ATLAS Deliverable 6.4

Improving business practice and costs through data-sharing and the identification of potential mitigation measures for adaptive marine spatial planning

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Authors:	Lea-Anne Henry, Anthony Grehan, Johanne Vad, J. Murray Roberts
Contributors	WP leaders assisted with creating the questionnaire on mitigation

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Executive Summary

In Europe alone, private companies spent up to €3 billion annually on marine data: collecting it, purchasing it, processing it. This volume of data has huge potential to advance our understanding of deep-sea ecosystems: in fact, many Vulnerable Marine Ecosystems (VMEs) were first discovered by the offshore fisheries, telecommunications, and oil and gas sectors, and more recently while companies explore for potential areas to mine. ATLAS has made substantial in-roads to advance the understanding of ecosystems in the deep North Atlantic. These innovations can be shared with industry to improve business practice by reducing the cost of marine data and the appropriate application of the mitigation hierarchy.

In Deliverable 6.4, ATLAS worked directly with its industry associate partners, Atlantic offshore industries and marine planners, regulators and authorities to disseminate some of its most industry-relevant innovations. Along the way, new data-sharing platforms such as the ATLAS GeoNode have been created to share key ATLAS outputs through the data broker EMODnet, and D6.4 also scoped out barriers within the industry to share privately held environmental data. A total of three industry-focussed international workshops and two questionnaires were implemented between 2016 and 2019. These helped to identify three principles of data-sharing to improve business practice and reduce costs: (1) future-proofing environmental datasets by considering potential future uses and collecting data at the highest possible resolution; (2) data collection techniques need to be standardised to allow comparisons to be made across years and datasets; and (3) the Atlantic community should endeavour to make maps of the seafloor, public assets, as approximately 75% of industry environmental data costs relate to bathymetric and geological data acquisition.

The workshops and questionnaires also led to several ATLAS recommendations to improve business practice and reduce costs around data-sharing. Joint recommendations for industry, academia and other stakeholders include: (1) further scoping of environmental datasets that could be readily shared using EMODnet as a data broker; (2) uptake of ATLAS' many new modelling techniques, e.g., particle trajectory modelling, species distribution modelling, to help inform industry of possible outcomes of scenarios; (3) strengthening the dialogue between science-industry-regulator to underscore the need to make privately held data more publicly available, e.g., as a regulatory requirement or as a condition of licensing; (4) promoting EMODnet as a data broker; (5) similarly, that EMODnet strengthens proactive

engagement with deep and open ocean offshore industries to ensure awareness is raised; (6) highlighting more prominently examples of successful case studies of data-sharing and science- industry partnerships in the deep ocean.

The workshops and questionnaires also led to several ATLAS recommendations to improve business practice and reduce costs around industry's requirements to avoid, minimise and even restore deep-sea ecosystems, with offsetting also discussed. ATLAS recommendations include: (1) exploring ways to uptake ATLAS products such as maps of the strength, direction, temperature and salinity of large-scale ocean currents and ecological connectivity across the North Atlantic; (2) explore ways to uptake ATLAS products such as models of hydrographic and biogeochemical control of VMEs; (3) increased dialogue with relevant industry fora and ATLAS to strengthen existing and forge new collaborations in data collection; (4) that industry consider more explicitly the information that ATLAS has collected regarding marine ecosystem services in the deep sea, as historically, the lack of such information meant that such services are not considered in industry EIAs; and (5) explore and uptake of ATLAS innovations on the ATLAS GeoNode, as these offer standardised visualisations of geospatial data relevant to marine planning and licensing.

1. Data-sharing to improve policy implementation for sustainable Blue Growth

The ATLAS project set its ambitions to make impacts in four areas:

1. Improve resource management (ecosystem approach) and governance;
2. Improve cooperation between the European Union (EU), Canada and the United States;
3. Contribute to the EU Integrated Maritime Policy (Marine Strategy Framework Directive or MSFD, Common Fisheries Policy or CFP, the EU Maritime Strategy for the Atlantic Ocean Area, and the Galway Statement on Atlantic Cooperation);
4. Strengthen international agreements to conserve vulnerable marine ecosystems (VMEs) and ecologically and biologically significant marine areas (EBSAs).

Deliverable 6.4 was designed to help operationalise Impact area 1, “Improve resource management and governance”, largely through the lens of the offshore industry and especially for those with operations in the ATLAS Case Study and equivalent areas around the Atlantic basin. Having rapid and economical means to access the very latest comprehensive and accurate environmental data is crucial for industry to undertake mandatory environmental impact assessments (EIAs). These include industry requirements to apply measures to avoid, reduce, restore or offset their environmental impacts, i.e. selecting the least impacting “mitigation hierarchy” measure starting with avoiding impacts in the first place, then moving higher up the hierarchy if impacts cannot be avoided (Figure 1).

Figure 1: The mitigation hierarchy. If impacts cannot be avoided, measures to minimise, then rehabilitate/restore, and even offset, can be considered.

ATLAS created a data management framework by which industry could acquire and exploit data and information generated by the ATLAS project, and by which industry could share data with other stakeholders including the general public. Although EIAs have key roles to play in the identification of adverse impacts and potential mitigating actions for development projects, synergies with other environmental policies such as the MSFD (Directive 2008/56/ EC) and the EU Directive on Maritime Spatial Planning or MSP (Directive 2014/89/EU) should be explored in order to refine best practices (Jacob et al., 2016).

Estimates suggest that by 2030, one-third of EEZs will have some form or MSP process (Ehler et al. 2019) to coordinate regulations and management actions that require spatial measures. But MSP does not replace sectoral planning and does not replace the current licensing and permitting processes in the oceans, such as undertaking EIAs *per se* (Ehler et al., 2019). However, in a blue economy with a drive for blue growth in certain sectors, MSP does offer an adaptive cross sectoral approach to planning: it is better suited to deal with uncertainty and to incorporate environmental change, political or economic shifts, climate change, and is flexible as new information is acquired (Douvere and Ehler, 2011).

Acquisition of the latest comprehensive, accurate data to identify the appropriate actions in the implementation of the mitigation hierarchy as part of Environmental Impact Assessment is immediately transferable to adaptive MSP, and *vice versa*. Money invested by industry upfront to implement the mitigation hierarchy, and engage stakeholders proactively and transparently, particularly in the support of key conservation goals, may ultimately translate into net financial gains. Thus, although the motivations for achieving those outcomes—conservation, in one instance, and profit, in the other—are different, there can be shared goals that result in positive outcomes for conservation and for business. But the challenge remains that effective data-sharing mechanisms are needed between all stakeholders (Polsenberg and Kilponen, 2018) and for multiple purposes to improve resource management and governance.

The ATLAS approach to improve business practice and costs

Estimates over a decade ago found that in Europe, private companies spent up to €3 billion annually on marine data, from conducting surveys to collecting new data, purchasing data from third parties, and processing data until it was fit for purpose (EC, 2009). During the ATLAS project (2016-20), three industry-focussed international workshops and two questionnaires were implemented to help improve business practice and costs through data-sharing and to identify potential mitigation measures. These opportunities took the format of:

- **disseminating** industry-relevant aspects of the ATLAS data management framework (EMODnet and the ATLAS GeoNode) to multiple user types including oil and gas producers, offshore renewable developers, regulators, national planning and governmental authorities, and scientists beyond the ATLAS project;
- **sharing** key ATLAS outputs across all workpackages to understand how these meet industry needs to mitigate environmental impacts;
- **scoping** barriers and mechanisms for industry to share privately held environmental data.

Using this approach, ATLAS aims to contribute to the implementation of the MSP Directive, which calls for improved resource management and governance (one of ATLAS's expected impacts). Notably, this deliverable also assists with implementing the MSFD (another ATLAS expected impact), which specifically refers to MSP as a key tool designed to properly manage and reduce the cumulative impact of all maritime activities in a given sea area.

By identifying data-sharing opportunities that could also support mitigation and adaptive MSP, this deliverable helps to implement various aspects of the MSP Directive. This Directive calls for four principles that we adhered to in order to disseminate, share and scope information:

- accounting for environmental, economic, and social aspects;
- aiming to promote coherence between MSP, plans, and processes;
- ensuring involvement of stakeholders (MSP Directive, Article 9);
- organising use of best available data (MSP Directive, Art. 10).

Next in Sections 2 and 3, we provide a high-level overview of key aspects of the ATLAS data management framework (through EMODnet and the ATLAS GeoNode) that allows industry to interact with, both to share ATLAS and industry data and information. More detailed descriptions of this framework are provided through WP8, which includes comprehensive summaries of ATLAS data and the information pipeline. Our purpose here in Deliverable 6.4 was to illustrate the key aspects of this framework that were presented to offshore industry during the three workshops and which formed the basis for some of the industry questionnaires completed during the project.

2. EMODnet as a knowledge broker for environmental data-sharing between industry and other users.

The European Marine Observation and Data Network (EMODnet; https://www.emodnet.eu) is a long-term initiative of the European Union that serves as a marine data harmoniser, integrator and broker. More than 150 organisations now contribute data, data management and services to deliver open source data and data products free of charge for all users.

With the underpinning philosophy of "collect once, use many times" EMODnet has developed over the past decade into an operational service delivering across 7 thematic areas: Bathymetry, Biology, Chemistry, Geology, Human Activities, Physics and Seabed Habitats. Now with data services also being made available to users, e.g., map viewers and web services allowing data discovery through machine-machine communication, EMODnet delivers free and open data for all that are Findable, Accessible, Interoperable and Reusable (FAIR) across multiple parameters, spatial scales and resolutions.

The EMODnet Data Ingestion Service is dedicated to assisting data providers such as offshore industry with sharing data. EMODnet also encourages industry to discuss opportunities with its Secretariat and to consider applying for Associated Partner status to enable greater dialogue and input from industry to further improve business practice and to unlock even more cost-effective mechanisms of data-sharing to reduce costs of environmental assessments.

3. ATLAS GeoNode as a content management system and as input to EMODnet

An open source geospatial content management system was created during the ATLAS project, which allows users to visualise and download ATLAS project data and other relevant data layers. The ATLAS GeoNode (https://www.emodnet.eu/atlas-project) is user-focussed, and facilitates collaborative use of geospatial data and maps. It will also be used to transfer ATLAS data and scientific outputs amongst ATLAS partners but also to wider stakeholders including industry and policy-makers.

