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Submitted manuscript: **Engaging with industry to spur Blue Growth**

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Abstract

Improving marine resource management and governance requires marrying science and socio-economics, which is key to the development of the Blue Economy. For sustainable growth of the Blue Economy (Blue Growth) to occur, there needs to be robust scientific information on the marine environment, detailed knowledge of activities occurring within ocean space, and comprehensive understanding of environmental impacts. To ensure Blue Growth is sustainable into the future, information is also needed on how the marine environment, activities and impacts may change with time, and at relevant spatial scales. ATLAS, a trans-Atlantic assessment and deep-water ecosystem-based EU H2020 Project, has undertaken pioneering research to understand the environmental status of the North Atlantic deep sea, and the interaction between Blue Growth scenarios and the marine environment. ATLAS research into North Atlantic Ocean circulation, species and habitat connectivity shows that the North Atlantic is changing, which will impact Blue Growth. As marine industries move progressively offshore, ATLAS work on defining elements of Good Environmental Status for deep-water ecosystems will improve the understanding of Blue Growth interactions with the deep-sea. Potential trade-offs to maintain ecosystem services at a sea-basin scale have also been explored through a selection of 12 ATLAS case studies. ATLAS interactions with industry have highlighted opportunities and challenges for Blue Economy sectors, particularly in the

context of marine spatial planning. Through interviews, questionnaires and workshops, ATLAS has discussed key scientific findings and Blue Growth scenarios with 10 major Blue Economy sectors and many supporting sectors. This work illustrates the complexities of Blue Growth in the North Atlantic, including spatial needs, synergies and conflicts, and data sharing opportunities. ATLAS-industry dialogue also highlights differences in Blue Economy sectoral expectations, and levels of understanding relating to new policy instruments.

Key words: Blue Growth, Blue Economy, North Atlantic, Marine Spatial Planning

Introduction

The Blue Economy concept can be summarized as the sustainable use of ocean resources for economic growth, improved livelihoods and ocean ecosystem health. Sustainable use implies balancing the need for resource exploitation with resource conservation and addressing any trade-offs that may be required, which can be a real challenge in busy ocean regions.

If managed sustainably, the Blue Economy offers the potential to contribute towards multiple United Nations Sustainable Development Goals (SDGs) (UN, 2015), the most pertinent being SDG 14: Life Below Water (World Bank and UNDECA, 2017). Sustainable bioeconomy sectors (fisheries, aquaculture and biotechnology) could also contribute towards SDG 2: Zero Hunger (Day, *et al*., 2016), whilst marine renewables (offshore wind, tidal and wave energy) could support SDG 7: Affordable and Clean Energy. The contribution of the global Blue Economy could surpass $3 trillion by 2030 (OECD, 2016), providing more than 40 million jobs worldwide and so contributing to SDG 8: Decent Work and Economic Growth. However, supporting sustainable growth of the Blue Economy (Blue Growth) presents multiple challenges and requires detailed knowledge of the marine environment and multiple ocean uses in an area.

The North Atlantic is a particularly busy region for the Blue Economy, with multiple sectors seeking space and resources for their activities. Greater connectivity between science and industry is being actively fostered through several ongoing and newly-established multi-year projects, such as AORA (AORA, 2019) and iAtlantic (iAtlantic, 2019). New financing options are also available for sustainable ocean projects, through initiatives such as the Blue

Sustainable Ocean Strategy by the European Investment Bank (EIB) (EIB, 2019). Several important political milestones occurred in 2019 to help progress towards international commitments regarding the ocean, including a regional workshop to facilitate the description of Ecologically or Biologically Significant Marine Areas in the North-East Atlantic (CBD, 2019) and two sessions of the Intergovernmental Conference on an international legally binding instrument (ILBI) under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond nation jurisdiction (BBNJ) (UN, 2018b). The complex interrelationships between these continuously developing aspects of the North Atlantic Blue Economy – industry, science, policy – provide a rich background to the study presented here, which sought to understand the future activities and business drivers of Blue Economy sectors, the nature of collaboration between sectors, technology developments that may support sector expansion, and how new scientific information and policy developments may influence business plans of the different sectors. This study was conducted under the ATLAS Project (ATLAS, 2019).

