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Marine governance in an industrialised ocean: A case study of the emerging marine renewable energy industry

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ABSTRACT

The world's oceans are currently undergoing an unprecedented period of industrialisation, made possible by advances in technology and driven by our growing need for food, energy and resources. This is placing the oceans are under intense pressure, and the ability of existing marine governance frameworks to sustainably manage the marine environment is increasingly being called into question. Emerging industries are challenging all aspects of these frameworks, raising questions regarding ownership and rights of the sea and its resources, management of environmental impacts, and management of ocean space. This paper uses the emerging marine renewable energy (MRE) industry, particularly in the United Kingdom (UK), as a case study to introduce and explore some of the key challenges. The paper concludes that the challenges are likely to be extensive and argues for development of a comprehensive legal research agenda to advance both MRE technologies and marine governance frameworks.

1. Introduction

An 'industrial revolution' of the oceans is underway [1–3]. A growing human population and appetite for resources, coupled with innovation and technological advancement, is driving unprecedented exploitation of the marine environment. This is not only placing further pressure on already exhausted ocean ecosystems [4], but also challenging existing legal and regulatory frameworks and changing the way we think about marine governance. Growing demand for private rights to marine resources and ocean space, coupled with the declining health of the oceans, necessitates the evolution of marine governance frameworks that can facilitate innovation and economic development, while also ensuring environmental sustainability.

This paper aims to advance the contemporary discourse on marine governance through a case study of the emerging marine renewable energy (MRE) industry. MRE is of particular interest as it sits at the confluence of a number of discourses, challenging all aspects of marine governance frameworks. At the same time, the marine governance discourse provides a framework for considering issues relating to the deployment of MRE technologies.

The paper first briefly explores the history of marine governance, from early conceptions, freedom of the seas and single-sector management, to the development of an increasingly integrated and holistic paradigm. The paper draws attention to the emergence of 'Blue Growth', which seeks to sustainably progress industrialisation of the oceans to meet economic and social objectives. The key themes of modern marine governance frameworks are then identified and elaborated, namely: rights and ownership; resource management; environmental sustainability; and management of ocean space.

The paper provides a preliminary discussion of the key issues and challenges facing marine governance frameworks, using the emerging MRE industry as a case study. This discussion shows that both marine governance frameworks, and the innovative marine industries subject to their regulation, face considerable challenges in an increasingly industrialised ocean. It is further suggested that the marine governance discourse provides a suitable starting point for developing a legal research agenda for MRE. Some concluding thoughts are offered, highlighting potential directions for future research.

2. Marine governance: a brief history

This section provides a brief overview of the key developments in marine governance, from terrestrial planning and early single-sector governance models, to the recent calls for a paradigm shift

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in thinking around marine spaces and the ongoing transition towards more integrated and holistic governance models.

2.1. From land to sea: onshore planning

Terrestrial land use and planning is a well-developed and central component of Western legal systems. The traditional permit-by-permit approach to land planning has been augmented by an overarching layer of planning processes that provide a strategic vision for future development. This combination of project-centric permitting and high-level strategic guidance and has become the standard model for onshore land-use planning and management [5].

While different planning systems have varied origins, two watershed events drove the emergence of modern planning regimes in many countries. Firstly, the industrial revolution precipitated enormous economic and social change that necessitated an overhaul of governance structures. Similarly drastic social and political upheavals then took place in the aftermath of World War II. In the UK, for example, the new socialist government committed to common ownership of the means of production and nationalised many industries [6]. This was not feasible in relation to general land ownership, and most land ultimately remained in private hands.[1] The planning system evolved to meet this context, allowing the interests of private landholders to be subordinated to the wider public good [7].

There is a strong parallel between the industrial revolution and the ongoing industrialisation of the oceans. While private rights in marine spaces have historically been rare, demand for private or quasi-private property rights is increasing, again challenging policymakers to ensure that such rights are subordinated to the public interest. It is therefore "tempting, but naïve" to suggest that land planning regimes can simply be replicated at sea [8]. The marine environment is inherently different to the terrestrial one, and marine planning mechanisms must be "built at sea" [9].

