



THE UNIVERSITY *of* EDINBURGH

Edinburgh Research Explorer

Rockall and Hatton: Resolving a Super Wicked Marine Governance Problem in the High Seas of the Northeast Atlantic Ocean

Citation for published version:

Johnson, DE, Barrio Froján, C, Neat, F, Van Oevelen, D, Stirling, D, Gubbins, MJ & Roberts, JM 2019, 'Rockall and Hatton: Resolving a Super Wicked Marine Governance Problem in the High Seas of the Northeast Atlantic Ocean' *Frontiers in Marine Science*, vol. 6. DOI: 10.3389/fmars.2019.00069

Digital Object Identifier (DOI):

[10.3389/fmars.2019.00069](https://doi.org/10.3389/fmars.2019.00069)

Link:

[Link to publication record in Edinburgh Research Explorer](#)

Document Version:

Publisher's PDF, also known as Version of record

Published In:

Frontiers in Marine Science

General rights

Copyright for the publications made accessible via the Edinburgh Research Explorer is retained by the author(s) and / or other copyright owners and it is a condition of accessing these publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

The University of Edinburgh has made every reasonable effort to ensure that Edinburgh Research Explorer content complies with UK legislation. If you believe that the public display of this file breaches copyright please contact openaccess@ed.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.





Rockall and Hatton: Resolving a Super Wicked Marine Governance Problem in the High Seas of the Northeast Atlantic Ocean

David E. Johnson^{1*}, Christopher Barrio Froján¹, Francis Neat², Dick Van Oevelen³, David Stirling⁴, Matthew J. Gubbins⁴ and J. Murray Roberts⁵

¹ Seascope Consultants Ltd., Romsey, United Kingdom, ² Marine Stewardship Council, London, United Kingdom, ³ Royal Netherlands Institute for Sea Research (NIOZ), Texel, Netherlands, ⁴ Marine Laboratory, Marine Scotland Science, Aberdeen, United Kingdom, ⁵ School of Geosciences, The University of Edinburgh, Edinburgh, United Kingdom

OPEN ACCESS

Edited by:

Daniela Zeppilli,
Institut Français de Recherche pour
l'Exploitation de la Mer (IFREMER),
France

Reviewed by:

Silvia Bianchelli,
Polytechnical University of Marche,
Italy
Igor Fernández-Urruzola,
Millennium Institute of Oceanography,
University of Concepción, Chile

*Correspondence:

David E. Johnson
david.johnson@
seascopeconsultants.co.uk

Specialty section:

This article was submitted to
Deep-Sea Environments and Ecology,
a section of the journal
Frontiers in Marine Science

Received: 18 October 2018

Accepted: 07 February 2019

Published: 27 February 2019

Citation:

Johnson DE, Barrio Froján C, Neat F,
Van Oevelen D, Stirling D, Gubbins MJ
and Roberts JM (2019) Rockall and
Hatton: Resolving a Super Wicked
Marine Governance Problem in the
High Seas of the Northeast Atlantic
Ocean. *Front. Mar. Sci.* 6:69.
doi: 10.3389/fmars.2019.00069

The Hatton-Rockall plateau in the northeast Atlantic Ocean has long been the subject of interest for fishers, prospectors, conservationists, managers, planners, and politicians. As a feature that straddles national and international waters, it is subject to a multitude of competing and confounding regulations, making the development of a holistic management plan for sustainable use fraught with difficulty. Here, the various stakeholders in the area are collated, together with the rules they have created or must abide by with respect to biodiversity assets, maritime resources, and governance frameworks. Blue Growth envisages optimal use of sea areas, including potential for additional commercial activities. Current research and stakeholder engagement efforts to achieve this integration are described, and the contribution of the EU-funded ATLAS project is analyzed. In particular, more precise, ground-truthed information has the potential to inform systematic conservation planning, providing the basis for sustainable development and improving adaptive management. By scrutinizing and exposing all the elements in this example of a spatially managed area we show how the expectations of each stakeholder can be better managed.

Keywords: Blue Growth, areas beyond national jurisdiction ABNJ, marine spatial planning MSP, ecosystem approach to fisheries management EAFM, ecologically or biologically significant area EBSA

INTRODUCTION

Beyond 200 miles from any coastline, in oceanic areas beyond national jurisdiction (ABNJ), no central authority holds the responsibility for controlling all of the activities that take place there (e.g., fishing, mineral extraction, shipping/communication, environmental protection). Instead, the regulation of each activity is entrusted to activity-specific stakeholders, whose objectives are not always compatible with each other or with long-term sustainability of the ecosystem. Resolution of any conflict between stakeholders is rarely straightforward, and no single solution is beneficial to all involved, often resulting in conflict or compromise, with unforeseen repercussions along a complex web of interacting forces. To further complicate matters, some ecosystems straddle ABNJ and the exclusive economic zone (EEZ) of a State or Union. As problems go, the governance of such straddling ecosystems and the coordinated management of activities that take place within them

(including the enforcement of restricted activities and prohibitions) represents a complex, dynamic, multifaceted and thus, inherently *wicked*¹ problem (Rittel and Webber, 1973). Consequently, there is no panacea to perfect governance of ABNJ (Ringbom and Henrikson, 2017).

As if the governance of ABNJ being a wicked problem wasn't enough of a burden—given the enormous interdependencies, uncertainties, circularities, and conflicting stakeholders implicated by any effort to improve the situation—seemingly definable examples of discrete governance practices in ABNJ can further qualify as *super wicked* problems because of even further exacerbating features that characterize them (Lazarus, 2009). Super wicked problems do not have time on their side, as current levels of resource exploitation are unsustainable; the longer it takes to address the problem, the harder it becomes to resolve it. In addition, those who are in the best position to address the problem (i.e., resource extractors and beneficiaries capable of regulation) are not only those who caused it, but also those with the least immediate incentive to act within that necessary shorter timeframe. Lastly, an absence thus far of an overarching law-making institution with a jurisdictional reach and legal authority that matches the scope of the problem only hinders any expedient regulation or resolution (Wright et al., 2019).

Here we set out to describe an ostensibly discrete example of a super wicked problem: the sustainable governance of an ecosystem that straddles ABNJ and EEZs around the Rockall and Hatton Banks in the northeast Atlantic Ocean [commonly referred to as the Hatton-Rockall plateau (Yiallourides, 2018)]. In doing so, we endeavor to capture both the complementary and the competing initiatives put forward by various stakeholders, authorities and interested parties, to illustrate the complexity of ideas and priorities held by each. By illustrating the interaction between science, policy and stakeholder imperatives, this super wicked problem is, admittedly, no closer to being solved (attesting to the impregnability of super wickedness), but at least the players and their rules, drivers, aims, and strategies can be better understood, which will hopefully allow for the better management of expectations in an effort to promote a sustainable future for all.

BACKGROUND

The Hatton-Rockall plateau (banks and associated slopes) is located midway between Greenland and Iceland to the west and Scotland and Ireland to the east. A submerged mass of continental crust, this seabed feature comprises two large elevated banks, Hatton Bank to the northwest, Rockall Bank to the southeast. They rise from the ocean floor on either side (>2,000 m deep) and are separated by a shallower basin between the two (c. 1,000 m deep). The plateau, delimited by steep-sided flanks in places, narrows as it extends north-eastwards toward the Faroe Islands (**Figure 1**), and the whole feature encompasses

diverse offshore bathyal habitats with high habitat heterogeneity between 200 and 3,000 m deep.

The marine climate of the Hatton–Rockall plateau is influenced predominantly by the strength of the North Atlantic subpolar gyre (Hátún et al., 2009). Depending on its strength, the plateau is either bathed in cold subarctic waters (strong gyre) or in warmer and more saline North Atlantic waters (weak gyre). Oscillations between the two regimes have a notable effect on pelagic faunal assemblage composition and biomass on a multi-decadal time scale.

