of wild pollinator populations.

Ecosystem service: Pest control - Regulation & maintenance

The ecosystem service(s) and beneficiaries

Pests (both plant and animal) and pathogens have adverse effects on agricultural yields and crop quality in Europe and globally (Oerke, 2006). Thus, there is significant economic value to the ecosystem service provided by natural predators, parasites and diseases (‘natural enemies’), known as natural or conservation biological control, which can limit or reduce these adverse impacts, if combined with a decreased use of pesticides (Losey and Vaughan, 2006). Natural biological control is a key component of Integrated Pest Management (IPM)[21]. However, farmer dependency on the service of natural biological control is currently generally low, with the notable exception of organic farmers, as pesticides are causing a significant reduction of the potential for natural biological control across Europe (Geiger et al., 2010).

Chemical control can be costly both for farmers, and society as a whole, through negative impacts on human health, water quality, and wildlife (Pimentel, 2005). Due to the increasing economic costs of pesticides, and regulatory restrictions due to concerns about their health impacts and damaging effects on wild species, there is a clear incentive to invest in an approach which limits their use. Although the true effect on yields of embracing IPM on a large scale in Europe is not yet fully known, the potential advantage of encouraging the conditions for the provision of this service are becoming apparent.

The nature of dependency

[21] http://www.fao.org/agriculture/crops/core-themes/theme/pests/ipm/en/

This analysis focuses on the role of native wild natural enemies in controlling pests, and does not cover the direct release of biological control agents. The extent to which natural enemies provide significant pest control depends upon the farming practices and control methods in place. The exact nature of the dependency of agricultural production on natural biological control is highly system specific. This dependency is difficult to quantify, as the provision of natural control depends on many factors, including other technological pest control interventions. There is evidence that natural biological control is higher and more stable when both species richness and species evenness of the natural enemy community is high (Crowder et al., 2010; Macfadyen et al., 2011). Niche complementarity between species enhances control, for example if natural enemies are more diverse; however, natural biological control can be significantly reduced by intra-guild predation, ie by generalist predators eating each other rather than the pests (Straub et al., 2008). Some natural enemies can be beneficial predators of pests in certain situations and damaging pests themselves in other situations, for example earwigs in herbaceous crops.

Key species on which services provided rely

A wide range of natural enemies control different pests and diseases in different crops. In some groups, the larval stage is the most active predator, in others the adult stage is the main predator, whilst in others both adult and larvae are key predators (see **Box 3**).

Box 3. Diversity of natural enemies of pests and diseases

Natural enemies fall into four main groups:

Pathogens: fungal, bacterial and viral pathogens are key factors limiting the abundance of pests such as caterpillars and aphids.

Parasitoids: insect parasitoids lay their eggs in or on a host species, thereby ultimately killing or sterilising the pest. Parasitoids are specialist natural enemies because they only attack one or a few host species. Key groups include:

- ichneumonid wasps (Hymenoptera: Ichneumonidae);
- flesh flies (Diptera: Sarcophagidae);
- tachinid flies (Diptera: Tachinidae).

Soil predators: key predators of soil pests include carabid beetles, centipedes, spiders, predatory mites, and pseudoscorpions (Pseudoscorpionida). Birds can eat large quantities of soil pests such as leatherjackets (Diptera: Tipidulidae).

Epigeal predators: arthropods and other generalist predators that are active on the soil surface and on the crop and weeds. Key groups include:

- predatory mites (Acari) preying on pest mites;
- predatory thrips (Thysanoptera) preying on pest thrips;
- hunting spiders (Araneae: various eg Salticidae, some Tetragnathidae);
- ground beetle adults and larvae (Coleoptera: Carabidae) both for pest predation and for weed seed predation (Bohan et al., 2011);
- ladybird adults and larvae (Coleoptera: Coccinellidae) are voracious predators of aphids;
- hoverfly larvae (Diptera: Syrphidae) are also key predators of aphids;
- lacewing larvae (Neuroptera: Chrysopidae) eg Common Green Lacewing (*Chrysoperla carnea*);
- predatory bugs (Heteroptera and Hemiptera) eg Minute Pirate Bug (*Orius insidiosus*);
- earwigs (Dermaptera) in fruit trees.

Aerial predators: arthropods and other animals that hunt flying pests in the air or pick pests off the crop plant surface. Key groups include:

- wasps;
- web-building spiders (Aranae: eg Linyphiidae, Theridiidae, some Tetragnathidae);
- robber flies (Diptera: Asilidae);
- dragonflies and damselflies (Odonata) can be important predators of smaller flying insects in crops near water;
- bats can consume large quantities of flying pests (moths and flies) along crop margins and around livestock.

The conservation status of many of these species groups is currently poorly known at the EU level, for example parasitoid wasps, and there may be ongoing species losses. For example, a substantial overall decline in carabid beetle biodiversity has been demonstrated in the UK using long-term carabid beetle monitoring data; three-quarters of the species studied declined, half of which were estimated to be undergoing population reductions of > 30%, when averaged over 10-year periods (Brooks et al., 2012). It is not known whether species declines are negatively affecting the natural biological control capacity in agricultural areas, or whether they are primarily restricted to species outside agricultural habitats.

Key habitats on which services provided rely

Natural biological control is generally enhanced in heterogeneous landscapes (Rusch et al., 2013) including field margins (Holland et al., 2012), hedgerows and other semi-natural features (Veres et al., 2013). However, it has been suggested that this effect is not constant, and as the pest population moves into later stages of development, or as the seasons progress, predators in more heterogeneous landscapes may move on to alternative food sources, no longer performing a service for the farmer (Letourneau et al., 2009). Agricultural intensification does not necessarily reduce natural biological control (Thies et al., 2011). Thus, the role of landscape structure in encouraging natural biological control is likely to be highly context specific.

Many arthropod natural enemy species are dependent on pollen and nectar food resources in the adult stage, notably parasitoid wasps, ladybirds and lacewings. Populations are therefore benefited by an abundance of flowering plants in weed populations, field margins, hedgerows etc (Landis et al., 2005). Field margins and vegetated strips (‘beetle banks’) within fields also provide overwintering sites and refuges that enhance survival during pesticide applications, tillage etc. If high densities of natural enemies overwinter close to the crop, they can move into the crop and control pest populations before they become abundant. However, field margins, cover crops and crop residues can also provide habitat for pests which can move into new crops.

Existing data collection and monitoring

There is no known European monitoring regime for the ecosystem service natural biological control, and there are data gaps with regard to information about some of the key species groups in the EU. Agronomists and farmers testing or evaluating crop practices tend to use their own observational datasets or generate further experimental data. However, a number of monitoring schemes of high priority crop diseases and pests are established at the national level. For example, the UK Cereal Pathogen Virulence Survey monitors cereal rusts and mildews in the UK, detecting and warning industry and growers of new races of disease emerging on resistant varieties.[22] The survey relies on samples sent in by farmers, agronomists, plant breeders and official trial operators.

[22] http://www.niab.com/pages/id/316/UKCPVS

Several initiatives at the EU level are providing access to data and information on integrated pest management to inform farmers, agricultural advisors and policymakers, for example the EuroWheat platform run by a collaboration of 13 agricultural research institutes[23].

An example of farmer involvement as 'citizen scientists' is an initiative piloted in 2012-2013 by the Dutch Mammal Society with the Centre for Agriculture and Environment involving farmers in appreciating the pest control factor of bats and improving bat roosting and hunting habitats on farms.[24]

The BioBio project (Targetti et al., 2014) proposes an EU-wide farm-scale monitoring scheme to measure six biodiversity parameters including spiders with cost ranging between €2700 and €8200 per farm depending on the degree to which the monitoring relies on volunteer involvement.

Potential contribution to EU BON

How strong is the incentive for the sector to manage the resource sustainably & hence to support monitoring and data provision?

MEDIUM/UNCLEAR BUT INCREASING - The current level of dependency of the EU agriculture sector on this service is unclear, as few comprehensive studies have been undertaken, and the potential for natural enemies to perform biological control is severely limited by pesticide use, which lowers population densities. The ideal landscape structure to promote the provision of this service is also unclear. It has not been clearly established what effect switching large areas of agricultural land from a pesticide regime to one drawing on IPM would have on crop yields. Nevertheless, there is a clear need for monitoring and further study of these predator-pest interactions and farming regimes, due to the potential value that this service, if promoted by sustainable farming practices, could offer the agriculture sector.

How strong is the potential capacity for data mobilisation and collection?

MEDIUM/HIGH – Trapping and monitoring natural enemies can be a useful component of integrated pest management strategies (as well as monitoring of pest populations), and farmers could be further encouraged and incentivised to participate. National and EU-wide monitoring networks for crop pests and diseases are already established or being set up. It would also be possible to assemble data on some key natural biological control species of particularly common and problematic crop pests at the regional level in Europe.

How high is the EU policy relevance of the habitats and species?

MEDIUM – Though there is no EU legislation that directly protects key natural enemies of crop pests, Member States are now obliged to demonstrate the implementation of Integrated Pest Management and reductions in pesticide use under the Sustainable Use of Pesticides Directive. The European Commission will review progress on pesticide reduction targets by the end of 2018, based on Member States reviews of their National Action Plans. Data on the abundance of key natural enemy species could provide a valuable indication of a reduction in the negative effects of pesticides. Measures to promote natural biological control are one of the features of agri-environment funding in many rural development programmes under the CAP, and objective evidence of the presence and abundance of natural enemies is essential for the efficient targeting and monitoring of these subsidies.

Ecosystem service: Soil ecosystem services – Regulation & maintenance

The ecosystem service(s) and beneficiaries

"Life in earth drives life on Earth, and soil biodiversity represents a vast biological engine, driving processes on which our very survival depends" (Jeffery et al., 2010).

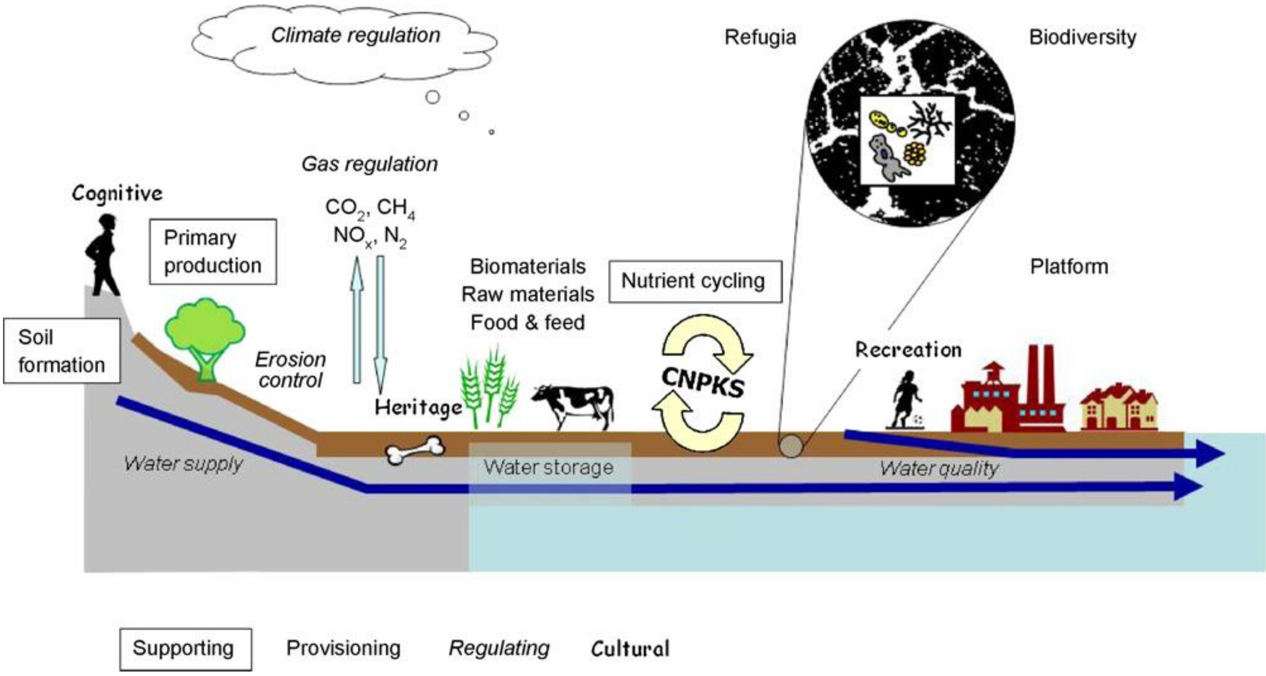
Human societies are reliant on many goods and services that depend on soil processes. **Figure 1** demonstrates the range of key goods and services which are provided by or dependent on soil systems.

[23] http://www.eurowheat.org/EuroWheat.asp

[24] EUROBATS national implementation report Netherlands 2010-2013

Clearly, the primary production sectors - agriculture and forestry - are highly dependent on the continued provision of many of these goods and services. Soil biodiversity is a key regulator of these services, and vital for our continued survival and well-being (Turbé et al., 2010). However, there are increasing pressures on soil biodiversity, and soil degradation remains an issue of global importance, particularly as rates of soil formation or recovery are often too slow to cope with current rates of loss (Pulleman et al., 2012).

Figure 1. The range of key ecosystem goods and services provided by soil systems



Source: Haygarth and Ritz (2009), Fig 2.

Agriculture and forestry are dependent upon the soil system and soil biota in multiple and complex ways. As well as the provisioning services such as crop growth and food supply, agriculture depends on a range of supporting and regulating services which are provided by soil systems (**Table 1**). This group of ecosystem services covers two main types of services:

- Weathering processes: maintenance of bio-geochemical conditions of soils including fertility, nutrient storage, or soil structure; includes biological, chemical, physical weathering.
- Decomposition and fixing processes: maintenance of bio-geochemical conditions of soils by decomposition/mineralisation of dead organic material, nitrification, denitrification etc.), N-fixing and other bio-geochemical processes.

Table 1. Ecosystem services provided by the soil system of significance to agriculture. Adapted from Haygarth and Ritz (2009) and Jeffery et al. (2010).

Service type	Ecosystem service	Associated processes and functions	Examples of soil biota involvement
Supporting	Soil formation	Bioweathering and accumulation of organic material	Lichens Organic acid production by many bacteria and fungi

Service type	Ecosystem service		Associated processes and functions	Examples of soil biota involvement
	Carbon cycling		Physical and biochemical decomposition of organic matter	Physical: macrofauna including earthworms, millipedes, ants and insect larvae Biochemical: a range of bacteria, fungi, archaea, protozoa, nematodes and other fauna
	Nutrient cycling	Nitrogen	N-fixation Ammonification Nitrification Denitrification	Numerous bacteria, e.g. for N-fixation: *Azospirillum* sp. *Azobacter* sp. *Rhizobium* sp. Mycorrhizal fungi.
		Phosphorus	P-solubilising bacteria and fungi Mycorrhizal mediated plant uptake	
		Other	Cycling of numerous other metals and trace elements	
Provisioning	Water storage		Retention of water in soil pore network, modulating biochemical processes	Structurally: any biota mechanically altering the soil system
	Provision of food / biomass supply		Provisioning plant growth; also primary production in soil, e.g. edible fungi	Entire biota; Also edible fungi
Regulating	Water quality regulation		Water purification (important for crop and livestock clean water supply)	Structurally: any biota mechanically restructuring or binding the soil system Also bacterial/fungal biodegradation
	Water supply regulation		Regulation of hydrological flows (for consistent water supply), by soil structural dynamics	Structurally: any biota mechanically restructuring or binding the soil system
	Atmospheric gas regulation		Regulation of atmospheric chemical composition, e.g. CO_2/O_2 concentrations	Entire biota
	Climate regulation		Regulation of global temperature, precipitation, and other biologically mediated climatic processes	e.g. Photoautotrops, Methanotrophs
	Erosion control		Soil retention and surface stabilisation	Structurally: any biota mechanically restructuring or binding the soil system

The nature of dependency

Maintaining the functional diversity of the soil system to protect its current function repertoire and increase system redundancy and thus resilience should be a priority. As Jeffery et al. (2010) argue, there is theoretical and experimental evidence that soils with higher levels of biodiversity are more resistant to environmental disturbances. More diverse systems are more resilient, meaning that they tend to recover well following environmental stress, maintaining soil function. Systems have thresholds, and if the level of biodiversity drops below these levels it is likely that ecosystem service provision would be threatened, causing major problems for agriculture. Thresholds will vary by system and soil function in question, but if practices are adopted which promote a diverse soil ecosystem, function can be maintained.

Species on which the service depends

It is estimated that greater than a quarter of all living species on Earth reside in the soil (Jeffery et al., 2010). Due to the taxonomic and functional complexity of soil communities, identifying key species of importance for service provision can be challenging, so a focus on functional diversity is often more useful (Künast et al., 2010). Functional diversity is the range of 'traits' present in a community which contribute to its repertoire of functional capabilities, rather than taxonomic diversity (Jeffery et al., 2010) (see **Box 4**).

Box 4. Functional groups of soil organisms

Turbé et al. (2010) have broadly classed soil organisms into three functional groups:

(1) chemical engineers - micro-organisms which decompose organic matter, releasing nutrients;
- bacteria, fungi and protozoans

(2) biological regulators - regulators of microbial activities, primarily through grazing but also through parasitic or mutualistic interactions, thereby effectively controlling resource supply; this class also contains pathogenic and herbivorous or parasitic regulators of plant abundance;
- small invertebrates such as nematodes, pot worms, springtails and mites

(3) ecosystem engineers which modify environmental conditions for other organisms through mechanical activities, such as bioturbation, mixing the soil and building resistant soil aggregates and pores.
- larger organisms such as earthworms, enchytraeid worms and ants

Monitoring of components of soil biota as an indicator for general soil or ecosystem health is used as part of risk assessment or land use change monitoring. In these approaches different soil organisms, selected for their sensitivity to particular pressures or practices or for their relevance to soil functions, are monitored over time to highlight any changes in the soil system. Earthworms, nematodes, and various microorganisms are three examples of commonly used soil indicator organisms. Sometimes soil structures created by biota, such as biogenic soil aggregates, are also used (Pulleman et al., 2012). Because of the hierarchical nature of the soil community it is important that soil biodiversity is monitored at multiple levels of organisation and spatial scales. It is also important to develop sets of complementary indicators, and consider both biotic and abiotic data. The soil community actually provides many potential indicators for environmental monitoring in response to a range of stresses, adding value to monitoring programmes. However, apart from earthworms and a few other soil macro-organism groups, the link between particular soil organisms or species and soil ecosystem services is not obvious to non-scientists.