Nonetheless, the interrelationship between terrestrial and offshore planning has been the focus of some research, which has considered: the potential use for land planning tools in the marine context [10]; the integration of land and sea planning [11]; the interface between land and sea planning for activities that cross the land-sea divide [8]; using terrestrial planning as a basis for understanding marine planning [12]; and using experience with novel marine governance mechanisms to inform and improve terrestrial planning systems [13].

2.2. Early marine governance

As far back as the Roman Empire, marine spaces were 'owned' as an extension of terrestrial territory (*Mare Clausum* or *Mare Nostrum*) [14,15]. That conception was fundamentally changed by Grotius' 1609 work, *Mare Liberum*, which introduced the 'freedom of the seas' concept. Nations' rights to the sea were limited to a specified band of water extending from the coastline; all waters beyond national boundaries were considered open to all nations, but property of none.[2] Independence of colonial states, industrialisation, expanding fisheries, and the discovery of mineral resources beneath the seabed subsequently provided the impetus for a widening of state jurisdiction. Beginning in 1958, three United Nations Law of the Sea conferences were held to decide upon the rights and duties of nations regarding ocean space.[3]

The process towards the 1982 United Nations Convention on the Law of the Sea (UNCLOS) represented a milestone in the development of modern marine governance, and is widely considered to be one of the longest and most complex treaty processes in the history of international law.[4] This process pushed states to think more systematically about their interests in ocean space and consider more systemic approaches to management of the oceans. It also underscored the need for increased coherence in marine governance, and thereby played a catalysing role the development of integrated marine policy.

Legal scholarship regarding marine governance has generally focused on the international ramifications of UNCLOS, however UNCLOS was also significant at the national level in three key ways [16]. Firstly, in recognising the rights of states in relation to the various parts of the ocean, particularly by creating Exclusive Economic Zones (EEZ),[5] UNCLOS substantially increased the scale of national jurisdiction and management of ocean space. This recognition of sovereign rights over both living and non-living resources provides an impetus for effective management in the form of self-interest. Secondly, the Convention also established some responsibilities for the management of the marine environment: by ratifying, states accept obligations to "protect and preserve the marine environment" and to undertake a range of actions to achieve this.[6] Thirdly, the preamble the Convention explicitly expressed the understanding that "the problems of ocean space are closely interrelated and need to be considered as a whole", endorsing a systems perspective for marine governance.

2.3. Towards modern marine governance

The imperative to develop institutions and policies for an integrated approach to marine governance is a relatively recent one. During the 1960s the 'systems' view of the world began to predominate, grounded in the growing understanding of marine ecology and an increasing appreciation of the impacts of human uses on the marine environment. In many places, the level of participation and influence of civil society increased at all levels of policymaking during this period [17,18], which went "hand in hand with the increasingly multi-level character of politics and policy making" [19].

Two major innovations occurred in marine governance, starting in the 1970s. Marine Protected Areas (MPAs) emerged as a tool for restricting human uses in the interests of conservation, and Integrated Coastal Zone Management (ICZM) emerged as the main multi-use management paradigm [20].

The use of MPAs for conservation has grown exponentially, particularly over the last two decades. The World Summit on Sustainable Development in 2002 highlighted the importance of MPAs in conservation and called for the "establishment of marine protected areas consistent with international laws and based on scientific information, including representative networks by 2012".[7] In 2010, States pledged to protect 10% of marine and coastal ecosystems by 2020 (Aichi Target XI).[8] Yet despite studies suggesting a level of effectiveness [83–85], particularly for MPAs following best practice [86], the conservation benefits are far from universal.

[1] Though some compulsory purchase powers were introduced.

[2] Note that though only a general overview is considered here, this conception does not acknowledge the many kinds of traditional management systems that treated marine resources as common-property.

[3] 1958, 1960 and 1973.

[4] Negotiations lasted almost a decade (1973–1982) and addressed the full spectrum of human uses of the marine environment known at the time.

[5] The EEZ stretches from the low water mark out to 200 nautical miles. The EEZ gives States a sovereign right to exploit the resources below the surface of the sea.

[6] Article 192. This is in addition to more specific obligations, such as in relation to fisheries (Article 194).

[7] Paragraph 32(c) of the Johannesburg Plan of Implementation.

[8] For more details, see 'Quick guide to the Aichi Biodiversity Targets: Protected areas increased and improved', http://www.cbd.int/doc/strategic-plan/targets/T11-quick-guide-en.pdf.