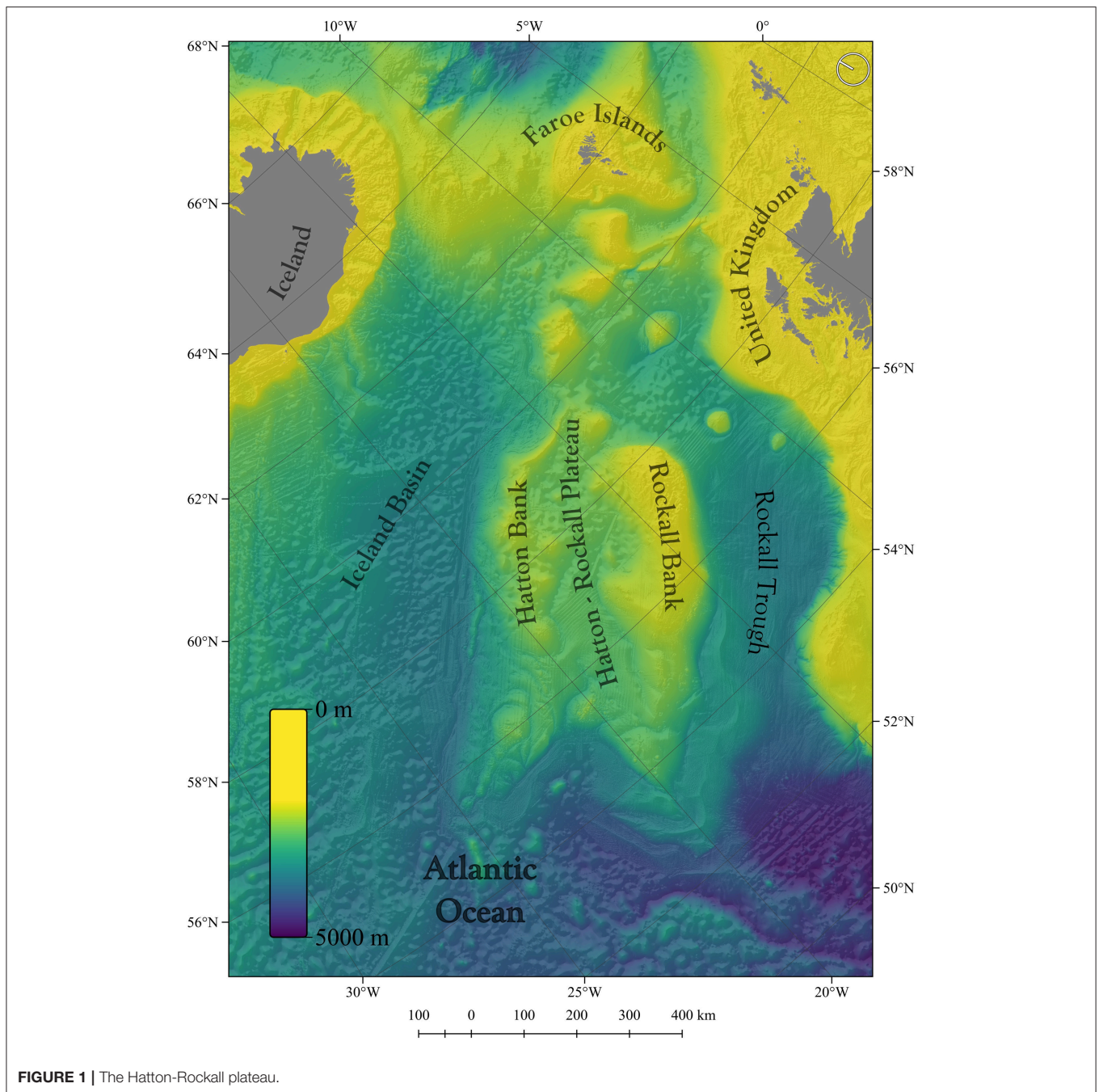
There is a history of dedicated hydrographic, fishery and oceanographic surveys of the area (reviewed by Davies et al., 2006), but with the advent of more sophisticated seabed mapping technologies (e.g., Evans et al., 2015) it has become even more evident that this is a dynamic and productive area of the ocean above a topographically complex seabed. The substrate consists of sedimentary mud and coarse sand punctuated by exposed bedrock, boulders and cobbles, all of which is host to a diverse burrowing and encrusting faunal assemblage that includes long-lived and fragile deep-sea coral gardens and sponge aggregations (Roberts et al., 2008). In places, these species aggregations can be regarded as vulnerable marine ecosystems² (VMEs). In addition, recent research (Berndt et al., 2012) has revealed the presence of large-scale geological features known as polygonal faults in the basin between the banks, which result from dewatering of sediments at great depth. There is also evidence that this area may support chemosynthetic species indicative of cold hydrocarbon seeps (Oliver and Drewery, 2014), as well as reduced sediments and bacterial communities (Neat et al., 2018). Given the expanse of the feature, there is likely much more to be discovered.

The Hatton–Rockall plateau has been targeted for resource exploitation, mainly fish, for at least two centuries (Blacker, 1982), although only in the latter half of the twentieth century has this gained political importance due to the feature's potential to confer oil, fishing, and continental shelf rights (Yiallourides, 2018). To date, there is no exploitation of oil and gas in the area, but bottom-fishing has impacted on the local environment (Piñeiro and Bañon, 2001; Durán Muñoz et al., 2011). A cumulative impact assessment encompassing all activities has not been conducted in the region (Gianni et al., 2016). An inventory of ecosystem goods and services around the feature to set the scene for future valuation has only recently been completed (Foley et al., 2018).

The water column overlying the feature also falls under the remit of several international activity-regulating bodies, such as the European Union (EU), the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention), the North-East Atlantic Fisheries Commission (NEAFC), the North Atlantic Salmon Conservation Organization (NASCO), the International Commission for the Conservation of Atlantic Tunas (ICCAT), the North Atlantic Marine Mammal Commission (NAMMCO), and the International Whaling Commission (IWC). Several of these

¹In this context, the term *wicked* does not carry connotations of evil or maleficence, but instead denotes problems that are tricky, circuitous, or would appear to have a fractal dimension.

²VMEs constitute areas containing fragile, unique, rare, long-lived, slow-growing and/or structurally complex species, communities or habitats that may be vulnerable to impacts from fishing activities (FAO, 2009).



organizations, either alone or in collaboration with others, have identified species, features or areas worthy of protection from potentially harmful activities. For example, three species of deep-water sharks have been identified (*Centroscyrnus coelolepis*, *Centrophorus granulosus*, and *C. squamosus*) that are threatened or declining in the region as a consequence of fishing activities (CITES, 2011). All three are also on the IUCN Red List of Threatened Species.

Established area-based environmental protection measures (or area-based management tools—ABMTs) vary in their

mandate, from simple recognition of a feature's ecological significance, to the prohibition or exclusion of certain activities from a defined area or time period. For example, under the EU's Bird and Habitat Directives and the UK's equivalent 2007 Offshore Marine Conservation (Natural Habitats, etc.) Regulations, several seabed features around the Hatton-Rockall plateau have been identified and designated as offshore marine protected areas (MPAs); these include the Hatton Bank candidate Special Area of Conservation (SAC), the North West Rockall Bank SAC, and the East Rockall Bank SAC. In addition, the

Hatton Rockall Basin Nature Conservation MPA has been designated under the 2010 Marine (Scotland) Act (JNCC website³) (Figure 2). Beyond the avoidance of deterioration of feature condition, the precise conservation or management measures that apply to each MPA can vary, although they all fall under the broader aspiration of the EU's Marine Strategy Framework Directive (EC, 2008) to achieve good environmental status (GES) across European waters (ECII, 2017).

In contrast to EC-backed MPAs, NEAFC has recommended and enforced the closure of a number of defined areas to bottom trawling and fishing with static gear for the protection of VMEs—the Hatton-Rockall closures—part of which are examples of other effective conservation measures (OECMs) contributing to Scotland's portfolio of MPAs (ICES, 2013a, 2014, 2015, 2016a, 2017, 2018a). In addition, the Rockall 'haddock box' has been closed to fishing since 2001/2002 to protect pre-recruitment stocks of commercially targeted haddock. To add to the complexity, part of this closure is within national waters and under EU legislation, and the other part is in ABNJ and regulated by NEAFC. These fishery-imposed closures overlap in extent with some of the designated MPAs (Figure 2) and their enforcement is monitored closely with the aid of satellite vessel tracking technology (VMS and AIS), with sanctions for deliberate non-compliance. Many of the conservation measures defined by the various regulatory bodies around the Hatton-Rockall plateau, both within and beyond areas of national jurisdiction, are acknowledged and promoted by OSPAR. OSPAR also maintains a register of MPAs in the wider northeast Atlantic Ocean⁴, and an expert group (ICG-MPA) gives annual consideration to candidate areas based on emerging lines of evidence.

PRESENT-DAY CONCERNS

At face value it would appear that management and governance of the sea and resources around the Hatton-Rockall plateau is relatively well-organized, integrated and comprehensive. However, to achieve adaptive management, better integration of ecological knowledge, recognition of past mistakes (e.g., destructive fishing), new prospects and evolving management frameworks, and changing stakeholder communities all require continuous and objective re-evaluation.

Biodiversity Assets

Benthic habitats and ecosystems (i.e., cold-water coral formations, rocky reefs, carbonate mounds, polygonal fault systems, sponge aggregations, steep, and gentle sedimented slopes) together with benthic and pelagic organisms (i.e., zooplankton, fish, cetaceans, turtles, and seabirds) are of ecological significance in the area. Many such organisms and ecosystems meet the criteria to feature on the IUCN Red List of Endangered Species and of Ecosystems. Species associations are thought to be particularly important; for example, cold-water coral formations reportedly support over 1,300 species (Roberts

et al., 2006; Henry et al., 2013) and their propagules likely provide strong genetic links between Rockall and Hatton populations, with weaker links to those in the wider region (Fox et al., 2016).

Important areas of biodiversity deserving of protection are increasingly being recognized, as predictive data (models, proxies, and analogs) are validated by ground-truthing surveys, and together have enabled the production of large-scale habitat maps (Howell et al., 2009, 2016). The most recent surveys by Marine Scotland (600 km of transects from 150 to 1,000 m using towed video) have contributed to habitat mapping of *Lophelia pertusa* reefs, coral gardens, black corals, sea fans and whips, sponge grounds, sea pen fields, and cold seeps. These sensitive benthic invertebrate species are highly susceptible to physical damage (Hall-Spencer et al., 2002) and have lengthy recovery times. In turn, damaged habitats and ecosystems can adversely affect pelagic fish communities and fisheries (Armstrong and Falk-Petersen, 2008).

