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Strengthening the role of science in marine governance through environmental impact assessment: a case study of the marine renewable energy industry

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ABSTRACT

This paper explores the role of environmental impact assessment (EIA) in advancing the 'Blue Economy'. The ability of EIA frameworks to act as the interface between science and regulation and advance scientific knowledge is assessed. This paper examines how regulators and regulatory frameworks can best use available science, as well as facilitate the generation and sharing of new scientific knowledge on environmental impacts, using the emerging Marine Renewable Energy (MRE) industry as a case study. Some reforms to traditional EIA frameworks are considered. In particular this paper represents the first contribution to the literature on the 'Deploy and Monitor' and 'Rochdale Envelope' approaches to EIA. Strategic Environmental Assessment (SEA) is also considered in the MRE context. It is argued that some simple reforms to EIA processes, as well as well-planned SEA, can augment the role of science, and contribute to a supportive regulatory environment that facilitates innovation whilst also protecting the environment.

Most things become exhausted with promiscuous use. This is not the case with the sea.

Grotius (1608)

1. Introduction

As Hugo Grotius was formulating his theory of the Freedom of the Seas in 1608, the marine environment would have seemed inexhaustible. Yet 400 years on, the oceans are looking increasingly exhausted (Rogers and Laffoley, 2011). Our growing population and appetite for resources, coupled with innovation and technological advancement, is driving unprecedented exploitation of the marine environment. The resulting increase in the number and intensity of marine activities is akin to an 'industrial revolution' of the oceans (Charter, 2007; Salcido, 2008).

This trend of ocean industrialisation has also intersected with the environmental imperative to decarbonise the energy system. While this imperative initially drove the development of solar and onshore wind power, interest has now spread offshore.[1] Offshore wind is growing rapidly (GWEC, 2013; pp. 53–57), while marine renewable energy (MRE) technologies, which utilise waves and tides to generate electricity,[2] are beginning to attract considerable interest and investment (REN21, 2013, pp. 39–40). MRE is also challenging existing marine governance frameworks (Wright, 2013, 2012).

In particular, there are concerns that MRE may cause negative environmental impacts, and scientific knowledge has developed at a much slower pace than the technology and industry. While scientific knowledge is improving, there remain considerable knowledge gaps and uncertainties, particularly as the scale of deployment grows. At the same time, the regulatory frameworks that bring this knowledge to bear in decision-making have also been slow to adapt in many jurisdictions.

The MRE industry is at the intersection of various concerns and interests: it seeks to generate clean electricity to advance carbon

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[1] For the most up-to-date figures on the renewable energy deployment, see the latest version of the REN21 Renewables Global Status Report at http://www.ren21.net/ren21activities/globalstatusreport.aspx.

[2] 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.

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reduction goals, but it is deploying devices into a complex and delicate environment; it offers potential job creation and economic growth, but there remains considerable uncertainty as to the environmental impacts of the technology; it is fledgling and innovative, but faces considerable regulatory and policy challenges.

The need to balance these economic, social and environmental concerns within marine governance frameworks is encapsulated by the 'Blue Economy' discourse (UNCSIDS, 2012). The EU's 'Blue Growth' agenda, for example, notes 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" (European Commission, 2012).

Environmental impact assessment (EIA) helps decision-makers consider the environmental consequences of proposed actions (Morgan, 2012; Sadler, 1996). EIA is the main tool utilised by regulatory authorities to ensure that the environmental protection goals are met in approving projects (Sadler, 1996). EIA is also one of the key interfaces between science and regulation, ensuring that existing knowledge is well utilised and that new scientific knowledge can be generated and disseminated.

This paper provides an overview of EIA and its role in connecting science to the regulatory process, utilising two MRE case studies. The dichotomy between precaution and risk in project-level decision-making is discussed, and it is concluded that some environmental risk is desirable in order to allow for generation of new scientific knowledge. The paper then discusses three methods for better balance environmental protection with knowledge generation and innovation through the EIA process: 'deploy and monitor'; adaptive management; and the 'Rochdale Envelope'. Finally, Strategic Environmental Assessment (SEA) and Marine Spatial Planning (MSP) are discussed in the MRE context.