While MPAs focused primarily on environmental protection and the exclusion or limitation of maritime activity in certain areas, ICZM was the first approach to marine governance that aimed to balance this with human use. Agenda 21 emphasised the need for integrated management of the coastal zone and a dramatic increase in the implementation of ICZM followed. By 1993 approximately 150 ICZM projects were underway in around 60 states [21], often coinciding with, and facilitating, legal changes and policy development. Nonetheless, "despite considerable interest in ICZM over the 1990's implementation has been limited in scope and geographic coverage" [8], and some have argued that there are "relatively few, if any, successful models of ICZM internationally" [20]. ICZM also provided limited answers to ocean industrialisation, given that its focus on is on the coastal zone. This has been noted in the offshore energy context, and there is a need to ensure that new governance efforts build on and integrate the advances made by ICZM [22]. In many ways Marine Spatial Planning (MSP), discussed below, is an extension of ICZM to the open ocean, though their intent and processes differ.

Both MPAs and ICZM have been criticised for their "notable imbalance in the degree of effort allocated to monitoring the ecological and social dimensions" [23]; i.e. they do not provide a framework for managing industrial uses of the marine environment in a holistic way. As ocean industrialisation has advanced, so too has the need for fresh thinking, both on options for sustainably developing marine resources and on governance structures to regulate and facilitate such developments.

In this rapidly evolving context even the conservation literature was beginning to recognise that "alternative solutions targeting human demand for ecological goods and services… should be prioritized and brought to the forefront of the international conservation agenda" [24]. The need to balance social and environmental concerns with economic interests has recently been brought into sharp focus by talk of 'Blue Growth', i.e. development of policy aimed at leveraging the natural resources of the marine environment to achieve economic growth. The EU in particular has pioneered this term, and its 'Blue Growth Agenda', highlights the need to "harness the untapped potential of Europe's oceans, seas and coasts for jobs and growth… whilst safeguarding biodiversity and protecting the marine environment" [25].

3. Contemporary discourse: marine governance in an industrialised ocean

In an industrialised ocean, policymakers and regulators will increasingly be required to responsibly evaluate trade-offs between economic benefits and social and environmental values, as well as between competing uses of the marine environment.

This is well articulated by Osherenko, who succinctly issues the following call to action [2]:

> We are entering a new era of rapidly expanding ocean use… New technologies are opening new discourses on ocean ethics and governance… Changes in our perceptions, values, and technology regarding the sea are driving the need for new rules and regulations as well as changes in systems of rights to occupy sea space and use ocean resources… We need to articulate a new discourse on sea tenure…, a new way to allocate ocean space and marine resources… We need a way for private enterprise to pioneer wind, wave, and tidal-energy offshore… We need new governance systems that protect the rights of this and future generations.

An expanded conception of marine governance began to take root in the post-UNCLOS period, primarily in Western Europe after the turn of the 21st century. Belgium, Germany and the Netherlands were able to adapt pre-existing legislative instruments to implement MSP initiatives. The UK was among the first to enact specific legislation for modern marine governance arrangements that went even further, providing for new licensing and regulatory systems for marine activities.[9]

A number of authors have advanced the evolution of the marine governance discourse, identifying and defining its constituent elements, converging on a general framework, and posing questions for future research and discussion. Nichols, Monahan and Sutherland suggest that modern marine governance consists primarily of: allocation of rights in, and management of, marine resources; regulation of resources and use (environmental protection, rights to economic and social benefits etc.); spatial management; and monitoring, enforcement and dispute adjudication [26].

Osherenko addresses similar issues, but also poses questions regarding ownership and tenure [2]. Such questions go one level deeper by acknowledging that establishing the nature of rights in the marine environment is an essential prerequisite to allocating such rights and exploiting marine resources. Such questions will be ever more important as marine users increasingly seek to 'privatise' ocean spaces for their particular ends.

Salcido proposes a similar framework, but takes the management of environmental concerns to be a distinct part of the overall marine governance framework that warrants separate discussion, rather than merely being part of the regulation of resource use. This is consistent with the commonly-held notion that sustainability must become a "fundamental norm" of marine governance [27], and with the Blue Growth Agenda, which emphasises environmental sustainability [28–30].

Given the foregoing discussion, this paper is structured around the following core aspects of modern marine governance frameworks, with the emerging MRE industry providing an exploration of each: rights and ownership; resource management; environmental impacts; and management of ocean space.