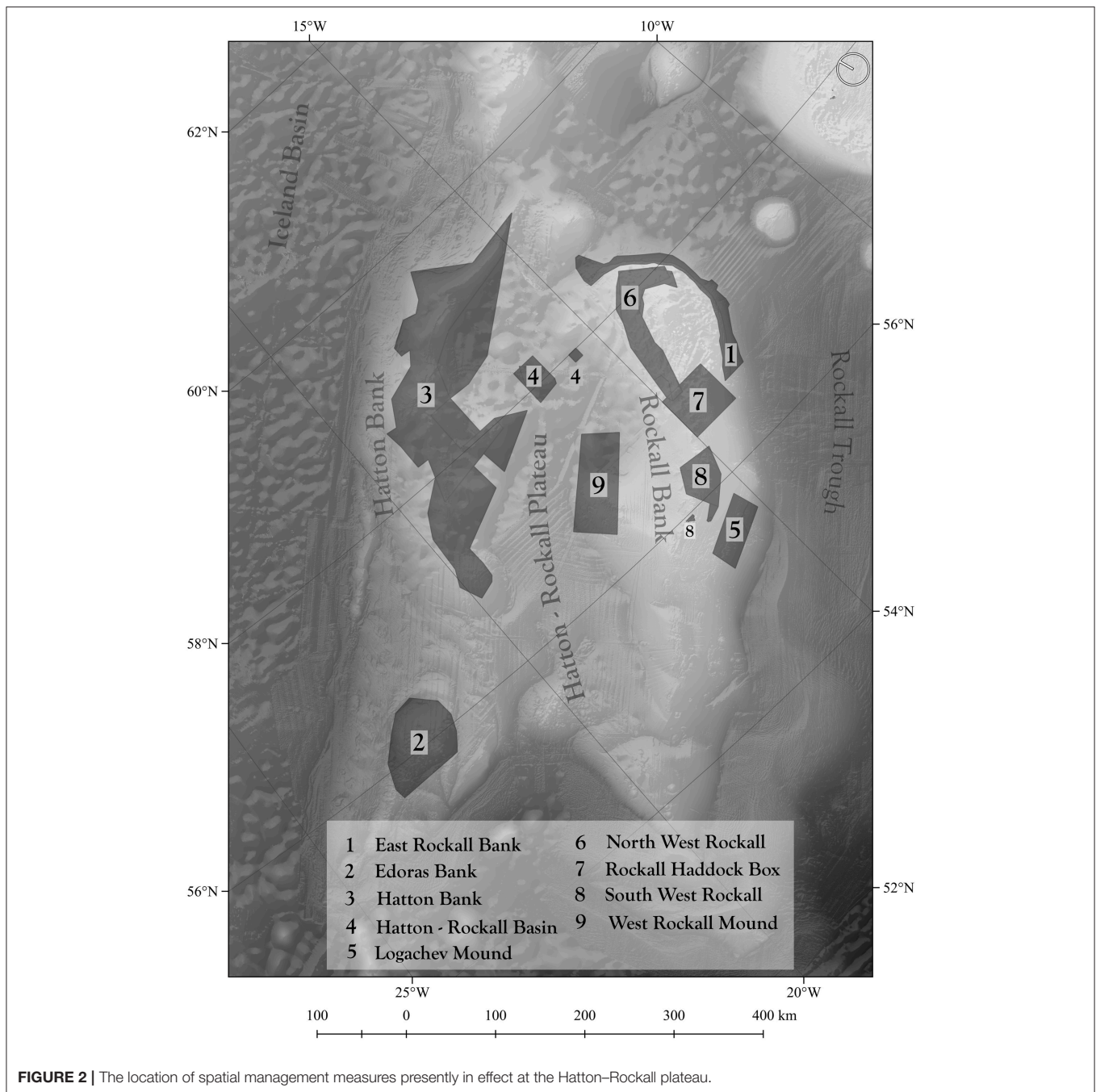
Within the Hatton-Rockall plateau cold-water coral species have been severely impacted by the deep-water trawl fishery (Hall-Spencer et al., 2002). In future, these species are also likely to be compromised further by climate change (Roberts and Cairns, 2014; Roberts et al., 2016) and ocean acidification (Perez et al., 2018). A review by Johnson et al. (2018a) considers the expected effect of changing environmental conditions under predicted climate change scenarios on taxa listed in the conservation objectives for Rockall and Hatton VMEs. It concludes that impacts will be felt within the next 20 years at a rate too fast for many species to adapt to, and resilience is already low.

Resource Pressure

Studies of fishing pressure show parts of the northeast Atlantic to be heavily impacted (Halpern et al., 2008; Benn et al., 2010), including, for example, areas of coral rubble and trawl marks on the northern Rockall Bank. The Hatton-Rockall plateau supports relatively shallow demersal fisheries targeting haddock, gurnard and monkfish (Newton et al., 2008; Neat and Campbell, 2011). Haddock has been surveyed since the 1980s, and despite volatile stock dynamics and failure to agree on an international fishery management plan, it is currently a profitable and important fishery; in 2018 it was certified as meeting the Marine Stewardship Council's standard for sustainable fisheries (MSC, 2018). Monkfish and megrim sole both contribute to a highly valuable fishery in the area, and although heavily exploited, data since 2005 suggest both are sustainable (ICES, 2016b). In the past, other important commercial species included saithe and cod, but these appear to have been over-exploited and are no longer main target species. Deep-water bottom fisheries target ling, blue ling, tusk, orange roughy, black scabbardfish, roundnose grenadier and deep-water sharks (Gordon et al., 2003; Large et al., 2013). The EU ban on trawling at depths > 800 m introduced in 2017 has ended these practices within the EU EEZ, but deep-water fisheries in ABNJ are still being undertaken on the Hatton Bank. Deep-water fisheries have impacts not only on target species, which are known to be highly susceptible to over-fishing and cannot sustain fishing intensity typical of shelf

³URL: <http://jncc.defra.gov.uk/page-4524> (Accessed October 2018)

⁴OSPAR MPA datasheets and access to an MPA map tool can be found at http://mpa.ospar.org/home_ospar/mpa_datasheets



seas (Bailey et al., 2009), but more generally on associated deep-sea fauna that also exhibit extreme longevity and slow growth rates, traits that make them vulnerable to repeated disturbance. International pelagic fisheries also target blue whiting in Hatton and Rockall; here, stocks have undergone periods of concern due to over-exploitation, although in recent years they have been doing well (ICES, 2018b). This is likely partly a result of reaching international agreements in 2006 for blue whiting between the EU, Norway, the Faroe Islands and Iceland, but may also be due to variation in natural environmental cycles, such as the strength

of the sub-polar gyre that is known to have a strong effect on blue whiting distribution and stock dynamics (Payne et al., 2012).

Exploration drilling for oil and gas on the Hatton–Rockall plateau has been considered relatively unsuccessful, although a recent reassessment of historical drilling wells in light of an advanced understanding of the region’s geology has exposed flaws in the original discouraging conclusions (Schofield et al., 2017). Newly acquired seismic data, combined with a better understanding of results from past explorations, are leading to a resurgence in interest in the area by the UK’s oil and gas sector.

Adoption by the European Commission (EC) of a Blue Growth strategy in 2012 (**Box 1**) has resulted in several initiatives related to Europe's oceans, seas and coasts, all intended to facilitate the cooperation between maritime business and public authorities across borders, sectors, and stakeholders (SWD, 2017). While the focus of the strategy is on five sectors with high innovation and growth potential (see **Box 1**), no significant developments or pressure points on resources—especially around the Hatton-Rockall plateau—appear to be close to fruition yet.

Governance Framework

The Hatton-Rockall plateau exemplifies the complex legislative framework that applies to many offshore transboundary situations, incorporating ABNJ, and subject to Commission on the Limits of the Continental Shelf submissions. The need for a tiered (nested), internally consistent and mutually reinforcing planning and decision-making system has been articulated (Raakjaer et al., 2014). As noted by Freestone et al. (2014), such situations also require agreement on overarching principles by regional management bodies, an important element of prospective negotiations within the BBNJ process.⁵

In the northeast Atlantic, OSPAR and NEAFC have signed a formal memorandum of understanding (MoU; the OSPAR Agreement 2008-4) and implemented a Collective Arrangement (OSPAR agreement 2014-09) (Johnson, 2013; Hoydal et al., 2014; NEAFC and OSPAR, 2015). This represents an ongoing trust-building exercise recognizing aspects of common purpose and respecting specific legal mandates.

Despite criticisms of the global pace of implementation of conservation efforts by regional fisheries management organizations and arrangements (RFMO/As) (e.g., Wright et al., 2015), NEAFC is one of the leading RFMO proponents, having closed areas to bottom fishing where there is strong evidence for the presence of VMEs (in line with UNGA resolutions) as part of a comprehensive High Seas fishery regime. For the past decade NEAFC has requested that the International Council for the Exploration of the Sea (ICES) provides scientific advice on the presence and distribution of VMEs within its regulatory area and suggests spatial management approaches (e.g., fishery exclusion zones/boxes around vulnerable features). VME boxes (also known as closed areas or closures) have been established on Hatton Bank, NW Rockall, West Rockall Mounds, SW Rockall, an area known as the Logachev Mounds, and in the Hatton-Rockall Basin. Focus to date has been on the protection of corals and the recently discovered cold-seep ecosystem, yet much of the intensive trawling also occurs on sedimented slopes.