The paper concludes that application of EIA processes must be adapted if they are to better serve science and better balance competing goals. A risk-based EIA process is needed to utilise existing knowledge and factor it into decision-making processes, while also encouraging the generation of new knowledge. It is argued that the incorporation of the regulatory mechanisms discussed can achieve this by providing for environmental protection in the absence of complete scientific certainty, while also allowing for the generation of new knowledge through considered, risk-based permitting and deployment of MRE devices. Strategic marine governance initiatives can play a complementary role in filling knowledge gaps and providing scientific certainty regarding new technologies in the marine environment.

2. Environmental impact assessment

The first formal EIA system was established in the United States in 1970 by legislation that was primarily a political response to the changing nature and scale of post-World War II development.[3] Public interest and concern regarding the environmental impacts of development was growing, and the adequacy of existing decision-making tools was criticised (Caldwell, 1988).

EIA is now a well-developed concept in environmental law, having been adopted in over 100 jurisdictions and in many bilateral and multilateral aid and funding agencies (Petts, 1999). While the exact nature of the process can vary, EIA generally follows a series of similar stages:

1. *Screening* the proposed development to determine whether there are likely to be significant effects on the environment.
2. *Scoping* the available environmental data and key issues at the proposed deployment site. This identifies additional studies that will be required in order to make a proper assessment.[4]
3. *Baseline studies* provide baseline data on the status of the receiving environment. At this stage, studies identified during the scoping phase will also be undertaken.
4. An *assessment of impacts* will then be made to assess the significance of potential identified interactions. Options to mitigate these impacts will be considered, and any residual effects will be detailed.
5. *Environmental reporting,* whereby the proponent compiles a statement of effects and supporting documentation.
6. *Submission and consenting.* The proponent submits the statement of effects and the appropriate consent applications and supporting documentation. Consenting and regulatory bodies then undertake a determination process set out by the relevant legislation and regulations to determine whether the project is permitted, and under what conditions.[5]

EIA will form a key part of the regulatory process for MRE in most, if not all, jurisdictions. Existing EIA regulation is likely to be applied unaltered to MRE proposals. This is partly because EIA is intended to be generally applicable. However, this is also a common pattern with new technologies, which are initially developed in the context of existing legal frameworks, but inevitably elicit new legal responses as commercialisation approaches Nyhart (1974, p. 830). It is in this context that some specific regulatory responses for development of new offshore technologies, particularly MRE, are considered later in this paper.

2.1. EIA as the interface between science and the regulation

In recent years, much has been written about the role of science in EIA (e.g. Cashmore, 2004; Lemons, 1994; Morrison-Saunders and Bailey, 2003), including EIA theory and practice, and empirical studies examining the scientific content of EIA documents (Culhane et al., 1987; Malik and Bartlett, 1993). Despite widespread adoption and the considerable literature on the topic, EIA has only had limited success in advancing environmental protection and the results "appear most favourable when compared with past neglect and failings, rather than when measured against sustainable development goals" (Cashmore, 2004, p. 404). This limited success may stem from EIA's poor theoretical basis: it is a quasi-scientific process that has emerged from a political, rather than scientific, imperative, such that EIA practice began before there was adequate scientific capacity to support it (Lee et al., 1995).

Later, broader theoretical conceptualisations of EIA developed, building on evaluative research and appropriating theoretical frameworks from other disciplines (Cashmore, 2004). As a result, the theoretical underpinnings of EIA have been lamented as being an uneven mixture of science, planning, social, economic and biological theories, with the process as a whole representing much less that than the sum of its parts (Lawrence, 1997).