Existing policy targets and indicators

There is currently no EU policy that specifically refers to soil biodiversity monitoring. Farmers and foresters receiving subsidies under the Common Agricultural Policy must follow the Good Agricultural and Environmental Condition (GAEC) rules, which include the obligation to maintain a minimum soil cover and soil organic matter, and minimum land management measures to limit soil erosion. Efforts to establish further EU policy referring to soils have stalled with the withdrawal of the proposal for a Soil Framework Directive.

The EU Soil Thematic Strategy included Commission objectives to raise awareness of soils including soil biodiversity and to consolidate harmonised soil monitoring across the EU, which is being pursued by the Joint Research Centre (European Commission, COM(2012) 46 final). The JRC's European Soil Portal brings together various datasets, information sources and links to monitoring projects across the EU[25].

Existing data collection and monitoring

Biological soil data has been collected increasingly since the 1980s in Europe in studies ranging from agricultural trials to regional or national monitoring programmes (Pulleman et al., 2012). As of 2010, 15 European countries had collected soil biological data as part of large scale monitoring programmes (Turbé et al., 2010). The French soil monitoring programme Inventaire Gestion et Conservation des Sols is an example of a national-level soil monitoring scheme[26]. However, Pullerman et al. (2012) note that this has not enabled large scale integrated assessments of soil biodiversity across Europe, as the data has been collected for different purposes using a variety of methods and indicators. The EU level LUCAS survey, which informs the assessment of Common Agricultural Policy measures, is now collecting soil data and may integrate soil biodiversity data once methods and standards are further developed.

At EU level, the FP6 project ENVASSO (Environmental Assessment of Soil Monitoring) developed pilot protocols for a uniform system for soil biodiversity monitoring across Europe, including the development of standardized indicator sets (Gardi et al., 2009). A current project aims to produce a Europe-wide assessment of forest mycorrhizal fungi[27]. These attempts at standardisation represent useful steps towards Europe-wide monitoring, but more work and greater uptake is still needed. Pullerman et al. (2012) note that the integration of soil biodiversity conservation into EU legislation has been hampered by the perception that the level of knowledge on the topic is insufficient to recommend policy. There is a strong need to establish reference values for different land-uses (Pulleman et al., 2012).

A few soil organism groups can easily be monitored by citizen scientists. For example, the OPAL citizen science project in the UK runs an earthworm survey with a photographic key to the seven most common grassland species[28]. The BioBio project (Targetti et al., 2014) proposes an EU-wide farm-scale monitoring scheme to measure six biodiversity parameters including earthworms with cost ranging between €2700 and €8200 per farm depending on the degree to which the monitoring relies on volunteer involvement.

Potential contribution to EU BON

How strong is the incentive for the sector to manage the resource sustainably & hence to support monitoring and data provision?

LOW/MEDIUM - The EU agriculture sector is highly dependent on the sustainable management of productive soils, and the biota and ecological processes upon which they depend, and the forestry sector also depends on soil productivity. These sectors should therefore have a significant interest in investing in policies and practices that will protect soil biodiversity and foster resilience in soil ecosystems. However, the relationship between soil biodiversity and soil ecosystem service provision is highly complex and still subject to high scientific uncertainty. The incentive for farmers to contribute directly to soil biodiversity research is therefore low in comparison to the incentive to contribute to soil ecosystem service research and monitoring, e.g. soil erosion, organic matter and productivity.

How strong is the potential capacity for data mobilisation and collection?

[25] http://eusoils.jrc.ec.europa.eu/
[26] http://www.gissol.fr/programme/igcs/igcs.php
[27] http://www.kew.org/discover/news/mapping-and-monitoring-mycorrhizal-fungi-on-european-scale%E2%80%A6-why-and-how
[28] http://www.opalexplorenature.org/soilsurvey

MEDIUM - Important steps are being made towards developing standardized monitoring protocols of soil biological parameters across Europe, but further work and greater uptake is needed before useful Europe-wide analysis can be undertaken with these data.

How high is the EU policy relevance of the habitats and species?

MEDIUM – There is currently no EU policy that specifically refers to soil biodiversity monitoring. However, efforts are being made to standardise and increase soil biodiversity monitoring in the EU, as described above. The European Commission through the Joint Research Centre continues activities to promote awareness of soil biodiversity and present harmonised data and information on soil for policy-makers.

3.2. Hunters and hunter groups, Anglers and angling sector

Ecosystem service: Hunting of wild animals – Provisioning & Cultural

The ecosystem service and beneficiaries

Hunting can be defined simply as the pursuit and killing or trapping of a living organism. Although driven in part, as many hunters claim, by the challenge, beauty, tranquility, or 'wildness' of place or environment, it is ultimately dependent on the presence of game animals to hunt. Recreational hunting is a large sector and has strong cultural links throughout Europe. The European Federation of Associations for Hunting and Conservation (FACE) claims to represent seven million hunters across Europe as a whole, making it "*probably one of the largest European civil society organisations*" (FACE, 2013). Hunting is organised formally via game management areas or less formally into hunting syndicates. According to the Secretary-General of FACE, hunting takes place on 80 to 90 per cent of Europe's land.[29] Many of these cover large areas and cover multiple primary uses from farming to forestry to protected areas.

It has been estimated that hunters contribute approximately €16 billion annually to the EU economy (Kenward and Sharp, 2008). A survey in 2005 of available bird bag statistics (number of recorded kills) (Hirschfeld and Heyd, 2005)[30] found that the five EU Member States which hunt the most birds are France, the UK, Italy, Spain, and Greece. Sport shooting in the UK is worth an estimated €2.5 billion[31] to the national economy, with nearly 2 million hectares of land actively managed for shooting (PACEC, 2014). Numbers of hunters appear to have declined since 1991 in seven Member States, including France, Sweden, Italy, Spain, and increased in five (Belgium, Poland, Austria, Hungary, Germany), based on a survey of hunting licenses (Massei et al., 2015).

The nature of dependency

Hunting can differ significantly in the level of dependence of the sector on natural populations and the natural processes that support them. For the purpose of this chapter, we can consider there to be three levels of dependency on natural provision of game species:

- *Low*: those that rely on the rearing and restocking of a game species;
- *Medium*: those that require the maintenance of a wild population at an artificially high level through human intervention (such as provision of supplementary feeding or predator control); and
- *High*: those that focus on wild populations occurring naturally in the wild with limited or no management required.

[29] http://www.face.eu/sites/default/files/attachments/denmark_conference_-_september_2012.pdf
[30] http://www.komitee.de/en/projects/hunting-bags/bag-statistics-country
[31] In GBP = £2 billion

It is important to note, nonetheless, that the distinction between the groups is often not clear; for instance, habitat management may often be required to ensure favourable conditions for a wild game species through recreating a process that is no longer occurring naturally due to the local extinction of keystone species, as will frequently be the case in Europe.

It is also important to consider the types of governance in place in Member States to regulate hunting which will influence the incentive to conduct monitoring and make available the data. Mustin et al. (2011a) identified three types of governance:

- *Landowner regulated*: the hunting rights belong to the landowner and there is typically no state monitoring or regulation of harvest (for example, game bird hunting in the UK and on private land in much of Europe).
- *State regulated*: hunting rights belong to the landowner, but hunting is by permit or licence. For some species, harvest levels are set by the state, which may or may not be based on monitoring of game populations.
- *State owned*: game and hunting rights belong to the state and there are usually bag limits imposed, which may or may not be based on monitoring of game populations. This is the case, for instance, in Hungary, Poland and Estonia.

Despite many reciprocal benefits, tensions exist between the interest of hunting and those of conservation which may affect the type of biodiversity monitoring the sector may be interested in contributing to. Hunting may be contributing to the decline of some bird populations in Europe, and hunters and game managers often conduct predator control through shooting, trapping and poisoning, with the aim of increasing the breeding success of game (Mustin et al., 2011a). Virgós and Travaini (2005) found that carnivore species richness was significantly lower in areas managed for small-game hunting than in areas where other land uses predominated. Illegal poisoning or shooting by hunters is reducing or limiting populations of endangered predators in several EU Member States, such as the Spanish Imperial Eagle (*Aquila adalberti*) in Spain (Mustin et al., 2011a; Mustin et al., 2011b), the Hen Harrier (*Circus cyaneus*) and Golden Eagle (*Aquila chrysaetos*) in the UK[32], the Goshawk (*Accipiter gentilis*) in Germany and the UK (NABU et al., 2014), and the wolf in Sweden (Liberg et al., 2012)[33].

Some game species populations are increasing to such high levels that they are causing economic damage and social conflicts and problems for conservation. For example, deer populations across Europe are so high they are threatening conservation of forest and scrub habitats in some areas (Kuijper, 2011). Wild boar populations are causing increasing crop damage and traffic accidents in Central Europe (ELO, 2012).

Species on which the services provided rely

Hunting can be split into main types: big and small game hunting (see **Box 5**). This distinction is useful in considering which hunting groups have the most to offer policy makers in terms of data monitoring. Big game hunting includes the ungulates, Wild Boar and large carnivores, and is usually carried out in forest or mountain habitats. Small game hunting (which includes birds, squirrels, rabbits and hares etc.) is heavily dependent on agricultural ecosystems (other than shoots which depend on intensive restocking) and is reported to have declined throughout Europe as a consequence of intensification and abandonment.[34]

Box 5. Hunted species in Europe

[32] http://www.theguardian.com/environment/2014/oct/30/hundreds-of-birds-of-prey-being-shot-or-poisoned-in-uk-rspb
[33] NB hunters are responsible for a significant share of wolf poaching because wolves kill hunting dogs
[34] http://www.face.eu/sites/default/files/attachments/denmark_conference_-_september_2012.pdf

Big game includes Red Deer (*Cervus elaphus*), Fallow Deer (*Dama dama*), Roe Deer (*Capreolus capreolus*), Alpine Ibex (*Capra ibex*)[35], Iberian Wild Goat (*Capra pyrenaica*), Chamois species (*Rupicapra rupicapra, R. pyrenaica*), Elk (*Alces alces*), Wild Boar (*Sus scrofa*), Grey Wolf (*Canis lupus*), Lynx (*Lynx lynx*) and Brown Bear (*Ursos arctos*).
The principal small game species that are hunted from wild native populations are Rabbit (*Oryctolagus cunniculus*), Hare (*Lepus europaeus*), Song Thrush (*Turdus philomelos*), Wood Pigeon (*Columba palumbus*), Willow / Red Grouse (*Lagopus lagopus*), Rock Ptarmigan (*Lagopus muta*), Grey Partridge (*Perdix perdix*), Mallard (*Anas platyrhynchos*), Teal (*Anas crecca*), Tufted Duck (*Aythya fuligula*), Pintail (*Anas acuta*), Pochard (*Aythya ferina*), Greylag Goose (*Anser anser*), Pink-footed Goose (*Anser brachyrhynchus*), Woodcock (*Scolopax rusticola*), Snipe (*Gallinago gallinago*), Golden Plover (*Pluvialis apricaria*)[36], Lapwing (*Vanellus vanellus*)[37]. Species which are no longer hunted in most countries because of their decline in numbers include Black Grouse (*Tetrao tetrix*), Capercaillie (*Tetrao urogallus*), Black-tailed Godwit (*Limosa limosa*)[38].
Grey Partridge (*Perdix perdix*) are reared and released in a number of MS including Sweden and the UK. Red-legged Partridge (*Alectoris rufa*) are hunted from wild native populations in France and other countries but also widely stocked including the UK, to which they are not native. Until recently, Quail (*Coturnix coturnix*) were reared and restocked in large numbers, notably in Italy, Greece, Romania, France and Spain; releases are banned in France since 2000 and in Cyprus.[39] An EU species management action plan in 2009 recommended the banning of Quail restocking both on public and private lands (Perennou, 2009). Mallard (*Anas platyrhynchos*) are reared and released on a large scale in France, Czech Republic, Sweden, Denmark, Italy, UK and other places. Woodcock (*Scolopax rusticola*) has been stocked recently in the UK to increase numbers.[40]

Stocked and released animals are affecting the genetic integrity of native species. In Spain, there is evidence that most of the stocked quail are hybrids between the European Common Quail (*Coturnix coturnix)* and the Japanese Quail (*Coturnix japonica)* (Sanchez-Donoso et al., 2012). Reared Mallard (*Anas platyrhynchus*) populations in the Czech Republic show a markedly lower genetic diversity than the wild population (Cizkova et al., 2012), and are hybridizing with wild ducks; though a study in France found that genetic introgression in the French populations is currently limited most likely due to the high mortality rate of released Mallard (Champagnon et al., 2013). European populations of Red-legged Partridge (*Alectoris rufa*) show widespread introgression of genes from Chukar (*Alectoris chukar*), with the exception of Corsican populations (Barbanera et al., 2010), and there is considerable commercial trade in Red-legged Partridge eggs and chicks between Italy, Spain, France and Portugal, contributing to gene flow. Most red deer in Europe are considered to be hybrids, and there is insufficient information about remaining authochthonous populations to protect their genetic integrity, other than the Corsican and Sardinian subspecies protected under the Habitats Directive (Burbaité and Csányi, 2010).
Releases of exotic game birds and mammals for shooting have been carried out for a long time in Europe, resulting in the establishment of feral populations of North American and Asian species, and of Palaearctic species outside their natural ranges, notably Pheasant (*Phasianus colchicus*), Chukar (*Alectoris chukar*), Wild Turkey (*Meleagris gallopavo*), Sika Deer (*Cervus nippon*), Reeves Muntjac Deer (*Muntiacus reevesi*), Chinese Water Deer (*Hydropotes inermis*), Muskrat (*Ondatra zibethicus*) and Rabbits (*Oryctolagus cuniculus*). Some of these have become problematic invasive alien species (DAISIE, 2009). Hunters shoot most of these invasive species, and others such as Racoon Dogs

[35] Eg in Spain http://www.greatspanishunts.com/en/big-game-species/search-by-species/alpine-ibex/
[36] Golden Plover are currently hunted in France, Ireland, Malta, Portugal and UK (Béchet, 2009).
[37] Lapwing are currently hunted in France, Spain, Italy, Malta and Greece (Petersen, 2009).
[38] Except France which did not accept the temporary ban agreement (Jensen and Perennou, 2007)
[39] Quail are hunted in Austria (only Burgenland), Bulgaria, Cyprus, France, Greece, Italy, Malta, Portugal, and Spain (Perennou, 2009).
[40] Personal communication, Game and Wildlife Conservation Trust UK

Nyctereutes procyonoides and Racoons *Procyon lotor*, and in a few cases have helped contribute to controlling population expansions[41].

Habitats on which the services provided rely

The hunting sector relies on the management of a very wide range of terrestrial habitats, including farmland (both arable and grassland), forestry, heathland, bogs and other wetlands. Particularly important habitats include wetlands, as numerous native and migratory species of interest to hunters are dependent on this widely threatened habitat (Eglington and Noble, 2010). In Spain, the dehesa habitat is an important habitat for both large game - such as Wild Boar, Red Deer and Roe Deer (*Capreolus capreolus*) - and small-game – such as Red-legged Partridge (*Alectoris rufa*) and Rabbit (*Oryctolagus cuniculus*) (Olea and San Miguel-Ayanz, 2006). A report on hunting in the UK suggests that land managed for the benefit of game has beneficial impacts on important habitats and species, and that conservation work is carried out for its own sake, with shooting providers in the UK spending close to £250 million a year on conservation (PACEC, 2014).

The maintenance of appropriate habitats is essential to the provision of game in many cases, because, where the game species is not being artificially stocked, the maximum sustainable population size is dependent on the availability of appropriate territory and food, or area and quality of suitable habitat. For example, on smaller hunting estates in Spain the annual harvest was found to be influenced by the availability of wild birds and Mediterranean scrubland habitat, and the release of stocked birds did not increase the hunting harvest, whilst on intensive hunting estates, the annual harvest was determined by the release intensity of stocked birds (Díaz-Fernández et al., 2012).

Existing policy targets and indicators

The hunting of wild bird species in the EU is regulated through the Birds Directive, which lists 82 species in Annex II that can be hunted in the EU or in specific Member States subject to the principles of wise use and ecologically balanced control of the species, in a way that is compatible with the conservation status of the species (European Commission, 2008). In addition, Member States can issue licenses for the hunting or trapping of other species if there are public interests of health and safety or damage to resources, and capture and judicious use of 'small numbers' for other reasons 'under strictly supervised conditions and on a selective basis'.

The Habitats Directive regulates the hunting of mammal species deemed to be of Community interest in Europe: the species listed in Annex IV are subject to strict protection measures, whilst the species listed in Annex V may possibly be taken subject to management measures, in some cases only in particular Member States or parts of Member States. Species on Annex V that are hunted in some countries include the large carnivores (wolf, bear, lynx, wolverine, golden jackal), Alpine Ibex, Spanish Ibex, Chamois and Mountain Hare. Member States must design and implement appropriate measures for these species including surveillance and monitoring.

The European Commission has concluded that EU management plans for 13 huntable bird species in unfavourable conservation status have been poorly implemented.[42] EU hunting community representatives are increasingly aware of the need to manage public opinion and promote an image of sustainable use, and to engage with policy development and conservation measures. The European Federation of Associations for Hunting and Conservation (FACE) are keen to highlight their commitment to biodiversity conservation in their recent 'Biodiversity Manifesto' (FACE, 2011), and,

[41] http://jagareforbundet.se/vilt/Mardhundsprojektet/

[42] Expert Group on the Birds and Habitats Directives. Ornis Committee meeting 15-16 October 2014. Doc Ornis 14-10/05b.

in their 2013 annual report, highlight their engagement with DG Environment's Mapping and Assessment of Ecosystem Services project (FACE, 2013).