Stakeholders

Wright et al. (2019) highlight that given the status of ABNJ as global commons, the challenge of identifying and consulting relevant stakeholders is significant. For the Hatton-Rockall

plateau there has been early recognition of the different stakeholder groups and a good dialogue between the fishing industry and government conservation agencies to assess where to apply spatial management; engagement with the fishing industry was crucial to the establishment of the first fishery closures. The ICES working group on deep-water ecology (ICES WGDEC) that provides the advice on VMEs to NEAFC is unusual in the sense that it includes members from environmental non-governmental organizations (NGOs). Therefore, the process has been stakeholder inclusive from the beginning.

SPATIAL MANAGEMENT AND PROTECTION MEASURES

Fishery Closures

The first example of spatial management at Rockall had little to do with habitat protection. In 2001, NEAFC (and in 2002, the EC in its waters) introduced a transboundary (ABNJ-EU) closed area for the protection of juvenile haddock in response to concerns over declining stock levels and the increased access to the area by international fishing fleets (prior to 1997 Rockall Bank was exclusively within the EU EEZ as part of the UK). Nevertheless, as this 'haddock box' area has remained largely closed for 17 years, it contains some important and relatively untouched benthic habitats.

In the early 2000s concerns were also growing over the impact bottom trawling was having on the cold-water coral reefs known to be in the area. With the emergence of the UNGA resolutions on VMEs (UNGA, 2006), RFMOs were called upon to protect areas where VMEs were known or likely to occur. NEAFC contracted ICES to advise on which areas were likely to contain VMEs. In 2005–6, ICES worked closely with the Scottish and Spanish fishing industries to assess where coral reefs were likely to be present. This, together with scientific survey data (from Spanish and British mapping efforts), provided the basis for several candidate areas for protection. NEAFC closed the first areas on the Rockall and Hatton Banks in 2007.

The NEAFC closures are extensive areas that capture the main distribution of coral on the plateau, although at the time ICES emphasized there was a high degree of uncertainty in the precise delineation of the boundaries. It is worth noting that not all areas proposed by ICES were acted upon by NEAFC. Where evidence for VMEs was less certain, or there were conflicting reports of intensive fishing activity, such areas (e.g., East Rockall) remained open to fishing. In the subsequent years, extensions and modifications to the closure boundaries were made as new evidence came to light on the presence of coral reefs in the area. These included a large seamount to the southwest of Hatton Bank known as Edoras Bank, and an area in the Hatton-Rockall basin where recent scientific surveys detected the presence of a cold-seep ecosystem. By 2015 all those areas where there was strong evidence for VMEs had been closed to bottom fishing (**Figure 2**). It has been a predictable process in many ways, with closed areas being accepted and implemented much more quickly in areas where fishing activity and corals are mutually exclusive of one

⁵The BBNJ process refers to the recent high-level political activities in support of the development of an international legally binding instrument under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine Biological diversity of Areas Beyond National Jurisdiction (<http://www.un.org/depts/los/biodiversity/prepcom.htm>).

BOX 1 | The Blue Growth agenda.

Blue Growth has no universally recognized definition; it embodies different meanings and approaches depending on the social contexts in which it is used (Eikeset et al., 2018). The interpretations presented here are those relevant to the stakeholders in the northeast Atlantic Ocean.

Blue Growth has its roots in the conceptualization of sustainable development, expounded over the years during four landmark international conferences: the 1972 UN Conference on sustainable development in Stockholm, the second such conference in 1992 in Rio de Janeiro, the third in Johannesburg in 2002, and lastly, the Rio+20 UN Conference in 2012. At the Rio+20 conference, the term Green Growth was coined to encompass the concept of fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. Translating this concept of growth into the marine realm, the multifaceted economic and social importance of the ocean and inland waters was encapsulated in the term Blue Growth. Since then, concept has been widely used and has become important in aquatic development in many nation states, regionally as well as internationally (Eikeset et al., 2018).

According to the Organization for Economic Co-operation and Development (OECD), Green/Blue Growth is the fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies (UN, 2012). To the World Bank, the 'blue economy' comprises the range of economic sectors and related policies that together determine whether the use of oceanic resources is sustainable. This concept seeks to promote economic growth, social inclusion, and the preservation or improvement of livelihoods while at the same time ensuring environmental sustainability of the oceans and coastal areas. For the Food and Agricultural Organization, Blue Growth is a cohesive approach for environmentally compatible, integrated and socioeconomically sensitive management of aquatic resources including marine, freshwater and brackish water environments. At the global scale, Blue Growth looks to further harness the potential of oceans, seas and coasts by promoting growth, improving conservation, building sustainable fisheries, fostering cooperation between countries and acting as a catalyst for policy development.

For the European Commission (EC), Blue Growth is an initiative to harness the untapped potential of Europe's oceans, seas and coasts for jobs and growth. Blue Growth is the long-term strategy to support sustainable growth in the marine and maritime sectors as a whole (EC, 2012). It is also the maritime contribution to achieving the goals of the Europe 2020 strategy for smart, sustainable and inclusive growth. Blue Growth is possible in a number of areas which are highlighted within three components of the strategy: (1) sectors that have a high potential for sustainable jobs and growth, (2) components to provide knowledge, legal certainty and security (this includes MSP to ensure efficient and sustainable management of activities at sea), and (3) sea basin strategies to foster cooperation between countries (e.g., the Atlantic Action Plan follows the Atlantic Strategy the EC adopted in 2011). Five sectors have been identified with a high potential for Blue Growth: aquaculture, coastal and maritime tourism (blue tourism), marine biotechnology (blue biotechnology), ocean energy (blue energy), and seabed mining. Fisheries, offshore hydrocarbon production and transportation are not in the EC's Blue Growth agenda (Klinger et al., 2018).

A Technical Study of MSP for Blue Growth (EC, 2018), coordinated by the EU MSP Platform, focussed on developing visions for MSP; investigating current and future potential spatial demands for key maritime sectors and developing indicators. In many ways Blue Growth is becoming a catch-all term to express more holistic management of complex marine social-ecological systems.

another. In areas where overlap occurs between fishing activity and coral, the process has been more protracted, with greater demands for, and scrutiny of, the evidence for the existence of VMEs (e.g., Hall-Spencer et al., 2009).

Data in the VME database for the North Atlantic—set up by ICES WGDEC following FAO (2009) criteria—originally consisted of observed occurrence records for VME indicators (taxa or features). To ensure the advice on new data on VME distribution is based on the best quality data, some understanding was needed on the likelihood of the occurrence of a VME indicator representing an actual VME. Previously, this had been based on expert judgement, meaning that inconsistencies could arise. Therefore, in 2015 and 2016 the ICES WGDEC developed a multi-criteria tool known as the VME weighting algorithm, which assigns a VME index score of High, Medium or Low likelihood of an area containing VME indicators representing a VME. This scoring is based on two main criteria: vulnerability of the indicator (based on scores against the FAO (2009) criteria for identification of VMEs) and taxon abundance data. Confidence in the resulting score is then assigned based on four further criteria: survey method (e.g., trawl vs. ROV), number of surveys to the area, the time range of the surveys undertaken, and the time since the last survey. Detailed results of this application are presented in Morato et al. (2018).

In 2017, the 36th Annual Meeting of NEAFC considered aspects of area management including a review of NEAFC VME closures under NEAFC Recommendation 19:2014, as amended by Recommendation 09:2015 (Table 1). The meeting agreed to

extend all current VME related bottom fisheries closures to 2022, and to expand the Hatton-Rockall Basin bottom-fishing closure. These decisions were based on ICES advice showing new records of VME indicator habitat (soft-bottomed deep sea sponge aggregations, including a mix of *Pheronema* spp. and *Hyalonema* spp. (stalked sponges) at a depth of c. 1,200 m) (ICES, 2017). An additional concern noted by ICES was the temporal disparity between AIS (vessel position) and VMS (vessel activity) data provided to ICES, which left unresolved will undermine the confidence that can be attributed to its advice.

Marine Protected Areas

At the same time as VMEs were being recognized, moves were afoot by States (UK and Ireland) to establish Special Areas of Conservation and MPAs on the Hatton-Rockall plateau and contribute to the Natura 2000 network (Figure 2). However, efforts to secure long-term *in situ* protection of biodiversity in ABNJ have been less successful. OSPAR has obligations to take necessary measures to protect and conserve the ecosystems and biological diversity of its maritime area, and to cooperate in the adoption of other relevant programmes and measures (OSPAR Convention Annex V). The latter include fisheries measures for which OSPAR has no mandate, rather OSPAR is obliged to liaise with relevant fisheries management authorities. Challenges and lessons learned have been cataloged from the OSPAR process of designating the first network of MPAs in the high seas in the period from 2000 to 2012 (O'Leary et al., 2012; Johnson et al.,

TABLE 1 | Summary of the review of NEAFC VME closures (NEAFC, 2017).