This lack of theoretical direction has given rise to a number of different conceptions of EIA, how it does and should operate, and the role of science in the process. The approach to the role of science EIA can be separated into two overlapping paradigms: EIA as applied science and EIA as civic science (Cashmore, 2004, p. 406). Under the former conceptualisation, EIA is a process by which objective scientific knowledge is brought to bear on practical

[3] National Environmental Policy Act of 1969 (NEPA).

[4] There may also be a formal process for engaging with consultees.

[5] These conditions will generally include monitoring and compliance, which could alternatively be viewed as a separate step in the process.

decisions. By contrast, the latter is a 'broad church' encompassing diverse opinions; the unifying belief is that EIA is a tool for "influencing decisions through the application of a pragmatic, inclusive and deliberative form of science" (Cashmore, 2004, p. 410). These categories are merely conceptualisations, rather than strict divisions, and the flexibility and adaptability of EIA is part of its appeal. In the MRE context, EIA has both relied on pure science to consider project approvals, but also drawn on the participatory nature of the EIA as civic science approach.

2.2. EIA and MRE projects

2.2.1. The current status of science and regulation

MRE technologies suffer from knowledge deficiency on two levels. Firstly, while other renewable energy technologies are well established,[6] there is limited practical experience with the deployment of MRE technologies. Secondly, the marine environment is notoriously difficult to study, with research being limited by cost, inaccessibility and relative lack of development in comparison to the onshore environment. Impact assessments in the marine environment have been called "the most challenging of all" (Smith, 2008).

The state of knowledge regarding device interactions is improving as the industry grows. The broad range of environmental interactions, both negative and positive, has now been mapped out, though often not yet thoroughly researched (Boehlert and Gill, 2008; Frid et al., 2012; Inger et al., 2009; Linley, 2012; Simmonds et al., 2010). The prevailing view appears to be that MRE technologies do not cause significant negative impacts. However, there remains considerable uncertainty, particularly from the perspective of the regulator. 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 terms of type and scale.

This lack of information affects MRE projects in two key ways. Firstly, there is little baseline data regarding the proposed receiving environment, whereas in other fields baseline data is often readily available or an established process exists for its collection. Secondly, there is little data regarding the impact of MRE devices, which is exacerbated by the lack of convergence on a particular device design.

This scientific uncertainty is compounded by under-developed regulatory frameworks and EIA processes that have not been adapted to better support emerging technologies. Huertas-Olivares and Norris (2008, p. 400) note that:

> *until now, a legal framework remains to be established in a standardised way, and in some countries the relevant legislation is still being developed or refined. More agreement on environmental legislation is needed in order to establish a coherent approach across this field.*

While some aspects of the relevant regulatory frameworks are being improved to better fit the MRE context (O'Hagan, 2012; Wright, 2014), recent commentary confirms that MRE continues to bear a considerable regulatory burden, particularly in relation to EIA. For example, Merry (2014) notes:

> *marine energy attracts 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.*

As a result, there is a shortage of relevant, reliable public information regarding MRE, resulting in an additional burden on developers who have to generate data on which to base environmental assessments. The resulting time and cost is a considerable barrier to development of MRE, while any privately collected data is less likely to be publicly available to benefit the industry as a whole (Sterne et al., 2009, p. 611).[7] This has a significant impact on the development and sustainability of MRE (Jeffrey and Sedgwick, 2011, p. 14).

2.2.2. The EIA process for MRE projects

The process for EIA in the MRE context is essentially the same as the outline set out above. The European Marine Energy Centre (EMEC)[8] has developed a set of guidelines, intended to encourage and assist developers to consider the full range and scale of impacts, which provides an outline of the EIA process for MRE projects and highlights the scientific knowledge that will have to be generated (EMEC, 2005). The precise regulatory requirements vary by jurisdiction, and will change as legislation is developed and implemented. The guidelines nonetheless provide a useful starting point.