This prototype tool was developed by Seascape Belgium (SBE) and the British Geological Survey (BGS), with input from UniHB and ATLAS data providers, to assist with the pipeline of marine data from research projects to open source data services like EMODnet. The live GeoNode already has many static maps and map layers of ATLAS data and remote services.

The ATLAS GeoNode was designed around the 12 ATLAS Case Studies but also provides information at the basin scale of the North Atlantic (e.g., Figure 2). It now provides an online platform for enhanced exchange of information amongst ATLAS partners on data produced across the project, and it has facilitated project development of area-based management plans for WP6.

The ATLAS GeoNode is embedded in an Atlantic ATLAS community page, hosted by EMODnet's central portal. This promotes the ATLAS project to a wide range and number of stakeholders already visiting the EMODnet web services. Importantly, it also ensures the long-term visibility and impact of ATLAS data beyond the duration of the project and so ensures a viable legacy of the ATLAS project.

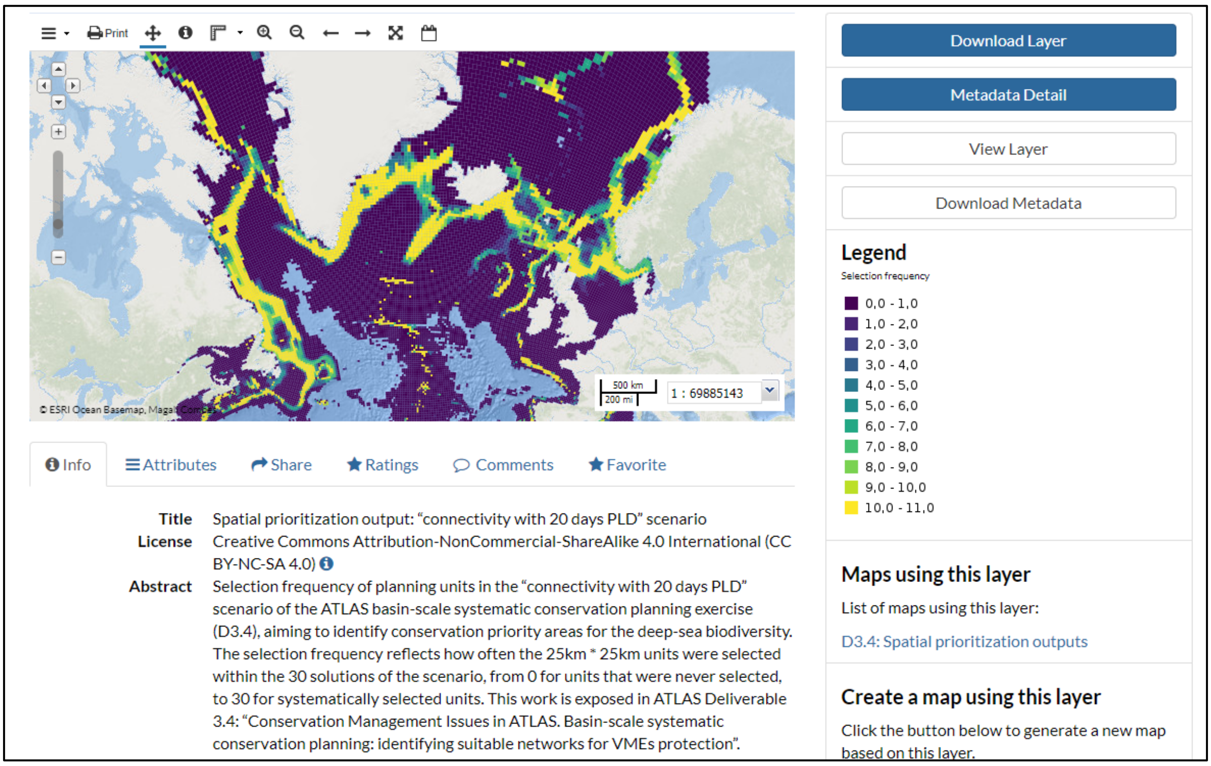

Figure 2: Example of a static map product with basin-scale information and data made open-access by the ATLAS GeoNode.

There is now clearly wider scope for translation of the ATLAS GeoNode into European marine spatial plans (MSP) for deep-water areas, which would benefit planners and national authorities on MSP. One user case in the eastern North Atlantic was already trialled in ATLAS Case Study 11, led by ATLAS partner IEO in Vigo in an area beyond national jurisdiction that includes the oceanic bank of Flemish Cap and the adjacent area of the Flemish Pass (García-Alegre et al., 2018).

Equally for industry users, the ATLAS GeoNode allows a free and rapid means by which industry can visualise and incorporate ATLAS geospatial data into environmental assessments and mitigation hierarchies. Being hosted by EMODnet's central portal, the ATLAS GeoNode then offers the industry community a tool to browse, identify and download data from ATLAS and the wider open source data housed on EMODnet.

4. Blue Growth data-sharing opportunities and barriers

Recognising that the ATLAS data management framework offers industry the opportunity to rapidly and inexpensively acquire environmental data from across the North Atlantic, notably in Case Study areas, the ATLAS approach to data-sharing was designed to be multilateral. Environmental data for decision-making in the deep sea needs to flow between multiple stakeholders, both public and private.

Offshore industry data were directly shared with and used by the ATLAS community to undertake many analyses and to construct new products. For example, maps that displayed the predicted distribution of 12 vulnerable marine ecosystem (VME) indicator species were constructed using datasets that in part relied on access to **fisheries** data through the International Council for the Exploration of the Seas (ICES) (Morato et al. 2020). Another example was the discovery and mapping of VMEs including sponge grounds using data collected during the MarineE-Tech project exploring **deep sea mineral resources** off the Canary Islands in a partnership with the International Seabed Authority (ISA) and Gardline, and Soil Machine Dynamics (Ramiro-Sánchez et al., 2019). A third example of industry data-sharing in ATLAS was the **oil and gas** industry sharing underwater remotely operated vehicle images: these allowed the magnitude of industry impacts to be compared to impacts of background environmental variability on benthic biodiversity in the Faroe Shetland Channel (Vad et al., 2019). These three examples are not exhaustive but illustrate the willingness to share data with the ATLAS scientific community on an as needed basis.

However, it is recognised that there is a wealth of industry-collected data that exist which, if made open-access on a more systematic basis, could further unlock opportunities to improve business practices, reduce costs, and adapt mitigation strategies. Over the series of three workshops, ATLAS collaborated with industry and other offshore stakeholders to disseminate the types of environmental data that are collected, identify the barriers to data-sharing, and to begin to scope out data that are more readily shared including opportunities that data-sharing and that knowledge brokers such as EMODnet can offer industry (e.g., improved business practices, reduced costs, adapting mitigation measures). Challenges and opportunities of data-sharing were explored in more detail with ATLAS industry partners through a data-sharing questionnaire. Here we describe a methodology that outlines the aims and outcomes of the three bespoke workshops, and summarise industry responses to the data-sharing questionnaire.

4.1 Blue Growth Data Workshop, 7 February 2017 in Edinburgh, United Kingdom

The aim of this workshop was to bring together members of the scientific community, government regulators and the oil and gas industry to start discussing the challenges and opportunities surrounding offshore environmental data and particularly those most relevant to decommissioning. The workshop was co-organised with the industry-funded INSITE Research Programme, which examined impacts of man-made structures on offshore ecosystems. A Marine Policy position paper was produced as an important outcome from this workshop (Murray et al., 2018). This outlined the issues surrounding sourcing and maintaining environmental data for the offshore energy industries (largely the energy sector but authorities on other sectors were also present at the workshop).

Topics covered by the workshop included:

- the challenge of providing holistic open access marine environmental data sets;
- the requirements for data to underpin integrated maritime spatial management;
- the opportunities from the Big Data revolution both in analytics and online storage from the integration of marine data repositories to national databases through to emergence of EMODnet;
- the technicalities of enabling regulators/operators/marine scientists to access information including existing examples of best practice and the most appropriate data standards;

- the barriers surrounding data access restrictions and confidentiality;
- the opportunities and best way forward to ensure that all stakeholders have access to appropriate data, including from industry surveys, to inform future management of shared resources.

The workshop was attended by an international and multiple stakeholder user group, spanning the public and private sector including ATLAS partners UEDIN, BGS, EMODnet, BP, Marine Science Scotland and SAMS (Figure 3). Beyond ATLAS the workshop included representatives from AWI, BMT Cordah, Cefas, the DataLab, DeepTek, Gardline, Heriot-Watt University, Hartley Anderson, Marathon Oil, MEDIN, NOC, the Oil & Gas Innovation Centre, Shell, UK Department of Business, Energy & Industrial Strategy and the University of Wageningen.

Figure 3: Attendees representing multiple stakeholders at the Blue Growth Data Workshop, 7 February 2017 in Edinburgh.

The workshop helped to disseminate the multitude of environmental data collected by the offshore industry, which demonstrated the same type of data being collected multiple times, and often in the same region (Table 1).

Industry	Parameter								Primary data sharing barriers			
	Physical				Biological							
	Bathymetry	*Water/ Sediment Quality*	*Sediment*	*Weather*	*Benthic*	*Birds*	*Fish*	*Mammals*	*Data is not collected to MEDIN standards*	*Additional Costs (time and/or money)*	*Commercial sensitivity*	*Unwilling to lose control of data use*
Oil & Gas	◊	✓	✓	✓	✓		◊		✓	✓		
Marine Aggregates	✓		✓		✓		✓		✓		✓	✓
Subsea Cables	◊	◊	◊	◊					✓	✓	✓	✓
Wave & Tidal Renewable Energy	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓
Offshore Wind	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	

Table 1: Range of environmental data collected by offshore industries in the North Atlantic. The check symbol indicates data can likely be routinely made available upon request, while the diamond symbol indicates data are not often shared with third parties (from Murray et al., 2018).