Area	Year closed	Basis for closure	New evidence on presence of VME	New evidence on absence of VME	Closure encompass VMEs	Evidence for expanding boundaries	Overlap with existing fishing areas
Hatton Bank	2007-2015	VME element (Bank feature) & VME indicators	Yes	No	Yes	No	Yes
Northwest Rockall	2007	VME habitats & VME indicators	Yes	No	Yes	Yes	Yes
Southwest Rockall (Empress of Britain Bank)	2008	VME habitats & VME indicators	Yes	No	Yes	No	Yes
Southwest Rockall	2013	VME indicators	Yes	No	Yes	No	Yes
Logachev Mounds	2007	VME habitats & VME indicators	Yes	No	Yes	No	Yes
West Rockall Mounds	2007	VME indicators	No	No	Yes	No	Yes
Hatton-Rockall Basin (cold seep)	2015	VME habitats & VME indicators	Yes	No	Yes	No	Yes
Hatton-Rockall Basin (sponge area)	2015	VME habitats & VME indicators	Yes	No	Yes	Yes	Yes

2014; Johnson, 2016). Whilst the Hatton-Rockall plateau was identified in 2007 by a University of York led scoping study as meeting the OSPAR MPA criteria, it was set aside as a candidate MPA in 2008 due to the political complexity of competing and unresolved submissions to the Commission on the Limits of the Continental Shelf (O'Leary et al., 2012).

Other Area-Based Management Tools

The outcome of a workshop convened by OSPAR and NEAFC to describe ecologically or biologically significant marine areas (EBSAs) in the Northeast Atlantic (held in Hyeres, France, 8–9 September 2011) included a proposal for an extensive area incorporating the whole of the Hatton-Rockall plateau approximating to the 3,000 m depth contour as a potential EBSA (see **Appendix** for the ranking of the proposed EBSA against the CBD EBSA criteria). A review of the workshop outcomes by ICES in March 2012 questioned the methodology and size of the EBSAs described. By further request, in 2013 ICES reviewed the EBSA proposals again and came to different conclusions to the original workshop (rankings against EBSA criteria) and proposed boundary revisions (ICES, 2013b). For Rockall and Hatton, ICES specified a more restricted area down to 1,500–1,800 m depth and excluded the abyssal plain, citing lack of evidence of biological or ecological significance at greater depth. For this area, the ICES review only modified one ranking (against the Productivity criterion, from Medium to Low on the basis that “*benthic secondary production in deep-water environments is generally considered to be low compared to other environments*”; ICES, 2013b). Subsequently, however, OSPAR and NEAFC Contracting Parties have failed to agree to submit any revised results to the CBD. Johnson et al. (2018b) provide a commentary on the global CBD EBSA process and recognize instances of evidence gaps with an underlying ‘political’ cause. With no EBSAs listed in the CBD EBSA Repository covering the northeast Atlantic Ocean, perhaps the whole region could be considered as a politically induced conservation gap, although CBD COP have consistently noted the ongoing process in the northeast Atlantic Ocean.

The EC’s Blue Growth strategy recognizes the importance of marine spatial planning (MSP), and it works closely with EU Member States to disseminate practical information on the implementation of MSP, sharing technical briefs, facilitating workshops to foster cooperation, and supporting the exchange of best practices at sea-basin and EU level. An example of a current EC-funded project to inform and refine spatial management plans in the north Atlantic and with a specific focus on the Hatton-Rockall plateau is the ATLAS Project (**Box 2**).

Janßen et al. (2017) critically examine issues associated with integrating fisheries into MSP. They highlight challenges including techniques to analyse where fishers fish, including long-term spatial changes of commercial fish species along their successive life stages, and effects of spatial competition. Spatially explicit solutions for integration of fisheries into MSP have proved elusive and the spatial resolution of ICES statistical rectangles was deemed too coarse to reflect fisheries’ requirements for spatial information. Attempts to develop a marine spatial plan for the Rockall Bank are currently underway as part of the ATLAS Project (**Box 2**; Grehan, 2018). By spatially assigning monetary value of fisheries across the area based on VMS and log-book data, the economic value of the fishing footprint can be evaluated and assessed in relation the ecological diversity and sensitivity of the area. Based on spatial overlap and mutually exclusive areas where high value fisheries persist in areas of low or average ecological diversity and sensitivity, it should be possible to develop a mutually agreeable spatial plan that meets both fisheries and conservation priorities.

FUTURE CONSIDERATIONS

ICES have provided advice on, and evaluation of, fishing abrasion pressure maps based on VMS and log-book data. This mapping of spatial and temporal intensity of fishing activities with mobile bottom-contacting gear and pelagic gear (excluding vessels <10–12 m long) appears to show decreasing intensity for Rockall and Hatton. On the basis of this information, there is no justification

BOX 2 | The EU ATLAS Project contribution.

The ATLAS Project (www.eu-atlas.org) started in 2016, with an objective to develop an integrated transatlantic assessment and deep-water ecosystem-based spatial management plan. To achieve this, ATLAS uses the output from the EU FP7 MESMA Project (2009–2013; www.mesma.org) on monitoring and evaluation of spatially managed areas to implement ecosystem-based marine management (Stelzenmüller et al., 2013). ATLAS has compiled existing information and generated new data from 12 case study areas, one of which is the Rockall Bank (see table below). All case study areas include deep-water habitats supporting a variety of VME indicator taxa across a range of jurisdictional regimes in areas where economic Blue Growth activities are either underway or are planned in the near to medium term.

ATLAS case study	Focus ecosystems	Current and BG sectors*	Jurisdiction
1. Love Observatory	CWC reefs, sponges	F, OG, T	Norway
2. W of Shetland & W Scotland slope	Sponge grounds	B, F, OG	UK (EU)
3. Rockall Bank (UK & Ireland)	CWC reefs, coral gardens, carbonate mounds, sponge grounds, cold seeps	B, F, OG	UK & Ireland (EU) and ABNJ
4. Mingulay Reef Complex	CWC reefs	F, T	UK (EU)
5. Porcupine Seabight	CWC reefs, coral gardens, carbonate mounds, sponge grounds	B, F, OG	Ireland (EU)
6. Bay of Biscay	CWC on slope and in canyon settings	B, F	France (EU)
7. Gulf of Cádiz/Strait of Gibraltar/Alborán Sea	CWC reefs, coral gardens, sponge grounds	B, F, OG	Spain & Portugal (EU)
8. Azores	Hydrothermal vents, seamounts, coral gardens, sponge grounds	B, F, M	Portugal (EU) and ABNJ
9. Reykjanes Ridge	Hydrothermal vents, CWC reefs, coral gardens, sponge grounds	B, F, M	Iceland and ABNJ
10. S Davis Strait/Western Greenland/Labrador Sea	CWC reefs, coral gardens, sponge grounds	B, F	Canada
11. Flemish Cap	Coral gardens, sponge grounds	B, F, OG	Canada and ABNJ
12. USA Mid-Atlantic canyons	CWC reefs on slope and in canyon settings	B, F, M, OG	USA and ABNJ

*Blue Growth (BG) sectors: **B**iototechnology, **F**isheries, **M**ining, **O**il & **G**as, **T**ourism.

The ATLAS approach offers a holistic means by which managers and policy makers can begin to grapple with High Seas ocean governance in what is now a rapidly changing ocean. For example, by using the eddy-resolving North Atlantic (30–80°N) basin-scale hydrodynamic model VIKING20 running at 1/20° resolution, ATLAS is able to conduct simulations to predict where larvae produced by VME indicator taxa would disperse under varying conditions, including during times of high and low Atlantic Meridional Overturning Circulation (AMOC) strength. By conducting parallel research using paleo-oceanographic approaches to reconstruct AMOC strength from sortable silt grain size analysis, ATLAS has recently shown that present-day AMOC strength is already exceptionally weak as compared to the last 1,500 years (Thornalley et al., 2018), a discovery mirrored using an approach comparing global sea surface temperature datasets with high-resolution climate modeling approaches (Caesar et al., 2018).

Other ATLAS outputs show substantial differences in modeled connectivity between case study areas, with Rockall Bank predicted as having a somewhat more restricted connectivity compared to other areas. Work is ongoing to ground-truth these predictions with genetic connectivity assessments from samples gathered across the Atlantic Ocean, and to infer the implications of altered AMOC strength on each case study area. These fundamental improvements in our understanding of Atlantic basin scale physical oceanography, allied with improved understanding of ecological connectivity, will be vital not only to design truly ecologically coherent offshore conservation areas but to understand their utility in the future (Roberts et al., 2016; Johnson et al., 2018a).

Spatial management at Rockall Bank is being assessed in the context of maintaining or potentially increasing fisheries productivity without compromising or significantly adversely affecting VME. The potential for hydrocarbon extraction must be considered in the context of both fisheries and the presence of VME. Thus, operational objectives are to: (i) protect areas where VME are known to occur as part of a network of MPAs, (ii) maintain current fisheries at or close to MSY taking into account wider ecosystem impacts, and (iii) assess potential impacts of potential oil and gas developments. It is hoped that analysis of the case study data (including a >15-year time series of fish communities, 600 km of transect imagery, and modeled predictions of species distributions) using marine spatial planning decision support tools will lead to evidence and advice for improved spatial management. This could be taken up in future revisions of Scotland's National Marine Plan, which extends to 200 nautical miles, and in considerations for a future deep-sea nature reserve currently under review in Scotland's Programme for Government.

for the whole of the Hatton-Rockall plateau being an MPA. The whole area fits the EBSA criteria (**Appendix**), but there are still vast areas within it that can be fished without having any major impact on biodiversity or VMEs (Weaver and Johnson, 2012). Furthermore, baseline information can change or be improved over relatively short timescales; this provides a rationale for re-examining key deep-sea areas and bringing new information to the attention of decision-makers quickly before damage is done. Area-based planning has to be responsive and adaptable, and the present situation attests to much improved dialogue and

conflation of objectives between fisheries and conservation (see Friedman et al., 2018).