4. The emerging marine renewable energy industry

The trend for ocean industrialisation has intersected with the environmental imperative to decarbonise the energy system, driving interest in offshore renewable energy resources. Offshore wind is growing rapidly [31], while other MRE technologies utilise waves and tides to generate electricity[10] and are attracting considerable interest [32]. As with other novel offshore activities, MRE is bringing its own unique challenges to marine governance frameworks [33,34]. Indeed, the development of MRE is not only a technically challenging extension of onshore technologies: *"the policy environment, governance, patterns of resource use, conservation values, and distribution of ownership rights are all substantively different from the situation onshore"* [35].

4.1. MRE as a case study of marine governance

The MRE industry provides an excellent case study through which to discuss emerging marine governance issues. At a conceptual level, the MRE industry sits at the confluence of a number of concerns, opportunities and discourses. The industry seeks to generate clean electricity and advance climate mitigation goals, but it is deploying its technology in a complex, delicate and poorly-understood receiving environment; it offers potential job

[9] Marine and Coastal Access Act 2009 (UK) and Marine (Scotland) Act 2010.

[10] MRE also encompasses ocean thermal energy technology (OTEC) and salinity gradient technology. However, these technologies have followed a different development pathway to wave and tidal. MRE in this paper refers primarily to the wave and tidal technologies currently in development.

creation and economic growth, but there remains considerable uncertainty as to the environmental impacts of the technology; it is a fast growing industry at the forefront of innovation, yet it faces significant regulatory and policy barriers that hinder its progress.

MRE challenges all aspects of marine governance frameworks. In most cases, developers desire or require rights and tenure in the ocean space they seek to exploit, challenging existing conceptions of rights and ownership. Resources are limited and there will be competition over access, challenging regulatory authorities to develop appropriate processes for resource allocation and management. The environmental impacts remain uncertain yet deployment of devices is necessary to advance the industry, thereby challenging risk-averse regulators to provide flexibility in environmental impact assessment (EIA) processes. Finally, MRE arrays will have large space requirements unprecedented in the nearshore environment, challenging single-sector management regimes and necessitating better integration of innovative industries into MSP efforts.

As a case study, MRE also provides two different perspectives from which to consider marine governance issues. On the one hand, there is the regulatory perspective, through which regulators and policymakers see MRE as one only of a growing number of marine-based activities that needs to be regulated, managed, and brought into line with overarching marine policy goals and objectives. On the other hand, there is the 'innovation' or 'law and technology' perspective, which focuses attention on the impacts of evolving marine governance frameworks on the development of innovative new marine industries.

4.2. Marine governance as a framework for legal studies of MRE

The use of MRE as a case study also contributes to the developing literature on this particular technology. The International Network for Social Studies in Marine Energy (ISSMER) recently developed a collaborative research agenda for social studies focussed on MRE [35] that notes, "research into MRE has focused on resource assessment, device design, and environmental impact… social science research into marine energy has been given low priority" [35]. Social sciences research has however been gradually developing in the last few years. In particular, issues such as community acceptance [36–38], attitudes of fishermen toward MRE development [39], and the economic impacts of industry development [40–42] are being actively investigated.

The ISSMER agenda refers to broad marine governance issues, including "policy environment, governance, patterns of resource use, conservation values, and distribution of ownership rights" [35], yet treatment of legal and regulatory issues is ultimately confined to 'dealing with uncertainty' and 'planning processes'. This reflects a broader trend within the MRE literature: far less attention has been given to legal and regulatory aspects, despite the role marine governance regimes play in industry development and the strong linkages between marine governance and social issues.

Though some commentators have provided a broad overview and context [2,33], consideration of legal and regulatory issues is usually conducted at a very high-level, e.g. in publications from strategic industry initiatives. Comparative studies of consenting and other regulatory processes have proven popular [43–45], while some literature discusses particular legal and regulatory issues. However, this literature has not sought to place MRE within the wider marine governance discourse, and there remains no established framework for conducting and organising such research according to a coherent agenda. The evolving discourse on marine governance could provide the basis for such an agenda, and this paper seeks to take a first step in this direction.

5. Marine governance in an industrialised ocean: case study

The following sections use the four core themes of the marine governance discourse as a structure to guide discussion of the issues for marine governance frameworks, and in turn the legal and regulatory challenges that these present to emerging marine industries such as MRE.