The Commission guidance on sustainable hunting under the Birds Directive states that, in the absence of good information on population dynamics and hunting take of sedentary and migratory species, high levels of exploitation should generally be avoided (European Commission, 2013a). It is is therefore in the interests of hunters to ensure a good flow of information, in order to ensure that hunting of protected species continues to be allowed. There are already established routes and frameworks for dialogue between conservationists and the hunting sector, which has included establishing means of increasing hunter participation in data collection. In a formal agreement between *Birdlife International* and FACE (2004), both organisations recognised the importance of data collation and use in conservation, agreeing that "*rational assessment of effects and measures, including those to be adopted in legislation and other rules on hunting, must be based on the best available and reliable data, especially for bird populations and hunting activity. The collection, scientific interpretation and proper use of hunting bag statistics is therefore necessary*."

Existing data collection and monitoring

It is challenging to make a rigorous assessment of the impact of hunting across the EU as there is currently no system for integrating bag statistics for all species and EU Member States. The hunting association FACE set up the FACE-ARTEMIS Information Portal to collect bag statistics on European huntable species in 2006, to aid scientific interpretation and ensure that hunting in the EU remains classified as a sustainable use of natural resources[43]. It finally became functional with links to existing national datasets in early 2015, however it reveals that no bag statistics are being collected in a number of Member States. Several hunter groups have registered with the EUMON (EU-wide monitoring methods and systems of surveillance for species and habitats of Community interest) platform as potential monitoring organisations (EUMon, 2011). Despite these efforts, no comprehensive and updated data on game bags are available (Monaco et al., 2013). Data on shooting of lagomorphs (rabbits and hares) are very fragmented and although data on ungulates and birds is more comprehensive, the data are frequently not collected in a harmonised manner (Apollonio et al., 2010a; Apollonio et al., 2010b). There is also currently very little monitoring of the genetic structure of released birds in EU Member States, although in Portugal, for example, the general hunting law mandates that released birds must be genetically pure and similar to the wild species (Perennou, 2009).

Birds are the most hunted group in terms of individuals killed. The pressure group Committee Against Bird Slaughter gathered bird hunting data in a study in 2005 that estimated that 102 million birds are legally killed in the EU annually, excluding poached birds[44]. Pheasant (21.9 million shot annually), Wood Pigeon (15.5 million) and Song Thrush (14.9 million) were reported to be the most hunted bird species (Hirschfeld & Heyd, 2005); however, these figures must be considered with the relative commonness of these species borne in mind. The study was not able to draw conclusions about the possible impact of hunting on bird species populations in the EU.

The extent and way in which hunters contribute to the monitoring of biodiversity (including the target species) varies considerably in countries across the EU. Better understanding of successful schemes should provide an insight into identifying barriers to involving hunters in monitoring and to where opportunities exist for further integration. There are numerous examples of local or national schemes which could be incorporated into an EU system (see **Table 2** and **Box 6**).

[43] http://www.artemis-face.eu/about-the-project

[44] http://www.komitee.de/en/projects/hunting-bags

A recent FACE survey found that hunting associations are often involved in monitoring of the legally protected large carnivore species in the EU.[45] One of the many controversies surrounding large carnivores relates to knowledge over their status (distribution, numbers and population trends), and a major part of this conflict concerns whose knowledge is 'right' when different stakeholder groups proffer disparate information (Rigg et al., 2014). Considerable effort has been invested in some parts of Europe to involve hunters and other stakeholders in the co-generation of knowledge on large carnivores through robust, objective approaches that maximise effort through 'citizen science'.

Table 2. Examples of hunter involvement in biodiversity monitoring

Country	Examples of hunter involvement in biodiversity monitoring
Finland	For over 40 years the majority of census data on game species has been collected by hunters on a voluntary basis, rather than by paid professionals (Monaco et al., 2013; Pellikka et al., 2007) (see **Box 6**).
Sweden	Species quotas are set based on censuses conducted by volunteer hunters (Mustin et al., 2011a). For Elk (*Alces alces*), a new method of devolved population management is being trialled in which hunters are being asked to take on greater responsibility for monitoring of the species – which is expected to require a significant and successful communication effort to enhance future participation (Lindqvist et al., 2014).
Estonia	Local hunters associations are obliged to collect monitoring data (sightings and biological samples from hunted specimens) and report annually on game bag statistics of all game species. These data are analysed by a state institution (Keskkonnaamet – the Estonian Environment Agency) and are used to evaluate the population status and trends and to compile the annual quotas for certain species. Hunters pay an individual fee for a hunting licence which goes towards funding applied wildlife research projects.[46]
Slovakia	A pilot project engaged hunter groups in non-invasive sampling of wolf populations using genetic sampling from urine, scat and hair (Rigg et al., 2014). The samples were gathered using snow tracking and surveying of forest roads within the study area, supplemented by camera trapping. This allowed the identification of the minimum population size, number of separate family groups, and the genetic diversity of the population. The project also concluded that there was no evidence of hybridization between wolves and dogs in that part of Slovakia.
Spain	Numbers of game birds shot each year need to be declared to the regional government to compile annual statistics, although in many cases declared numbers are estimates and monitoring of birds shot within hunting estates is not very tight (Mustin et al., 2011a). Nevertheless, between 2002 and 2011, collaboration between hunters and conservationists in Spain resulted in the Quail (*Coturnix coturnix*) monitoring programme (Domingo Rodriguez-Teijeiro et al., 2010).
UK	In the UK, where the majority of shooting for occurs on private land, landowners set their own bag limits, usually establishing their own monitoring systems in order to do so (Mustin et al., 2011a). This appears to be the case for both small and big game. The Game and Wildlife Conservation Trust (GWCT), a UK charity dedicated to the conservation of game and its associated flora and fauna, have run the National Gamebag Census since 1961 to provide a central repository of records from shooting estates in England, Wales, Scotland and Northern Ireland.[47] It covers 20 mammal and 36 bird (huntable and 'pest') species. The longest data series of they hold stretches back to 1794. The information is provided on a voluntary basis by hunting groups. The British Association for Shooting and Conservation has been running the Green Shoots Programme since 2000 which provides records of wildlife and habitats, both

[45] http://www.face.eu/about-us/resources/news/involvement-of-hunting-associations-and-hunters-in-the-monitoring-of-large

[46] Pers. comm. Peep Männil, Wildlife Monitoring Department, Estonian Environment Agency (Keskkonnaamet)

[47] https://www.gwct.org.uk/ngc

	on and off hunters' shooting areas.[48] The Grey Partridge count is a voluntary population monitoring scheme targeted at farmers, land managers, gamekeepers etc[49].

Box 6. An example of voluntary game monitoring by hunters in Finland

In Finland, censuses covering the whole country have been largely carried out by hunters on a voluntary basis for over 40 years. The main method in the monitoring of many game species in Finland is the wildlife triangle scheme (WTS), providing abundance estimates for around 30 species. A study by Pellikka et al. (2007) investigated the characteristics of the hunting teams that have been active in the WTS to establish motivations and their range of activity. Their results found that the current hunters' participation in the WTS is not just related to their own hunting interest as demonstrated by the fact that hunters also monitor many game species with hunting limited or prohibited in their district (e.g. grouse hunt in southwest of Finland).

The data suggests the larger hunting groups are more likely to carry out the censuses regularly, although small groups of motivated individuals were also found to successfully participate in the WTS. Other possible factors which may explain the probability of carrying out censuses, but which are difficult to put into numbers, are the social settings of the activities. Many of the participating persons in the WTS described the census in a way that can be seen as an indication of tradition or recreational factors motivating to the censuses. For example, the shared activity together with the company, walking, skiing, orienteering along the census line, enjoyment of seeing animals and tracks, and feeling of responsibility for providing information to the administration and research may be seen as valuable to the participants regardless of the value of the census results.

It should be noted that no large-scale experiments have been made to validate the data provided by hunters against those provided by professionals although the study refers to anecdotal evidence that the results from the grouse censuses made by hunters have been very similar to those reported from the grouse censuses made by bird watchers using the same WTS-method.

Source: Pellikka et al. (2007)

Potential contribution to EU BON

How strong is the incentive for the sector to manage the resource sustainably & hence to support monitoring and data provision?

HIGH - Voluntary game monitoring by hunters has the potential to make an important contribution to the monitoring of important species. In cases where the hunting is dependent on wild rather than restocked populations, the sector has a strong motive to ensuring the sustainability of wild populations. Hunters are also well placed to monitor other key species that affect their hunting interests, such as certain invasive alien species, the large carnivores, and predators of game species. However, there are also significant barriers to access to data relevant to nature conservation. Data on the detrimental impacts of hunting activities, such as the illegal persecution of protected predators, such as large carnivores and birds of prey, are very scarce and difficult to come by.

How strong is the potential capacity for data mobilisation and collection?

HIGH - In a number of countries, hunters are already providing valuable monitoring data, which are being used by national authorities for reporting and/or wild population management. A variety of birds and mammals are valued as wild game, and thus hunting represents an opportunity for the monitoring and data collection of a wide number of species. There is a history of monitoring within the sector at various scales, and a growing engagement with various EU level monitoring schemes amongst hunting organisations.

[48] http://basc.org.uk/conservation/green-shoots/green-shoots-mapping/
[49] http://www.gwct.org.uk/research/long-term-monitoring/partridge-count-scheme/

How high is the EU policy relevance of the habitats and species?
HIGH – Most of the species hunted from wild native populations are regulated by the Birds or the Habitats Directives at the EU level, which includes policy mechanisms at the EU level to restrict hunting of species that are not at favourable conservation status. This means that hunters have a direct interest in ensuring that hunting is sustainable in order to avoid restrictions and contribute to conservation efforts, as expressed by the agreement between the European Federation of Associations for Hunting and Conservation (FACE) and BirdLife International.[50] Better data on wild game populations would also help to more accurately assess the risks associated with diseases shared by wild animals and domesticated animals and/or humans.[51]

Ecosystem service: Angling – Recreation/Cultural

The ecosystem service and beneficiaries

Angling is the sport or pastime of fishing with a rod and line – and therefore does not include commercial fishing which is dealt with in section 3.3. It is estimated that across Europe, the number of people who can be classified as anglers is approximately 25 million, at 6.5% of the EU population (Hickley, 2009), although participation is difficult to quantify and varies between Member States, with generally lower participation rates measured in Eastern Europe, and higher rates in the Nordic countries. These figures include both marine and freshwater angling, with both varieties being extremely popular, although it is noted many anglers engage in multiple different types of fishing. The European Anglers Alliance represents 18 member organisations in 17 countries with around 3 million anglers[52]. This activity contributes significantly to the European economy and has a strong multiplier effect due to spending on equipment, travel, tourism, clubs etc.: it is estimated that in Europe the average annual expenditure by anglers is EUR 25 billion (Hickley, 2009). In England and Wales, it is estimated that coarse freshwater fisheries alone contribute £850 million to the economy (Maltby et al., 2011), out of a total spend of up to £2.75 billion on the sport as a whole (Environment Agency, 2006). This analysis focuses on the anglers who directly benefit from angling wild fish populations (ie not including stocked fish) and on the inland angling sector only.
It should be noted that angling represents only a small proportion of the annual inland fish take and a large part of recreational angling in Western Europe involves re-releasing the fish, although in Southern Europe many fishermen fish part time mainly for recreation whilst still selling their catch. Commercially significant freshwater fisheries exist in 19 EU Member States, with an estimated 17,100 commercial inland fishermen operating within the EU in 2008-2009, many of whom were part time (Newman, 2014). Anglers have been known to come into conflict with commercial fishermen and co-operation is often poor (Cowx, 2015). However, in most Member States commercial inland fisheries are concentrated on one or a few larger water bodies, and are in decline in most areas of Europe (Cowx, 2015), whilst angling takes place on a much wider range of freshwater habitats, which makes it more interesting from the point of view of biodiversity data.

[50] European Commission 23 September 2014, Brussels. Janez Potočnik European Commissioner for Environment Speech. 35 years of cooperation to protect wild birds in Europe. Speech/14/618.
[51] Eg Chronic Wasting Disease in deer: EFSA (2010) Scientific Opinion on the results of the EU survey for Chronic Wasting Disease (CWD) in cervids. EFSA Journal 8(10):1861, and African swine fever in wild boar: Lange (2015) Alternative control strategies against ASF in wild boar populations. Study for the European Food Safety Authority. EFSA supporting publication 2015:EN-843.
[52] http://www.eaa-europe.org/

The nature of dependency

Though the catching of wild fish is highly valued by many anglers, forming a key part of the cultural services these fisheries provide (i.e. their recreational and personal value to participants), the stocking of fish to enhance inland fisheries, particularly in lakes, is a widespread practice across the EU, and the degree of dependency on the provision of wild fish populations therefore varies. Fish stocking can have damaging effects on wild fish populations and the aquatic environment, so should not take place where natural recruitment is satisfactory (Hickley, 2009). A lot of stocking activity has been introduced as a reaction to the degradation of freshwater habitats and declines in native fish populations (Cowx, 2015). Angling is highly regulated in most countries of Europe. Fishing rights are controlled by landowners or angling associations and anglers must obtain licenses to fish most species. License fees are used, to varying degrees, by government agencies to fund management and conservation activities related to recreational fishing. Anglers have been foundational in the formation of many freshwater conservation initiatives in Europe. Often, as exemplified by the organisation 'Fish Legal' in the UK, the angling agenda is well aligned with that of conservation[53]. The Council of Europe developed the European Charter on Recreational Fishing and Biodiversity[54] under the Bern Convention in 2011, in an attempt to recognize and promote sustainable recreational fishing as a legitimate use of fish resources and as an important tool in biodiversity conservation.

It is important to note the threat posed by non-native invasive freshwater fish species. Angling has often been a driver of exotic introductions which can be damaging for native biodiversity including native fish species, as illustrated by the recent extinction of Vendace (*Coregonus albula*) in Bassenthwaite Lake, Cumbria, UK (Maltby et al., 2011). The European Code of Conduct on Recreational Fishing and Invasive Alien Species[55] endorsed by the Council of Europe in 2014 states that anglers should prevent the release, spread and translocation of invasive alien species that have impacts on native fish populations or the environment, and recreational anglers are now contributing to EU policy implementation on invasive alien species[56].

Species on which the services provided rely

There are two main groups of species targeted by freshwater anglers: coarse and game fish. Hickley (2009) argues that European recreational fisheries are based mostly on coarse fish although game fish species are popular in Nordic countries and have a high value for specialist anglers. Coarse fish species (such as Bream *Abramis brama*, Carp *Cyprinus carpio*, Chub *Squalius cephalus*, Roach *Rutilus rutilus*, Pike *Esox Lucius*, Tench *Tinca tinca* and Zander (*Sander lucioperca*) prefer slow-flowing or still lowland waters. Game fish species (such as Brown Trout *Salmo trutta* morpha *fario* and *S. t.* morpha *lacustris*, Grayling *Thymallus thymallus*, Arctic Char *Salvelinus alpinus* and Salmon *Salmo salar*) prefer fast-flowing waters (Maltby et al., 2011).

Widespread non-native stocked fish include Rainbow Trout (*Oncorhynchus mykiss*) and Largemouth Bass (*Micropterus salmoides*). Pumpkinseed Sunfish (*Lepomis gibbosus*) and Round Goby (*Neogobius melanostomus*) have spread through various routes including deliberate introduction, Black Bullhead Catfish (*Ameiurus melas*) have escaped from fish farms, and Fathead Minnow (*Pimephales promelas*)

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[53] http://www.fishlegal.net/

[54] Council of Europe, Strasbourg, 4 February 2011. European Charter on Recreational Fishing and Biodiversity. Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) Standing Committee.

[55] Council of Europe, Strasbourg, 5 December 2014. European Code of Conduct on Recreational Fishing and Invasive Alien Species. Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) Standing Committee.

[56] http://www.eaa-europe.org/news/7847/recreational-anglers-gain-a-new-voice-in-brussels-to-tackle-invasive-species.html

have been accidentally or deliberately released as bait fish. Furthermore, freshwater fisheries are highly affected by invasive alien invertebrates such as Signal Crayfish (*Pacifastacus leniusculus*) and Killer Shrimp (*Dikerogammarus villosus*), plants such as Floating Pennywort (*Hydrocotyle ranunculoides*). Thus, these species should also be a focus of monitoring or data requirements.
Fishery managers sometimes undertake predator control, notably cormorants (*Phalacrocorax carbo*) but also Red-breasted Mergansers (*Mergus serrator*), Goosanders (*Mergus merganser*), gulls (*Larus* spp), and herons (*Ardea* spp).

Habitats on which the services provided rely

Angling habitats include a wide range of freshwater streams, rivers, ponds, lakes and artificial water bodies, including habitats important for biodiversity conservation (see **Box 7**). Certain habitats are particularly significant for fish recruitment; for example, coarse species such as pike, eel and carp rely on floodplain and wetland habitats as nurseries (Maltby et al., 2011).

Box 7. Key habitats of European conservation interest important for angling include:

- Chalk streams, listed under the Habitats Directive as 'Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation' (Annex I habitat type 3260), are notable for their important fisheries in northern Europe, particularly game species such as Brown Trout (*Salmo trutta*) and Atlantic Salmon (*Salmo salar*) which utilise the gravel beds in the upper reaches of the rivers for building their redds during reproduction;
- Oligotrophic to mesotrophic lakes with natural benthic and shoreline vegetation (e.g. Habitats Directive Annex I habitat types 3110, 3120, 3130, 3140), are known to host rare fish such as the Arctic Charr (*Salvelinus alpinus*), Vendace (*Coregonus albula*), and distinct populations of Brown Trout (*Salmo trutta fario*);[57]
- Natural eutrophic lakes (Habitats Directive Annex I habitat type 3150) are the habitat of coarse fish species including some threatened endemic species such as Aristotle's catfish (*Silurus aristotelis*);
- The lower reaches of Europe's large rivers (e.g. Danube and Rhine) used to host large populations of anadromodous or catadromodous fish which were the basis of valuable fisheries, including the sturgeon species (*Acipenser* spp.), European Eel (*Anguila anguila*), and shad species (*Alosa* spp.), many of which are now highly threatened or locally extinct.
- Coastal lagoons (Habitats Directive Annex I habitat type 1150) low intensity fishing is an important part of local cultural traditions in Mediterranean countries.