In addition to resolving the spatial demands of conservation and fisheries, future planning for a sustainable blue economy should evaluate synergies and/or tensions between other potential commercial interests (ABPmer, 2016). For example, securing energy supply, emission cuts related to climate change, and targets for renewable energy provision all combine to influence opportunities for investment in oil and gas and increased use of offshore renewable energy resources. The

third UK Offshore Energy Strategic Environmental Assessment (Department of Energy Climate Change, 2016) recognized a continuing and significant role for oil and gas with further seaward rounds of oil and gas licensing on the UK continental shelf. Environmental impacts, impact on existing activities, as well as co-location issues, especially with fish and shellfish farming, and future decommissioning obligations are relevant considerations if oil and gas exploitation were to go ahead within the Hatton-Rockall plateau. Here lessons can be learned from the northern North Sea where the long-term impacts of drill cuttings piles have been studied thanks to repeat industry monitoring (Kingston, 1992; Henry et al., 2017) and recent work has shown how colonies of the cold-water coral *L. pertusa* form ecological networks with potential to connect with adjacent Swedish MPAs (Henry et al., 2018).

Offshore aquaculture, also known as open ocean aquaculture, located in deeper and less sheltered waters in rigid submersible cages, is an emerging approach to mariculture still at a research stage (Troell et al., 2009). This could be relevant to the Hatton-Rockall plateau, with potential impacts on existing commercial fisheries. Upton and Buck (2010) considered that a complex and unpredictable mix of technological, biological and economic factors will determine the future profitability of open ocean aquaculture. Although government may play a role in funding research and pilot projects, large-scale production will likely depend on private investments and innovation. Others consider that a more supportive and streamlined regulatory framework is necessary to create the opportunity and the incentive for industry to invest in such endeavors (Corbin et al., 2017).

Limited evidence of bioprospecting activity around the Hatton-Rockall plateau currently exists. However, the ecosystems present suggest potential for bioresources and possible commercialization of new materials and derivatives (i.e., DNA, RNA, proteins/enzymes, metabolites), particularly from interesting strains of bacteria and sponges. Regulation of marine genetic resources is a core topic for negotiations in the BBNJ Implementing Agreement, and consideration must be given to future biotechnology demands in space that has not been compromised by other activities.

CONCLUSION

The Hatton-Rockall plateau makes an interesting case study and it now has a long enough history of scientific study, resource exploitation and governance arrangements to show what works and what does not (in terms of ABMTs). It also illustrates the complexities of how science, policy and stakeholders can interact. Here we have highlighted the interaction between the availability and quality of data (a scientific issue), the urgency of conservation (a mainly political issue) and the consequences of management (mainly a stakeholder issue). This interaction changes over time and space, so some conservation actions are readily adopted while others never see the light of day (sometimes for good reasons, sometimes not). An additional and increasingly important element for consideration is the implication of climate change, with an increased need for cold refugia and preservation of areas with resilience to predicted environmental changes.

The Hatton-Rockall plateau is an interesting and important feature for many diverse reasons, both ecological, and economic; thus, appropriate and varied management measures should be applied at the correct scale. To date there have been some real conservation success stories for the area, even if actions might not have been as precautionary as some parties may have liked. The EU ATLAS Project is seeking to develop Good Environmental Status (GES; ECII, 2017) criteria for the deep seas and relate these criteria to the area, as advocated by the European Marine Board, who have noted a lack of standards for offshore and deep water, and a harmonized methodology relating to the Marine Strategy Framework Directive (Rogers et al., 2015; EC, 2018). Current thinking is that Blue Growth scenarios will likely demand the intervention of States through the new BBNJ Implementing Agreement to impose an appropriate production-distribution system—i.e., a balance between greater competition (more micro-efficiency) and more value in the economy as a whole (more macro-efficiency) (Tirole, 2017).

Thus, State intervention in the form of a new institutional arrangement with capacity to apply an ecosystem based approach—whilst understanding the implications of changing future conditions, competing demands for ocean space, opportunities for monitoring and enforcement created by developing technologies, and better response to informed societal values—could, after all, provide a super wicked solution.

AUTHOR CONTRIBUTIONS

DEJ originated the concept of this manuscript with its emphasis on ocean governance. DEJ, CBF, and FN contributed equally to the writing of the manuscript, while DVO, DS, MJG, and JMR provided specific detail from recent research efforts.

FUNDING

This work is a contribution to the ATLAS project and has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 678760. It reflects the authors' views and the European Union is not responsible for any use that may be made of the information it contains.

ACKNOWLEDGMENTS

DEJ and CBF are supported by the Global Ocean Biodiversity Initiative (GOBI). GOBI is part of the International Climate Initiative (IKI). The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) supports this initiative on the basis of a decision adopted by the German Bundestag.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fmars.2019.00069/full#supplementary-material>