5.1. Rights and ownership

Rights and ownership are at the core of contemporary marine governance issues as they provide the basis for occupation of marine space and use of marine resources. MRE has the potential to present a major challenge to traditional conceptions of rights and "may play an important role in the redistribution of ownership rights in the marine environment" [35].

The ability to exploit and control the sea through new technological innovations is underpinning a gradual shift in the way marine space is conceptualised, whereby public rights are supplanted by private rights, firstly at the international level by the creation of sovereign rights, and subsequently by the creation of new private rights [35,46].[11] For example aquaculture leases, which by their nature exclude other users of the marine environment, and oil and gas activities, which generally incorporate exclusion and safety zones.

In the distant past, prior to the creation of a public right to fish by the Magna Carta in 1215, it had been "accepted practice for offshore tidal waters to be privately owned by the local communities living adjacent to them" [47]. However the seas have been considered to be under common ownership for much of modern history.[12] As a result there are virtually no examples in modern history of complete ownership or exclusive rights in marine spaces in the same way as on land [13].

The limited rights available in the marine environment are better conceived as a three-dimensional 'stack', rather than a single, defined right to a particular space. Rights are generally allocated for use of only one part of the stack or for specific activities or resources; the coexistence of rights increases the potential for conflicts. Interests in marine space also tend to naturally come in smaller 'parcels', in that the management of marine interests tends to focus on specific resources or activities rather than broader geographic areas.

MRE developers will require exclusive rights over both the resources and the physical marine space in which those resources are contained. Even if such rights are not explicitly sought, the needs and modalities of the technology will nonetheless exclude other users, establishing a rights-like occupation of the marine space.[13] By requiring exclusive rights over a particular resource, as well as exclusive occupation of physical marine space, MRE is effectively privatising a common good and creating potential conflict with: (1) public rights, e.g. to fishing and navigation; (2) other private rights in the marine environment; and (3) the perceived 'rights' of communities and existing marine users.

The question of public rights in the UK context has already been explored [48]. Though a MRE developer holds any lease subject to public navigation and fishing rights, the government can limit these rights when granting consents to MRE developers [48].[14] The Government has already done this in relation to oil and

[11] E.g. seabed leases, planning permission, and tradable quotas.

[12] Certain exclusive rights arise in some limited circumstances [48].

[13] For example, a wave energy device sitting on the sea surface will require rights to occupy the surface, but would likely also preclude use of the area below and around the devices.

[14] Section 99 of the Energy Act 2004, adding a new section 36A to the Electricity Act 1989, allows navigation rights to be extinguished or suspended "so

gas developments. This is likely to cause conflict once the MRE industry reaches an appreciable size and represents a significant gap in the governance framework. Todd argues that it would be "better for the legislation to grapple properly with the public rights to navigate, and to fish" and notes that there is "also a case, where rights are removed or curtailed, for providing for a fair compensation regime" [48].

The relative novelty of private rights in marine spaces means that there is little indication of how we may manage conflicts. On land such private rights are usually 'bundled' with certain other rights defensible at law, e.g. the right to light, right of support, and rights in water. However in the marine context, there are questions as to how conflicts between rights will be managed. For example, rights over fisheries have begun to take on a private nature,[15] so it is unclear whether rights to living resources or energy resources will take precedence in the event of a conflict between a MRE developer and the owner of fishing rights. As new uses of the marine environment emerge, it is likely that this trend of privatisation, and therefore conflict, will continue, with each new industry seeking exclusivity of use for its own purposes. These are "not simple questions, but they are critically important as the demand for exclusive rights to ocean resources increases" [2].

Finally there are 'rights' that do not exist legally, but are perceived by existing marine users. In particular this applies to local communities that may perceive their public rights as more concrete ownership or rights to exclusively use and/or manage 'their' sea space, including through limiting other uses or receiving income from them. In the 1970s, the Shetland Islands successfully translated this sentiment into "extraordinary powers" over its marine spaces [49] by negotiating rights and powers to manage offshore oil & gas exploitation in the North Sea. The stated aim was to promote the "well-being of all Shetlanders and all their descendants" and "maintenance of their traditions".[16] Reactions to MRE proposals elsewhere suggest that this is not an isolated case [50], but rather an important issue requiring careful consideration.