This dissemination activity also helped workshop attendees to identify a successful model case study in which sharing data helped to unlock Blue Growth potential. In the German North Sea offshore wind industry, developers collect data for EIAs and legally obligated to submit raw EIA data to their regulatory body. These data and data collected from research projects (e.g., from the Alfred Wegener Institute) and monitoring programmes (e.g., in relation to the Marine Strategy Framework Directive, Directive 2008/56/ EC) are stored in a data information system then standardised, collated, harmonised and quality-checked by independent scientific institutions (https://www.geoseaportal.de/mapapps/?lang=en). Information can then be extracted as required by various authorities, regulators, industry and researchers directly or through EMODnet, yet still keeps the raw data anonymous so they cannot be reconstructed or linked to the original source. Furthermore, this allows companies applying for neighbouring clusters of offshore wind farm sites to carry out joint EIA monitoring and to share reference sites, both improving data coverage and reducing costs. The first such cluster-monitoring solution was conducted by DONG Energy in 2014 and is estimated to have reduced their monitoring costs by millions of Euros (Murray et al., 2018).

Issues around data collection more generally were also discussed, resulting in a series of seven conclusions (Murray et al., 2018):

- challenges around raw data access remain (very much less so for metadata), while cost effective, quality controlled ways of processing data are required (particularly for images and videos);
- clear standardisation guidance is needed (especially for biological data) if data are to be “collected once, used many times”;
- costs to industry are likely to continue to be an issue;
- managing expectations, ensuring clear and transparent communication across sectors and building trust are vital;
- changing sampling methods over time limits future use of data;
- even if there is a new and better method, the benefits of consistency must be considered;
- quality control standards need to be applied, noting this was perhaps much easier for physical and chemical parameters than biological ones.

In terms of barriers to data-sharing, workshop attendees discussed a suite of issues that clustered into five broad themes (incentives, risk perception, working culture, financial models, and data ownership; Figure 4).

Notably, many of these barriers were also later re-iterated by ATLAS industry partners in our data-sharing questionnaire as well (see Section 4), particularly regarding issues around data misinterpretation (risk perception), staff time to consolidate and format data and obtain permissions (working culture), and how data may be held by consultants and they need to permit access (data ownership).

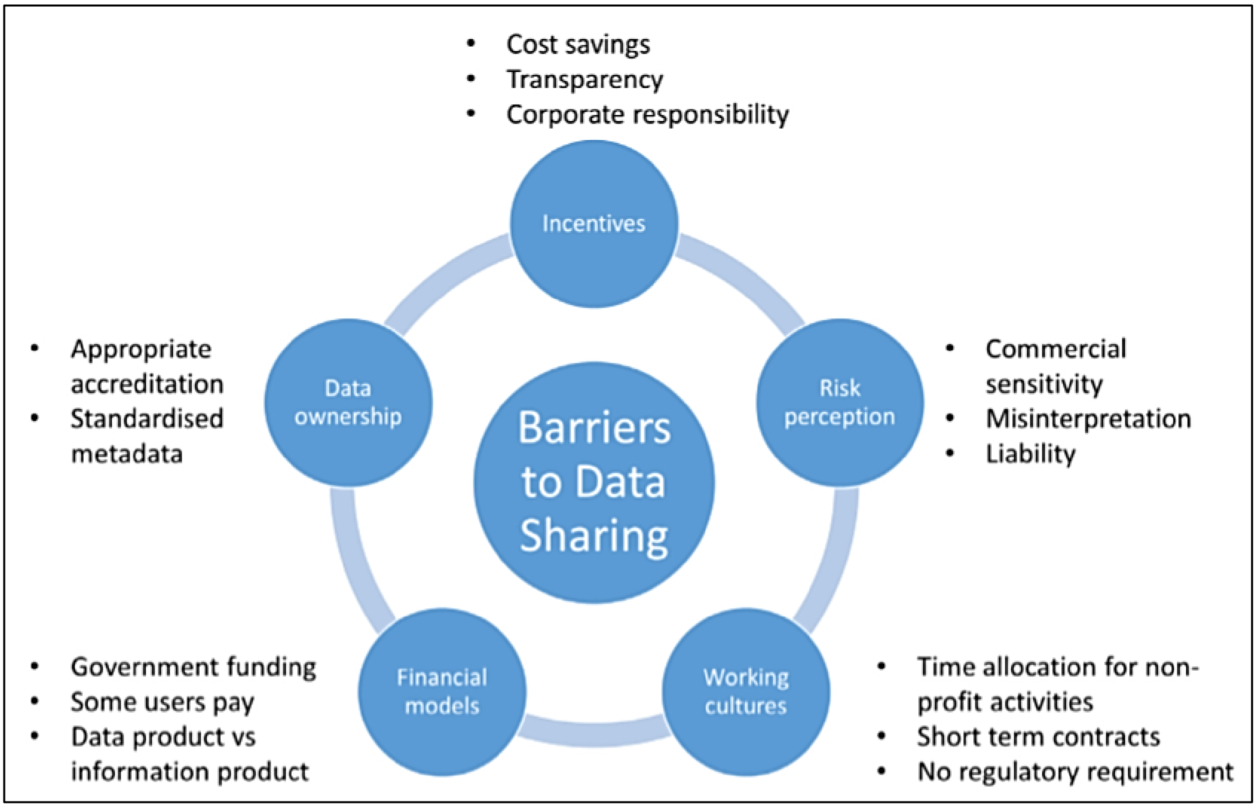

Figure 4: Five broad themes of data-sharing identified by multiple stakeholders at the Blue Growth Data Workshop in Edinburgh (Murray et al. 2018).

The workshop concluded that active and transparent communication and collaboration between stakeholders will be key to unlocking the data (Murray et al., 2018), a perception was then later re-iterated at the second workshop about data-sharing to further unlock Blue Growth opportunities.

4.2 Blue Growth Data Challenge Part 2: Offshore Energy Case Studies on 18 May 2017 in Poole, UK

This workshop formed part of the EU's Maritime Day, "The Future of Our Seas" over 18–19 May 2017. This workshop formed the second part of two "Blue Growth Data Challenge" workshops, with the first organised by the EMODnet with the COLUMBUS project to discuss "Engaging Industry". The ATLAS workshop organised once again with the INSITE programme discussed "Offshore Energy Case Studies" bringing together key players in the provision, analysis, application and long-term storage of marine environmental data. Emerging Blue Growth data issues, especially around the decommissioning of oil and gas installations alongside the development of marine renewables was discussed. The multiple challenges of providing holistic, open-access environmental data were discussed, as well as the issue of enabling regulators, operators and marine scientists to access information.

As with the Blue Growth Data Workshop in Edinburgh earlier that year, multiple stakeholders from both the private and public sector attended, including the European Marine Board Executive Director at the time, Niall McDonough (Figure 5), who launched the EMB's Decommissioning Policy Brief at the workshop.

Figure 5: Clockwise from top: the panel chairs (left to right: Silvia Camporeale, Valter Martinotti, Niall McDonough, Chelsea Bradbury, Mark Johnston, Richard Heard) on industry data-sharing at the Blue Growth Data Challenge Part 2 Offshore Energy Case Studies Workshop in Poole; Niall McDonough presenting a policy brief on decommissioning at the workshop; ATLAS co-ordinator Murray Roberts introducing the workshop.

The outcomes of the Offshore Energy Case Studies workshop broadly converged on three principles that emerging marine industries in sea basins across Europe could benefit from. These principles were largely lessons learned by the North Sea decommissioning sector, and highlight the need to more fully consider the entire lifecycle of the infrastructure. It was also widely recognised that a range of maritime industries can produce a wealth of data that needs to be gathered and stored in a central data repository such as EMODnet. Finally, it was noted that compared to biological data, physics and chemistry datasets are significantly easier to standardise and produce data products from. The three principles on data-sharing, which also brought together conclusions from the Blue Growth Data Workshop earlier that year in Edinburgh, are outlined next.

Principle 1: Environmental datasets need to be future-proofed by considering potential future uses and marine environmental data should always be collected at the highest possible resolution.

Principle 2: Collection techniques for time series data need to be standardised to allow comparisons to be made across years and datasets.

Principle 3: Mapping the entire North Sea basin (and other basins for that matter) and making it a freely available public asset needs to be considered. Notably, approximately 75% of environmental data costs relate to bathymetric and geological data acquisition (EC, 2009), and thus data-sharing this information could lead to large cost-savings. To make proactive steps towards achieving this, ongoing dialogue needs to continue to take place between regulators, data providers (industry) and data portals at the national and European scale.

Besides discussions among stakeholders about barriers to data collection and sharing, the workshop also offered the ideal platform to promote the recently established EMODnet Data Ingestion Facility, the facility of choice for the uptake of ATLAS data to reach EMODnet users as part of the ATLAS data management pipeline in WP8.

4.3 Supporting Blue Growth workshop, on 11 December 2019 in Dublin, Ireland.

This Blue Growth workshop was jointly hosted by ATLAS with the Science Foudation Ireland Marine and Renewable Energy Research, Development and Innovation Centre (MaREI) and RPS (international engineering consultancy) and the Irish Offshore Operators Association (IOOA). The aim was to disseminate WP6 activities on the ATLAS approach to adaptive MSP in the deep North Atlantic and how improved open-access decision-support tools such as EcoImpactMapper are helping ATLAS to address the complexity of planning industry development in the deep marine environment using the Porcupine Seabight/Rockall Bank ATLAS Case Studies as examples (Figure 6).

The workshop also provided the platform to disseminate and then further scope out with the attendees about how improved data access can lead to more cost-effective EIAs including how it may assist with identifying the latest mitigate options to avoid, minimise, restore or offset impacts (Figure 6). Discussions that followed also allowed for further feedback on environmental mitigation options discovered during the ATLAS project that would be of great interest to the offshore industries and the oil and gas sector in particular to learn more about. These are discussed in more detail in Section 5.