Methods

Industry perspectives were obtained from Blue Economy sectors in the North Atlantic: bioeconomy (fisheries, aquaculture, biotechnology), extractive (oil & gas, deep-sea mining), renewables (wind, tidal & wave), transport and communication (shipping and submarine cables), tourism, and cross-cutting (cross-sectoral service provision and underwater technology).

The study employed a qualitative approach consisting of semi-structured interviews and questionnaires based on the interview questions (Bernard, 2006), and a subjectivist approach where responses from participants were anonymized (Wahyuni, 2012), so that participants were not individually or institutionally recognizable through their responses. A list of potential interviewees representative of different Blue Economy sectors was contacted and asked to participate. The initial group was expanded by snowball sampling (Bhattacherjee, 2012). Interviews were conducted either in person or through virtual meeting platforms between February and July 2019. Questionnaires were conducted with delegates at the Ocean Business trade show, Southampton, UK in April 2019.

Prior to interview, participants were briefed with an overview of the ATLAS Project and the study, a summary of the current status and challenges for their sector, ATLAS key scientific findings for their sector, and the interview questions (Table 1).

Blue Economy summary sheets used for the questionnaires were prepared based on a literature review for each sector and formatted similarly to the sector fiches prepared by the EU Marine Spatial Planning Platform (EU MSP Platform, 2018).

This survey complied with the General Data Protection Regulations (GDPR) (2018) and was scrutinized and granted Ethical Approval through the University of Edinburgh School of GeoScience's ethical approval process. Considering that the same questions were used in both the semi-structured interviews and questionnaires, the responses from both methods were combined in all analyses.

Table 1. Questions posed to participants via interview or questionnaire

Questions about the participant
1. What is your Blue Economy sector? 2. What is your sub-sector (if applicable)? 3. What is your institution type? 4. What country is your institution based in?
Questions about the participant's Blue Economy sector
5. Do you envisage new or expanded activities in the North Atlantic before 2030? If so, what sort of activities and where? 6. Do you have any plans to work collaboratively with other sectors to address your business challenges? If so, how and with which sectors? 7. What are your main business drivers moving towards 2030? For example, Brexit, technology developments, business opportunities created by climate change? 8. How will the key findings of ATLAS influence your plans? What type of additional scientific information could help you plan for your business heading towards 2030? 9. Are there any current of anticipated technology developments in your sector that may help to address some of the issues that ATLAS has identified? If so, what are they? 10. Do you anticipate that the development of a new ILBI for BBNJ will influence your sector's business plans?

Results

A total of 55 responses was obtained from semi-structured questionnaire and interview (Table 2). An unequal number of responses were obtained under each of the traditional Blue Economy sectors, with a median of 3 responses per sector, ranging from 1 response (submarine cables) to 4 responses (offshore wind). The greatest number of responses was obtained from the 'cross-cutting' sector, largely reflecting the responses obtained at the Ocean Business tradeshow, where delegates represented sub-sectors which provided technology and other services to multiple traditional Blue Economy sectors.

Participants came from 12 countries, with 18% being from a multinational institution. The greatest proportion of participants was from UK institutions (33%), followed by Portugal (18%) and USA (9%), with the remaining nine nations (Norway, Canada, Netherlands, Denmark, France, Germany, Russia, Spain Sweden) each constituting less than 5% of the participants.

Participants were predominantly from either private or public companies (63%), and also research institutes (13%), not-for-profit associations (9%), regulatory bodies (7%), consultancy (4%) and advisory bodies (4%).