Wild freshwater fish populations in the EU are being strongly negatively affected by the fragmentation of freshwater habitats, particularly rivers, through dams, weirs, and other artificial constructions, as well as through movements of sediment, changes in river flow, and loss of riverine habitats caused by barriers, channelisation and other river bed modifications, and water abstraction (EEA, 2012a). Angling groups in some areas contribute to monitoring the impacts of obstructions on fish populations and have been instrumental in removing artificial features and barriers – such as weirs and culverts - that have restricted wild fish populations.[58]

Existing policy targets and indicators

A few freshwater fish species are subject to fishing restrictions under the EU Habitats Directive, including Salmon (*Salmo salar)* in freshwater, Grayling (*Thymallus thymallus*), Huchen or Danube Salmon (*Hucho hucho*), Common Zingel (*Zingel zingel*), and others. Member States must set up licensing and monitoring systems for these species and report on their efficacy at protecting the species to the European Commission.

[57] http://jncc.defra.gov.uk/protectedsites/sacselection/habitat.asp?FeatureIntCode=H3130
[58] http://www.wyeuskfoundation.org/; http://www.wandletrust.org/

The EU Water Framework Directive (WFD) requires Member States to monitor, assess and report on the quality of their water bodies, including their ecological status, using biological, chemical, and hydro-morphological parameters. The Biological Quality Elements (BQEs) specified in the WFD to help define ecological status include fish composition, abundance, and age structure. Member States have therefore established, improved and standardised their freshwater monitoring programmes, including the monitoring of fish populations (CEC, COM(2009)156 final).

A number of indicators have been developed to assess the environmental status of freshwater bodies, and the impact of environmental stress, based on sampling of invertebrate species such as river flies (Ephemeroptera, Trichoptera etc) and/or macrophyte sampling.

The EU Regulation on invasive alien species is introducing restrictions and reporting obligations on anglers with regard to invasive alien species, including fish, species used as bait, and species that can be transferred between water bodies on fishing gear and boats. Anglers are an important stakeholder group both for the implementation of control measures to stop species spreading, and for contributions to the monitoring and reporting of invasive alien species, including fish, invertebrates, and aquatic and waterside plants.

Existing data collection and monitoring

WFD monitoring programmes are generating a large quantity of data on freshwater fish, invertebrates and flora; for example biodiversity records gathered under the WFD in the WISER database include 17,376 records of river fish populations, 185,343 records of lake fish populations, and 17,003 records of transitional and coastal water fish populations (Lyche-Solheim et al., 2013). In contrast, catch information from EU inland fisheries is currently scarce, with information not routinely collected at the EU level, and data collection by Member States on inland fishing is highly variable, and not necessarily comparable (Newman, 2014). Angler catch data are not collected in a uniform manner across Member States, but could be obtained from angling clubs and groups in most areas with more or less effort. For example, in the UK, the Environment Agency uses data from match catch reports, angler log books and fishing licenses to complement data from electronic and manual expert fish surveys (Williams, 2012). Thus, there is potential for the expansion of monitoring using angler catch data.

Some angling associations are active in monitoring the environmental quality of their fishing areas, for example using invertebrate indicators (see **Box 8**).

Box 8. Involvement of anglers in biological water quality monitoring in the UK

In the UK, there is a growing movement to encourage anglers to engage specifically in biological water quality monitoring. For example, the Riverfly Partnership Angler Monitoring Initiative, launched in 2007 offers training courses to groups of anglers to enable them to monitor the water quality of their local watercourse themselves. This monitoring is alongside routine environment agency monitoring which generally occurs once a year, and is designed to flag pollution events quickly and act as a deterrent to those who negatively affect water quality. As the Partnership notes, anglers are the "natural guardians" of rivers, and "in an ideal position" to monitor their health using riverflies as an indicator[59]. These groups are put in contact with officers from the appropriate authorities (e.g., the Environment Agency in England), who they will alert if certain thresholds are exceeded in their monitoring. Work is now ongoing by the Freshwater Biological Association to create a central online repository for the data produced by this partnership, which will enable graphical analysis, and ensure that data are created to archive standards, so that they will not be rendered useless when technology moves on[60]. Examples of similar monitoring schemes exist elsewhere in the EU. It seems that there would be potential for angler involvement, as the UK example demonstrates willingness to engage with conservation activities and protect the environments that they fish. There is often also a strong organisational structure to the angling community, as anglers tend to be members of angling clubs or trusts, and have associations with river trusts or

[59] http://www.riverflies.org/rp-riverfly-monitoring-initiative
[60] http://www.riverflies.org/work-begins-rp-data-repository

conservancies. Such structures can be utilised to coordinate monitoring work, as the UK example has demonstrated, for example in the Thames Valley[61].

Potential contribution to EU BON
How strong is the incentive for the sector to manage the resource sustainably & hence to support monitoring and data provision?
MEDIUM - Although stocking is used in many cases, many anglers seek wild species, and report catch data to their local angling club. Many anglers are also interested in monitoring the water quality of their fishing areas and monitoring threats such as barriers to fish connectivity and invasive alien species.
How strong is the potential capacity for data mobilisation and collection?
MEDIUM - Some monitoring, for example through catch reporting, is already commonplace, but generally only on an informal basis. There is potential however for such monitoring to be expanded and structured. Furthermore, there is a growing movement for angler involvement in habitat monitoring to protect their local watercourses, for example through the monitoring of indicator species. Currently such initiatives are generally run parallel to, rather as part of, existing EU required monitoring regimes, e.g. under the Water Framework Directive.
How high is the EU policy relevance of the habitats and species?
HIGH – Freshwater fish are amongst the most highly threatened groups in Europe (Freyhof and Brooks, 2011), and many species are listed in the annexes to the Habitats Directive and thus subject to protection and monitoring and reporting requirements at the EU level. Fish populations are also key elements of freshwater quality monitoring and assessment under the EU Water Framework Directive, including the impact of barriers to fish connectivity and the impact of fish stocking on wild populations. Both the Water Framework Directive and the Habitats Directive also require the monitoring of the biological quality of freshwater habitats, including aquatic invertebrates and plants. Anglers could also play a key role in controlling and monitoring invasive alien species in freshwater habitats, as required by the EU Invasive Alien Species Regulation.

3.3. Commercial fisheries sector

Ecosystem service: Wild marine fish, crustaceans and shellfish - Provisioning

The ecosystem service and beneficiaries
Commercial fisheries are a major sector in the EU maritime economy, catching nearly 4 million tonnes in the European Atlantic and over 450 000 tonnes in the Mediterranean annually.[62] The size of the sector and total fishery productivity varies significantly across the EU, with four countries accounting for almost half of the total EU catches (Spain, Denmark, the UK and France) (European Commission, 2014). The majority of EU fishing vessels (83 per cent) are small in scale, generating 53 per cent of direct employment and representing a quarter of total catch value (Guyader et al., 2013). Larger scale vessels account for a smaller proportion of total vessels, but a larger proportion of total catch value. The small scale fleets generally travel shorter distances to fishing grounds, and are therefore more reliant on coastal areas. They also tend to use more passive fishing gear but this is certainly not always the case. Commercial marine fisheries are highly regulated and monitored in the EU. For example, the monitoring of location, speed and direction of all fishing boats of 12m or more in length using a satellite-based vessel monitoring system (VMS) is obligatory since 2012 (and monitoring of boats over 15m outside home waters since 2005).

[61] http://www.rivertac.org/riverfly-monitoring/
[62] http://ec.europa.eu/fisheries/documentation/publications/pcp_en.pdf

The nature of dependency

The viability of the commercial fishing sector depends almost entirely on the continuation of the natural, provisioning ecosystem service of fisheries production. However, rates of recruitment and productivity within fish stocks are related to fishing mortality – sustainable recruitment and yields rely on anthropogenic fishing mortality being kept at sustainable levels. In other words, fisheries depend on fish stock provisioning, but fish stock provisioning depends on fisheries being maintained at a certain level. An exception to this are certain fisheries for European Eel (*Anguila anguila*), where stocks are maintained or supplemented with translocated juvenile eels (Pawson, 2012).

This high dependency on natural processes implies that the fishing sector has a large interest in supporting the scientific examination of such processes. Scientific assessment of what constitutes a sustainable yield underpins the management of EU fisheries, and should determine the quantities of fish the sector is permitted to catch, at least theoretically. Fishers therefore have a direct interest in the accuracy and timeliness of data on fished species.

It is important to note that different types and scales of fishing boats and gear have markedly different impacts on commercial fish species and non-target species and marine habitats (N2K Group, 2013). Fishing can have damaging impacts on non-target species through catching them as bycatch in fishing gear. Drift netting is liable to catch marine mammals, turtles and seabirds, although some small-scale drift net fisheries can avoid bycatch[63]. Drift nets are banned in the Baltic Sea since 2008, and drift nets over 2.5 km in length are banned in all EU fishing vessels[64]. All vessels of 12 m or longer in the Atlantic and North Sea must use acoustic devices to deter cetaceans when fishing with certain nets during some or all of the year, and their efficacy must be monitored[65]. In the Mediterranean, longline fisheries take large numbers of sea turtles. Lost or ghost fishing nets and other gear made of long-lasting synthetic materials cause long-term damage to fish, shellfish and marine mammals. Certain fishing practices have significant negative impacts on marine habitats, notably bottom (demersal) trawling with beam trawlers (Svedäng, 2010; Tillin et al., 2006).

Species on which the services provided rely

Many marine species of fish, mollusc (shellfish) and crustacean are commercially exploited in EU waters (see **Box 9**). Marine ecosystems are complex, and there are numerous biological, chemical and physical parameters which influence the productivity of exploited fish species. Provision of the service thus indirectly depends on many other species, including plankton and other marine organisms that the target fish species feed on. Note that there are often predator-prey relationships between target species too. For example, adult cod is carnivorous and will eat almost any marine animal including other cod, but it feeds mainly on smaller fatty fishes such as herring, capelin and sand eels, and on shrimp and squid. Young cod feed mostly on the eggs and larvae of copepods and adult amphipods. Small pelagic fish such as mackerel and herring feed on zooplankton (fish larvae, small crustaceans, pteropods) and small fish. Other demersal fish such as plaice, sole and red mullet feed on small benthic crustaceans, worms and molluscs.

Box 9. Commercially exploited species in EU marine waters

Commercially important **fished, dredged or collected** species include:

[63] http://www.rspb.org.uk/news/details.aspx?id=377867

[64] Council Regulation (EC) No 812/2004 of 26 April 2004 laying down measures concerning incidental catches of cetaceans in fisheries and amending Regulation (EC) No 88/98 (as amended by Regulation (EC) No 809/2007). http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:l66024

[65] Council Regulation (EC) No 812/2004 of 26 April 2004 laying down measures concerning incidental catches of cetaceans in fisheries and amending Regulation (EC) No 88/98 (as amended by Regulation (EC) No 809/2007). http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:l66024

- in the **Baltic** Sea - Atlantic Cod (*Gadus morhua*), Baltic Herring (*Clupea harengus membras*), European Sprat (*Sprattus sprattus*), Atlantic Salmon (*Salmo salar*) and European Eel (*Anguila anguila*);
- In the **North Sea** - Whiting (*Merlangius merlangus*), Atlantic Cod, Haddock (*Melanogrammus aeglefinus*), Saithe (*Pollachius virens*), Mackerel (*Scomber scombrus*), Atlantic Herring (*Clupea harengus*), Sprat (*Sprattus sprattus*), European Plaice (*Pleuronectes platessa*), Dover Sole (*Solea solea*), Lemon Sole (*Microstomus kitt*) Monkfish (*Lophius piscatorius*), North Sea Shrimp (*Crangon crangon*), European Squid (*Loligo vulgaris*), Edible Crab (*Cancer pagurus*), Norway Lobster (*Nephrops norvegicus*), Northern Horse Mussel (*Modiolus modiolus*), King Scallop (*Pecten maximus*), European Oyster (*Ostrea edulis*), Clam (*Venerupis decussata*), Winkle (*Littorina littorea*), and Common Cockle (*Cerastoderma edule*);
- In the eastern **Atlantic** - Atlantic Cod, Silver Hake (*Merluccius bilinearis*), European Anchovy (*Engraulis encrasicolus*), Horse Mackerel (*Trachurus trachurus*), Ling (*Molva molva*), Boarfish (*Capros aper*), European Squid (*Loligo vulgaris*), Edible Crab (*Cancer pagurus*), European Lobster (*Homarus gammarus*), Northern Horse Mussel (*Modiolus modiolus*), King Scallop (*Pecten maximus*), European Oyster (*Ostrea edulis*), Clam (*Venerupis decussata*), Winkle (*Littorina littorea*) and Common Cockle (*Cerastoderma edule*);
- In the **Black Sea** - Black Sea Sprat (*Sprattus sprattus ssp*), European Anchovy, Horse Mackerel, Turbot (*Scophthalmus maximus*), Whiting (*Merlangius merlangus*), and European Lobster (*Homarus gammarus*); and
- in the **Mediterranean** - European Hake (*Merluccius merluccius*), Red Mullet (*Mullus barbatus)* and Striped Red Mullet (*Mullus surmuletus*), Blue Whiting (*Micromesistius poutassou*), European Anchovy (*Engraulis encrasicolus*), European Sardine (*Sardina pilchardus*), Sardinella (*Sardinella aurita*), Bluefin Tuna (*Thunnus thynnus*), Swordfish (*Xiphias gladius*), Albacore (*Thunnus alalunga*), European Squid (*Loligo vulgaris*), Blue-red Shrimp (*Aristeus antennatus*), European Lobster (*Homarus gammarus*), European Oyster (*Ostrea edulis*), Mediterranean Scallop (*Pecten jacobaeus*), Clam (*Venerupis decussata*) and Mediterranean Mussel (*Mytilus galloprovincialis*).

Commercially important marine **aquaculture** species include Atlantic Salmon (*Salmo salar*), Sea Bass (*Dicentrarchus labrax*), Atlantic Cod (*Gadus morhua*), Gilthead Seabream (*Sparus aurata*), Pacific Oyster (*Crassostrea gigas*) and Northern Horse Mussel (*Modiolus modiolus*).

Habitats on which the services provided rely

There are numerous habitats that are essential for EU commercial fisheries, serving as nursery, spawning or feeding grounds for commercial fish stocks. These habitat types may have different functions or be of differing importance depending on the fish species in question. The EU Habitats Directive lists ten marine habitats particularly important for biodiversity, including commercially important species (see **Box 10**). Each of these habitats may be found in several of the predominant habitat types listed in the Marine Strategy Framework Directive (MSFD), except estuaries, which typically fall under the Water Framework Directive and are therefore mostly outside the scope of the MSFD, and coastal lagoons, which are only considered within the scope of the MSFD if they have a permanent connection to the sea.

Box 10. Importance of the marine habitats listed under the Habitats Directive for commercially important fish and shellfish

Sandbanks which are slightly covered by sea water all the time (1110). An example of this habitat is the Dogger Bank in the North Sea. The habitat includes segmented polychaete worms, shrimp-like amphipods and small clams which burrow into the sand (JNCC, 2015). Hermit crabs, flatfish and starfish also live on top of the sandbank. Sand eels are also abundant on the sides of the sandbank providing food for fish such as cod, as well as marine mammals and birds (Joint Nature Conservation Committee, 2014).

Posidonia beds (Posidonion oceanicae) (1120). These Mediterranean seagrass beds are biologically productive ecosystems that provide food resources for a diversity of fish. Many fish species live in the *P. oceanica* meadows during their juvenile stage, including red mullets (Díaz-Almeda and Duarte, 2008).

Estuaries (1130). River estuaries are coastal inlets subject to the tides (except Baltic estuaries) but with a substantial freshwater influence, and often contain extensive mudflats and sand banks (see below), with fringing vegetation and saltmarsh habitats. Large estuaries are found mainly on the Atlantic coast. Material derived directly from the salt marsh feeds a few detritus-feeding species such as species of Grey Mullet (e.g. *Liza ramada*), but the salt marsh habitat has a more significant role providing shelter from predation for juvenile fish, such as Sea Bass (*Dicentrarchus labrax)*, which spend the first three or four years of their lives in estuaries (Doody, 2008). The salt marshes of the Wadden Sea, for example, provide a vital habitat for the reproduction and life cycle of other fish species such as the Atlantic Herring (*Clupea harengus*), European Plaice (*Pleuronectes platessa*) and Dover Sole (*Solea solea*). In the Mira Estuary in Portugal, the mudflats and creeks associated with the salt marsh act as a nursery area for more than 40 per cent of the fish species present in the estuary (Cattrijsse and Hampel, 2006).

Mudflats and sandflats not covered by seawater at low tide (1140). These sediments are usually coated with blue-green algae and diatoms, which provide rich feeding for invertebrates and juvenile fish at high tide (European Commission, 2013b).

Coastal lagoons (1150). These are salty or brackish water bodies which are separated from the sea by a tongue of land or other similar topography, with limited permanent or seasonal connections to the sea. They can provide habitat for *Cyprinus* fish species and Red Mullet (*Mullus barbatus)* (European Commission, 2013b).

Large shallow inlets and bays (1160). Coastal indentations that are not estuaries, where the sheltered water allows the accumulation of sediments and zoned benthic communities rich in benthic algae or *Zostera* or *Potamogeton* meadows, with a high diversity of invertebrates, providing fish nursery habitats (European Commission, 2013b).

Reefs (1170). Reefs are either formed by rock structures (e.g. rock walls, sea mounts, boulder fields) or by structures formed by corals, bivalves (e.g. blue mussels), or polychaete worms. They host rich algal and/or sessile invertebrate communities which provide a diverse habitat and shelter for many species (European Commission, 2013b).

Submarine structures made by leaking gases (1180). Submarine structures consist of sandstone slabs, pavements, and pillars up to 4 m high, formed by the accumulation of carbonate cement resulting from microbial oxidation of gas emissions, mainly methane, originating most likely from the microbial decomposition of fossil plant materials (JNCC, 2007). Little is known about the ecology of this habitat. Carbonate structures within depressions in the seabed provide a potentially favourable habitat for a variety of deep-water fish species such as Atlantic Cod (*Gadus morhua*), Haddock (*Melanogrammus aeglefinus*), Atlantic Wolf-fish (*Anarhichas lupus*) and Conger Eel (*Conger conger*) presumably through the provision of food and shelter (JNCC, 2007).

