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

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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 wicked1 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 (*Centroscymnus 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 website) (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 Ocean, 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 sediments 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
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; Hoyalal 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 where 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
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.

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 VMFs (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 VMFs) 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 Hyaloloma 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 VMFs 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 fishers’ requirements for spatial information. Attempts to develop a marine spatial plan for the Rockall Bank and Hatton 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
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 bioresearch 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; ECll, 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.

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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? Mar. Ecol. Prog. Ser. 35, 817–821. doi: 10.1017/S014357790800692

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

Ben, 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 thermohaline 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/ac/25/E25i-07.pdf

Corbin, J. S., Holmyard, J., and Lindell, S. (2017). Regulation and permitting of standalone 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. ODESEA 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 community. In: Northeast Atlantic: an assessment of spatial extent. Policy�Sciences, Ltd. 2012. 5: 105.

Eikeset, A. M., Mazzarella, A. B., Davidsdóttir, 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

FAD (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#.XDrzyyOcZGM

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, L., Pike, R., 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.savetheseabeds.org/wp-content/uploads/2016/07/DSCC-Review-2016_Launch-29July.pdf

Gordon, J. D. M., Bergstad, O. A., Figureziredo, I., and Menenez, 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. M., 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., Softker, 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. (2014). Regional governance: the case of the Hatton Bank. Proc. Royal Soc. London B 381, 305–308. doi: 10.1098/rspb.2013.12.007

Henry, L. A., Mayorga-Adame, C. G., Fox, A. D., Polton, J. A., Ferris, J. S., Howell, K. L., Davies, J. S., Jacobs, C., and Narayanaswamy, B. E. (2009). Cold-water coral reef habitats benefit recreationally valuable sharks. Biol. Conserv. 161, 67–70. doi: 10.1016/j.biorto.2013.03.002

Henry, L. A., Harries, D., Kingston, P., and Roberts, J. M. (2017). 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). Broadscale survey of the habitats of Rockall Bank, and mapping of Annex I ‘Reef’ habitat. Joint Nature Conservation Committee Report No. 422

Howell, K. L., Piekach, 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, Floeavigen, 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%20etc%20review.pdf

ICES (2014). Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDE), 24-28 February 2014. Copenhagen. ICES CM 2014/ACOM:29.

ICES (2015). Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDE), 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 (WGDE), 15-19 February 2016.Copenhagen. ICES CM 2016/ACOM:28.

ICES (2016b). Report of the Working Group for the Celtic Seas Ecoregion (WGCE), 4-13 May 2016. Copenhagen. ICES CM 2016/ACOM:13.

ICES (2017). Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDE), 20-24 March 2017. Copenhagen. ICES CM 2017/ACOM:23.

ICES (2018a). Report of the ICES/NAFO Joint Working Group on Deep-water Ecology (WGDE), 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.

Jønassen, H., Bastardie, F., Hamon, K. G., Hinrichsen, H.-H., Marchal, O. and Munday, P., et al. (2018). Multi criteria assessment method for identifying vulnerable Significant Areas (EBSAs) between NEAFC and OSPAR. UNEP Regional Seas Reports and Studies No. 196 Neaf, F., C., Campbell, N. (2011). Demersal fish diversity of the isolated Rockall platea compared with the adjacent west coast shelf of Scotland. Biot. J. Linnean Soc. 104, 138–147. doi: 10.1111/j.1095-8312.2011.01699.x

Newton, A. W., Peach, K. J., Cooll, 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 Dreyer, J. (2014). New species of chemosymbiotic clams (Bivalvia: Vescomyidae 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/S0025315414001136

Payne, M. R., Egan, A., Fussier, S., Hätün, 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:10.1007/s11686-011-9577-8

Pérez, F. F., Fontela, M., Garcia-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

Pituëo, C. G. O., and Báñon, 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

Raakaer, 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

Ringborn H., and Henriksen, T. (2017). Governance Challenges, Gaps and Management Opportunities in Areas Beyond National Jurisdiction. Global Environment Facility-Scientific and Technical Advisory Panel, STAPGEF, 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., Long, D., and Hartley, J. P. (2008). Cold-water corals in a changing ocean. Marine Policy 32, 549–556. doi: 10.1016/j.marpol.2008.03.012

Steinberg, V., and Kushner, P. (2017). "Cold-water corals in an era of rapid global change: are these the 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 313, 543–547. doi: 10.1126/science.1119861

Rogers, A. D., Brierey, 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, P., 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
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.216/16andLang=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

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