As part of the screening and scoping stages, developers will have to identify available information regarding the proposed deployment site, while at stage 3 they will likely have to undertake baseline studies in order to describe the nature of the site.[9] This data is then used to identify all possible impacts and assess worst-case scenarios and potential mitigation options (stage 4) before compiling the documents for submission to the relevant regulatory authorities.

As the sector develops the focus of the EIA process will likely shift. In the early stages of development, environmental interactions will primarily be assessed in relation to individual devices. However, as the industry expands, the potential cumulative impacts will become progressively more important.

2.3. Case studies

The following two case studies provide a practical perspective on how the EIA process unfolds in the real world and highlights how the slow development of both science and regulation is affecting the emerging MRE industry.

2.3.1. Marine Current Turbines, Northern Ireland

Since April 2008, Marine Current Turbines' (MCT) SeaGen device has been deployed in Strangford Lough, Northern Ireland, and has generated over 3 GWh of electricity to date. As the first deployment of a commercial-scale tidal energy device, MCT is a natural choice of case study for any aspect of MRE regulation, and has already informed policy development in the UK (Keenan et al., 2011, p. 10).

Over several years, MCT proceeded through each stage of the EIA process outlined above, producing: a Scoping Report; an Environmental Statement; an EIA report; an Environmental Action and Safety Management Plan; and an Environmental Monitoring Programme (EMP).

[6] For example, regulators can draw on over a century of experience with conventional hydropower technologies.

[7] Nonetheless, some efforts to collaborate on data sharing are taking place. See, e.g. Tethys (http://tethys.pnnl.gov/).

[8] A MRE test and research centre based in Orkney in Scotland.

[9] These baseline studies could relate to a range of issues, such as determining local fish and mammal populations. At EMEC, baseline data is already available for use in EIA.

The EMP is remarkable in its extent and depth. Arguably the most striking part is the compliance and monitoring regime. This regime cost MCT £3 million over 3 years (Riddoch, 2009, p. 21). The regime involves a range of pre- and post-deployment monitoring activities, including: surveillance for and post-mortem evaluation of animal carcasses; establishment of a sonar marine mammal detection system to detect marine life moving past the turbine and enable automatic precautionary shut-down; manual shutdown when a mammal is within 50 m of the device; land-based visual surveys; and telemetry studies and acoustic data logging for harbour porpoise activity (Keenan et al., 2011; pp. 13–18).

MCT's approach to EIA represents a combination of the two conceptions of EIA previously discussed. On the one hand, MCT established a scientific working group to advise on the scientific and operational details of the EMP and mitigation measures, while a broader liaison group was established to place the scientific research in context.

The improved scientific knowledge gained through the EMP process allowed MCT to take an adaptive management approach (see below) and has reduced the company's mitigation burden in subsequent variations of MCT's SeaGen licence (Keenan et al., 2011, p. i).

Although MCT agrees that the EMP process has ensured that deployment of their MRE device is sustainable and environmentally friendly, it notes that the cost of undertaking such an intensive EIA process is burdensome and "could prove too much for future projects" (Riddoch, 2009, p. 22). This onerous process was partly due to the fact that the receiving environment was a protected area[10] and partly because it was the first deployment of its kind, necessitating extensive EIA to convince regulators that the device caused minimal impact and that the project should be permitted.

2.3.2. Case study: Crest Energy, New Zealand

In July 2006, Crest Energy applied to the local council for a range of consents to establish an array of 200 turbines on the seabed of Kaipara Harbour. The Crest Energy project underwent a lengthy process in the New Zealand court system in order to obtain consent (Wright, 2011) and provides an example of how precautionary-minded regulators may approach MRE projects.

A range of existing legislative and regulatory instruments exist in New Zealand that may apply to MRE projects (Wright and Leary, 2011); Crest Energy was the first to attempt to navigate the regulatory process. Crest followed the usual EIA process, however a number of issues were identified regarding potential environmental impacts, resulting in two hearings in the Environmental Court. These issues included: sustainable management of the MRE resource; coastal planning; impacts on marine life; impacts on fish and fisheries; and the need for a suitable monitoring regime.