Figure 6: Supporting Blue Growth workshop in Dublin. Top to bottom: Tom Woolley from the Irish Department of Housing, Planning and Local Government explains the Irish Marine Planning Framework; Oisín Callery (NUIG) describes the development of novel decision support tools such as EcoImpactMapper to assist with MSP.Lea-Anne Henry (UEDIN) presents industry feedback on barriers and opportunities of data-sharing;

Additionally, the workshop allowed the opportunity for dissemination to all attendees on the latest open source science, data resources and services being used in ATLAS to share data and information including OpenAire (https://www.openaire.eu) and EMODnet. OpenAIRE provides unlimited and open-access to anyone seeking research outputs financed by public funding in Europe. In WP8, an ATLAS research community dashboard is being developed by OpenAIRE-connect to facilitate the curation, monitoring and reporting of community specific research outputs.

The workshop was attended by multiple stakeholders from the Norwegian and Irish oil and gas industry including ATLAS associate industry partner Equinor, as well as engineering and environmental consultancies, Irish government officials and academia (Figure 6). ATLAS project partners NUIG, UEDIN, SBE, BGS and Bremen (UniHB by remote participation) presented ATLAS outputs to date, while other ATLAS partners also attended including Marine Scotland Science Scotland (MSS) and Seascape Consultants UK (SC).

4.4 ATLAS – industry data-sharing questionnaire

A questionnaire entitled, "Unlocking Industry Environmental Data with the European Marine Observation and Data network, EMODnet" was designed by UEDIN for ATLAS associate partners operating or exploring the deep-water areas in ATLAS Case Study regions. These included the Faroe Shetland Channel (currently exploited and being explored by the oil and gas industry but also used by the fisheries, shipping and telecommunication industries), the Porcupine Seabight (under exploration license by the oil and gas industry but also used by the shipping and fishing industries), the LoVe observatory (currently used as an *in situ* environmental monitoring site by the energy sector), and the Flemish Cap and adjacent Channels (currently exploited by the oil and gas industry but also exploited by the fisheries sector).

Having already scoped out barriers and opportunities for environmental data-sharing with a range of offshore industries operating across Europe primarily during the first two workshops in 2017, the primary purpose of this questionnaire was to obtain more detailed responses to these same questions specifically from ATLAS associate industry partners (Figure 7). The aim was to scope out the potential and willingness for industry to upload private sector data most relevant to ATLAS Case Study areas that would supplement ATLAS data already ingested into EMODnet and thus enhance the overall ATLAS GeoNode experience.

Type of data collected	Current access level (private, restricted access, or open-access)	Is this access level a regulatory requirement?	What data repositories do you upload data to already?	Current data/file format sand size in KB, MB, GB, TB, PB	Do you foresee any barriers to sharing data with EMODnet? Which ones are barriers (Incentives, Risk Perception, Working Culture, Financial Models, Data Ownership)?	Does your company use EMODnet for any purposes (please explain how)?
multibeam acoustic backscatter interpreted maps						
sidescan sonar backscatter interpreted maps						
sedimentary feature maps						
locations of protected features, e.g., listed in Annexes of EU Birds and Habitats Directive, taxa that form Vulnerable Marine Ecosystems						
benthic grab station locations						
water quality station locations						
sediment quality station locations						
remotely operated vehicle or other camera survey locations						
oil spill plume scenarios						

Figure 7: The questionnaire as distributed to ATLAS associate industry partners operating or exploring ATLAS Case Study regions.

The questionnaire was first subjected to an Ethics Assessment and reviewed, in line with ATLAS project guidelines, by the University of Edinburgh's Ethics Committee. It fully complied with the University's Ethics Guidance policy and the EU General Data Protection Regulation and responses were anonymised to protect the identity of the responders (UEDIN Ethics Assessment Ref. 2019/377). The full questionnaire can be viewed as Appendix I to D6.4.

Questionnaires were distributed by email to the partners in November 2019 and responses collected by December 2019. Responses have been collated and anonymised in line with the data questionnaire policy for associate industry partners.

Following analysis of these responses, six key recommendations on data-sharing opportunities and barriers were identified to unlock Blue Growth potential and these are summarised below:

1. Much environmental data collected by industry can be made open-access, or already is. For example, sedimentary feature maps, locations of protected features, e.g., those listed in Annexes of the EU Birds and Habitats Directive (92/43/EEC), taxa that form VMEs, benthic grab station locations, water quality station locations and sediment quality station

locations. However, sometimes the regulators may apply restriction on access levels for wider use. **Opportunities to further scope out the type of environmental data that can be shared are recommended, and in dialogue with EMODnet as a data broker.**

2. Multibeam and sidescan sonar, underwater video footage, and industry oil spill scenarios are usually restricted or kept private. These may be commercially sensitive, or may be subject to misinterpretation and misused, e.g., oil spill scenarios. Opportunities to share such data may be explored on a case-by-case basis, but **it is recommended that projects like ATLAS continue to share new modelling techniques, e.g. particle trajectory modelling, species distribution modelling to help inform industry of possible outcomes of such scenarios.**
3. The level of data-sharing is often determined by regulators. This reinforces the vital role that on-going science-policy-industry dialogue plays in establishing minimal requirements; **it is therefore recommended that this dialogue is strengthened through fully participatory approaches in marine planning and licensing processes.**
4. Industry sometimes already upload the latest maps of sedimentary features and habitat maps to national repositories, e.g., the MAREANO project (https://www.mareano.no). **It is further recommended that more use be made of EMODnet as a data broker and opportunities for direct industry engagement, e.g., through dedicated industry workshops, be explored so these maps can be fully exploited by the scientific community.**
5. Notably, the associate industry partners were not widely aware of using EMODnet for assisting with environmental assessments. This strongly flags the need to raise more awareness around the portal and its potential to greatly assist the wider offshore community in best practices and reducing costs of EIAs, e.g., as in the German windfarm use case study identified during the very first Blue Growth Data workshop in Edinburgh in 2017 (Murray et al., 2018). **Building on the fourth recommendation above, it is recommended that EMODnet continue and strengthen proactive engagement with deep and open ocean industries to ensure awareness is raised.**
6. Key barriers were consistently identified across associate industry partners, and reflect the opinions expressed earlier by other offshore companies and stakeholders who attended the Blue Growth Data workshop in Edinburgh in 2017 (Murray et al., 2018). Specifically, the ATLAS associate industry partners identified working culture (staff time

to consolidate/format data and obtain permissions); data ownership (data may be held by consultants who can provide access); and risk perception (e.g., an oil spill plume model scenario being misinterpreted by non-experts) as key barriers that prevent them from pursuing open-access data-sharing on EMODnet. **It is recommended that more regular dialogue between science and industry take place in order for solutions to be uncovered. Where possible, successful case studies of data-sharing and science-industry partnerships need to be highlighted more prominently: this will help transform both science and industry working cultures to solve basin-scale issues and unlock Blue Growth potential.**

5. Industry implementation of the mitigation hierarchy and options for ATLAS Case Studies

Application of the mitigation hierarchy is a key part of industry decision-making regulatory approval, and is part of a robust and sound EIA. The hierarchy requires the developer to first consider measures to avoid environmental impacts, and if impacts cannot be avoided then approaches to minimise impacts must be built in. If impacts are unavoidable and cannot be minimised, measures to restore ecosystems need to be integrated into the assessment, and finally offsetting measures are considered when impacts cannot be avoided, minimised or when ecosystems cannot be restored.

5.1 ATLAS-industry mitigation questionnaire

For D6.4, a bespoke two-part questionnaire titled, "Adaptive Management in ATLAS Case Studies: the Industry Mitigation Hierarchy and Relevance of ATLAS Innovations" was designed by UEDIN for ATLAS associate partners operating or exploring the deep-water areas in ATLAS Case Study regions. The goal of the questionnaire was to determine how ATLAS associate industry partners operating in ATLAS Case Study regions currently implement the mitigation hierarchy and then to collect highly specific information on which ATLAS innovations in data, information, and other products that these industry partners would find most useful in helping them to implement the hierarchy.

The responses were used to build on the related series of three data-sharing principles (Section 4) to derive a further series of additional ATLAS recommendations on mitigation options that these operators could in future consider to help them particularly to avoid and minimise their environmental impacts in the Case Study regions. Equally, their responses help the ATLAS science community to better understand industry needs and drivers for such information. The questionnaire also provided free text options with every question in order for the associated partners to elaborate on their responses and even expand on these for other parts of the world where they have exploitation or exploration licenses.

The questionnaire was broken down into two components. The first component (Section 1) helped ATLAS to ascertain what the associate industry partner's current practice is with regards to conducting the mitigation hierarchy in their Case Study region. However, the respondent was free to comment on its application with respect to operations globally. Questions in Section 1 broadly followed industry-accepted best practice guidance provided by the publication, "A cross sector guide for implementing the mitigation hierarchy", by the Cross-Sector Biodiversity Initiative (CSBI, 2015). The CSBI comprises IPIECA, who are the global oil and gas industry association for advancing environmental and social performance. Also involved are the International Council on Mining and Metals (ICMM), and Equator Principles, who employ a risk management framework adopted by financial institutions that helps to determine, assess and manage environmental and social risk in project finance.

Questions in Section 1 could apply to any operational phase or "project" in the lifecycle of an asset in the Case Study area, from exploration and production to decommissioning. These can apply to any type of subsea infrastructure for which mitigation might need to be considered as part of the consenting and licensing process. Following guidance and structure from CSBI (2015), the questionnaire asked associate industry partners specifically about their full range of mitigation measures along the hierarchy. These included:

- **avoidance measures** that were taken or are routinely undertaken during site selection, project design and project scheduling phases, but also whether the performance of these avoidance measures are monitored and evaluated as well as whether there are any knowledge gaps that the operator would like to see addressed to help them avoid environmental impacts and improve best practice;
- **minimisation measures** that are used in their practices, which include physical controls to minimise impacts as well as operational controls and abatement controls, whether the operator adopts any kind of adaptive management approaches, whether they considered co-locating their operations with other operators or sectors to minimise their footprint and overall impact, and if there were knowledge gaps that the operator would like

addressed to help them in future to further minimise environmental impacts of their operations;

- **restoration measures** that are currently implemented or being considered, including any adoption of spontaneous (passive) restoration methods, or assisted (active) restoration techniques, and any knowledge gaps that the operator would like to see addressed that would help them to more fully restore and not cause permanent long-term adverse damage to deep-water ecosystems;
- **offsetting measures** were also included, and the associate industry partners were first asked about their company's policy on biodiversity offsetting as a means to implement the mitigation hierarchy when impacts cannot be avoided, minimised or the ecosystem restored. Operators were also asked whether their company would consider restoration or protection offsets in the future, their general awareness of offsetting measures adopted by any deep-water marine industry, and what they felt the key knowledge gaps were regarding the potential for using offsets in the deep sea.