5.2. Resource management

The management of marine resources is a central function of modern marine governance arrangements. There are two aspects to the resource management issue. Firstly permitting processes for access to resources should be principled, in that they should address substantive questions regarding resource use in a manner that ensures economic efficiency, equity, sustainability, and financial return [51]. Secondly, they should be practical, in that they should implement simple and user-friendly processes that do not add unnecessary regulatory burden, time and cost.

As industrial activity in the oceans increases so will competition over the best resources. Who can access these resources, how rights are determined, and by whom, are all becoming increasingly important questions. Once a particular party is granted access to the resource, there are then questions as to what conditions should be placed on its use and exploitation. This is particularly pertinent to MRE as the most viable MRE resources are generally concentrated in particular locations.[17] The specific nature of MRE resources means that there will likely be competition over resources as the cost of MRE technologies falls and more companies become involved.

As to the practicability of resource management processes, there is a range of activities related to the construction of a MRE facility that require a permit or licence, or may otherwise trigger some sort of licensing procedure. In the absence of targeted reform, regulators and developers generally have to make do with a range of ill-fitting legal instruments forming a regulatory 'maze' [52]. Regulators often rely on ad hoc permitting processes, created as a project develops [53], or on legislation that was not designed with MRE in mind. The resulting permitting processes are unlikely to be fit for purpose, and are unlikely to persist from one project to the next. They give proponents no continuity or certainty and make the process onerous, expensive and time-consuming [54,55]. As such, this may be the major threat to efficient development and deployment of MRE technologies [55].

From a governance perspective, complex administrative procedures can hinder translation of high-level policy measures, such as government commitments to renewable energy and marine governance, into concrete action, such as assisting developers test MRE devices. By their nature, regulators and public bodies are risk averse,[18] and are unlikely to assume responsibility for permitting projects they perceive as risky or to give priority to new technologies [55].

O'Hagan conducted a comparative study of these processes, finding that in many jurisdictions "the consenting process for ocean energy is not yet fit-for-purpose", though progress is being made [56]. An assessment by this author of the UK's efforts, widely considered to represent best practice, concluded that "reforms are broadly fit for purpose, but that there is still scope for further optimisation of the consenting process", with political will highlighted as a key factor in achieving this [51].

5.3. Environmental impacts

Ensuring that the deployment of innovative new technologies in the oceans does not compromise environmental sustainability is one of the defining challenges of ocean industrialisation and Blue Growth. The challenge is particularly acute in relation to renewable energy as there is concern that governance processes will be relaxed in pursuit of carbon mitigation goals without accounting sufficiently for local environmental impacts, thereby causing what may be termed 'paradoxical harm' [57,58]. In this context, it is essential that the discourse on marine governance, and the literature on MRE, address the questions of how such technologies are to be approached by EIA frameworks, alongside consideration of the broader issue of how regulatory regimes can balance the demand for resources and innovation with long-term sustainability.

EIA is the primary means by which decision-makers consider the environmental consequences of proposed actions [59],[19] and is a well-developed concept in environmental law.[20] The exact nature of the process can vary, yet EIA processes are relatively uniform, generally following a series of broadly similar steps in most legal systems. Guidelines for MRE developers have been produced outlining how to navigate the process [60].

The broad range of potential environmental interactions of MRE has now been mapped out, though there remain considerable knowledge gaps and uncertainties, particularly as the size of

(*footnote continued*)
far as they pass through some or all of' renewable energy installations situated at places in relevant waters" (i.e. extending to the seaward limits of the territorial sea).

[15] Fishing quotas, quasi-private rights over living resources in the marine environment, are already traded in a quasi-market [8].

[16] http://hansard.millbanksystems.com/commons/1973/apr/30/zetland-county-council-bill. See the Zetland County Council Act 1974

[17] This is in contrast to other sources, such as wind and solar, which tend to be more spread out.

[18] A discussion of the precautionary principle as implemented by regulators in relation to MRE projects would be an interesting lens through which to discuss risk aversion, but this is beyond the scope of the current essay.

[19] EIA, as with the general notion of planning, was primarily a political response to the changing nature and scale of post-World War II development [85].