In the Court's view, the effect of the project on marine fauna and fisheries was a particularly important feature of the case. Having heard extensive evidence, the Court remained concerned about the infancy of the science surrounding environmental impacts and ultimately decided that the issue was too important for it to attempt to resolve the ambiguities in the evidence itself.

Upon granting consent, the Court acknowledged Crest Energy's extensive and constructive input. However, the Court also called for: further caucusing of the experts; noise monitoring; a baseline monitoring regime for a period of two years prior to deployment; and more detailed research into the Maui's Dolphin.[11] Crest was also limited to a staged deployment of its devices, subject to a pre-defined adaptive management plan.

Similar to MCT, Crest Energy's experience was ultimately positive, suggesting that decision-makers will not reject projects simply because they are novel and scientific evidence is not yet clear. However, it is also clear that Crest bore an unusually high burden for being the 'first off the block' and due to the lack of existing scientific knowledge concerning the potential environmental impacts of their proposal.

2.4. Toward improved EIA processes

These case studies highlight a number of issues with the application of unaltered EIA processes to MRE projects. Firstly, lack of scientific certainty regarding impacts causes the EIA process to be time consuming. The implementation of MCT's EMP began in June 2005 and ended in 2011 with a final report concluding that no major impacts on marine mammals were detected in 3 years of post-installation monitoring. Crest Energy made its first application for permits in July 2006, and received them in March 2011, with ongoing scientific studies to be conducted once deployment commences.

Secondly, EIA approvals came at a considerable cost to the developers. The reporting and research requirements for EIA are expensive, with post-installation monitoring adding further cost. This is in addition to the opportunity cost incurred due to a delay in consenting and deployment.

Thirdly, the case studies highlight that the availability of suitable scientific data regarding environmental impacts will be a key factor in the regulatory process, in particular the establishment of baseline data. Fourthly, and related to the need for data, are issues with regulator capability. Regulators need to be equipped with tools to acquire scientific data relevant to policy and consenting decisions, rather than require it solely from the proponent. For example, regulators need certain data in order to set standards, monitor the receiving environment, and enforce compliance with legal instruments, including permits and licences awarded to developers. Without the appropriate resources and capabilities, this task falls to developers.

Finally, innovation may be hampered as new projects bear onerous responsibilities for generating new scientific knowledge, proving new technology and providing examples to regulators. Indeed, the final SeaGen EMP report echoes this sentiment, stating that "the SeaGen EMP provides an ambitious plan beyond what might be expected of future projects now that more knowledge is available" (Keenan et al., 2011, p. 10).

These early EIA processes are crucial because minimising environmental damage and maximising environmental benefits will inevitably attract investors and reassure governments and decision-makers who may otherwise view potential environmental impacts as a barrier (Huertas-Olivares and Norris, 2008; pp. 397–398). This suggests that each successful and environmentally benign deployment generates useful knowledge that can be factored in to the EIA process for later projects. As such, a key question is how EIA regimes can encourage the generation and dissemination of knowledge that will provide environmental and scientific certainty for future projects.

However, the completion of an EIA process will not necessarily mean that regulators will be more accepting of other projects, or that the EIA will become less onerous. The Crest Energy case suggests that continued regulator uncertainty, the scale of a proposed project and highly localised environmental conditions may still necessitate an extensive EIA process and the development of a comprehensive and detailed EMP. At the very least it seems that it is going to take more than one or two successful deployments of

[10] Designated as both the Strangford Lough Special Protection Area and a Special Area of Conservation.

[11] A marine mammal with a vanishingly small population of approximately 100 individuals, confined to a small geographic range, meaning that the death of one dolphin could threaten the survival of the entire species.

single devices to convince regulators that the appropriate level of scientific certainty has been achieved.