The second component of the questionnaire (Section 2) regarded how relevant the associate industry partners specifically felt that ATLAS innovations were with respect to how they might improve best practice in implementing the mitigation hierarchy and adaptive management as new information is received. These questions were also designed to provide a high-level roadmap for industry to understand how ATLAS innovations can help to implement the mitigation hierarchy. For example, this might be in the form of new species and habitat maps to help avoid impacts, or studies that show environmental thresholds of habitat-forming species so as to guide minimisation measures, advancements in the *in situ* laboratory culturing methods of deep-sea animals to aid restoration, or whether ATLAS helps to identify areas in the North Atlantic under threat that might be considered for biodiversity offsetting.

To construct this aspect (Section 2) of the questionnaire, UEDIN first conducted a systematic review of work-package outputs. A subset of these were then selected on the basis that they were the most relevant to ATLAS associate industry partners operating in these Case Study regions. The questionnaire was sent to the partners in November 2019 and responses were collected and anonymised in line with our industry partners' requirements. The responses were collated and are described here in Deliverable 6.4 to identify specific ATLAS innovations that could help businesses to make improvements in implementation and best practice. Recommendations on ATLAS innovations that could be exploited by industry combined with the series of three data-sharing principles arising from the three data-sharing workshops (Section 4) formed the basis for Deliverable 6.4. This aspect of the Deliverable finalised a suite of overall recommendations on data-sharing and mitigation options to improve best practice and reduce costs.

As with the data-sharing questionnaire (Section 4) and in line with agreed ATLAS protocols, the mitigation questionnaire was subjected to an Ethics Assessment reviewed by the University of Edinburgh's Ethics Committee. It fully complied with the University's Ethics Guidance policy and the EU General Data Protection Regulation and responses were anonymised to protect the identity of the responders (UEDIN Ethics Assessment Ref. 2019/377). The full questionnaire can be viewed as an Appendix II to D6.4.

5.2 Responses to Section 1, Business implementation of the mitigation hierarchy in the deep North Atlantic

We maintained the broad overall structuring outlined by the CSBI (2015) guidance to collate responses into how industry avoids, minimises, and applies or uses restoration and offsetting measures. These are broken down into further subsections depending on how much information and the quality of information provided back to us on the industry responses.

5.2.1 Avoidance

Site selection:

Operators did not identify EMODnet as a key source of information for their operations. These responses also reflect the lack of awareness around EMODnet as a knowledge broker that was already identified in the first questionnaire that was implemented on data-sharing (Section 4). They did, however, identify some of the environmental datasets and tools that they already use to help them avoid sensitive areas during site selection. Besides national repositories, these include the Integrated Biodiversity Assessment Tool (IBAT; this tool includes user access to, e.g., the International Union for Conservation of Nature (IUCN) Red List of Threatened Species; the World Database on Protected Areas (a joint IUCN-World Conservation Monitoring Centre-United Nations Environment venture); and the World Database of Key Biodiversity Areas managed by BirdLife International. Operators responded that datasets on ecosystem services were not yet exploited but of those that are, socioeconomic values and importance of fisheries are often used.

Project design:

Operators responded that when they considered their projects more globally beyond the ATLAS Case Study regions, their project designs try to avoid sensitive areas such as migration routes and breeding grounds. Model simulations are also used to help avoid impacts, largely around oil spill scenarios, drilling waste discharges, sediment dispersal, underwater sound, and produced water discharge modelling including changes in water temperature.

Project scheduling:

Operators noted that, as with project design, they try to avoid having environmental impacts in the first place by avoiding times known to be important to protected species. For example, activities are avoided during seasons of marine mammal calving, during their migrations, when seabird nest, and known fish spawning events.

5.2.2 Minimisation

Operational controls:

All of the businesses contacted by ATLAS as associate industry partners have commercial interests in the exploitation of oil and gas from the deep sea. Oil and gas is one of the most heavily regulated offshore industries, and are legally bound to comply with best practices and multilateral agreements and international conventions, e.g., the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL 73/78).

Abatement controls:

The companies reported that the use of dispersants is actively being investigated as an area of research with considerable importance to the industry. Notably, during the third ATLAS workshop, “Supporting Blue Growth” in Dublin in December 2019, the use of dispersals to minimise impacts and the spatio-temporal footprint of an accidental spill or blowout was discussed in greater detail. ATLAS research on potential impacts of dispersants on sponges similar to those found in the ATLAS Case Study of Faroe Shetland Channel revealed that an oil spill mixed with dispersant has far more significant adverse impacts on shallow-water sponges than the oil spill alone. Later in Section 2 of this questionnaire, associate industry partners also found this ATLAS innovation highly relevant to their business practices, and emphasised the need for further research on the performance and consequences of applying this type of abatement control.

Co-location:

Operators reported that the use of co-location with other oil and gas companies already frequently occurs and offers considerable cost-sharing benefits as well as the effect of minimising environmental impacts. Co-location already includes sharing space, infrastructure, ports, bases and vessels. More recently, benefits of co-location between the oil and gas sector and the offshore renewable sector are also now being explored.

5.2.3 Restoration

Spontaneous (passive) restoration:

The associate industry partners reinforced the concept of existing measures to passively restore ecosystems simply by leaving discharged cuttings piles undisturbed on the seafloor. Along with national regulators and governmental agencies, there are also active research programmes investigating the values of alternate options to expedite the process, including bioremediation, or to further ensure they cuttings are not disturbed for example by covering the cuttings with rock dump, etc. They also highlighted the important role of environmental monitoring to ensure the performance of these spontaneous restoration methods.

During the ATLAS workshop, "Supporting Blue Growth" in Dublin in December 2019, additional spontaneous restoration methods were also discussed. This included discussions on the role that man-made structures play in the marine ecosystem with regards to their potential function as artificial reefs. A key ATLAS innovation highlighted to the industry later in Section 2 of this questionnaire was that oil and gas platforms are now colonised by protected species of cold-water corals, which go on to disperse larvae that have the potential to connect to downstream natural populations including a marine protected area in Norway (Henry et al., 2018).

Assisted (active) restoration:

Operators reported that these methods of assisted restoration, e.g., transplanting deep-sea fauna back into the ecosystem, have not yet been investigated within their company. Following this, there was strong consensus among operators that this represents a big knowledge gap, particularly with respect to the practicalities and costs associated with restoring deep-water protected benthic species such as cold-water corals.

5.2.4 Offsetting

Company policy on offsets:

The associate industry partners reported that their company's priorities are always around prevention in the first place, e.g., to avoid having the environmental impact, then remediation (restoration) is considered in so far as companies leave things to degrade naturally or remove debris. One operator reported that company policy was that biodiversity offsetting was simply not an acceptable option and this view was reinforced during discussions at the Dublin workshop.

Biodiversity, restoration and protection offsets:

The operators all reported that if biodiversity offsets, and for that matter, also restoration and protection offsets, are ever considered, offsets must be as a last resort. Furthermore, these respondents noted that offsets should only be considered when it can be determined that no net loss of biodiversity (NNL) will not be achieved earlier in the mitigation hierarchy (e.g., by avoiding, minimising or restoring impacts). These are only undertaken when theoretically, technically and economically feasible, and are "like for like", e.g., within the same region or landscape of the areas within which planned activities are undertaken or where deemed equivalent by regulations.

At the ATLAS workshop, "Supporting Blue Growth" in Dublin in December 2019, the "like for like" concept was discussed further by workshop attendees. Here, it was noted that the feasibility of offsetting to achieve NNL in other deep-water industries such as deep seabed mining still in their exploration phase has been debated (Niner et al., 2018): in the Niner et al. paper, experts agreed that offsetting could never replace like for like in the deep sea because it cannot replicate biodiversity and ecosystem services lost through mining of the deep seabed and thus cannot be considered a true offset (Niner et al., 2018).

All respondents noted that a key knowledge gap regarding offsets in the first place needs to be urgently addressed as there is to date little to no guidance on the acceptability of offsetting as a mitigation measure.

5.3 Responses to Section 2, Relevance of ATLAS innovations for the mitigation hierarchy

Not all associate industry partners responded to every question, but nearly every question had some responses. Industry feedback was collated and anonymised, with key comments interpreted and summarised here, workpackage by workpackage. Industry representatives were asked to score each ATLAS innovation on a scale of 1 to 5, with 5 being highly relevant to help them improve and implement their mitigation hierarchies in the ATLAS Case Study regions but also perhaps more widely in their operations elsewhere (Table 2).

Table 2: Industry responses regarding the relevance of ATLAS innovations to mitigation hierarchy. Relevance scores from 1 (not very relevant) to 5 (highly relevant).