Boreal Baltic narrow inlets (1650). Narrow elongated bays in the Boreal Baltic sea area, partly separated from the open sea by a submerged sill, surrounded by rocky shores. Characterised by large fluctuations in salinity and consisting of soft mud with dense stands of reedbeds, *Potamogeton* and *Myriophyllum* pondweeds and algae, with typical molluscs, crustacean, polychaete worm species and abundant fish populations.[66]

Submerged or partly submerged caves (8330). Widespread in karstic rock formations, particularly in the Mediterranean, typically associated with reef structures. They harbour communities of marine invertebrates and algae including rare and endemic species, eg of sponges (Gerovasileiou and Voultsiadou, 2012), and provide shelter for crustaceans (crabs, lobsters, crayfish), and fish such as the Leopard-spotted Goby *Thorogobius ephippiatus*.

Existing policy targets and indicators

The commercially targeted species are of particular policy importance. Their exploitation is regulated under the Common Fisheries Policy (CFP), which aims to achieve sustainable rates of exploitation by

[66] HELCOM biotope information sheets. http://helcom.fi/Red%20List%20of%20biotopes%20habitats%20and%20biotope%20complexe/HELCOM%20Red%20List%201650%20Boreal%20Baltic%20narrow%20inlets%201650.pdf

2015 where possible and 2020 at the latest. Furthermore, the Marine Strategy Framework Directive (MSFD) requires populations of all commercially exploited fish and shellfish to be within safe biological limits, and exhibiting a population age and size distribution that is indicative of a healthy stock (Descriptor 3). These requirements are combined in the EU Biodiversity Strategy Target 4 objective of fishing at levels that will achieve a maximum sustainable yield (MSY) by 2020. Under Target 4, the Commission and Member States have agreed to 'significantly step up' the collection of data to support implementation of MSY, with the aim of incorporating ecological considerations in the definition of MSY by 2020. Under the MSFD Member States are required to provide information for an assessment of the environmental status of their seas and distance from/ progress towards good environmental status (see **Box 11**) (Zampoukas et al., 2012).

There are a number of streamlined and workable indicators already in existence to measure progress towards meeting the CFP and MSFD objective and EU Biodiversity Strategy Target 4. EU indicators relevant to commercial fish stocks are 'Proportion of European commercial fish stocks outside of safe biological limits' (SEBI indicator no 21) and 'the Marine Trophic Index' (SEBI indicator no 12) (defined as the trends in the mean trophic level of fisheries landings per European sea, where a declining trend in mean trophic level in a multispecies fishery indicates unsustainable exploitation). The former requires precautionary reference points in order to be calculated, but not all commercial stocks are monitored in respect to the precautionary approach, even in the North east Atlantic and the Baltic Seas where the availability of data is relatively good. Thus data poor stocks are assessed as to whether they are overfished or not based on landing trends, biomass surveys and data on catch per unit effort, in the absence of data on fishing mortality.

Other policy needs for marine biodiversity data in the EU include the Baltic Sea Action Plan of the Helsinki Commission (HELCOM BSAP)[67], the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean[68], the Black Sea Biodiversity and Landscape Conservation Protocol to the Convention on the Protection of the Black Sea Against Pollution[69], and the Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention)[70].

Box 11. MSFD descriptors of good environmental status and required biodiversity data

Descriptor 1: Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climate conditions.

Assessment of Descriptor 1 must be done at the species (species distribution, population size and population condition), habitat (distribution, extent and condition) and ecosystem level (composition and relative proportions of ecosystem components ie habitats and species). A few indicators are specified for each of these criteria.

Descriptor 4: All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.

Indicators include the performance of key predator species using their production per unit biomass, as an indicator of productivity, and abundance trends of functionally important selected groups/species (such as groups with fast turnover rates including phytoplankton and zooplankton, or groups/species at the top of the food web).

Descriptor 6: Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.

67 http://www.helcom.fi/Documents/Baltic%20sea%20action%20plan/BSAP_Final.pdf
68 http://ec.europa.eu/environment/marine/international-cooperation/regional-sea-conventions/barcelona-convention/index_en.htm
69 http://www.blacksea-commission.org/_convention-protocols-biodiversity.asp
70 http://jncc.defra.gov.uk/page-1370

Descriptor 6 requires assessment of the condition of the benthic community, using indicators such as the presence of particularly sensitive and/or tolerant species, species diversity and richness.

Existing data collection and monitoring

Member States are required to summit data on fish stocks through the EU Data Collection Framework (DCF)[71], which is collated by the International Council for the Exploration of the Sea (ICES) and used to assess the status of stocks. However, ICES estimates that out of more than 200 stocks for which it provides advice, 122 do not have population estimates from which catch options can be derived using the existing MSY framework (ICES, 2012). This is largely because there is limited knowledge of their biology or a lack of data on their exploitation. ICES developed a framework to assess these data poor stocks as to whether they are overfished or not based on available data and modelling, but recognizes that there are alternative approaches to many of the methods proposed, and Member State expert groups are encouraged to explore the most appropriate approach, checking for consistency among the responses (ICES, 2012). ICES catch statistics do not cover the Mediterranean and Black Sea. This area is covered by the General Fisheries Commission for the Mediterranean set up under the FAO,[72] but the data are scarcer and sporadically collected in comparison with the NE Atlantic (Tsikliras et al., 2013). A recent study that combined various indicators from available data confirmed that the fisheries resources of the Mediterranean and Black Sea are at risk from overexploitation (Tsikliras et al., 2015).

Direct routes for fishing sector involvement in European research include participation in EU research projects (for example Jakfish, CEVIS, GAP1 and GAP2). It is also possible for the sector to instigate research projects itself, using support available under the European Maritime and Fisheries Fund (Article 28). This fund covers data collection and management activities, studies, pilot projects, dissemination of knowledge and research results, seminars and best practices. The concept of involving the fishing sector in scientific research is not new. It is endorsed at a high level, and understood that involving stakeholders in scientific research will improve the data and knowledge required for management and governance (Mackinson et al., 2011). In addition to improving the quality and quantity of data, involving the fishing industry in research is thought to build trust and foster openness and transparency (Mackinson et al., 2011). Despite these intentions and high-level support, stakeholder participation in research has met with stumbling blocks. The type of research that has produced the most successful collaborations is fishing gear research, i.e. practical studies to develop and test new gear alterations (Mackinson et al., 2011). Fishermen sometimes contribute to biodiversity data collection for nature conservation purposes, for example some research projects have successfully worked with fishermen to monitor seabird bycatch (Degel et al., 2010).

Fishermen need to get involved in the surveying of impacts on biodiversity and the development of sustainable fishing practices and measures in marine protected areas such as Natura 2000 sites (Pedersen et al., 2015; Zaharia et al., 2014). A common methodology has been developed at EU level to assess the impact of fisheries on marine protected areas (European Commission, 2012).

Marine habitat data are increasingly being made available for research and policy purposes. For example, the European Marine Observation and Data Network (EMODnet), consisting of more than 100 organizations, assembles and offers marine data, products and metadata to public and private users[73]. Researchers used marine habitat data collected under the EUSeaMap project and ICES data on fish catches and landings from demersal trawling to map the impact of trawling and other human activities that can affect seafloor ecosystems in the Baltic Sea (Korpinen et al., 2015). A method to map

[71] Council Regulation (EC) No 199/2008 of 25 February 2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.
[72] http://www.gfcmonline.org/data/reporting
[73] http://emodnet.eu/

the sensitivity of marine habitats to fishing activities has been developed in the Welsh part of the Irish Sea (Eno et al., 2013).

Potential contribution to EU BON

How strong is the incentive for the sector to manage the resource sustainably & hence to support monitoring and data provision?

HIGH (PARTIAL) – Interest is primarily restricted to the commercial species. However, fishermen may be increasingly willing to finance access to local marine biodiversity data if they see an opportunity to gain fishing opportunities under the requirement of the new Common Fisheries Policy to allocate fishing opportunities according environmental criteria, and require an objective evidence base of the environmental impact of their fishery. The implementation of management measures for marine protected areas will require the collaboration of fishermen in monitoring impacts on biodiversity and implementing sustainable fishing practices. Small-scale or specialized fisheries have an increasing interest in providing the evidence base for the allocation of fishing opportunities according to environmental criteria under CFP Article 17.

How strong is the potential capacity for data mobilisation and collection?

MEDIUM – Commercial fisheries already do quite a lot of data collection, the sector is not new to the idea, but there are habitats and species which the sector could potentially help to monitor which they do not currently.

How high is the EU policy relevance of the habitats and species?

HIGH – Data on commercial fish species are of interest to CFP monitoring and assessment. All species and habitats are of interest to monitoring under the MSFD, and a number of habitats and non-commercial species that are caught as bycatch are of interest to monitoring and assessment under the Habitats Directive. Mapping and assessing the impacts of fisheries on marine species and habitats is relevant for the management of marine protected areas including the Natura 2000 network, and for the protection of marine species under the Birds and Habitats Directives.

3.4. Water supply sector

Ecosystem services: Surface & ground water for drinking / Hydrological cycle and water flow maintenance / Pollutant filtration, sequestration, storage, accumulation – Regulation & maintenance

The nature of dependency

The water supply industry is highly dependent on ecosystems to regulate water provision for drinking, both the provision of surface and groundwater for drinking and the bio-physiochemical filtration, sequestration, storage and accumulation of pollutants from this water in ecosystems, improving water quality (Bishop, 2011). It is clear that the provision of precipitation and its temporary storage as surface water or groundwater in ecosystems is the fundamental input on which this industry relies, thus dependency on this ecosystem service is very high. It is quite hard to place an economic value on the provision of such a fundamentally essential service. As such, values tend to vary widely and when calculated are often highly context-specific, so should be considered at best indicative (Russi et al., 2013). Drinking water can also be obtained via desalination, but the infrastructure costs associated with this process are so great that it is currently impractical on a large scale.

The water supply industry constructs and manages an extensive infrastructure of wells, reservoirs, pipes, canals, and treatment plants, which is expensive to maintain. There is a growing appetite in the EU to replace grey infrastructure (e.g. embankments, dykes, dams and treatment plants), with green infrastructure, i.e. more natural habitats and ecosystems.

Some of the key substances negatively affecting water quality for drinking in Europe are nitrates from agricultural fertilizer run-off, nitrogen pollution from animal manure and slurry, pesticides, and organic compounds from peat erosion that discolor water brown (Jennings et al., 2006) and may cause cancer (EPA and HSE, 2011). Water treatment plants carry out purification to remove pollutants, sediment and colour, but there is significant potential for cost saving of expensive treatments through sensitive catchment management, which promotes natural filtration and storage of pollutants in ecosystems. Some substances cannot currently be removed through treatment. If quality can be improved in the catchment, these costs can be reduced. Water supply companies must also address catchment water quality issues both because of legal obligations and because of customer public image problems.

Water companies are increasingly investing in catchment management schemes which pay land managers to conserve catchment habitats to reduce pollution, regulate water supply, and filter out pollutants. These include Vittel's scheme in north-eastern France, designed to decrease nitrate contamination of the aquifer caused by agricultural intensification (Perrot-Maître, 2006), Evian's long-term voluntary agreement with dairy farmers to manage the catchment area in a manner which preserves the quality of their natural mineral water (EPI, 2011), and United Utilities' Sustainable Catchment Management Programme (SCaMP) in the UK (United Utilities, 2011). Such schemes demonstrate that there is a commercial interest in investing in catchment management and the monitoring of key habitat types. Governments are also increasingly focusing on catchment management in order to fulfill the requirements of the EU Water Framework Directive, for example the UK government is currently running a series of Demonstration Test Catchments[74] to investigate the services that a catchment approach can provide.

Habitats on which the services provided rely

Key habitats include wetlands, riparian vegetation buffers, and upland ecosystems susceptible to soil erosion, such as peat. Vegetation plays an important buffering role, increasing lag time, and acting as a structural filter for sediment and pollutants (both above and below ground), but soil fauna are also important. The burrowing and casting activities of these organisms contributes to surface roughness and the maintenance of stable porosity, both critical for the regulation of runoff and water retention in soils (Harrison et al., 2010). Soils also have a buffering capacity, through absorption and bacterial biodegradation.

Wetlands and functioning floodplains are key regulators of local water availability and quality, slowing the movement of water through catchments, regulating supply, and contributing significantly to water purification through denitrification and detoxification (Russi et al., 2013). Microbial communities found in these environments are also the main processors of organic sewage (Harrison et al., 2010). Increasingly wetlands are being created with the primary intention of acting as a buffer to filter water before it reaches water courses or treatment plants, with numerous environmental and economic benefits.

Riparian vegetation also regulates flow, increases system lag time, and filters pollutants. Riparian habitats can act as a buffer preventing pollutants, sediments, and nutrients entering water courses important for drinking water supply (Harrison et al., 2010). Other habitats, upland and riparian woodland or forest for example, can also have positive impacts for the regulation of water quantity and quality, and general catchment management.

Peatlands in good condition can store large quantities of pollutants such as sulphur, nitrogen and heavy metals (Hirst, 2012), but many peatlands in Europe are now severely degraded and are a key source of organic compounds that cause water quality problems. The role of other habitat types, such as semi-

[74] http://www.demonstratingcatchmentmanagement.net/

natural grasslands, is poorly known (Harrison et al., 2010). Arable areas generally contribute negatively to water quality (Stoate et al., 2001).

Species on which the services provided rely

Habitats and soil structure are generally much more significant for the provision of water quality and supply regulation than specific species. However, certain keystone species for ecosystem function could be used as indicators of habitat and water quality. Micro-organisms provide a vital service in many upland and riparian environments, helping to prevent the contamination of watercourses and extraction points. In bogs, sphagnum mosses are keystone species that underpin the proper function of the ecosystem and the key services of water retention and purification.

Existing policy targets and indicators

The EU Water Framework Directive sets the target that the water quality in drinking water areas (catchments) should not decline, and requires the designation of drinking water areas on all surface water and groundwater catchments used to supply drinking water. The EU Drinking Water Directive sets legal limits for contaminants in drinking water at the tap, which raises some issues with regard to substances that can only currently be removed from water with very expensive treatments.

It is likely that with increasing awareness in the water supply sector of the importance of catchment management, monitoring by the water industry of biotic ecosystem variables will increase. The European Federation of National Associations of Water and Waste Water Services (EUREAU) have expressed their support for Common Agricultural Policy measures, such as buffer strips, that have beneficial effects on water quality and quantity (EUREAU, 2011). The European Commission's 'Blueprint to Safeguard Europe's Water Resources' calls for the development of buffer strips and restoration of riparian vegetation, wetlands and floodplains (European Commission, COM(2012) 673 final).

Existing data collection and monitoring

The monitoring of water quality and supply levels is widespread across the EU, in part due to the EU Water Framework Directive requirements (see **Box 12**). The European Environment Agency maintains the Waterbase data reported by Member States on water quality in lakes[75], rivers[76] and groundwater[77] and emissions of nutrients and hazardous substances to water, aggregated within River Basin Districts[78]. Until recently the European Commission's Joint Research Centre maintained a database on the monitoring of agrochemicals in terrestrial ecosystems[79]. Online databases provide information on ecological preferences and distribution of the species and groups used to characterize the ecological status of water under the WFD[80].

Monitoring is primarily focused on water quality in streams and rivers, rather than the status of key habitats and ecosystems contributing to water quality. However, some water companies are investing in habitat assessments and monitoring to complement water quality testing. For example, the UK SCaMP project commissioned a specialist ecological consultancy to carry out annual monitoring of various botanical and hydrological parameters to establish the impact of catchment habitat restoration measures (Anderson and Ross, 2011).

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[75] http://www.eea.europa.eu/data-and-maps/data/waterbase-lakes-10
[76] http://www.eea.europa.eu/data-and-maps/data/waterbase-rivers-10
[77] http://www.eea.europa.eu/data-and-maps/data/waterbase-groundwater-10
[78] http://www.eea.europa.eu/data-and-maps/data/waterbase-emissions-4
[79] http://fate.jrc.ec.europa.eu/monitoring/monitoring-overview/
[80] For example, http://www.freshwaterecology.info/, described in (Schmidt-Kloiber and Hering, 2015)

Box 12. Freshwater species groups used as indicators of biological status of water bodies under the WFD
The Biological Quality Elements (BQEs) specified in the WFD to help define the biological component of ecological status are:

(1) Phytoplankton – composition, abundance, biomass

- Example: lake phytoplankton morpho-functional groups eg large chrysophytes/haptophytes (*Dinobryon, Mallomonas*), dinophytes and euglenophytes (*Gymnodinium, Ceratium*)

(2) Aquatic flora – composition and abundance

- Example: river macro-phytes eg *Littorella uniflora, Chara spp.*

(3) Benthic invertebrates – composition and abundance

- Example: river macro-invertebrates – insect larvae, crayfish, shellfish, snails eg freshwater mussels *Anodonta spp., Pseudanodonta spp, Unio spp.*

(4) Fish – composition, abundance, age structure

- River fish, lake fish, transitional and coastal water fish

The combinations of BQEs and the categories of water bodies defined in the WFD result in around 20 different kinds of biological measurements, but the WFD does not specify which techniques and methods should be used. Member States have chosen to adapt their previous monitoring methods or develop country-specific methods, and as a result have adopted over 300 different bio-assessment metrics (Birk et al., 2012). These have been assessed and compared in an inter-calibration exercise, and the European Commission has now defined a set of standard metrics that have been recognised as equivalent to one another for over 100 classes of surface water (Council Decision 2013/480/EU). The WISE (Water Information System for Europe) database maintained by the EEA contains a large volume of biodiversity records gathered under the WFD. An analysis of the WISE data reveals some biases in terms of giving an EU overview of the state of aquatic biodiversity (Lyche-Solheim et al., 2013). The data are biased by certain countries which put greater emphasis on certain BQEs, eg fish in France and transitional/coastal macro-invertebrates in Spain (Lyche-Solheim et al., 2013). The highest taxon richness per country was recorded for river macro-invertebrates (>1,000 taxa in a few central-European countries) and for lake phytoplankton (300-1,000 taxa in many countries) (Lyche-Solheim et al., 2013). Data from rivers were found to be relatively balanced for the five biological quality elements, but dominated by records from Central Europe. Data from lakes were dominated by phytoplankton and fish records from northern and central European countries. Data from coastal and transitional waters were dominated by records of macro-algae and angiosperms and fish from central- and southern-European countries.