These case studies make it clear that EIA frameworks must be customised to better fit the MRE context. Tailoring the EIA process to MRE regulation will be a difficult balancing act; weighing environmental interactions on the one hand, with the need to develop an innovative source of clean energy on the other. In this vein, a recent report of the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea (ICP) notes that MRE technologies (United Nations General Assembly, 2012).

> *could foster increased energy security, generate employment and play a role in mitigating the impacts of climate change. At the same time, the importance of assessing and studying the impacts of [MRE], including on the marine environment, was stressed by several delegations [to the ICP].*

There are two core aspects to the regulation of the environmental interactions of MRE that must be discussed: the project-level regulatory framework and the marine governance framework within which projects are consented. This section of the paper explores both aspects.

Three modifications to the EIA process are considered below: 'Deploy and Monitor'; Adaptive Management; and the 'Rochdale Envelope'. Adaptive management is a longstanding concept in environmental law and is widely discussed in the literature, however the Rochdale Envelope and the Deploy and Monitor approaches have received little attention in the academic literature to date, despite being widely discussed and increasingly utilised within the industry. While some of these regulatory innovations are already in place in some countries, the ability to make such changes to development consent processes in practice will depend on the jurisdiction. This is a difficult issue to address comprehensively and will need to be explored on a case-by-case basis. In relation to the broader aspects of marine governance, marine spatial planning and strategic environmental impact assessment are discussed.

2.5. Project-level regulation

2.5.1. Precaution versus risk

In the context of imperfect information, two general approaches can be taken which will set the tone for EIA processes: the precautionary approach and a risk-based approach. The choice has the potential to shape regulation and facilitate or hinder industry development, and as such it is a heated issue. For example, offshore wind farm developers and regulators in the UK have had a "fiercely contested" debate over which model is appropriate (RenewableUK, 2011, p. 18).

The precautionary principle is a well-entrenched tenet of environmental law that dictates that if an action risks causing harm to the environment, in the absence of scientific consensus or certainty that the action is not harmful, the burden of proof falls on the proponent of the action to provide this certainty (Cross, 1996). Regulators have traditionally taken the precautionary approach, including towards renewable energy projects, resulting in developers shouldering the burden of undertaking surveys and data analysis when the risk of environmental impact is comparatively low (RenewableUK, 2011, p. 18).

The nature of the marine environment, coupled with the emerging consensus the MRE is relatively benign, leaves developers with the near impossible task of detecting a "relatively small change in a highly variable environment" in order to prove to the regulator that there are no significant impacts (RenewableUK, 2011, p. 18). By failing to allow for some risk, the precautionary approach leads to a potential impact being perceived as being more likely than it truly is, and thereby "threatens to be paralyzing" (Sunstein, 2003, p. 1).

A risk-based approach 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 (Peterson and Fensling, 2011).

A risk-based approach would enable existing research to be more fully accounted for, shifting the burden away from the developer by not requiring them to prove complete certainty. It also would be more permissive, thereby driving additional scientific study into impacts. There are a number of ways that this approach can be operationalised and each of the three concepts discussed below rely, to varying extents, on a move towards risk-based management.

2.5.2. The Rochdale envelope

The Rochdale Envelope approach, named after a UK planning law case,[12] allows a project description to be broadly defined, within a number of agreed parameters, for the purposes of a consent application. This allows for a level of flexibility while a project is in the early stages of development. As development progresses, further scientific study takes place, creating more certainty regarding impacts that can feed into the ultimate project design.

The Rochdale Envelope enables projects to take full advantage of the constant evolution of technologies, rather than locking in a detailed proposal at the consent application stage. This is essential to the planning process at this early stage of MRE industry development as it enables scientific advancements to be taken into account during the installation, rather than the earlier design phases.

Whereas the approaches discussed below primarily centre on the receiving environment, the Rochdale Envelope focuses attention on the generation of new scientific knowledge in relation to the technology itself. This can in turn feed into other processes, such as the classification of risk for the purposes of a 'deploy and monitor' policy.