[20] Having been adopted in over 100 jurisdictions and in many bilateral and multilateral aid and funding agencies [86]

deployments grows [61–66].[21] MRE technologies suffer from knowledge deficiency on two levels, in that there is limited practical experience with the deployment of MRE technologies[22] and the marine environment is notoriously difficult to study: impact assessments in the marine environment have been called "the most challenging of all" [67]. This means that there is limited data regarding the impact of MRE devices, which remain diverse in the absence of convergence on one or two technologies, as well as a lack of baseline data concerning the receiving environment. This presents a major challenge for developers in carrying out EIA, and for regulators in approving projects.

The difficulties presented by these data gaps are compounded by under-developed regulatory frameworks and EIA processes that have not been adapted to better manage uncertainty, improve knowledge generation and better serve emerging technologies [68]. In particular, MRE developments attract a "depth of scrutiny from environmental regulators and statutory nature conservation bodies that more established marine industries such as fishing and shipping have managed to escape" [69]. The resulting time and cost is a considerable barrier to development of MRE and hinders the generation of additional environmental and technological knowledge that could advance both MRE and marine governance efforts.

In the context of imperfect information, regulatory frameworks must balance precaution and risk. Assumptions as to which takes precedence shapes regulation and can therefore be a heated issue.[23] Regulators have traditionally taken a precautionary approach, in line with long established norms of environmental law. This leaves developers to shoulder the burden of undertaking surveys and data analysis when the risk of environmental impact is comparatively low [70]. By perceiving a risk as being more likely than it truly is, the precautionary approach "threatens to be paralyzing" [71].

A risk-based approach, by contrast, aims to shift the focus away from precaution and toward the assessment and management of risk. Risk-based regulation provides a systematic framework that prioritises regulatory activities, and the scientific studies required to meet regulatory requirements, according to an evidence-based assessment of risk [72]. There are a number of ways that this can be operationalised, in particular: adaptive management permits deployment accompanied by a monitoring regime which allows the regulatory approach and requirements to be adapted over time; the 'Deploy and Monitor' approach allows a developer to deploy before having complete certainty as to impacts in order to conduct monitoring and data collection and generate new and improved scientific data [73,74]; and the 'Rochdale Envelope' approach allows a project description to be broadly defined, within a number of agreed parameters, for the purposes of a consent application [74]. In addition, strategic environmental assessments (SEA) can potentially strengthen and streamline EIA at the project level by identifying the scope of potential impacts and information needs at a higher level [74,75].

5.4. Ocean space

MRE enters an increasingly congested marine environment. Developers will not only compete with each other to gain access to resources, but will also vie for space with other marine users. Deciding which activities are to take place and where presents a huge challenge and necessitates a paradigm shift towards a more strategic model of marine governance. MSP has emerged as the frontrunner concept for meeting this need [76]. MSP is [77]:

> a process of analysing and allocating parts of three-dimensional marine spaces to specific uses to achieve ecological, economic and social objectives that are usually specified through the political process.

MSP is a future-oriented planning process that allows policy-makers to select between different marine uses and conservation measures in order to sustainably develop marine resources. Comprehensive MSP provides an integrated framework for management that provides a guide for, but does not replace, single-sector management. The principal output of MSP is a comprehensive spatial management plan for a marine area or ecosystem, though MSP is better conceptualised as an ongoing process. The plan sets out priorities for the area and, more importantly, defines what these priorities mean in time and space. Typically, a comprehensive spatial management plan has a 10- to 20-year horizon and reflects political and social priorities for the area.

MRE has not yet been one of the primary drivers of MSP processes [78], however this is changing. Offshore wind has been a driver [79], and it is likely that as MRE develops it will elicit similar concerns regarding conflict over space, perhaps even more so given the closer proximity to shore and communities. Despite an extensive literature concerning MSP generally [5,80], discussion of MRE's role and place in MSP processes has generally been limited. Usually this discussion either merely asserts that MSP is crucial for the development of the MRE industry [78,81], or considers how MSP applies to MRE on a practical level [82,83].

MSP is advancing rapidly, yet it is not be the only tool available. For example, many industrial users of the oceans are likely to require exclusive occupation of marine spaces with high resource potential. As a result, actors within these industries may prefer to be 'zoned', either outside of MSP processes, or within them, to ensure that they have this access. There has already been some debate as to the relationship between zoning and MSP that may be relevant to the MRE sector and other industrial users [84]. Nonetheless, exclusivity over resources is one of the problems that MSP is aiming to solve, whereas zoning may entrench these issues and exacerbate them.