Potential contribution to EU BON
How strong is the incentive for the sector to manage the resource sustainably & hence to support monitoring and data provision?
MEDIUM (partial) - The water industry is beginning to invest in catchment management schemes, which include monitoring of both ecological and biochemical parameters, as they are seeing the economic benefits of promoting water purification in the catchment area. There is significant interest in developing this approach, so it is likely that monitoring of key habitats will expand, as companies attempt to assess restoration efforts and payments for ecosystem services approaches. It has the added advantage that the industry will be motivated to monitor the condition of habitats and of the ecosystem service being provided, both of which are under-represented in biodiversity reporting.
How strong is the potential capacity for data mobilisation and collection?
LOW/UNCLEAR - Remaining questions about this sector refer to how applicable it will be across Europe as conclusions made for this chapter draw heavily on examples from the UK. More information is needed on the habitats and species that underpin this service in other countries.
How high is the EU policy relevance of the habitats and species?
LOW/MEDIUM - There is extensive, legally required, monitoring of water quality in the EU, but no universal monitoring of key habitats for natural water quality regulation. The EU Water Framework

Directive sets the target that the water quality in drinking water areas (catchments) should not decline. Water quality regulation relies mainly on the maintenance of general ecosystem quality and structure rather than on individual species or habitats.

3.5. Insurance industry

Ecosystem service: Prevention of natural hazards eg mass stabilisation and control of erosion rates – Regulation & maintenance

The ecosystem service and beneficiaries

Insurance can be defined as a promise of compensation for a specific potential future loss, in exchange for a periodic payment (Mulder, 2007). Insurance policies to protect against natural hazard damage to individuals and companies are widespread in Europe, as a range of natural hazards threaten communities and businesses, including landslides and avalanches, floods (both inland and coastal), storm damage (due to direct wind effects, as well as coastal wave damage), forest and scrub or heath fires, and drought. Insurance prices for customers have been increasing recently in response to increases in insured losses due to extreme weather events (Mulder, 2007). Climate change is increasing the intensity and frequency of extreme weather events such as storms, floods, droughts and harsh winters. This is increasing the loss burden on the insurance sector, whilst also increasing demand for both private property and business loss policies. For example, a recent study concluded that claims relating to winter storm damage in Europe are likely to increase by 16-68% over the period 1975-2085 (in constant currency) (Schwierz et al., 2010). The number of wildfires since the 1970s has doubled with about 50,000 outbreaks now recorded annually, covering an area of 60,000ha, and are estimated to cost €1 billion annually (Palahi et al., 2008).

The impacts of some potential natural hazards can be effectively attenuated or prevented by particular environmental features or processes. The insurance sector benefits from ecosystem services that mitigate damage or income loss from natural hazards because they regulate the level of insured losses within limits that allow for sustainable economic planning of insurance premiums and returns. If the likely severity of damage and/or the frequency of damage become too high, insurance companies can only offer very expensive insurance coverage or none at all. In reality the costs of significant natural disasters, where insured losses are very high, are often borne by reinsurers (companies who take on the risks borne by insurance companies – i.e. those who insure the insurers). The exact extent to which the mitigation of impacts on insured assets benefits the insurance sector depends on how much of the cost can be passed on to the consumer by raising insurance premiums. However, an increasing frequency of insured losses and rising loss ratios are a risk to this sector. Therefore, attention to natural risk mitigation by ecosystem services is valuable for the sector itself, as well as the individuals and businesses it provides a service to.

There is a growing awareness in the sector of the need to engage in environmental policy as the vulnerability of insured property increases and demand for policies grows, particularly in response to uncertainty about future change, for instance, the Munich Climate Insurance Initiative – initiated by the insurer Munich Re - which aims to find insurance solutions to climate adaptation.[81]

The nature of dependency

The reliance of this sector on ecosystem services depends on the institutional and legislative context, as well as on business context, i.e. the risks concerned and the property or potential income being insured.

[81] http://www.climate-insurance.org/front_content.php?idcat=876

Certain risks are heavily regulated by governments, with public funding for risk prevention, so that private companies and individuals do not need to take out insurance. There are variations across the EU in what risks the sector will insure against, and also in the market penetration of this cover (Munich Re Group, 2008). For example, in Austria approximately 90% of household policies include coverage against snow load losses, whereas in Germany less than 10% of homeowners have this cover (Munich Re Group, 2008). Furthermore, of course, natural hazard risks and risk perception vary greatly across Europe (Maccaferri et al., 2012).

As the insurance sector operates based on the balance of risk, the industry invests heavily in risk modelling and projections to guide strategic decision making regarding policy pricing and coverage. The insurance sector for natural hazards is heavily reliant on accurate, fine-grained and long-term environmental data and trends to help them assess current and future risks and damage from natural hazards. Environmental data are also necessary to help verify the authenticity of insurance claims.

Habitats on which the services provided rely

The habitats of importance to the insurance sector are varied and highly context specific, depending on the risk in question. However, some broad habitat types can be identified which provided clear impact mitigation or prevention benefits (**Table 3**).

Table 3. Natural hazards and habitat types that mitigate damage

Natural hazard	Damage mitigation provided by natural habitats and vegetation
Landslides	Any vegetation which stabilises hillsides and sediments helps prevent landslides, particularly mature vegetation with well-established root systems such as woodland (but not intensive agriculture or deforested land)
Floods	Upland woody vegetation and habitats and soils that retain water contribute to increasing lag time and water storage in the upper catchment, thus decreasing the likelihood of flash floods. Sustainable management of these habitats also slows the sedimentation of river channels, which can decrease flooding. Lower in the catchment, floodplain vegetation buffer zones and wetlands serve as spillover areas to limit the impacts of flooding on nearby properties.
Storm damage	The direct impacts of wind storms are difficult to mitigate using an ecosystem services approach, although the resilience of forests can be increased by removing non-native species. The impacts of coastal storms can be mitigated by encouraging the development or preservation of coastal wetlands which attenuate wave energy, bind sediment and act as a buffer zone to protect property from flooding (Russi et al., 2013).
Forest fires	Reintroducing traditional grazing processes has been cited as a means of reducing the secondary forests and scrub that exacerbate forest fires which have expanded in range due to land abandonment.[82]

Species on which the services provided rely

The species of significance for the mitigation of natural disaster impacts on the insurance sector are highly context specific and dependent on the risk concerned. The insurance sector is concerned with the potential of ecosystems or environmental features to either mitigate or amplify the impacts of a natural hazard on insured property or incomes, or to increase risks. The important environmental functions which can mitigate insured losses vary widely and can be performed by a range of organisms, and it is often the structure of habitats and ecosystems which is actually significant in mitigating the impacts of natural disasters, rather than specific species.

[82] http://ec.europa.eu/environment/forests/pdf/meeting140504_wwffirstdocument.pdf

Certain species can increase the risk of natural disaster damage and may therefore be associated with insurance claims. For example, the non-native invasive Coypu (*Myocastor coypus*) dig holes in earth dykes around reservoirs and other water bodies, increasing the risk of flood damage. In the UK, insurance companies are offering insurance to house owners against the risk of invasion by Japanese Knotweed (*Fallopia japonica*), as they are legally liable for any property damage caused[83].

Existing data use and monitoring

Earth observation data and satellite imagery are increasingly being advertised to insurers[84], and companies specialize in providing natural hazard data to the insurance industry[85]. For example, a consortium of insurers and reinsurers, promoted by the European Space Agency, is assessing the utility of receiving real-time flood extent information based on data from European and Canadian remote sensing satellites[86]. Microwave remote sensing of soil moisture can be used to provide better drought prediction[87]. The European Commission's Joint Research Centre curates some datasets relevant to mapping natural hazards, including:

- Global Disaster Alert & Coordination System GDACS[88];
- European Floods Awareness System EFAS[89];
- European Forest Fire Information System EFFIS[90].

Potential contribution to EU BON

How strong is the incentive for the sector to manage the resource sustainably & hence to support monitoring and data provision?

MEDIUM (UNCLEAR) – The insurance sector has an increasing need for high quality and long-term environmental data such as real time satellite imagery and land cover data. However, the exact extent to which insurance companies are or will invest in biodiversity data collection and monitoring is unclear, as there is often only a weak link between natural hazard occurrence and specific habitats and species. However, the insurance industry may become increasingly interested in data on invasive alien species as regulatory requirements and legal obligations on companies and property owners increase.

How strong is the potential capacity for data mobilisation and collection?

UNCLEAR – The engagement of the insurance and reinsurance sector in biodiversity and ecosystem monitoring activities does not seem currently widespread. It seems that any significant engagement in the direct monitoring of biodiversity or ecosystem services by the insurance industry would need to be in collaboration with a range of other sectors. The portfolio of the insurance sector as a whole is so wide-ranging and reliant on the benefits provided by so many different ecosystem services that a realistic targeted scheme would be impossible to develop. However, on a smaller scale, in collaboration with insured communities or businesses, there may be potential to develop monitoring schemes as part of wider nature-based risk management strategies in response to specific threats such as invasive alien species.

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[83] http://www.cli.co.uk/Public/japanese-knotweed.aspx
[84] http://www.cgi-group.co.uk/public-sector/space/earth-observation
[85] https://www.perils.org/
[86] http://www.esa.int/Our_Activities/Observing_the_Earth/Insurance_industry_adopts_Earth_observation_for_assessing_floods
[87] http://www.geo-informatie.nl/projects/glossy/2011/GLOSSY_NikoWanders.pdf
[88] http://www.gdacs.org/
[89] https://www.efas.eu/efas-archive.html
[90] http://forest.jrc.ec.europa.eu/effis/

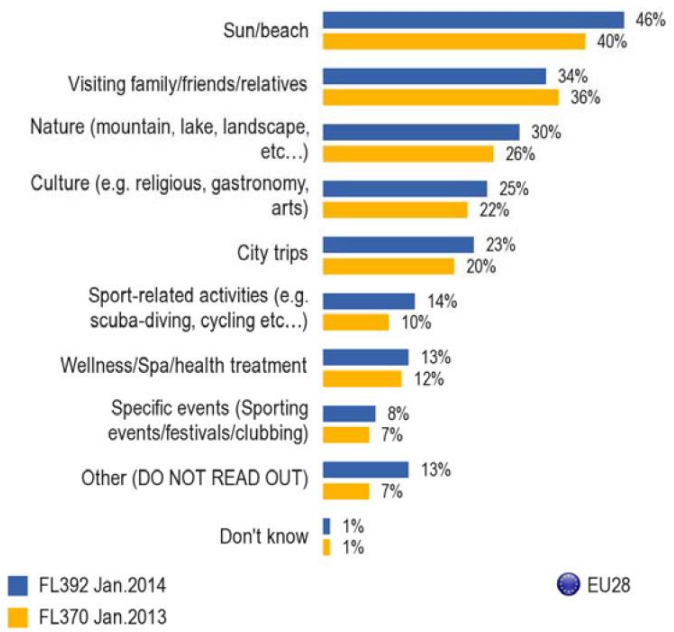
How high is the EU policy relevance of the habitats and species?
LOW/UNCLEAR - The habitats and species important for the provision of these services to insurers are highly context specific, and vary based on the risk concerned, geographical location, and local institutional and legislative frameworks. However, certain habitat types provide recognised services, including coastal wetlands as a buffer against storms, attenuating wave energy and preventing coastal erosion; the flood prevention service provided by upland peat bogs and woodlands; the landslide prevention capacity of mature forests.

3.6. Tourism sector

Ecosystem service: Physical and experiential interactions - Cultural

The ecosystem service and beneficiaries
The travel and tourism sector constitutes an important part of the European economy representing 7.9% of EU GDP in 2011 and expected to grow to 8.1% by 2022 (World Travel & Tourism Council, 2012). This assessment focuses on nature-based tourism, i.e. travel to natural places to experience and enjoy nature, as distinct from eco-tourism, i.e. tourism where the net impact of travel on the environment and on local people must be positive (TEEB, 2009). Nature-based tourism is increasing in most parts of the world (Balmford et al., 2009). A recent Eurobarometer study found that 30% of people in the EU say that nature was one of the main reasons they went on holiday in 2013 (see **Figure** 2) (TNS Political & Social, 2014).[91] Even where nature is not the main purpose for tourism, it is often a significant contributor to the amount of enjoyment obtained from tourism (Tisdell and Wilson, 2012). The tourism industry therefore benefits from the experiential and/or physical use of nature and ecosystems for recreation and enjoyment.

Figure 2. The main reasons for going on holiday in 2013 amongst EU citizens



Source: TNS Political & Social (2014)

[91] Enjoying nature was the main reason for taking a holiday in two countries – the Czech Republic (54%) and Israel (41%); it was also relatively widespread in the Netherlands (43%) and in the Former Yugoslav Republic of Macedonia (42%), although not the main reason. Nature was least important as a reason of the questions asked for going on holiday in Turkey (14%), Ireland (15%), Portugal (18%) and the UK (18%).

The CICES classification of this cultural service describes it principally in terms of outdoor recreation activities such as walking, cycling hiking, in-situ whale watching and bird watching, climbing and boating. For the purposes of this work, we have excluded leisure angling and hunting which we have covered in separate sections. The ecosystem service is provided by the landscapes and habitats and their characteristics (biotic including species and abiotic) to which people are drawn (Church et al., 2011). A subset of nature tourism is 'wildlife tourism' i.e. tourism based on viewing wild animals in their natural habitat. Although still relatively small compared to the industry as a whole, wildlife tourism is often locally important and likely to occur in areas of limited economic development and therefore constitute an important income stream for local communities and businesses (Jurado et al., 2012; RSPB, 2011). For instance, in Scotland, it has been estimated that the net economic benefit of wildlife tourism is £65 million (€82 million)[92] supporting 2,763 jobs, with the highest economic benefit experienced in the Highlands and Islands region (ICTHR, 2010).

The nature of dependency

Nature based tourism may have both significant potential for positive benefits for biodiversity through generating funds for conservation, and shaping people's attitudes to the environment (Balmford et al., 2009) and negative impacts through development in important sites for wildlife and opening up previously inaccessible areas). Tourism and recreation can be a significant negative pressure on particular habitats such as sand dunes (Farris et al., 2013) and certain species populations. The nature tourism industry is therefore also a key stakeholder to engage in efforts to promote sustainable tourism in protected areas (BfN, 2010).

Nature based tourism and wildlife tourism benefits greatly from protected areas, notably the Natura 2000 network. The recreational benefits supported by the Natura 2000 network in the EU are estimated at around 5 to 9 billion Euros, i.e. an average willingness to pay of 4 Euros per visit to a Natura 2000 site (BIO Intelligence Service, 2011). A national assessment in Finland found that total annual revenue linked with visitor spending in national parks was €70.1 million and supported local employment of 893 FTE jobs (Metsähallitus, 2009).

Rewilding Europe highlighted a case in mountainous areas of Romania of hides originally built for shooting bears being used instead for tourism, which – as a result of strict quotas on bear shooting limiting the intake - would generate as much as twice the revenue from using it for hunting; up to €20,000 and €30,000 per annum.[93]

Species on which the services provided rely

Charismatic species are thought to be a primary motivator for tourist decision-making (Goodwin and Leader-Williams, 2000). Reynolds and Braithwaite (2001) identify the two most important factors affecting a wildlife tourists' experience as species popularity (driven by factors such as the publicity that the species enjoys in the media, physical attractiveness, size) and conservation status, with rare and endangered species holding special appeal. In the case of Europe, these species may be expected on these grounds to be the larger and rarer species that generate the greatest level of wildlife tourism, such as Grey Wolf (*Canis lupus*), Brown Bear (*Ursus arctos*), Eurasian Lynx (*Lynx lynx*) and European Bison (*Bison bonasus*). Although no overall figures have been found in the course of this review with respect to the amount of tourism these species generate within the EU, a high interest in rare species provides obvious advantages to policy-makers and management authorities who require more data to conserving these species in fulfilment national and European legal requirements. Birdwatching is also

[92] Assuming €1 = £0.793

[93] http://www.rewildingeurope.com/blog/bears-worth-more-alive-than-dead/

an important component of wildlife tourism, relying both on areas with a high abundance of bird populations such as wetlands, and areas with particularly rare species.

Habitats on which the services provided rely

Scenery is a major factor in the choice of destination for many tourists (Bell et al., 2007). In Finland, for instance, this was found to outweigh interest in the species assemblage of the site in question (Tyrväinen et al., 2001). Certain habitat types can have characteristics which make them suitable for particular outdoor pursuits, and thus valuable to the tourism and outdoor recreation sector (see **Table 4**). However, such a method of conceptualising the value of habitats to this sector cannot truly capture the aesthetic or spiritual elements or attachments which draw people to certain landscapes, as it is primarily focused on activity as the source of value.

Table 4. The opportunities and potential benefits of different habitats for recreation and tourism

Habitat/habitat characteristic	Significant features	Potential recreation opportunities
Mountains, crags and hills	Vertical and near vertical inclines	Climbing, mountaineering, rock scrambling, long rage views and picnicking
Sea	Wind and waves	Surfing, kite surfing, boating/sailing, sea-fishing
Upland streams	Fast-flowing shallow waters	Game angling, white water canoeing and rafting
Limestone rocks	Caves and fissures	Caving and potholing
Alpine landscapes	Snow cover	Snow sports
Woodlands	Tree cover with tracks, rides and clearings	Walking, cycling, horse riding, many types of informal recreation
Estuarine environments	Sheltered waters	Moorings, marinas
Lakes	Wind, calm waters	Water sports, swimming
Beaches	Sand and sea	Outdoor swimming and beach activities
Parks and open spaces	Publicly accessible green spaces	Walking, dog walking, cycling, running, picnicking and informal recreational activities

Source: Adapted from Chapter 16 of the UK NEA (Church et al., 2011)

Existing indicators, data collection and monitoring

A screening of the extent to which standards and awards relevant for the tourism industry include biodiversity aspects in their policy documents found that most do not require baseline data to be collected nor any monitoring of the effects of development on biodiversity (Marsden et al., 2014). However, it is possible that increasing awareness of the ecological damages that tourism can create will put pressure on the tourism sector to provide evidence of the impacts the industry is having on biodiversity. For example, a study of German holiday makers found that 40% want their holiday to be as ecologically sustainable and environmentally friendly as possible.[94]

Tourism companies that depend on sightings of wild animals are likely to have in-house expertise which could provide high quality monitoring data. Some wildlife tour operators are regularly providing biodiversity data. For instance, accredited operators offering trips to see a resident population of Common Bottlenose Dolphins (*Tursiops truncatus*) in a Natura 2000 site must provide monitoring data

[94] ReiseAnalyse. (2014). Retrieved from http://www.fur.de/index.php?id=ra20140. Cited in Marsden et al. (2014).