Table 2. Interviews and questionnaires by Blue Economy sector, with a description of sub-sectors

Sector	No. of responses	Subsectors
Aquaculture	3	Integrated multitrophic aquaculture; marine
Fishing	3	Deep-sea bottom fisheries; pelagic fisheries
Biotechnology	3	Bioprospecting and applications
Oil and gas	2	Exploration; exploitation
Deep-sea mining	2	Exploration; regulation
Offshore wind	4	Research & Development; utility development
Tidal and wave	3	Tidal energy arrays; utility development
Shipping	3	Research; education; training; cargo shipment
Submarine cables	1	Communication cables; power cables
Tourism	2	Whale & dolphin watching; cruise liners

Cross-cutting	29	Regulatory bodies; underwater technology; service provision
Total	55	

Discussion

Blue Economy activities are often grouped into sectors, although in reality these sectors are highly interdependent, relying on common skills and infrastructure and depending on others using the seas sustainably (EC, 2012). The concept of an interconnected North Atlantic Blue Economy was a consistent view expressed by the participants in this study, with interviews revealing many complex interconnections between the 10 traditional Blue Economy sectors investigated.

Another key concept expressed by participants was the important role played by supporting sectors, such as underwater technology developers, marine survey companies, and regulators; alongside the importance of scientific research. Multiple participants shared the view that whilst marine ecosystems hold the potential to address many of the world's socio-economic challenges, science and technology will be key to the responsible management of marine resources (OECD, 2019). The importance of appropriate scientific research to support Blue Growth was expressed by many participants, and science may be expected to play an even bigger role in the development of the Blue Economy as during the UN Decade of Ocean Science for Sustainable Development (UN, 2018a). The views expressed by participants are explored in more detail for each interview question below.

Do you envisage new or expanded activities in the North Atlantic before 2030? If so, what sort of activities and where?

All sectors surveyed expected to increase and/or expand their activities or areas of operation in the North Atlantic before 2030.

Target areas and species are expected to change (fisheries), with a shift from monospecific towards multitrophic practices and increased targeting of higher trophic levels (aquaculture). The search for novel compounds will see increased focus on biodiversity hotspots and extreme environments (biotechnology), whilst prospecting and exploration for non-living resources will continue (oil & gas, deep-sea mining). Exploitation for hydrocarbons will continue, whilst commercial exploitation for polymetallic sulphide minerals along the Mid-Atlantic Ridge may occur before 2030. Many fields are nearing maturation in the North Atlantic (oil & gas), spurring some companies to look to marine renewables for future prospects (offshore wind, tidal & wave). The development of floating turbines is expected to increase the water depth of operation, (offshore wind), with site-dependent opportunities anticipated for location further offshore (offshore wind, tidal & wave). Wave energy is still at the early stages of development but progress towards commercial operations is anticipated through 2030. Cargo transport is anticipated to increase, with the addition of new routes, such as through the Northwest Passage (shipping). Increased telecommunications will lead to new cable routes, alongside cable upgrades for existing routes (submarine cables). Expansion is anticipated for ocean cruises and whale & dolphin watching tours (tourism), with a wider range of cruise destinations being considered and greater demand for nature tours. Cross-cutting responses all anticipated an expansion in either the geographic area they are currently working in, or in the range of sectors that they provide technology or services to.

Do you have any plans to work collaboratively with other sectors to address your business challenges? If so, how and with which sectors?

All of the sectors interviewed currently collaborate or plan to collaborate with one or more other Blue Economy sectors. The most frequently mentioned partners were companies or research institutes with engineering or analytical solutions to the business challenges faced by the different sectors. No cases of colocation or shared infrastructures offshore were offered by participants. However, some examples of shared infrastructure on land or in ports were given and participants cited the lack of incentives or even regulatory hurdles for not engaging in more cross-sectoral collaborations, such as colocation.

Aquaculture collaborations included working with engineering and technology companies who could increase automation, and with biotechnology to breed better target species and develop alternative feeds. Biotechnology had collaborations with port authorities to help mitigate environmental impacts; with the shipping industry and offshore installations to develop better biocides for anti-fouling; and with the textiles industry to develop pigments from algae and alternatives to plastic. Submarine cables cited strong links to research institutes to understand seabed recovery following cable burial, interactions between benthic animals with cables, and the possibility of mounting sensors on cables to monitor environmental change at the seafloor. Close collaboration between submarine cables and the fishing and deep-sea mining sectors was considered key to ensure submarine cable protection, and reduce spatial conflicts between these sectors. The oil and gas sector indicated that collaborations are being sought with offshore renewables as an alternative cleaner energy source, with co-location with offshore wind being considered in the North Sea. Offshore wind, fisheries, aquaculture and oil and gas are all collaborating to address potential spatial conflicts, and to explore synergies, such as providing wind energy to power aquaculture or sharing supply vessels between the offshore installations of different sectors. Underwater technology and service providers were working with a range of sectors to develop technology and analytical techniques for underwater research and monitoring.