Alternatively, the specific needs of different industries and innate preference for avoidance of conflict with others may provide sufficient incentive for 'self-zoning', though such a deregulatory step would be an incredibly bold move. The onus would then be on the developer to reach an agreement with other users, with regulatory authorities being involved only if agreement cannot be reached.

6. Conclusion

This paper set out to explore the challenges for evolving marine governance structures in an industrialised ocean, and to contribute to the growing literature on MRE in particular. It is clear that, while the discourse on marine governance has expanded and advanced over recent years, so have policies and technologies that challenge our existing conception of governance in the marine environment. The challenges are extensive.

In terms of rights and ownership, there is a need for a more nuanced discourse on trend for private rights in the oceans and how these can be managed in relation to public rights. Emerging issues, such as the status and role of 'perceived rights', provide fertile ground for such discussion. For example, what

[21] Research to date has generally studied theoretical aspects or the interactions of small-scale deployments. Real life deployments and a commercial-scale industry will likely have different interactions with the marine environment, both in type and scale.

[22] Cf. conventional hydropower technologies, where regulators can draw on over a century of experience.

[23] For example, offshore wind farm developers and regulators in the UK have had a "fiercely contested" debate over which model is appropriate [70].

may we learn from the Shetland example, or even indigenous communities?

Ongoing efforts to improve resource management need to be evaluated, both for their ability to improve management of the resource for the public good, and, from the industry perspective, for their ability to provide a smooth and consistent consenting process that can give developers the line of sight they need to create bankable projects. It would be interesting to assess whether current efforts in relation to MRE also represent a positive outcome for other developing marine industries and if reforms in leading jurisdictions like the UK can be transferred to other jurisdictions.

EIA frameworks have a long way to go in many jurisdictions, and further research into the modalities and effectiveness of innovations such as Deploy and Monitor and the Rochdale Envelope could help in advancing these. Research on EIA would greatly benefit from the involvement of planning professionals, whose experiences in project development could be applied to this new context.

Finally, there is a clear need to develop more nuanced thinking about MSP frameworks, particularly how these relate to emerging ocean uses such as MRE. How can MSP be leveraged to improve outcomes for innovative new industries, and, conversely, how can emerging industries can drive and shape development of MSP? The relationship between zoning and MSP in the context of exclusive occupation of marine space also requires further discussion.

One thread that runs through many of these questions is the need to develop research that focuses on the practical perspective. For example, the literature needs to move beyond simply asserting that comprehensive MSP should be implemented, or that EIA and consenting should be streamlined, and instead conduct the substantive research and evaluation of marine governance processes that enable useful reform to be advanced. One way to pursue this would be to focus on qualitative research into the impacts of marine governance frameworks and ongoing reforms on the industries subject to them, e.g. by consulting MRE developers regarding how broader marine governance issues impact on their decision making and innovation processes.[24]

The elaboration of a more comprehensive legal research agenda for MRE could provide a framework for advancing research on MRE and marine governance. The ISSMER agenda demonstrates a novel and collaborative method for generating such an agenda: a semi-structured workshop involving a range of actors, producing a 'laundry list' of issues subsequently organised into a coherent agenda. Indeed, a legal and regulatory research agenda on MRE would both advance and extend the ISSMER agenda, providing a more complete picture of MRE research needs. The structure of such an agenda could be applied to other case studies: assessing other industries using the same elements of marine governance elaborated here as a guide would enable useful comparisons to be made between industries and could provide interesting insights into the effects these frameworks have on different marine users.

The brief discussion here suggests that the challenges are extensive, calling into question our ability to rationally regulate ocean industrialisation in a way that balances numerous competing goals, in particular environmental protection and industrial innovation. The elaboration of a research agenda for MRE and the development of further research in this area could contribute to the evolution of effective and balanced marine governance frameworks. Such an evolution is necessary if marine governance policies are to effectively support new industries, progress the 'Blue Economy', and ensure the health of the oceans.

[24] It may be that such research has not occurred to date because in such a small industry developers work closely with regulators and may be reluctant to go 'on record' with criticism, preferring instead to simply 'make do' until the industry is sufficiently large to wield significant influence

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