(Hoyt, 2003). A naturalist takes part in every trip and carries out monitoring with hydrophone and photo-ID work. A whale watching company in the Azores operates a rotational monitoring system together with marine biologists (Hoyt, 2003). Involving tourism operators in protected area planning and management can increase engagement in biodiversity monitoring and data collection. For example, the Lake District National Park Partnership in the UK includes Cumbria Tourism as equal partners alongside the park authority and conservation organisations[95].

The tourism industry is a consumer of biodiversity information on protected areas, attractive species and habitats for advertising, information and planning purposes. Wildlife tourists are consumers of information on species and habitats they are hoping to see or have seen, for example species check lists for particular sites, species ID guides both online and printed, and web sources that provide added information, that all increase the pleasure and interest gained from the tourism experience.

Potential contribution to EU BON

How strong is the incentive for the sector to manage the resource sustainably & hence to support monitoring and data provision?

MEDIUM (PARTIAL) - Although it is difficult to determine specifically to what extent wild species and natural habitats contribute to the sector, it is clear that the nature-based tourism is locally economically important - as much nature-based tourism occurs in remote areas – and there is some evidence to suggest that it is growing as a proportion of the industry as a whole. There are a number of reasons why this sector could become an important provider of biodiversity monitoring for policy makers:

1. Much of the nature-based tourism sector is based in remote areas, where there are fewer citizen scientists to carry out monitoring. Currently, many of these areas are covered by professionals at high cost to the Member State.
2. Tourism (and tourism potential) is high in parts of Europe where monitoring is currently low (e.g. southern and eastern Europe).
3. Conservation status is one of the most important factors affecting a wildlife tourists' experience as species popularity, with rare and endangered species holding special appeal. In many cases, these species are highly protected and member states have to fulfil reporting requirements on their conservation status.
4. Tourism companies that depend on sightings of wild animals are likely to have in-house expertise which could provide high quality monitoring data if required.
5. Nature-based tourism can be important for local and regional economies, creating a higher demand for conservation and biodiversity data.

How strong is the potential capacity for data mobilisation and collection?

HIGH - Examples of specific involvement in monitoring through tourism do exist, but it is proposed that different approaches should be embraced, such as partnership working, and innovative funding mechanisms, to engage this sector more broadly in work on monitoring and ultimately protecting biodiversity and ecosystem services. There are already a number of citizen science projects that encourage visitors to protected areas to submit their sightings e.g. via smart phones. The degree of engagement tends to depend heavily on the efforts of public authorities responsible for protected areas to engage tourists and the tourism industry.

How high is the EU policy relevance of the habitats and species?

MEDIUM (PARTIAL) - There is potential for nature tourism to contribute to monitoring certain European protected species and habitats, particularly within the Natura 2000 network and other protected areas, and for particularly attractive and easily identified species.

[95] http://www.lakedistrict.gov.uk/caringfor/partnership/ldnppmanagementplan

3.7. Planning authorities and development sector

The sector's relationship to ecosystem services and biodiversity

The focus of interest of this sector is not a dependence on ecosystem services, but the regulatory requirements that protect certain habitats and species from destruction or disturbance through infrastructure and building development, and that require developers to mitigate adverse impacts of developments on habitats and species and, in some cases, to compensate for unavoidable impacts. Developers are required to assess, evaluate, avoid, and mitigate impacts according to the mitigation hierarchy as part of the environmental impact assessment (EIA) of each project. In some cases they must also compensate unavoidable impacts, or they develop compensation measures voluntarily. In some Member States, developers are also required to quantify and mitigate and sometimes offset impacts on ecosystem services, for example impacts on soil functions and local climate in Germany (Rayment et al., 2014). The assessment and evaluation require information about the biodiversity present in the impact zone of the proposed development site, and in most cases requires an on-the-ground site survey.

The nature of dependency

Developers benefit significantly from access to high-quality and up to date information on habitats and species of conservation value in order to rapidly screen a planned development site for the presence of any features that might make the EIA more complicated, notably the presence of European protected species or habitats. This information can be used to inform the decision between alternative sites, avoiding sites where planning permission might be refused or restricted. An example is the I-BAT tool provided by UNEP-WCMC.[96] The screening can also be used to estimate the costs and difficulties of the EIA and the planning application process. A site survey by qualified experts may then be required, possibly including specific species surveys, e.g. bats or birds of conservation interest.

The EU Habitats and Birds Directive require the assessment and mitigation, and possibly the compensation of impacts on protected species. It may be necessary to offset the expected impacts on a protected species population or on several species. This requires an assessment of the species local and regional population status, the site features on which the species depends, including the combination of habitats, structures and vegetation types, and the existence of other pressures on the species which might combine with the negative impacts of the planned development. The calculation of species offsets is normally complex and requires a considerable amount of ecological data including habitat maps, distribution data, and the ecological requirements of species. Habitat suitability indices, assembled from matching species ecological requirements with a habitat classification system, can provide a standardised methodology (Somerset County Council, 2014).

Development offsetting measures in EU Member States such as Germany mainly aim to address the general ecological value of affected habitats or biotopes (i.e. their values in terms of communities of species or as an ecosystem), independently of the requirements of the EU nature directives (Rayment et al., 2014). In order to assess offsetting requirements, habitats are categorised according to their potential (i.e. inherent) relative biodiversity conservation value (e.g. in terms of species-richness, distinctiveness, naturalness, biogeographical importance or ecosystem service value) irrespective of the condition of the specific site. This is usually done using the site survey and standard national or regional lists of habitat values or value bands, or more simple classifications of value according to degree of naturalness and/or difficulty of recreation or restoration.

Species which play a significant role for the sector

Developers in the EU are legally required to assess the impacts of proposed development on the around 1200 European protected species listed in the Habitats Directive Annexes II and IV and the 193 bird

[96] http://www.unep-wcmc.org/featured-projects/biodiversity-data-for-business

species and subspecies listed in the Birds Directive Annex I. Developers are generally also obliged by national legislation to assess the impacts of development on nationally protected species, and in some cases regionally protected species. Developers might therefore have to consider a long list of species in an environmental impact assessment.

Habitats which play a significant role for the sector

Developers in the EU are legally required to assess the impacts of development on Natura 2000 sites (SPAs, SACs, SCIs). They are also required by national legislation to assess the impacts of development on nationally designated protected areas, such as national parks, nature reserves, specific protected habitats and other forms of area and habitat protection. In the German mandatory offsetting regulation, all semi-natural and natural habitats and habitat features must be offset (Rayment et al., 2014).

Existing indicators, data collection and monitoring

The legally responsible authority for the environmental impact assessment may be a private developer or a public authority in the case of publicly funded developments. There is a significant unmet need for biodiversity data for planning and environmental impact assessment in both the private and public sector. For example, regional planners in Poland were found to have no data on species and habitats because detailed surveys at local level did not exist for most of the areas, with the exception of road planners who had access to detailed survey data in the immediate proximity of planned roads (Blicharska et al., 2011).

Planning authorities may fund the development of publicly accessible data sets. For example, the Netherlands Nature Data Authority commissioned SOVON (Dutch Centre for Field Ornithology) to produce potentiality maps for bat species, using presence-absence data in correlation with other landscape parameters, for use in spatial planning.[97] At the same time, EIA site surveys are generating a large volume of localised but potentially interesting data sets, which could be made available to other users. Policy makers also need the results of such data for higher level analyses, for example to assess whether the cumulative impact of existing and foreseeable development in a region is unsustainable in terms of ecosystem functioning and ability to support characteristic biodiversity. This requires accurate graphic representations of the spatial influence of cumulative impacts arising from development.

Potential contribution to EU BON

How strong is the incentive for the sector to support monitoring and data provision?

HIGH – The requirement for biodiversity data for environmental impact assessment is considerable, and may increase with the expansion of offsetting programmes.

How strong is the potential capacity for data mobilisation and collection?

HIGH (partial) – Developers and planners in both the private and public sectors generate a large volume of local biodiversity data from EIAs and other impact assessments.

How high is the EU policy relevance of the habitats and species?

HIGH – The data on impacted European protected species and habitats, and on the success or failure of compensation measures, are directly relevant to assessing the effectiveness of the Habitats and Birds Directives. Data on the impacts of development on habitats and species more broadly is relevant to informing EU policy related to land use and spatial planning, for example efforts to reduce the impacts of urban sprawl.

[97] EUROBATS national implementation report Netherlands 2010-2013

4. The potential contribution of stakeholder groups to biodiversity data provision and use

4.1. The potential contribution to the EU BON biodiversity data portal

EU BON aims to provide mechanisms for delivering integrated biodiversity information to meet specific policy needs, and design concepts for sustaining integrated environmental information systems with the active participation of citizens, business and industry. This review aimed to identify opportunities to enhance the collection and mobilization of data on biodiversity and ecosystem services from stakeholders who benefit directly because they have a high dependency on ecosystem services and/or biodiversity to maintain their business model.

The sectors reviewed in this study were prioritized for their potential contribution to biodiversity data integration in the EU using three criteria: 1. How strong is the incentive for the sector to support monitoring and data provision? 2. How strong is the potential capacity for data mobilisation and collection? 3. How high is the EU policy relevance of the habitats and species?

The sectors and their ranks for each of these criteria are summarised in **Table 5**. In conclusion, those sectors that rank highest for their potential to provide policy relevant data are:

- Construction industry, developers and planning authorities for data on habitats and species affected by development;
- Farmers and agricultural organisations for data collection and monitoring of pollinators and natural biological control;
- Hunters and hunters groups for data collection on hunted species and other contributions to species and habitat monitoring;
- Angling groups for monitoring and data collection on freshwater biodiversity and habitat status.

The prioritized sectors all have a relatively high interest in an organized data flow, based both on their dependency on ecosystem services and related biodiversity, and/or the negative impacts their sector has on ecosystems and biodiversity, and therefore their biodiversity data requirements. For example, the construction industry has a considerable requirement for biodiversity data for environmental impact assessment, which may increase with the expansion of offsetting programmes. These sectors could also provide added value through integration into the EU BON data portal because they are not currently contributing to monitoring and data provision at the EU level but have data available, and/or have unfulfilled data requirements. For example, hunting organizations are in some cases collecting useful information that remains at the local level or they could be mobilised to do more, whilst marine fishermen are already reporting their data on fish catches and the data are assembled in a database at EU level, and they are unlikely to respond to calls for more extensive data collection.

Some of the sectors that ranked lower are not benefiting from biodiversity resources directly, but are part of a chain involving others. For example, crop breeders very rarely use genetic material directly from wild populations; they rely on material that has already been collected and characterised for its genetic and phenotypic attributes, and therefor rank low for incentive. Data on the occurrence and conservation status of crop wild relatives in Europe is currently assembled only by research institutions and publicly funded research projects.

Table 5. Summary of ranking of sectors for their potential to contribute added value to EU data portal

Sector	Biodiversity	incentive	capacity	relevance	Overall score including potential added value	Summary of main points influencing scoring
Construction	Various	High	High (partial)	High	**High** – including potential offsetting	high dependence on accurate fine-grain information on habitats and species potentially impacted by developments, may increase with wider offsetting requirements developers and planners generate large volume of local biodiversity data that is currently not made available publicly-funded initiatives to supply planning authorities and developers with data sets relevant to appropriate assessments of impacts on Natura 2000 sites and protected species impacts under Birds and Habitats Directives
Farmers & agricultural organisations	Wild pollinators	High (partial)	Medium	Potentially high	**High** (link to impacts of pesticide use)	high incentive due to high dependency of some crops plus increasing concerns re pesticide use opportunities for citizen science level monitoring large data gaps on species in southern EU emerging policy area with no EU level targets but recent national strategies and action plans data highly relevant to assess impacts of pesticide use
Farmers & agricultural organisations	Natural biological control	Medium/ unclear but increasing	Medium	Medium	**High** (link to reductions in pesticide use)	high incentive due to increasing implementation of integrated pest management major data gaps in key species groups providing the ecosystem service opportunities for citizen science level monitoring of some species groups data highly relevant to assess impacts of pesticide use and national action plans under the Sustainable Use of Pesticides Directive to reduce pesticide use

Hunting	Birds, mammals	High	High	High	**High**	generally high incentive due to desire and policy requirement to demonstrate sustainable hunting some groups highly motivated to contribute to species and habitat monitoring beyond direct hunting interests generally rel. organized sector with some obligatory local bag reporting requirements no unified hunting statistics collection at EU level – barriers due to diversity of hunting governance forms & legal frameworks data gaps re genetic structure of hunted game problem of illegal killing of predator species data directly relevant to policy targets of Birds and Habitats Directives and Invasive Alien Species Regulation
Angling	Freshwater fish / IAS	Medium	Medium	High	**High**	angling groups increasingly motivated to contribute to species and habitat monitoring beyond direct angling interests generally rel. organized sector with some obligatory local catch reporting requirements no unified angling statistics collection at EU level data relevant to Water Framework Directive fish monitoring and Invasive Alien Species Regulation
Tourism	Various	Medium (partial)	High	Medium (partial)	Medium	potential incentive both to contribute to biodiversity data collection and as consumers of biodiversity information but currently only a few good examples generally small-scale and poorly organized sector so systematic data collection difficult - protected area managers have key bridging role in organizing and motivating data collection potential to contribute to biodiversity monitoring in protected areas including Natura 2000 network

Marine fisheries	Marine fish	High (partial)	Medium	High	Low – already established reporting	limited incentive as quite extensive reporting on commercial species already obligatory range of existing initiatives to increase data collection from fishermen but key barriers remain related to trust and perception already established obligatory data reporting and data collation at EU level through ICES but not Med or Black Sea
Farmers & agricultural organisations / foresters & forestry organisations	Soil biodiversity	Low/ Medium	Medium	Medium	Low	Rel. low incentive due to large unknowns with regard to influence of soil biodiversity on farming & forestry emerging data collation initiatives opportunities for citizen science level monitoring of some species groups e.g. earthworms currently no EU policy target re soil biodiversity but efforts to standardise soil biodiversity monitoring and need for data to establish reference levels and baseline
Crop breeders	Crop wild relatives	Medium	Low	Potentially high	Low	increasing interest in data on crop wild relative occurrence but data collection, conservation and research driven by other actors low incentive and capacity to contribute to data collection on crop wild relatives emerging policy area with need for better defined indicators for EU Biodiversity 2020 Strategy and CBD Aichi Target 13
Water supply sector	Catchment habitats	Medium (partial)	Low / unclear	Low / medium	Low	currently low demand for data on habitats and species, but increasing demand for data on land cover change and environmental pressures and threats in specific catchments driven by EU Water Framework Directive policy target that quality of drinking water areas should not decline low incentive to contribute to biodiversity data collection

Insurance	Various	Medium (unclear)	Low / unclear	Low / unclear	Low	currently low demand for data on habitats and species, but increasing demand for data on land cover change and environmental pressures and threats low incentive to contribute to biodiversity data collection

4.2. Key factors influencing the potential of stakeholder groups to contribute to the EU BON biodiversity data portal

Biodiversity policy needs to be informed by Indicators based on routinely collected, clearly defined, verifiable and scientifically accepted data (EEA, 2012b). This requires an integrated information chain from monitoring to policy reporting, minimal data standards and common monitoring protocols, semantics and ontologies for data interoperability and modelling (Schmeller et al., 2015). It also requires organisations or networks that can operate as 'data brokers' by gathering and synthesizing data and translating findings into policy-relevant messages. Lindenmayer and Likens (2010) argue that the major characteristics of effective biodiversity monitoring programs include: (1) good questions; (2) a conceptual model of an ecosystem or population; (3) strong partnerships between scientists, policy-makers and managers; and (4) frequent use of data collected.
Systematic biodiversity monitoring should include records of absences as well as occurrences, systematic spatial coverage, repeated observations over time, and a stratified sampling regime using comparable sampling methods. However, most existing monitoring schemes do not meet all of these criteria. Some comprehensive descriptions and analysis of European biodiversity monitoring practices have been carried out recently (Henle et al., 2010; Henry et al., 2008; Lengyel and Kosztyi, 2013; Lengyel et al., 2008; Schmeller et al., 2009; Schmeller et al., 2012). New techniques have been developed to integrate trend estimates from different monitoring programs (Henry et al. 2008) and efforts to integrate monitoring programmes themselves have been outlined as well (Lengyel et al. 2008b). Diverse species distribution data can be converted into useful maps (Jetz et al., 2012). There is therefore an increasing potential to combine fragmented data sets or disparate sources of data using various tools and generate policy-relevant findings, presented as trends, maps and messages. For example, biodiversity monitoring schemes can provide indicators for trends in ecosystem service supply (Geijzendorffer and Roche, 2013).

We identify here some of the key factors influencing the potential of stakeholder groups to contribute to the EU BON biodiversity data portal.

Relevance of data

Stakeholder groups usually gather data either because they are required to do so by legislation, for example EU fishermen who are already subject, at least in theory, to quite extensive data reporting, or because the data are important for management of the common resource, for example hunting groups. Few stakeholder groups run data gathering networks that respond directly to policy-relevant questions or problems. It may therefore be necessary instead to identify the extent to which existing data sets can answer policy relevant questions or problems, taking into account data gaps.

Data brokers could establish joint ventures with stakeholder groups interested in developing particular indicators or products relating to current and future biodiversity assets and risks relevant to them. This could mobilise new data sources that could be used to inform wider policy-relevant questions.

Quality of data collection and curation

Biodiversity policy needs to be informed by data collected using standard methods with known accuracy and precision, using determinable baselines and targets for the assessment of improvements and declines (EEA, 2012b). Data collection must also be efficient if it is to be sustained over long enough time periods to be able to assess trends.

Key components of accuracy include taxonomic correctness, which requires a unified European taxonomy, and correctness of data location and other characteristics. This requires both a sufficient capacity amongst individual data collectors, eg to register GIS coordinates, and a data checking and cleaning function in the primary data collecting organization, that highlights inaccurate records, eg picking out terrestrial records with incorrect spatial coordinates out at sea.