	Relevance to Mitigation (1 - 5)	**Feedback Summary**
WP 1 Ocean Dynamics Driving Ecosystem Response		
ATLAS created maps of the strength, directions, temperatures and salinities of large-scale ocean currents across the North Atlantic.	5	important for improving baseline data on conditions, also for safety implications
ATLAS has also created downscaled maps of these properties and dynamics across your region(s) of operations in the North Atlantic.	4	maps are useful but need to be inter-operable with industry systems
ATLAS created maps showing how connected deep marine ecosystems could be from one place to another, including your region(s) of operations.	4	helps to understand baselines and ecosystem vulnerabilities
ATLAS identified thresholds of oxygen, food supply and other environmental conditions beyond which deep-sea coral ecosystems no longer thrive.	3	helps to understand baselines and ecosystem vulnerabilities, but presence/absence data on these ecosystems is probably more valuable to help industry avoid impacts
WP2 Functional Ecosystems		
ATLAS identified how water column and near seabed hydrodynamics can affect food supply to Vulnerable Marine Ecosystems (cold-water coral reefs, coral gardens, sponge grounds).	4	helps to understand baselines and ecosystem vulnerabilities, but also to aid the industry's own dispersal models and to understand potential outcomes of spills and use of dispersants
ATLAS determined important sources of food and mechanisms of food uptake in these same Vulnerable Marine Ecosystems.	2	helps to understand baselines and ecosystem vulnerabilities
ATLAS measured the combined effects of food supply and ocean acidification on Vulnerable Marine Ecosystems.	2	helps to understand baselines and ecosystem vulnerabilities including cumulative impacts from climate change
ATLAS measured the effects of an oil spill treated with dispersants on sponges, which can form Vulnerable Marine Ecosystems.	5	industry would like more information on this research in ATLAS but noted that this would be critically important information to understand potential impacts including when and where dispersant can or cannot be used

(continued)	Relevance to Mitigation (1 - 5)	Feedback Summary
ATLAS created a new class of mathematical model that predicts how changes in the biogeochemistry of the environment or the hydrodynamics of the area affect the biomass of deep-sea coral and sponge ecosystems.	4	adds important knowledge and could help to improve industry monitoring capabilities, and potentially very useful with industry noting that more information on this ATLAS research is welcome
WP3 Biodiversity and Biogeography		
ATLAS created maps at the North Atlantic and regional scales that predict present-day and future distribution of species and habitats that form Vulnerable Marine Ecosystems.	4	useful for EIAs and project design but role of maps on future distributions more challenging to integrate into the EIA
ATLAS developed new protocols and validated the use of quantitative polymerase chain reaction (qPCR) methods and environmental DNA (eDNA) to detect and quantify the biomass of pelagic sharks and rays such as tope (*Galeorhinus galeus*) and mobulid ray (*Mobula tarapacana*), deep-sea teleosts such as blackbelly rosefish (*Helicolenus dactylopterus*) and orange roughy (*Hoplostethus atlanticus*), and hydrothermal vent shrimp *(Mirocaris fortunata*).	2	still a relatively novel method, applications need to continue to be evaluated
ATLAS identified regions of the North Atlantic that are biogeographically unique, containing species with highly restricted distributions.	5	helps to identify areas to avoid
ATLAS demonstrated that background variability in environmental conditions has strong effects on deep-sea biodiversity and biogeography, even in the absence of human activities.	4	useful as it allows industry to disentangle their impacts from natural variability
ATLAS validated occurrences of Vulnerable Marine Ecosystems (VME) in the North Atlantic including in your region(s) of operations using a VME index.	4	useful to understand sensitive area and areas to avoid, more so as it is based on good scientific evidence

(continued)	**Relevance to Mitigation (1 - 5)**	**Feedback Summary**
ATLAS conducted systematic conservation planning, which identified areas in the North Atlantic that should be prioritised for (additional) area-based management based on conservation and human activity criteria: many of these priority areas include your region(s) of operations.	4	useful to understand sensitive area and areas to avoid, more so as it is based on good scientific evidence
ATLAS identified regions of the North Atlantic that are going to experience critical shifts in environmental conditions over the next 50 years due to climate change. These will likely alter or degrade deep-sea ecosystems, including in your region(s) of operations.	3	somewhat relevant as industry projects operate over a lifetime of 5 to 30 years so it's important to know how this may affect existing operations in the future
WP4 Connected Resources		
ATLAS has developed bespoke laboratory protocols to measure genetic variability in species that are part of Vulnerable Marine Ecosystems including deep-sea corals (*Lophelia pertusa, Madrepora oculata*), their symbionts (*Eunice* spp.), and cidarid sea urchins. These protocols are called restriction site associated DNA markers (RAD sequencing), and require fewer samples to be collected than with other methods.	3	learning more about the cost-efficiency and potential of these applications would be useful
ATLAS conducted next-generation sequencing (NGS) on three commercially important fisheries species: boarfish (*Capros aper*), horse mackerel (*Trachurus trachurus*), and Norway lobster (*Nephrops norvegicus*). These sequences now allows for genomic analysis to reconstruct changes in fish stocks over management-relevant timescales.	1	
ATLAS helped to create and distribute low-cost, low-profile Coral Kits to industry for the scientific collection of deep-sea coral samples from oil and gas infrastructure by industry during remotely operated vehicle (ROV) and saturation diver inspection surveys. These help scientists understand the ecological connectivity of man-made structures.	5	important to monitor baseline conditions and industry requested more information on this ATLAS research

(continued)	Relevance to Mitigation (1 - 5)	Feedback Summary
ATLAS compiled a database on longevity, growth rates and other life history traits of deep-sea species forming Vulnerable Marine Ecosystems.	3	contributes to improved understanding of ecosystems and their dynamics
WP5 Valuing Ecosystem Services		
ATLAS conducted an expert risk assessment that scored the magnitude and likelihood of deep-sea ecosystem impacts resulting from climate change and different industry sectors. Pollution was scored by experts as being the most likely impact on deep-sea ecosystems resulting from human activities.	3	useful to understand the relative risks and impacts of different sectors
ATLAS identified ecosystem goods and services provided by deep-sea ecosystems in all case study areas including your region(s) of operations.	4	perhaps more relevant to share this information with governments and authorities, but noted that ecosystem services are poorly assessed in the EIA framework but should be if data become available
ATLAS applied value transfer methods to estimate the economic value provided by these ecosystem goods and services.	1	no demand for this for now by the industry
ATLAS assessed the public’s willingness to pay for deep-sea conservation in 4 case study areas: the LoVe observatory, the Mingulay Reef Complex, the Flemish Cap, and the Azores.	2	
WP6 Maritime Spatial Planning		
ATLAS created a series of GIS templates for each case study region including your region(s) of operations. These templates include new ATLAS data and maps, and offer standardised visualisations of geospatial data relevant to marine spatial planning downloadable from the European Marine Observation and Data network (EMODnet) and its European Atlas of the Seas Central Portal.	4	this is highly relevant provided that these are inter-operable with industry GIS systems too, and will also help to identify sensitive areas assuming there is high resolution.
WP7 Policy Integration to Inform Key Agreements		
ATLAS found that climate change could degrade the effectiveness of most area-based management tools (ABMTs) in the deep North Atlantic.	1	

(continued)	Relevance to Mitigation (1 - 5)	Feedback Summary
ATLAS has investigated co-location opportunities as a means to foster Blue Growth.	3	potentially useful perhaps more for the offshore wind sector, but more needs to be known about the ecological benefits of co-location, noting that this is perhaps even more relevant for governments and authorities
WP8 Open Science Resources for Stakeholders		
ATLAS is developing an open source geospatial content management system called GeoNode to facilitate collaborative use of geospatial data and maps collated by ATLAS and including new data and maps. The GeoNode is designed around all 12 case study areas including your region(s) of operations.	3	open-access information is very welcomed but needs to be inter-operable with industry systems too

5.4 Final summary of ATLAS recommendations for mitigation measures

Analysis of industry responses where an output was scored as being highly relevant (i.e., a score of 4 or 5) leads to several key recommendations that industry could take forward to assist with implementing their mitigation measures in an EIA, or equally, regarding a Strategic Environmental Assessment that will also need to consider mitigation in its scenarios of a different marine policy, plan, programme or strategy. Mostly, these recommendations are already being implemented through the data-sharing mechanisms offered to ATLAS through EMODnet and the ATLAS GeoNode. Other recommendations are there to underscore the need to look for further collaborative opportunities to advance research.

First, industry should use ATLAS' various maps of the strength, direction, temperature and salinity of large-scale ocean currents and ecological connectivity across the North Atlantic (and downscaled products). These are openly shared, e.g. on EMODnet, and can improve baseline knowledge to underpin mitigation options such as avoid, minimise and perhaps even passively restore ecosystems if a project, plan, programme, policy or strategy (PPPPS) might impact on deep-sea ecosystems.

Second, ATLAS improved our understanding of how closely VMEs are tied to the properties and dynamics of the water column, near seabed hydrodynamics and biogeochemistry, and their vulnerability to current mitigation measures under an oil spill scenario wherein dispersant is applied to minimise further ecosystem impacts. It is recommended that industry use such evidence to design or consider appropriate minimisation controls, to understand the ecosystem vulnerabilities, and to improve monitoring capabilities, e.g. using ATLAS' new class of coupled hydrodynamic-biogeochemical models.

Third, ATLAS produced a considerable amount of highly relevant outputs at the basin and regional scales to can help industry avoid having impacts. It is also imperative that dialogue with relevant industry fora and ATLAS be maintained to strengthen existing and forge new collaborations in data collection, e.g., during exploration surveys, or decommissioning work (e.g. which led to a unique collection of deep-sea coral genetic material from oil and gas platforms and locations of corals as well). These include maps of species distribution models (predictive) pertaining to VMEs built on validated maps of VME indicator species (ground-truthed), and maps of biogeographically unique regions (ground-truthed). ATLAS' systematic conservation planning methods also found areas in the North Atlantic that should be prioritised for (additional) area-based management based on multiple criteria.

Fourth, it is recommended that industry consider more explicitly the information that ATLAS has collected regarding marine ecosystem services in the deep sea, as historically, the lack of such information meant that such services are not considered in industry EIAs. Thus, it is difficult to assess how to avoid, minimise or restore ecosystem services if there is not already a baseline understanding of what is already provided by the ecosystem.

Fifth, it is recommended that industry visit the ATLAS GeoNode to use the GIS templates for its case study regions as these offer standardised visualisations of geospatial data relevant to marine planning and licensing. ATLAS favours the use of open source QGIS and R programming software which should facilitate interoperability with industry GIS systems already in-house. Here too, science-industry dialogue needs to continue in order to ensure uptake of ATLAS offerings.

References

C.S.B.I., 2015. A cross-sector guide for implementing the mitigation hierarchy. Prepared by the Biodiversity Consultancy.

Douvere, F. and Ehler, C.N., 2011. The importance of monitoring and evaluation in adaptive maritime spatial planning. Journal of Coastal Conservation, 15:305-311.

European Commission, 2009. European Commission Marine Data Infrastructure Framework Service Contract, No. FISH/2006/09 – Lot 2 Final report December 2009.