REFERENCES

- ABPmer, and ICF and International. (2016). *Future Trends in the Celtic Seas, Scenarios Report*. ABPmer and ICF International for Celtic Seas Partnership.
- Armstrong, C. W., and Falk-Petersen, J. (2008). Habitat-fisheries interactions: a missing link? – *ICES J. Marine Sci.* 65, 817–821. doi: 10.1093/icesjms/fsn092
- Bailey, D. M., Collins, M. A., Gordon, J. D. M., Zuur, A. F., and Preide, I. G. (2009). Long-term changes in deep-water fish populations in the North East Atlantic: a deeper reaching effect of fisheries? *Proc. Royal Soc. B* 276, 1965–1969. doi: 10.1098/rspb.2009.0098
- Benn, A. R., Weaver, P. P., Billet, D. S., van den Hove, S., Murdock, A. P., Doneghan, G. B., et al. (2010). Human activities on the deep seafloor in the North East Atlantic: an assessment of spatial extent. *PLoS ONE* 5:e12730. doi: 10.1371/journal.pone.0012730
- Berndt, C., Jacobs, C., Evans, A., Gay, A., Elliott, G., Long, D., et al. (2012). Kilometre-scale polygonal seabed depressions in the Hatton Basin, NE Atlantic Ocean: constraints on the origin of polygonal faulting. *Marine Geol.* 332–334, 126–133. doi: 10.1016/j.margeo.2012.09.013
- Blacker, R. W. (1982). Rockall and its fishery. Ministry of agriculture, fisheries and food directorate of fisheries research. Laboratory Leaflet No. 55. *Lowestoft*, 27pp
- Caesar, L., Rahmstorf, S., Robinson, A., Feulner, G., and Saba, V. (2018). Observed fingerprint of a weakening Atlantic Ocean overturning circulation. *Nature* 556: 191–196 doi: 10.1038/s41586-018-0006-5
- CITES (2011). “Deep-sea shark species for consideration of a CITES listing,” in *Twenty-Fifth Meeting of the Animals Committee* (Geneva). Available online at: <https://www.cites.org/sites/default/files/common/com/ac/25/E25i-07.pdf>
- Corbin, J. S., Holmyard, J., and Lindell, S. (2017). Regulation and permitting of stand-alone and co-located open ocean aquaculture facilities. in *Aquaculture Perspective of Multi-use Sites in the Open Ocean*, eds B. Buck, and R. Langan (Cham: Springer).
- Davies, A. J., Narayanaswamy, B. E., Hughes, D. J., and Roberts, J. M. (2006). *An Introduction to the benthic ecology of the Rockall-Hatton area (SEA 7)*. A Report for the DTI by the Scottish Association for Marine Science, Dunstaffnage Marine Laboratory. Oban.
- Department of Energy and Climate Change (2016). *UK Offshore Energy Strategic Environmental Assessment*. OSEEA3 Environmental Report: Future Leasing/Licensing for Offshore Renewable Energy, Offshore Oil and Gas, Hydrocarbon Gas and Carbon Dioxide Storage and Associated Infrastructure. Available online at: www.gov.uk/decc
- Durán Muñoz, P., Murillo, F. J., Sayago-Gil, M., Serrano, A., Laporta, M., Otero, I., et al. (2011). Effects of deep-sea bottom longlining on the Hatton Bank fish communities and benthic ecosystem, north-east Atlantic. *J. Marine Biol. Assoc. UK*. 91, 939–952. doi: 10.1017/S0025315410001773
- EC (2008). *Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 Establishing a Framework for Community Action in the Field of Marine Environmental Policy (Marine Strategy Framework Directive)*. Official Journal of the European Union L 164/19. Available online at: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0056&from=EN>
- EC (2012). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Blue Growth Opportunities for Marine and Maritime Sustainable Growth*. COM/2012/0494 final. Available online at: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0494&from=EN>
- EC (2018). *Maritime Spatial Planning (MSP) for Blue Growth – Technical Study*. EUR EA-01-18-377-EN-N 309.
- ECLL (2017). *Commission Decision (EU) 2017/848 of 17 May 2017 Laying Down Criteria and Methodological Standards on Good Environmental Status of Marine Waters and Specifications and Standardised Methods for Monitoring and Assessment, and Repealing Decision 2010/477/EU*. Official Journal of the European Union L 125/43. Available online at: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0056&from=EN>
- Eikeset, A. M., Mazzarella, A. B., Daviðsdóttir, B., Klinger, D. H., Levin, S. A., Rovenskaya, E., et al. (2018). What is blue growth? The semantics of “Sustainable Development” of marine environments. *Marine Policy* 87, 177–179. doi: 10.1016/j.marpol.2017.10.019
- Evans, J. L., Peckett, F., and Howell, K. L. (2015). Combined application of biophysical habitat mapping and systematic conservation planning to assess efficiency and representativeness of the existing High Seas MPA network in the Northeast Atlantic. *ICES J. Marine Sci.* 72, 1483–1497. doi: 10.1093/icesjms/fsv012
- FAO (2009). *International Guidelines for the Management of Deep-sea Fisheries in the High Seas*. Rome, FAO.
- Foley, N., Armstrong, C., Hynes, S., Needham, K., and Ressurreição, A. (2018). *ATLAS Deliverable 5.1 Inventory of Ecosystem Services*. Zenodo. Available online at: <https://zenodo.org/record/1172054#.XDRzzyOcZGM>
- Fox, A., Henry, L.-A. M., Corne, D. W., and Roberts, J. M. (2016). Sensitivity of a marine protected area network to shifts in atmospheric state and ocean circulation. *Royal Soc. Open Sci.* 3:160494. doi: 10.1098/rsos.160494
- Freestone, D., Johnson, D., Ardron, J., Morrison, K., and Unger, S. (2014). Can existing institutions protect biodiversity in areas beyond national jurisdiction? Experiences from two on-going processes. *Marine Policy* 49, 167–175. doi: 10.1016/j.marpol.2013.12.007
- Friedman, K., Garcia, S. M., and Rice, J. (2018). Mainstreaming biodiversity in fisheries. *Marine Policy*, 95, 209–220. doi: 10.1016/j.marpol.2018.03.001
- Gianni, M., Fuller, S. D., Currie, D. E. J., Schleit, K., Goldsworthy, I., Pike, B., et al. (2016). *How Much Longer Will it Take? A Ten-Year Review of the Implementation of United Nations General Assembly resolutions 61/105, 64/72 and 66/68 on the Management of Bottom Fisheries in Areas Beyond National Jurisdiction*. Deep Sea conservation coalition, Amsterdam. Available online at: http://www.savethehighseas.org/wp-content/uploads/2016/07/DSCC-Review-2016_Launch-29-July.pdf
- Gordon, J. D. M., Bergstad, O. A., Figueiredo, I., and Menezes, G. (2003). Deep-water Fisheries of the Northeast Atlantic: description and current trends. *J. Northwest Atlantic Fish. Sci.* 31, 137–150. doi: 10.2960/J.v31.a10
- Grehan, A. (2018). ATLAS Deliverable 6.1 Marine Spatial Planning goals and operational objectives. Zenodo. doi: 10.5281/zenodo.1147702
- Hall-Spencer, J., Allain, V., and Fossa, J. H. (2002). Trawling damage to Northeast Atlantic ancient coral reefs. *Proc. Royal Soc. London B* 269, 507–511. doi: 10.1098/rspb.2001.1910
- Hall-Spencer, J. M., Tasker, M., Soffker, M., Christiansen, S., Rogers, S., Campbell, M., et al. (2009). Design of marine protected areas on high seas and territorial waters of rockall bank. *Marine Ecol. Progress Series* 397, 305–308. doi: 10.3354/meps08235
- Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D’Agrosa, C., et al. (2008). A global map of human impact on marine ecosystems. *Science* 319, 948–952. doi: 10.1126/science.1149345
- Hátún, H., Payne, M. R., Beaugrand, G., Reid, P. C., Sandø, A. B., Drange, H., et al. (2009). Large bio-geographical shifts in the north-eastern Atlantic Ocean: From the subpolar gyre, via plankton, to blue whiting and pilot whales. *Progress Oceanogra.* 80, 149–162. doi: 10.1016/j.pocean.2009.03.001
- Henry, L.-A., Moreno Navas, J., Hennige, S. J., Wicks, L. C., Vad, J., and Roberts, J. M. (2013). Cold-water coral reef habitats benefit recreationally valuable sharks. *Biol. Conserv.* 161, 67–70. doi: 10.1016/j.biocon.2013.03.002
- Henry, L. A., Harries, D., Kingston, P., and Roberts, J. M. (2017). Historic scale and persistence of drill cuttings impacts on North Sea benthos. *Marine Environ. Res.* 129, 219–228. doi: 10.1016/j.marenvres.2017.05.008
- Henry, L. A., Mayorga-Adame, C. G., Fox, A. D., Polton, J. A., Ferris, J. S., McLellan, F., et al. (2018). Ocean sprawl facilitates dispersal and connectivity of protected species. *Nat. Sci. Rep.* 8:11346. doi: 10.1038/s41598-018-29575-4
- Howell, K. L., Davies, J. S., Jacobs, C., and Narayanaswamy, B. E. (2009). *Broad-scale survey of the habitats of Rockall Bank, and mapping of Annex I ‘Reef’ habitat*. Joint Nature Conservation Committee Report No. 422.
- Howell, K. L., Piechaud, N., Downie, A.-L., and Kenny, A. (2016). The distribution of deep-sea sponge aggregations in the North Atlantic and implications for their effective spatial management. *Deep Sea Res. Part I* 115, 309–320. doi: 10.1016/j.dsr.2016.07.005
- Hoydal, K., Johnson, D., and Hoel, A. H. (2014). Regional governance: the case of NEAFC and OSPAR. Chapter 16: 225–238, in *Governance for Fisheries and Marine Conservation: Interaction and co-evolution*, eds S. M. Garcia, J. Rice and A. Charles (Wiley-Blackwell).
- ICES (2013a). *Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC)*, 11–15 March 2013, Floedevigen, Norway. ICES CM 2013/ACOM:28.
- ICES (2013b). *OSPAR/NEAFC Special Request on Review of the Results of the Joint OSPAR/NEAFC/CBD Workshop on Ecologically and Biologically*