The precision or resolution of biodiversity data is often a limiting factor for policy relevance. For example, agricultural policy is targeted at the regional and the farm level, whereas data on the distribution of farmland biodiversity, eg arable weeds, are usually only available at the 10 km^2 grid scale.

Organisation of data flow

Stakeholder groups do not usually have sufficient capacity and expertise to gather biodiversity data on their own, but require partnerships with scientific experts and research organisations in order to ensure scientific validation and curation. A further distinct role is the data broker who bridges the gap between primary data collators and policy decision makers. Some key components of the information chain include organisations that have active surveillance networks to pick up and authenticate data, organisations or individuals who collate, clean and verify data records, and networks that can develop and implement common standards and common data infrastructure.

Data ownership and recognition of effort

It is important to recognize the significant effort invested by the providers of good quality data. Recognition does not have to involve financial payments to access privately owned data. Both academic experts and practitioners derive benefits from recognition of their work through citation in publications. One way to increase citations of datasets is to use the DOI system to register datasets and to provide standard citations, and to encourage the recognition of data papers in academic journals (Costello et al., 2014). The efforts of citizen scientists can be recognized through interactive websites that provide feedback on policy relevance and social networking tools that provide an additional incentive to supply data (Tulloch et al., 2013). A further key point is data security, particularly where there is private ownership of data. Data suppliers require a legal basis for the protection of data and assurance that the data governance and dissemination structure will protect their data rights.

Reliability and credibility of the data

It is important to examine non-technical barriers to data flow, such as the credibility of data sources. For example, hunters find that their data are sometimes regarded with suspicion. If hunters were to provide data on raptors the credibility will be undermined in some countries by the ongoing illegal killing of raptors by a few hunters and gamekeepers.

Motivation and incentive

In analyzing the key factors affecting stakeholder engagement in biodiversity monitoring, it is important to recognize that stakeholders attach a wide range of benefits to biodiversity, including ethical, social, economic and environmental values, and monetary incentives are not necessarily very important drivers. Stakeholder attitudes differ both because of individual personality types and because of identification with particular groups, for example organic farmers. Biodiversity and associated benefits are often expressed in social and psychological values and perceived in non-scientific and non-monetary terms, e.g. as the basis of human life, as providing balance, for its aesthetic functions, or as a sense of place (Buijs et al., 2008).

Biodiversity monitoring using stakeholder groups also requires an appropriate translation of scientific and decision context knowledge. For some ecosystem services there is still some scientific uncertainty about the degree to which particular habitats and species provide the service. In some cases this limits the motivation of beneficiaries to monitor the providing habitats and species rather than the direct benefit from the ecosystem services they use. Experience of fisheries research has shown that finding common ground between fishermen, researchers and policy interests is harder when the research relates to knowledge of processes (rather than technical aspects such as fishing gear), where alternative viewpoints can lead to different understanding and perceptions, such as how the different groups encounter and perceive nature (Mackinson et al., 2011).

Next stage of the work

The next stage of the work will focus on policy-makers as key users of the EU BON data portal. The policy-makers are defined as public authorities who use biodiversity data to design, target, implement and assess policy at the regional and national level. The analysis will build on the current review by focusing on the agricultural sector, the development sector, and the freshwater sector, with focus on biodiversity data use by the following policy groups:

- Agricultural rural development programming agencies
- Local planning authorities and developers
- River basin management committees

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ANNEX 1 MAPPING BENEFICIARIES OF ECOSYSTEM SERVICES

Sources: (Bishop, 2011; EASAC, 2009; Ecosystem Markets Task Force, 2013; EEA, 2014)
Key: n/a = not assessed
* Note this section is open in that many class types can potentially be recognised and nested in the higher level classes, depending on the ecosystems being considered.

CICES for ecosystem service mapping and assessment								
CICES for ecosystem accounting								
Section	**Division**	**Group**	**Class**	**Class type***	***Description***	**Sector**	**Environment**	**Impact/ dependency**
Provisioning	Nutrition	Biomass	Cultivated crops	*Crops by amount, type*	Cereals (e.g. wheat, rye, barely), vegetables, fruits etc.	Agriculture	Farmland	n/a
			Reared animals and their outputs	*Animals, products by amount, type*	Meat, dairy products (milk, cheese, yoghurt), honey etc.	Agriculture	Farmland	n/a
			Wild plants, algae and their outputs	*Plants, algae by amount, type*	Wild berries, fruits, mushrooms, water cress, salicornia (saltwort or samphire); seaweed (e.g. *Palmaria palmata* = dulse, dillisk) for food	[General public - foraging communities] Hospitality sector (food); health sector Subsistence cultures	Coastal Forests Farmland – grassland, hedges Uplands – heath, scrub	Low

CICES for ecosystem service mapping and assessment								
CICES for ecosystem accounting								
Section	**Division**	**Group**	**Class**	**Class type***	***Description***	**Sector**	**Environment**	**Impact/ dependency**
			Wild animals and their outputs	*Animals by amount, type*	Game, freshwater fish (trout, eel etc.), marine fish (plaice, sea bass etc.) and shellfish (i.e. crustaceans, molluscs), as well as equinoderms or honey harvested from wild populations; Includes commercial and subsistence fishing and hunting for food	Hunting Foraging communities - general public Fisheries Subsistence cultures	Marine Freshwater Forests Uplands Grassland Farmland	**High**
			Plants and algae from in-situ aquaculture	*Plants, algae by amount, type*	In situ seaweed farming	Cosmetics & toiletries Food sector	Coastal Marine	n/a
			Animals from in-situ aquaculture	*Animals by amount, type*	In-situ farming of freshwater (e.g. trout) and marine fish (e.g. salmon, tuna) also in floating cages; shellfish aquaculture (e.g. oysters or crustaceans) in e.g. poles	Aquaculture	Marine Coastal	n/a
		Water	Surface water for drinking	*By amount, type*	Collected precipitation, abstracted surface water from rivers, lakes and other open water bodies for drinking	Water companies (public and private)	Rivers Lakes Catchments	**High**

CICES for ecosystem service mapping and assessment								
CICES for ecosystem accounting								
Section	**Division**	**Group**	**Class**	**Class type***	***Description***	**Sector**	**Environment**	**Impact/ dependency**
			Ground water for drinking		Freshwater abstracted from (non-fossil) groundwater layers or via ground water desalination for drinking	Water companies (public and private) bottled water business	Groundwater under Uplands Mountains Forests etc	**High**
	Materials	Biomass	Fibres and other materials from plants, algae and animals for direct use or processing	*Material by amount, type, use, media (land, soil, freshwater, marine)*	Fibres, wood, timber, flowers, skin, bones, sponges and other products, which are not further processed; material for production e.g. industrial products such as cellulose for paper, cotton for clothes, packaging material; chemicals extracted or synthesised from algae, plants and animals such as turpentine, rubber, flax, oil, wax, resin, soap (from bones), natural remedies and medicines (e.g. chondritin from sharks), dyes and colours, ambergris (from sperm whales used in perfumes); Includes consumptive ornamental uses.	Non-plantation forestry & timber industry Agriculture & Agroforestry Subsistence cultures Taxidermy	Various	Low
			Materials from plants, algae and animals for agricultural use		Plant, algae and animal material (e.g. grass) for fodder and fertilizer in agriculture and aquaculture;	Aquaculture Agriculture	Various	Low

CICES for ecosystem service mapping and assessment								
CICES for ecosystem accounting								
Section	**Division**	**Group**	**Class**	**Class type***	***Description***	**Sector**	**Environment**	**Impact/ dependency**
			Genetic materials from all biota		Genetic material (DNA) from wild plants, algae and animals for biochemical industrial and pharmaceutical processes e.g. medicines, fermentation, detoxification; bio-prospecting activities e.g. wild species used in breeding programmes etc.	Crop breeders Pharmaceuticals Biochemistry industry	Various	**High**
		Water	Surface water for non-drinking purposes	*By amount, type and use*	Collected precipitation, abstracted surface water from rivers, lakes and other open water bodies for domestic use (washing, cleaning and other non-drinking use), irrigation, livestock consumption, industrial use (consumption and cooling) etc.	Industry eg energy sector Agriculture	Rivers Lakes Reservoirs Estuaries	High
			Ground water for non-drinking purposes		Freshwater abstracted from (non-fossil) groundwater layers or via ground water desalination for domestic use (washing, cleaning and other non-drinking use), irrigation, livestock consumption, industrial use (consumption and cooling) etc.	Industry eg energy sector Agriculture	Groundwater	High

CICES for ecosystem service mapping and assessment								
CICES for ecosystem accounting								
Section	**Division**	**Group**	**Class**	**Class type***	***Description***	**Sector**	**Environment**	**Impact/ dependency**
	Energy	Biomass-based energy sources	Plant-based resources	*By amount, type, source*	Wood fuel, straw, energy plants, crops and algae for burning and energy production	Forestry Agriculture & agroforestry Biofuels industry	Forest Farmland Marine	n/a
			Animal-based resources		Dung, fat, oils, cadavers from land, water and marine animals for burning and energy production	Agriculture Fisheries Subsistence cultures	Various	Low
		Mechanical energy	Animal-based energy	*By amount, type, source*	Physical labour provided by animals (horses, elephants etc.)	Agriculture Transport Subsistence cultures	Farmland Transport	n/a
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals	*By amount, type, use, media (land, soil, freshwater, marine)*	Bio-chemical detoxification/decomposition/ mineralisation in land/soil, freshwater and marine systems including sediments; decomposition/ detoxification of waste and toxic materials e.g. waste water cleaning, degrading oil spills by marine bacteria, (phyto)degradation, (rhizo)degradation etc.	agriculture industry eg energy sector waste disposal transport incl shipping	Soil Vegetation Freshwater Marine	High

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CICES for ecosystem accounting								
Section	**Division**	**Group**	**Class**	**Class type***	***Description***	**Sector**	**Environment**	**Impact/ dependency**
			Filtration/ sequestration/ storage/ accumulation by micro-organisms, algae, plants, and animals	*By amount, type, use, media (land, soil, freshwater, marine)*	Biological filtration/sequestration/storage/ accumulation of pollutants in land/ soil, freshwater and marine biota, adsorption and binding of heavy metals and organic compounds in biota	agriculture industry eg energy sector waste disposal transport incl shipping	Soil Vegetation Freshwater Marine Groundwater	High
		Mediation by ecosystems	Filtration/ sequestration/ storage/ accumulation by ecosystems	*By amount, type, use, media (land, soil, freshwater, marine)*	Bio-physicochemical filtration/sequestration/storage/ accumulation of pollutants in land/soil, freshwater and marine ecosystems, including sediments; adsorption and binding of heavy metals and organic compounds in ecosystems (combination of biotic and abiotic factors)	Water companies (public & private) bottled water business Agriculture Industry eg energy sector	Uplands Farmland Freshwater	**High**
			Dilution by atmosphere, freshwater and marine ecosystems		Bio-physico-chemical dilution of gases, fluids and solid waste, wastewater in atmosphere, lakes, rivers, sea and sediments	Water companies Agriculture Industry eg energy sector	Air Lakes Rivers Marine Soil	High
			Mediation of smell/ noise/ visual impacts		Visual screening of transport corridors e.g. by trees; Green infrastructure to reduce noise and smells	Transport sector Urban sectors Industry	Transport corridors Urban	Medium

CICES for ecosystem service mapping and assessment								
CICES for ecosystem accounting								
Section	**Division**	**Group**	**Class**	**Class type***	***Description***	**Sector**	**Environment**	**Impact/ dependency**
	Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates	*By reduction in risk, area protected*	Erosion / landslide / gravity flow protection; vegetation cover protecting/stabilising terrestrial, coastal and marine ecosystems, coastal wetlands, dunes; vegetation on slopes also preventing avalanches (snow, rock), erosion protection of coasts and sediments by mangroves, sea grass, macroalgae, etc.	Insurance industry Urban sectors Transport sector etc	Forest Uplands Coastal Rivers	**High**
			Buffering and attenuation of mass flows		Transport and storage of sediment by rivers, lakes, sea	Transport sector & other users of waterways & coast	Rivers Lakes Coast Estuaries Marine	Medium
		Liquid flows	Hydrological cycle and water flow maintenance	*By depth/volumes*	Capacity of maintaining baseline flows for water supply and discharge; e.g. fostering groundwater; recharge by appropriate land coverage that captures effective rainfall; includes drought and water scarcity aspects.	Water companies Agriculture	Rivers Lakes Uplands	**High**

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CICES for ecosystem accounting								
Section	**Division**	**Group**	**Class**	**Class type***	***Description***	**Sector**	**Environment**	**Impact/ dependency**
			Flood protection	*By reduction in risk, area protected*	Flood protection by appropriate land coverage; coastal flood prevention by mangroves, sea grass, macroalgae, etc. (supplementary to coastal protection by wetlands, dunes)	Insurance industry Housing Agriculture	Forest Uplands Wetlands Coastal	**High**
		Gaseous / air flows	Storm protection	*By reduction in risk, area protected*	Natural or planted vegetation that serves as shelter belts	Agriculture Housing	Farmland Built environment etc	Medium
			Ventilation and transpiration	*By change in temperature/humidity*	Natural or planted vegetation that enables air ventilation	Agriculture Housing	Farmland Built environment etc	Medium
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal	*By amount and source*	Pollination by bees and other insects; seed dispersal by insects, birds and other animals	Agriculture	Farmland Wild plants & animals	**High**
			Maintaining nursery populations and habitats	*By amount and source*	Habitats for plant and animal nursery and reproduction e.g. seagrasses, microstructures of rivers etc.	Fisheries (freshwater and marine)	Marine Freshwater	**High**
		Pest and disease control	Pest control	*By reduction in incidence, risk, area protected*	Pest and disease control including invasive alien species	Agriculture Aquaculture Forestry	Farmland Freshwater Coastal Forest etc	**High**

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CICES for ecosystem accounting								
Section	**Division**	**Group**	**Class**	**Class type***	***Description***	**Sector**	**Environment**	**Impact/ dependency**
			Disease control		In cultivated and natural ecosystems and human populations	Agriculture Aquaculture Forestry	Farmland Freshwater Forest etc	**High**
		Soil formation and composition	Weathering processes	*By amount/concentration and source*	Maintenance of bio-geochemical conditions of soils including fertility, nutrient storage, or soil structure; includes biological, chemical, physical weathering and pedogenesis	Agriculture Forestry	Farmland Forest	Medium
			Decomposition and fixing processes		Maintenance of bio-geochemical conditions of soils by decomposition/mineralisation of dead organic material, nitrification, denitrification etc.), N-fixing and other bio-geochemical processes;	Agriculture Forestry	Farmland Forest	**High**
		Water conditions	Chemical condition of freshwaters	*By amount/concentration and source*	Maintenance / buffering of chemical composition of freshwater column and sediment to ensure favourable living conditions for biota e.g. by denitrification, re-mobilisation/re-mineralisation of phosphorous, etc.	Water companies Fisheries Aquaculture	Rivers Lakes	**High**

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CICES for ecosystem accounting								
Section	**Division**	**Group**	**Class**	**Class type***	***Description***	**Sector**	**Environment**	**Impact/ dependency**
			Chemical condition of salt waters		Maintenance / buffering of chemical composition of seawater column and sediment to ensure favourable living conditions for biota e.g. by denitrification, re-mobilisation/re-mineralisation of phosphorous, etc.	Aquaculture Fisheries	Marine	Medium
		Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	*By amount, concentration or climatic parameter*	Global climate regulation by greenhouse gas/carbon sequestration by terrestrial ecosystems, water columns and sediments and their biota; transport of carbon into oceans (DOCs) etc.	Carbon markets Forestry	Marine Forestry Peatlands	Medium
			Micro and regional climate regulation		Modifying temperature, humidity, wind fields; maintenance of rural and urban climate and air quality and regional precipitation/temperature patterns	Urban sectors Agriculture	Urban Farmland	Medium
Cultural	Physical and intellectual interactions with biota, ecosystems,	Physical and experiential interactions	Experiential use of plants, animals and land-/seascapes in different environmental settings	*By visits/use data, plants, animals, ecosystem type*	In-situ bird and mammal watching, eg cetaceans, snorkelling, diving etc.	Tourism/recreation: Whale & Dolphin Boat Touring companies Sub-aqua Societies	Various including marine	**High**

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Section	**Division**	**Group**	**Class**	**Class type***	***Description***	**Sector**	**Environment**	**Impact/ dependency**
	and land-/seascapes [environmental settings]		Physical use of land-/seascapes in different environmental settings		Walking, hiking, climbing, boating, leisure fishing (angling) and leisure hunting	Tourism/ recreation: incl sea-angling, hunting	Various including marine	**High**
		Intellectual and representative interactions	Scientific	*By use/citation, plants, animals, ecosystem type*	Subject matter for research both on location and via other media	Researchers Citizen scientists	Various	Medium
			Educational		Subject matter of education both on location and via other media	Educators General public	Various	Medium
			Heritage, cultural		Historic records, cultural heritage e.g. preserved in water bodies and soils	General public Researchers Rural communities	Various	Medium
			Entertainment		Ex-situ viewing/experience of natural world through different media	Artists General public Advertising	Various	Medium
			Aesthetic		Sense of place, artistic representations of nature	Artists General public Rural communities	Various	Medium

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CICES for ecosystem accounting								
Section	**Division**	**Group**	**Class**	**Class type***	***Description***	**Sector**	**Environment**	**Impact/ dependency**
	Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Spiritual and/or emblematic	Symbolic	*By use, plants, animals, ecosystem type*	Emblematic plants and animals e.g. national symbols such as American eagle, British rose, Welsh daffodil	General	Various	Low
			Sacred and/or religious		Spiritual, ritual identity e.g. 'dream paths' of native Australians, holy places; sacred plants and animals and their parts	General public Religious communities Sami	Various	Low
		Other cultural outputs	Existence	*By plants, animals, feature/ecosystem type or component*	Enjoyment provided by wild species, wilderness, ecosystems, land-/seascapes	Recreation Tourism General public	Protected areas Green spaces etc	High (linked to experiential interactions)
			Bequest		Willingness to preserve plants, animals, ecosystems, land-/seascapes for the experience and use of future generations; moral/ethical perspective or belief	General public (everyone)	Various	Medium