Ehler, C., Zaucha, J. and Gee, K., 2019. Maritime/marine spatial planning at the interface of research and practice. In, Maritime Spatial Planning, Zaucha, J. and Gee, K. (eds.) Palgrave Macmillan, Cham. pp. 1-21.

García-Alegre, A., Sacau, M., Durán Muñoz, P. 2018. Monitoring and evaluation of a spatially managed area in the Case Study No 11, following the MESMA framework: Step 1 - Context Setting. ATLAS work package 6 presentation at ATLAS 3rd General Assembly, doi: 10.5281/zenodo.1254479.

Henry, L.-A., Mayorga-Adame, C.G., Fox, A.D., Polton, J.A., Ferris, J.S., McLellan, F., McCabe, C., Kutti, T., Roberts, J.M. 2018. Ocean sprawl facilitates dispersal and connectivity of protected species. Nature Scientific Reports 8: 11346.

Jacob, C., Pioch, S. and Thorin, S., 2016. The effectiveness of the mitigation hierarchy in environmental impact studies on marine ecosystems: A case study in France. Environmental Impact Assessment Review, 60: 83-98.

Morato et al. 2020. Climate-induced changes in the suitable habitat of cold-water corals and commercially important deep-sea fishes in the North Atlantic. Global Change Biology, doi: 10.1111/gcb.14996.

Murray F, Needham K, Gormley K, Rouse S, Coolen JWP, Billet D, Dannheim J, Birchenough SNR, Hyder K, Heard R, Ferris JS, Holstein JM, Henry L-A, McMeel O, Calewaert J-B, Roberts JM (2018) Data challenges and opportunities for environmental management of North Sea oil and gas decommissioning in an era of blue growth. Marine Policy 97: 130-138.

Niner, H.J., Ardron, J.A., Escobar, E.G., Gianni, M., Jaeckel, A., Jones, D.O., Levin, L.A., Smith, C.R., Thiele, T., Turner, P.J. and Van Dover, C.L., 2018. Deep-sea mining with no net loss of biodiversity—an impossible aim. Frontiers in Marine Science, 5: 53.

Polsenberg, J. and Kilponen, A., 2018. It starts with a conversation: Achieving conservation goals in collaboration with the offshore energy industry. In, Offshore Energy and Marine Spatial Planning, Edited By Katherine L. Yates, Corey J. A. Bradshaw. Routledge. pp. 34-55.

Ramiro-Sánchez, B., González-Irusta, J.M., Henry, L.-A., Cleland, J., Yeo, I., Xavier, J.R., Carreiro-Silva, M., Sampaio, Í., Spearman, J., Victorero, L., Messing, C.G., Kazanidis, G., Roberts, J.M., Murton, B. 2019. Characterization and mapping of a deep-sea sponge ground on the Tropic Seamount (Northeast tropical Atlantic): implications for spatial management in the High Seas. Frontiers in Marine Science 6: 278.

Vad, J., Kazanidis, G., Henry, L.-A., Jones, D.O.B., Gates, A.R., Roberts, J.M. 2019. Environmental controls and anthropogenic impacts on deep-sea sponge grounds in the Faroe-Shetland Channel, NE Atlantic: the importance of considering spatial scale to distinguish drivers of change. ICES Journal of Marine Science doi:10.1093/icesjms/fsz185.

Appendix I: Unlocking Industry Environmental Data with the European Marine Observation and Data network, EMODnet

Unlocking Industry Environmental Data with the European Marine Observation and Data network, EMODnet

About ATLAS

The ATLAS project is a four-year Horizon 2020 project funded by the EU with partners from multinational industries, small and medium enterprises (SMEs), governments and academia. Together, these partners are assessing Atlantic deep-sea ecosystems to create the integrated and adaptive planning products needed for sustainable Blue Growth. ATLAS is coordinated by the University of Edinburgh and you can find out more about the Project on our website: https://www.eu-atlas.org.

This questionnaire

This questionnaire is an important component of ATLAS Workpackage 6, Marine Spatial Planning. The goal of the questionnaire is to see if the ATLAS project can help to unlock industry environmental data through data-sharing opportunities with EMODnet. The recently formed Business for Nature Coalition and the UNEP-WCMC Proteus collaboration both recognise that the provision of biodiversity information collected by industry is critical to helping all ocean stakeholders to achieve more sustainable development. In the same way that ATLAS brings new information into EMODnet, industry too can help to unlock information in areas not readily accessible to most and where activities will, or are, taking place. The questionnaire will take approximately 20 minutes in total. Participation is voluntary.

Background information

The data collected will be used for research purposes and you may request a copy of your responses. Data collected will be stored by the University of Edinburgh on a password-protected computer system and will be accessible only to the researchers involved in the project. We would like to retain your name and email address for 18 months after the survey date, then erased. Under the General Data Protection Regulation (GDPR) the legal basis for using your answers to this questionnaire is "processing in the public interest". You are under no obligation to complete the survey and can stop at any point if you so wish. If you subsequently wish your answers to be deleted, you can email me (l.henry@ed.ac.uk) and I will delete them.

For research archiving purposes I will keep only a fully anonymised set of data with all identifying features (in particular, email addresses) stripped out.

This survey complies with the General Data Protection Regulations (GDPR) (2018) and has been scrutinised and granted Ethical Approval through the University of Edinburgh School of GeoScience's ethical approval process. If you have ethical concerns about this survey or the conduct of the researchers involved, you may contact the University of Edinburgh's School of GeoScience's Research Ethics and Integrity Committee: ethics.geos@ed.ac.uk .

I confirm that I am over 18 years of age, have read and understood the Privacy Notice, and consent to participate in this survey.

Name: **Date:**

Email address:

Type of data collected	Current access level (private, restricted access, or open-access)	Is this access level a regulatory requirement?	What data repositories do you upload data to already?	Current data/file format sand size in KB, MB, GB, TB, PB	Do you foresee any barriers to sharing data with EMODnet? Which ones are barriers (Incentives, Risk Perception, Working Culture, Financial Models, Data Ownership)?	Does your company use EMODnet for any purposes (please explain how)?
multibeam acoustic backscatter interpreted maps						
sidescan sonar backscatter interpreted maps						
sedimentary feature maps						
locations of protected features, e.g., listed in Annexes of EU Birds and Habitats Directive, taxa that form Vulnerable Marine Ecosystems						
benthic grab station locations						
water quality station locations						
sediment quality station locations						
remotely operated vehicle or other camera survey locations						
oil spill plume scenarios						

Appendix II: Adaptive Management in ATLAS Case Studies: the Industry Mitigation Hierarchy and Relevance of ATLAS Innovations

Adaptive Management in ATLAS Case Studies: the Industry Mitigation Hierarchy and Relevance of ATLAS Innovations

About ATLAS

The ATLAS project is a four-year Horizon 2020 project funded by the EU with partners from multinational industries, small and medium enterprises (SMEs), governments and academia. Together, these partners are assessing Atlantic deep-sea ecosystems to create the integrated and adaptive planning products needed for sustainable Blue Growth. ATLAS is coordinated by the University of Edinburgh and you can find out more about the Project on our website: https://www.eu-atlas.org.

This questionnaire

This 2-part questionnaire is an important component of ATLAS Workpackage 6, Marine Spatial Planning. The goal of the questionnaire is to determine how our industry partners operating in our Case Study areas implement the mitigation hierarchy and to identify which ATLAS innovations in data, information and other products our industry partners find most useful in helping them to implement the hierarchy. The questionnaire will take approximately 60 minutes in total, and ATLAS invites participation from its Advisory Board Industry partners currently operating in at least one of ATLAS' Case Study areas. Participation is voluntary.

Background information

The data collected will be used for research purposes and you may request a copy of your responses. Data collected will be stored by the University of Edinburgh on a password-protected computer system and will be accessible only to the researchers involved in the project. We would like to retain your name and email address for 18 months after the survey date, then erased. Under the General Data Protection Regulation (GDPR) the legal basis for using your answers to this questionnaire is "processing in the public interest". You are under no obligation to complete the survey and can stop at any point if you so wish. If you subsequently wish your answers to be deleted, you can email me (l.henry@ed.ac.uk) and I will delete them. For research archiving purposes I will keep only a fully anonymised set of data with all identifying features (in particular, email addresses) stripped out.

This survey complies with the General Data Protection Regulations (GDPR) (2018) and has been scrutinised and granted Ethical Approval through the University of Edinburgh School of GeoScience's ethical approval process. If you have ethical concerns about this survey or the conduct of the researchers involved, you may contact the University of Edinburgh's School of GeoScience's Research Ethics and Integrity Committee: ethics.geos@ed.ac.uk .

I confirm that I am over 18 years of age, have read and understood the Privacy Notice, and consent to participate in this survey.

Name: **Date:**

Email address:

Section 1:

Business implementation of the mitigation hierarchy in the deep North Atlantic

The purpose of Section 1 is to understand your business' current practice in implementing the mitigation hierarchy in our ATLAS case study areas. This understanding identifies where ATLAS innovations could help businesses to make substantial improvements in implementation (Section 2).

Questions in Section 1 broadly follow guidance provided by the publication, "*A cross sector guide for implementing the mitigation hierarchy*", by the Cross Sector Biodiversity Initiative comprising IPIECA, ICMM and Equator Principles (2015). The mitigation hierarchy is a key part of industry decision-making regulatory approval, and is part of a sound environmental impact assessment. The hierarchy first considers measures to avoid environmental impacts, and if impacts cannot be avoided then approaches to minimise impacts must be built in. If impacts are unavoidable and cannot be minimised, measures to restore ecosystems need to be integrated into the assessment, and finally offsetting measures are considered when impacts cannot be avoided, minimised or when ecosystems cannot be restored.

Questions in Section 1 can apply to any operational phase or "project" in the lifecycle of an asset in the Case Study area, from exploration and production to decommissioning. These can apply to any type of subsea infrastructure for which mitigation might need to be considered as part of the consenting and licensing process.

Case Study Details

Have you implemented the mitigation hierarchy as part of an environmental assessment in your region(s) of operations? ☐ **Yes** ☐ **No**

Which ATLAS Case Study did your mitigation hierarchy apply to, or to which Case Study are you reporting on in Section 1? ☐ **Flemish Cap** ☐ **LoVe observatory and region** ☐ **Porcupine Seabight** ☐ **Faroe Shetland Channel** (Please always feel free to mention other regions of your operations if this applies.)