Despite proving popular with offshore wind and MRE developers, there is little literature available on best practice use of the Rochdale Envelope approach. The Infrastructure Planning Commission has issued some limited guidance for developers (Infrastructure Planning Commission, 2011).

2.5.3. Deploy and Monitor

The 'Deploy and Monitor' approach allows a developer to deploy a device before having complete certainty as to impacts, in order to conduct monitoring and data collection and generate new and improved scientific data. This allows for existing scientific knowledge to be better accounted for: where good baseline exists data for an area, a deployment can be made with little regulatory oversight, otherwise, a survey component can be incorporated to preliminarily rule out particularly sensitive sites before proceeding with deployment (House of Commons Energy and Climate Change Committee (2012); Leary and Esteban, 2009).

This approach therefore exercises a certain level of precaution by utilising existing scientific knowledge to exclude certain sites, while also allowing deployment in other areas, thereby enabling additional studies to be undertaken. This will then provide both scientific data in relation to the technology and the receiving environment.

[12] In fact two cases: R. v Rochdale MBC ex parte Milne (No. 1) and R. v Rochdale MBC ex parte Tew [1999] and R. v Rochdale MBC ex parte Milne (No. 2) [2000].

The Deploy and Monitor approach is embodied in Scotland's *Survey, Deploy and Monitor Licensing Policy Guidance* (SDM Guidance. Marine Scotland, 2012). This is currently the only such guidance, and Scotland is apparently the only jurisdiction actively applying a deploy and monitor approach (O'Hagan, 2012). The Guidance is an attempt to turn the broad proposition of 'deploy and monitor' into something concrete that can be used by regulators to ensure sustainable deployment of devices and the generation of new scientific knowledge.

By providing for an evidence-based decision on consenting applications, the guideline ensures that existing science is fully utilised before requiring additional studies. The guideline allows a decision maker to fast-track an MRE proposal where existing scientific knowledge is sufficient to provide a suitable EIA. Otherwise the proposal is assessed for its level of risk, which depends on the level of scientific certainty regarding: the sensitivity of the receiving environment; the scale of the proposed deployment; and the risk posed by the particular technology. This risk assessment should allow more rapid deployment and therefore provide developers with the opportunity to generate new scientific information regarding impacts, without having to study every potential impact in advance to a high level of certainty.

Furthermore, where environmental data generated alerts the regulator to the need for further information regarding a particular aspect of the receiving environment or project, the guideline allows the EIA process to continue in parallel with the additional research. While the outcome of the consent application will not be determined all additional data requirements have been met, this flexibility ensures that a lack of data will not significantly slow the approval process for a relatively low risk project where there are only some discrete uncertainties remaining.

Overall, this process attempts to apply a more appropriate, proportionate and individualised approach to licensing and EIA based upon the nature and circumstances surrounding the development proposal, the level of scientific knowledge already available, and the need to improve such knowledge, rather than a 'one size fits all' approach.

2.5.4. Adaptive management

Adaptive Management is a more process-oriented concept, with a long history in the fields of conservation and resources management.[13] As uncertainty cannot always be resolved, improved management processes are needed in order to learn from actions as they progress. Adaptive Management is a structured, iterative process for making robust decisions when faced with uncertainty. It requires that all parties work together to share existing knowledge, identify scientific uncertainties, fill knowledge gaps and consider multiple mitigation options. Deployment is permitted under a monitoring regime and the regulatory approach and requirements are adapted on the basis of newly obtained information.

Adaptive Management thereby treats regulatory decisions and deployments as experiments that can be used not only to change deployment plans, but also to learn about the interaction with the receiving environment (Folke et al., 2002, p. 9). In this way, the EIA process itself becomes an integral part of generating scientific knowledge under an Adaptive Management approach. By responding to and managing feedbacks observed during deployment, instead of blocking them out at the start of the consenting process through unduly restrictive conditions, Adaptive Management has the potential to "avoid the pathology of natural resource management that threatens the existence of many social and economic activities" (Holling and Meffe, 1996).