- Significant Areas (EBSAs). Special request, Advice June 2013, Available online at: <http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2013/Special%20requests/OSPAR-NEAFC%20EBSA%20review.pdf>
- ICES (2014). *Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 24-28 February 2014*. Copenhagen. ICES CM 2014/ACOM:29.
- ICES (2015). *Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 16-20 February 2015*. Horta. ICES CM 2015/ACOM:27. 113 pp.
- ICES (2016a). *Report of the Joint ICES/NAFO Working Group on Deep-water Ecology (WGDEC), 15-19 February 2016*. Copenhagen. ICES CM 2016/ACOM:28.
- ICES (2016b). *Report of the Working Group for the Celtic Seas Ecoregion (WGCSE), 4-13 May 2016*. Copenhagen, Denmark. ICES CM 2016/ACOM:13.
- ICES (2017). *Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 20-24 March 2017*. Copenhagen. ICES CM 2017/ACOM:25.
- ICES (2018a). *Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDEC), 5-9 March 2018*. Dartmouth, NS. ICES CM 2018/ACOM:26.
- ICES (2018b). *Report of the Working Group on International Pelagic Surveys (WGIPS), 15-19 January 2018*. Den Helder. ICES CM 2018/EOSG:14.
- Janßen, H., Bastardie, F., Eero, M., Hamon, K. G., Hinrichsen, H.-H., Marchal, P., et al. (2017). Integration of fisheries into marine spatial planning: Quo vadis? *Estuarine Coastal Shelf Sci.* 201, 105–113. doi: 10.1016/j.ecss.2017.01.003
- Johnson, D., Ardron, J., Billett, D., Hooper, T., Mullier, T., Chaniotis, P., et al. (2014). When is a marine protected area network ecologically coherent? A case study from the North-East Atlantic. *Aqua. Conserv.* 24, 44–58. doi: 10.1002/aqc.2510
- Johnson, D., Ferreira, M. A., and Kenchington, E. (2018a). Climate change is likely to severely limit the effectiveness of deep-sea ABMTs in the North Atlantic. *Marine Policy* 87, 111–122. doi: 10.1016/j.marpol.2017.09.034
- Johnson, D. E. (2013). "Can competent authorities cooperate for the common good: Towards a collective arrangement in the North-East Atlantic," in *Environmental Security in the Arctic Ocean*, eds P. Berkman, and A. Vylegzhanin (Springer), 333–343.
- Johnson, D. E. (2016). "Chapter 15: Conserving the charlie-gibbs fracture zone: one of the world's first high seas marine protected areas," in *Marine Transboundary Conservation and Protected Areas. Earthscan Oceans*, ed P. Mackelworth (Oxford; New York, NY: Routledge), 271–285.
- Johnson, D. E., Barrio Fróján, C., Turner, P. J., Weaver, P., Gunn, V., Dunn, D. C., et al. (2018b). Reviewing the EBSA process: improving on success. *Marine Policy* 88, 75–85. doi: 10.1016/j.marpol.2017.11.014
- Kingston, P. F. (1992). Impact of offshore oil production installations on the benthos of the North Sea. *ICES J. Marine Sci.* 49, 45–53. doi: 10.1093/icesjms/49.1.45
- Klinger, D. H., Eikeset, A. M., Davíðsdóttir, B., Winter, A.-M., and Watson, J. R. (2018). The mechanics of blue growth: Management of oceanic natural resource use with multiple, interacting sectors. *Marine Policy* 87, 356–362. doi: 10.1016/j.marpol.2017.09.025
- Large, P. A., Agnew, D. J., Álvarez Pérez, J. A., Barrio Fróján, C., Cloete, R., Damalas, D., et al. (2013). Strengths and Weaknesses of the Management and Monitoring of Deep-Water Stocks, Fisheries, and Ecosystems in Various Areas of the World—A Roadmap Toward Sustainable Deep-Water Fisheries in the Northeast Atlantic? *Rev. Fish. Sci.* 21, 157–180. doi: 10.1080/10641262.2013.785475
- Lazarus, R. (2009). Super wicked problems and climate change: restraining the present to liberate the future. *Cornell Law Rev.* 94, 1153–1233. Available online at: <https://scholarship.law.cornell.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=3143&context=clr>
- Morato, T., Pham, C. K., Pinto, C., Golding, N., Ardron, J. A., Durán Muñoz, P., et al. (2018). Multi criteria assessment method for identifying vulnerable marine ecosystems in the North-East Atlantic. *Front. Marine Sci.* 5:460. doi: 10.3389/fmars.2018.00460
- MSC (2018). *Scottish Fisheries Sustainable Accreditation Group (SFSAG) Rockall haddock*. Available online at: <https://fisheries.msc.org/en/fisheries/scottish-fisheries-sustainable-accreditation-group-sfsag-rockall-haddock/@@view>
- NEAFC (2017). *Report of the 36th Annual Meeting of the North-East Atlantic Fisheries Commission 13-17 November 2017*. Available online at: <https://www.neafc.org/system/files/Report%20Final.pdf>
- NEAFC and OSPAR (2015). *The Process of Forming a Cooperative Mechanism between NEAFC and OSPAR*. UNEP Regional Seas Reports and Studies No. 196
- Neat, F., Jamieson, A., Stewart, H., Narayanaswamy, B., Collie, N., Stewart, M., et al. (2018). Visual evidence of reduced seafloor conditions and indications of a cold-seep ecosystem from the Hatton–Rockall basin (NE Atlantic). *J. Marine Biol. Assoc.* 1–7. doi: 10.1017/S0025315418000115
- Neat, F. C., and Campbell, N. (2011). Demersal fish diversity of the isolated Rockall plateau compared with the adjacent west coast shelf of Scotland. *Biol. J. Linnean Soc.* 104, 138–147. doi: 10.1111/j.1095-8312.2011.01699.x
- Newton, A. W., Peach, K. J., Coull, K. A., Gault, M., and Needle, C. L. (2008). Rockall and the Scottish haddock fishery. *Fish. Res.* 94, 133–140. doi: 10.1016/j.fishres.2008.03.012
- O'Leary, B. C., Brown, R. L., Johnson, D. E., von Nordheim, H., Ardron, J., and Packeiser, T. (2012). The first network of marine protected areas (MPAs) in the high seas: the process, the challenges and where next. *Marine Policy* 36, 598–605. doi: 10.1016/j.marpol.2011.11.003
- Oliver, P. G., and Drewery, J. (2014). New species of chemosymbiotic clams (Bivalvia: Vesicomidae and Thyasiridae) from a putative 'seep' in the Hatton–Rockall Basin, north-east Atlantic. *J. Marine Biol. Assoc. UK.* 94, 389–403. doi: 10.1017/S0025315413001136
- Payne, M. R., Egan, A., Fässler, S., Hátún, H., Holst, J. C., Jacobsen, J. A., et al. (2012). The rise and fall of the NE Atlantic blue whiting (*Micromesistius poutassou*). *Marine Biol. Res.* 8, 475–487. doi: 10.1080/17451000.2011.639778
- Perez, F. F., Fontela, M., García-Ibáñez, M. I., Mercier, H., Velo, A., Lherminier, P., et al. (2018). Meridional overturning circulation conveys fast acidification to the deep Atlantic Ocean. *Nature* 554, 515–518. doi: 10.1038/nature25493
- Piñeiro, C. G., and Bañón, M. C. R. (2001). The deep-water fisheries exploited by Spanish fleets in the Northeast Atlantic: a review of the current status. *Fish. Res.* 51, 311–320. doi: 10.1016/S0165-7836(01)00254-5
- Raakjaer, J., van Leeuwen, J., van Tatenhove, J., and Hadjimichael, M. (2014). Ecosystem-based marine management in European regional seas calls for nested governance structures and coordination – a policy brief. *Marine Policy* 50, 373–381. doi: 10.1016/j.marpol.2014.03.007
- Ringbom H., and Henriksen, T. (2017). *Governance Challenges, Gaps and Management Opportunities in Areas Beyond National Jurisdiction*. Global Environment Facility-Scientific and Technical Advisory Panel, STAPGEE, Washington, DC. Available online at: <http://www.stapgef.org>
- Rittel, H. W. J., and Webber, M. M. (1973). Dilemmas in general theory planning. *Policy Sci.* 4, 155–169.
- Roberts, J. M., and Cairns, S. D. (2014). Cold-water corals in a changing ocean. *Curr. Opin. Environ. Sustain.* 7, 118–126. doi: 10.1016/j.cosust.2014.01.004
- Roberts, J. M., Henry, L.-A., Long, D., and Hartley, J. P. (2008). Cold-water coral reef frameworks, megafaunal communities and evidence for coral carbonate mounds on Hatton Bank, north east Atlantic. *Facies* 54, 297–316. doi: 10.1007/s10347-008-0140-x
- Roberts, J. M., Murray, F., Anagnostou, E., Hennige, S., Gori, A., Henry, L.-A., et al. (2016). "Cold-water corals in an era of rapid global change: are these the deep ocean's most vulnerable ecosystems?," in *The Cnidaria, Past, Present and Future*, eds S. Goffredo, and Z. Dubinsky (Springer International Publishing), 593–606
- Roberts, J. M., Wheeler, A. J., and Freiwald, A. (2006). Reefs of the deep: the biology and geology of cold-water coral ecosystems. *Science* 213, 543–547. doi: 10.1126/science.1119861
- Rogers, A. D., Brierley, A., Croot, P., Cunha, M. R., Danovaro, R., Devey, C., et al. (2015). "Delving Deeper: Critical challenges for 21st century deep-sea research," in *Position Paper 22 of the European Marine Board*, eds K. E. Larkin, K. Donaldson, and N. McDonough (Ostend: European Marine Board), 224
- Schofield, N., Jolley, D., Holford, S., Archer, S., Watson, D., Hartley, A., et al. (2017). "Challenges of future exploration within the UK Rockall Basin," in *Geological Society, London, Petroleum Geology Conference Series* (Geological Society of London).
- Stelzenmüller, V., Breen, P., Stamford, T., Thomsen, F., Badalamenti, F., Borja, A., et al. (2013). Monitoring and evaluation of spatially managed areas: A generic framework for implementation of ecosystem based marine management and its application. *Marine Policy* 37, 149–164. doi: 10.1016/j.marpol.2012.04.012
- SWD (2017). *Report on the Blue Growth Strategy: Towards more sustainable growth and jobs in the blue economy*. European Commission Staff Working Document

- 128.Brussels. Available online at: https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/swd-2017-128_en.pdf
- Thornalley, D. J. R., Oppo, D. W., Ortega, P., Robson, J. I., Brierley, C. M., Davis, R., et al. (2018). Anomalously weak Labrador Sea convection and Atlantic overturning during the past 150 years. *Nature* 556, 227–230. doi: 10.1038/s41586-018-0007-4
- Tirole, J. (2017). *Economics for the Common Good*. Princeton, NJ: Princeton University Press, 576.
- Troell, M., Joyce, A., Chopin, T., Neori, A., Buschmann, A. H., and Fang, J.-G. (2009). Ecological engineering in aquaculture - Potential for integrated multi-trophic aquaculture (IMTA) in marine offshore systems. *Aquaculture* 297, 1–9. doi: 10.1016/j.aquaculture.2009.09.010
- UN (2012). *Report of the United Nations Conference on Sustainable Development. Rio de Janeiro, Brazil 20-22 June 2012. A/CONF.216/16*. Available online at: http://www.un.org/ga/search/view_doc.asp?symbol=A/CONF.216/16&Lang=E
- UNGA (2006). *A/RES/61/105 - Sustainable fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments*. Available online at: <https://undocs.org/A/RES/61/105>
- Upton, H., and Buck, E. (2010). *Open Ocean Aquaculture. Congressional Research Service 7-5700*. Available online at: www.crs.gov RL 32694
- Weaver, P., and Johnson, D. (2012). Think big for marine conservation. *Nature* 483:399. doi: 10.1038/483399a
- Wright, G., Ardron, J., Gjerde, K., Currie, D., and Rochette, J. (2015). Advancing marine biodiversity protection through regional fisheries management: a review of bottom fisheries closures in areas beyond national jurisdiction. *Marine Policy* 61, 134–148. doi: 10.1016/j.marpol.2015.06.030
- Wright, G., Gjerde, K. M., Johnson, D. E., Finkelstein, A., Ferreira, M. A., Dunn, D. C., et al. (2019). Marine spatial planning in areas beyond national jurisdiction. *Marine Policy*. doi: 10.1016/j.marpol.2018.12.003
- Yiallourides, C. (2018). It takes four to tango: quadrilateral boundary negotiations in the North-East Atlantic. *Marine Policy* 87, 78–83. doi: 10.1016/j.marpol.2017.10.007

Conflict of Interest Statement: DEJ and CBF are employed by Seascope Consultants Ltd.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Copyright © 2019 Johnson, Barrio Froján, Neat, Van Oevelen, Stirling, Gubbins and Roberts. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.