What kind of project was it, e.g., drilling a well, installing infrastructure, decommissioning, etc.?

Which types of environmental receptors did you have to scope in for this Case Study, and did this include any Vulnerable Marine Ecosystems (cold-water coral reefs, sponge grounds, hydrothermal vents, coral gardens, etc.)?

Avoidance Measures

Site Selection
Which sources of data or databases did you use to help your project avoid impacts during site selection?

Site Selection
Did you specifically consider any kind of ecosystem goods, services and valuations to help you avoid impacts during site selection?

Site Selection
Did you consider potential impacts of future climate change including changes in ocean circulation on the baseline environmental conditions of your site?

Site Selection
Is there anything you would like to note about your measures to avoid environmental impacts at the site selection stage?

Project Design
Did your company modify the project's design in any way to avoid any environmental impacts? If so, please explain.

Project Design
Did you apply any kind of models or simulations to help you avoid environmental impact at the project design phase, e.g., oil spill scenarios, habitat or species distribution models? If so, please explain.

Project Design
Is there anything you would like to note about your measures to avoid environmental impacts at the project design stage?

Project Scheduling

Has your company considered how to avoid impacts by considering the timing of biological events or phenomena, e.g., during seasonal migrations, during spawning events, etc. If so, please explain.

Project Scheduling

Is there anything you would like to note about your measures to avoid environmental impacts at the project scheduling stage?

Monitoring and Evaluating Avoidance Measures

How does your company monitor the effectiveness of its avoidance measures at the site?

Knowledge Gaps

What sorts of data or information did you feel was incomplete in order to improve avoidance measures?

Minimisation

Physical Controls

Did you adapt the physical design of your project to minimise any environmental impacts that you scoped in? If so, please explain.

Operational Controls

Were there any aspects of project operations that you altered to minimise environmental impacts, e.g., all waste kept on board dive support vessels for shore disposal, etc.? If so, please explain.

Abatement Controls

Did your company take any steps to minimise how pressures or stressors reach an environmental receptor, e.g., were different oil spill treatments considered, were different drilling methods considered, were protected species translocated to other locations, etc. If so, please explain.

Adaptive Management Approaches

Are any minimisation measures monitored to see if they have been effective, and have you had to modify any measures as a result? If so, please explain.

Co-location

Does your company consider co-location with other sectors as a means to minimise environmental impacts? If so, please explain.

Knowledge Gaps

What sorts of data or information did you feel was incomplete in order to improve minimisation measures?

Restoration

Spontaneous (passive) restoration

Did your project consider or implement any kind of restoration methods to passively restore the site, e.g., natural degradation of cuttings piles, considering the infrastructure as a man-made substrate that would attract biodiversity, etc.? Please explain.

Assisted (active) restoration

Did your project consider or implement any kind of restoration methods to actively restore the site, e.g., transplant species grown in the laboratory or from unimpacted areas? Please explain.

Knowledge Gaps

What sorts of data or information did you feel could help your business to more broadly consider using restoration measures?

Offsetting

Company Policy

Does your company have a general policy or position about biodiversity offsetting, or do you feel this is still a field in its infancy? Please explain and what might be your company's concerns about this type of mitigation strategy.

Restoration Offsets

Would your company consider rehabilitating or enhancing biodiversity at a degraded offset site if a project in question could not avoid, minimise or restore ecosystems from impacts related to your project? Please explain.

Protection Offsets

If impacts cannot be avoided, minimised or ecosystems restored, would your company consider rehabilitating or enhancing biodiversity at an offset site that was under imminent or project loss of biodiversity, e.g. under climate change or from other factors unrelated to your project? Please explain.

Cross-sectoral implementation of biodiversity offsets

Are you aware of any deepwater projects that have implemented offsetting as part of their mitigation hierarchy? Please explain.

Knowledge Gaps

What sorts of data or information did you feel could help your business to more broadly consider biodiversity offsetting?

Section 2:

Relevance of ATLAS innovations for the mitigation hierarchy

The purpose of Section 2 is to identify which innovations in ATLAS are most relevant to adaptive management. The questions are also designed to provide a roadmap for industry to understand how ATLAS innovations can help to implement the mitigation hierarchy, whether it is new maps to help avoid impacts, or identifying areas in the North Atlantic under threat that might be considered for biodiversity offsetting.

Oceanography

ATLAS created maps of the strength, directions, temperatures and salinities of large-scale ocean currents across the North Atlantic.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS has also created downscaled maps of these properties and dynamics across your region(s) of operations in the North Atlantic.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS created maps showing how connected deep marine ecosystems could be from one place to another, including your region(s) of operations.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS identified thresholds of oxygen, food supply and other environmental conditions beyond which deep-sea coral ecosystems no longer thrive.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

Ecosystem Functioning

ATLAS identified how water column and near seabed hydrodynamics can affect food supply to Vulnerable Marine Ecosystems (cold-water coral reefs, coral gardens, sponge grounds).

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS determined important sources of food and mechanisms of food uptake in these same Vulnerable Marine Ecosystems.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS measured the combined effects of food supply and ocean acidification on Vulnerable Marine Ecosystems.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS measured the effects of an oil spill treated with dispersants on sponges, which can form Vulnerable Marine Ecosystems.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS created a new class of mathematical model that predicts how changes in the biogeochemistry of the environment or the hydrodynamics of the area affect the biomass of deep-sea coral and sponge ecosystems.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

Biodiversity and Biogeography

ATLAS created maps at the North Atlantic and regional scales that predict present-day and future distribution of species and habitats that form Vulnerable Marine Ecosystems.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS developed new protocols and validated the use of quantitative polymerase chain reaction (qPCR) methods and environmental DNA (eDNA) to detect and quantify the biomass of pelagic sharks and rays such as tope (*Galeorhinus galeus*) and mobulid ray (*Mobula tarapacana*), deep-sea teleosts such as blackbelly rosefish (*Helicolenus dactylopterus*) and orange roughy (*Hoplostethus atlanticus*), and hydrothermal vent shrimp (*Mirocaris fortunata*).

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS identified regions of the North Atlantic that are biogeographically unique, containing species with highly restricted distributions.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS demonstrated that background variability in environmental conditions has strong effects on deep-sea biodiversity and biogeography, even in the absence of human activities.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS validated occurrences of Vulnerable Marine Ecosystems (VME) in the North Atlantic including in your region(s) of operations using a VME index.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS conducted systematic conservation planning, which identified areas in the North Atlantic that should be prioritised for (additional) area-based management based on conservation and human activity criteria: many of these priority areas include your region(s) of operations.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS identified regions of the North Atlantic that are going to experience critical shifts in environmental conditions over the next 50 years due to climate change. These will likely alter or degrade deep-sea ecosystems, including in your region(s) of operations.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

Genetics and Connected Resources

ATLAS has developed bespoke laboratory protocols to measure genetic variability in species that are part of Vulnerable Marine Ecosystems including deep-sea corals (*Lophelia pertusa*, *Madrepora oculata*), their symbionts (*Eunice* spp.), and cidarid sea urchins. These protocols are called restriction site associated DNA markers (RAD sequencing), and require fewer samples to be collected than with other methods.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS conducted next-generation sequencing (NGS) on three commercially important fisheries species: boarfish (*Capros aper*), horse mackerel (*Trachurus trachurus*), and Norway lobster (*Nephrops norvegicus*). These sequences now allows for genomic analysis to reconstruct changes in fish stocks over management-relevant timescales.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS helped to create and distribute low-cost, low-profile Coral kits to industry for the scientific collection of deep-sea coral samples from oil and gas infrastructure by industry during remotely operated vehicle (ROV) and saturation diver inspection surveys. These help scientists understand the ecological connectivity of man-made structures.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS compiled a database on longevity, growth rates and other life history traits of deep-sea species forming Vulnerable Marine Ecosystems.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

Socioeconomics

ATLAS conducted an expert risk assessment that scored the magnitude and likelihood of deep-sea ecosystem impacts resulting from climate change and different industry sectors. Pollution was scored by experts as being the most likely impact on deep-sea ecosystems resulting from human activities.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS identified ecosystem goods and services provided by deep-sea ecosystems in all case study areas including your region(s) of operations.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS applied value transfer methods to estimate the economic value provided by these ecosystem goods and services.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS assessed the public's willingness to pay for deep-sea conservation in 4 case study areas: the LoVe observatory, the Mingulay Reef Complex, the Flemish Cap, and the Azores.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

Adaptive Marine Spatial Planning

ATLAS created a series of GIS templates for each case study region including your region(s) of operations. These templates include new ATLAS data and maps, and offer standardised visualisations of geospatial data relevant to marine spatial planning downloadable from the European Marine Observation and Data network (EMODnet) and its European Atlas of the Seas Central Portal.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

Policy

ATLAS found that climate change could degrade the effectiveness of most area-based management tools (ABMTs) in the deep North Atlantic.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

ATLAS has investigated co-location opportunities as a means to foster Blue Growth.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Not at all relevant **Highly relevant**

Please explain:

Geospatial Data and Maps

ATLAS is developing an open source geospatial content management system called GeoNode to facilitate collaborative use of geospatial data and maps collated by ATLAS and including new data and maps. The GeoNode is designed around all 12 case study areas including your region(s) of operations.

How relevant is this information to helping your company avoid or minimise environmental impacts?

☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5**

Not at all relevant **Highly relevant**

Please explain:

Appendix III: Document Information

EU Project N°	678760	**Acronym**	ATLAS
Full Title	A trans-Atlantic assessment and deep-water ecosystem-based spatial management plan for Europe		
Project website	www.eu-atlas.org		

Deliverable	**N°**	D6.4	**Title**	Improving business practice and costs through data-sharing and the identification of potential mitigation measures for adaptive marine spatial planning
Work Package	**N°**	6	**Title**	Maritime Spatial Planning

Date of delivery	**Contractual**
Dissemination level	Public

Authors (Partner)	**UEDIN**			
Responsible Authors	**Name**	Lea-Anne Henry	**Email**	L.Henry@ed.ac.uk

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