What are your main business drivers moving towards 2030? For example, Brexit, technology developments, business opportunities created by climate change?

Climate change (CC) was considered as a challenge or an opportunity, depending on the sector. For many participants, CC was primarily an economic driver, with businesses being required to meet environmental or sustainability requirements to continue operations, rather than sustainability concerns in the strictest sense. Some sectors considered CC to have a direct impact of day-to-day business, with fish stocks changing migratory patterns in response to ocean warming and changes in circulation (fisheries) and lost business opportunities resulting from the loss of biodiversity that is expected to accompany CC (biotechnology). Faster growth rates in warmer waters and the potential to farm new species was considered an opportunity, but this would need to be weighed with the potential for new pathologies and damage to installations from more extreme weather events (aquaculture). CC was considered a business opportunity by the oceanic cruise liner industry as it would potentially open-up the Arctic and other northern latitude tourist destinations (tourism). The move towards ‘greener’ shipping in response to CC was also considered positive, although it would introduce more restrictions and necessitate newer, greener ships (shipping).

Public perception and consumer demands were also considered drivers by all sectors, alongside technology developments. Technologies that enable sectors to respond to new or changing markets, shifts in consumer demands, new regulations, or shifts in environmental conditions as a result of CC, or to increase automations, were considered particularly important. Geopolitical considerations, such as securing independence of energy supply (offshore wind, tidal & wave) and food production (aquaculture, biotechnology) to meet increasing domestic and global demands were also considered drivers.

Policy measures, new regulations and legal requirements were cited as significant drivers, as these provide the framework within which it is possible to operate. Brexit was considered a driver either due to concerns over future access to European Union (EU) funding for research and development, or uncertainty relating to resource management and regulatory requirements (aquaculture, fishing, tourism, offshore wind, tidal & wave).

Marine scientific research was considered an important driver by many of the cross-sectoral service providers, particularly those involved in environmental survey, assessment, and monitoring. The need for scientific information to underpin Environmental Impact Assessments and to inform siting decisions for infrastructure was considered particularly important.

How will the key findings of ATLAS influence your plans? What type of additional scientific information could help you plan for your business heading towards 2030?

All sectors perceived the ATLAS Project to be an important contribution towards increasing the scientific knowledge of the North Atlantic basin and saw the potential for ATLAS to influence policy and management at that scale. ATLAS findings were considered important and useful to: i) inform Marine Spatial Planning (MSP), including identification of suitable areas for the different sector activities, and areas which may merit further conservation actions; ii) inform industry adaptation strategies, based on the improved understanding ATLAS offers of the current and future status of living marine resources and ecosystems in the North Atlantic; iii) decide whether potential sites or target species are suitable, given the current or future environmental status of the region (aquaculture); iv) help operators anticipate changes in the migratory patterns and locations of fish stocks and for helping to identify areas that could be considered Vulnerable Marine Ecosystems (fisheries). ATLAS findings were also considered to have a key role in conflict management between Blue Economy sectors to effectively utilize marine space (aquaculture, biotechnology, offshore wind). Mapping of North Atlantic ecosystems was considered important, as it may influence how and where the industry can operate (oil & gas). The resolution of environmental data collected by ATLAS (basin scale) may not provide the information needed for decisions on infrastructure placement (site scale) but will provide a useful insight into some of the additional environmental considerations and challenges that may accompany the move to deeper waters further offshore (offshore wind). The desire was expressed for ATLAS scientific information to underpin suggestions for new MPAs to conserve cetaceans and the marine environment more broadly (tourism). Scientific findings at the basin scale, in terms of currents, circulation, habitat suitability and biogeography, were also considered important in the context of the developing Regional Environmental Management Plan for the northern Mid-Atlantic Ridge (deep-sea mining).

A broad range of additional scientific information was considered helpful by the different sectors, including on weather patterns and weather prediction (aquaculture, offshore wind, tidal and wave, shipping, tourism); higher resolution seabed maps (aquaculture, offshore wind, tidal & wave, fisheries); seasonal cycles in primary production to inform site choice or temporal closures (aquaculture, fisheries, tidal & wave); location of hotspots of biodiversity and migration routes (biotechnology, tourism); biological connectivity between seabed sites (deep-sea mining); and real-time data collection for fish catches and information on trophic-level interactions (fishing). One participant suggested that there needed to be a road map of which activities can coexist in the North Atlantic, to help collaborative planning and to avoid future conflicts.

Are there any current of anticipated technology developments in your sector that may help to address some of the issues that ATLAS has identified? If so, what are they?

Participants referred to many different types of technological developments, current or anticipated, many of which related to increasing automation and digitalization. For example, rapid sequencing technology to identify species (biotechnology); underwater observatories to observe the marine environment in real time (biotechnology); development of cages that can move vertically through the water column to seek the best environmental conditions (aquaculture); development of better feed and reduction of waste (aquaculture, biotechnology); increased digitalization/automation of offshore platforms (oil & gas); progress towards highly automated vessels (shipping); improved data collection and transfer at sea (shipping, fishing); progress towards cleaner energy sources (shipping); better technologies to detect and track cetaceans (tourism); technology for real-time monitoring catch and preventing bycatch (fisheries); and improved technology for remote detection of seabed minerals and determining mineral grade (deep-sea mining). The cross-sectoral service providers, particularly those in the underwater technology industry, referred to technology developments which are leading to rapid advancement in marine autonomous systems, increased digitalization of ports and shipping, improved ballast water management, use of cleaner fuels in shipping, and the development of more environmentally friendly fishing gear.

Further discussion with participants identified a series of barriers to developing technological solutions. These included the harsh and at times unpredictable ocean environment of the North Atlantic (offshore wind, tidal & wave); the cost of developing new technology (aquaculture, biotechnology, tidal & wave, shipping, tourism, deep-sea mining); regulatory uncertainty (biotechnology, shipping, underwater technology); legal issues and enforcement (aquaculture, blue biotechnology); public perception (aquaculture, offshore wind, tidal & wave, shipping, deep-sea mining, oil & gas); liability issues (underwater technology); and sectoral resistance to change (fisheries, shipping).

Do you anticipate that the development of a new ILBI for BBNJ will influence your sector's business plans?

Some participants did not anticipate that a new ILBI for BBNJ would directly influence their sector's business plans, as they largely work within national jurisdictions (oil & gas, offshore wind, tidal & wave) or generally considered here to be little impact from this instrument (shipping). Some participants considered that an ILBI for BBNJ may impact the sourcing of feed ingredients (aquaculture) or impinge on existing freedoms to lay cables beyond national jurisdiction (cables). For some sectors, it was considered that a new ILBI for BBNJ would create both opportunities, such as increased equity and transparency in using marine genetic resources (biotechnology) or better resource management (fisheries), and challenges, such as a greater administrative burden or spatial restrictions (biotechnology, fisheries).

Many participants from the underwater technology or cross-sectoral service providers were unaware of the development of the ILBI for BBNJ, but once they were informed of its purpose, generally considered that it would enhance their business opportunities, especially with regards to environmental surveying and monitoring. One participant was of the view that the ILBI for BBNJ should be negotiated with all stakeholders, including the Blue Economy sectors, as all sectors are likely to be influenced by the outcome of these negotiations.

Conclusions

The oceans are changing, in terms of environmental status, the way ocean resources are utilized, and how activities are regulated and managed. This is especially true for the North Atlantic, where multiple existing and emerging users may have different spatial requirements, and cumulative impacts on the marine environment are often poorly understood. For the North Atlantic Blue Economy to flourish sustainably, multiple levels of cooperation and collaboration are needed in terms of national and international science, industry, and policy. This can only be achieved through open, constructive, and continued dialogue amongst all sectors. By understanding cross-sectoral needs, it is possible to work together towards common goals and overcome shared challenges, in the collective move towards a 'Blue' future in the North Atlantic.

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