2.6. Broader marine governance frameworks: SEA and MSP

Marine Spatial Planning (MSP) and Strategic Environmental Assessment (SEA) provide and additional overarching layer of regulation, and could potentially play a role in better incorporating science into decision-making.

The Intergovernmental Oceanographic Commission defines MSP as:

> *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 … usually results in a comprehensive plan or vision for a marine region. [MSP] is an essential element of sea use management.*[14]

MSP asks: "(1) where are we today?; (2) where do we want to be?; and (3) how do we get there?"(Merrie, 2009). Science will clearly play a key role in understanding the current status of ecosystems and the potential impacts of human activities, thereby helping to answer the questions that MSP poses.

SEA is either undertaken independently, or in the course of a wider MSP process, and is essentially an EIA process conducted at the policy level rather than the project level. The early conception of SEA was as an extension of project-level EIA, centred on the production of a written report. Later formulations instead recognised SEA as a continuous, proactive and integrated process for evaluating the environmental impacts of a policy.

SEA can potentially strengthen and streamline EIA at the project level by identifying the scope of potential impacts and information needs, addressing strategic issues and concerns related to justification of proposals, and reducing the time and effort necessary to conduct individual reviews. A key benefit of SEA in the context of MRE is that it could take some of the burden off developers. In theory, if a SEA can establish some baseline data and/or assist with device siting, developers will have to spend less time and capital developing detailed EIAs and forging a process for project approval. SEAs also have the potential to disclose licensing and consenting requirements, particularly helpful in jurisdictions that have not yet streamlined these processes or consolidated them (Huertas-Olivares and Norris, 2008, p. 400).

2.6.1. MSP and SEA in Scotland

The Scottish Government has undertaken a world-leading program of MSP in order to sustainably develop its waters.[15] Initial framework documents for the plan and a Regional Locational Guidance have been published, while consultations and further development of an eventual MSP are ongoing.

In 2007, as part of the MSP process, the Scottish Government commissioned a SEA to examine the environmental interactions of MRE, inform a strategy for MRE development, and provide a reference for regulators and stakeholders to support project-level decision-making (Edwards, 2008).

The complexity of the environment, large knowledge gaps, and limited understanding of the environmental interactions of MRE technologies necessitated a different approach to the SEA process than taken with 'traditional' SEAs on land. The SEA was essentially a

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[13] Adaptive Management is sometimes also called "adaptive resource management" in these fields.

[14] See http://www.unesco-ioc-marinesp.be/msp_faq.

[15] For the most up-to-date information on the stats of this process, see http://www.scotland.gov.uk/Topics/marine/marineenergy/Planning.

large-scale environmental baseline exercise used to provide an indication of the environmental constraints upon sections of the marine environment. The SEA therefore entered into more detail than typical SEAs. Taking the high-level approach usually used in SEAs, or reverting to a more project-centred approach, would have led to some potentially significant impacts being overlooked.

The results of the SEA were subsequently used to inform the development of planning guidance for MRE project proponents. The SEA therefore provides the Scottish Executive, as decision makers on RE developments, with an invaluable resource for ensuring that decisions about MRE are taken in an informed manner (Edwards, 2008, p. 97).

The Scottish SEA was productive insofar as it identified key areas of sensitivity, and resulted in the production of a number of relevant studies. However, although all parties agreed that data gaps were a key shortcoming and that there was an obvious need to develop a structured and prioritised research programme, the SEA did not contain any recommendation or provision for filling the knowledge gaps identified.

The Scottish Government made subsequent efforts to this effect. Shortly after the completion of the SEA, a follow-on group was formed to identify the projects that needed to be initiated and funded to work towards filing knowledge gaps. The Marine Renewable Energy Programme was established in 2011 to provide scientific input and support to policy making and licensing of MRE[16] and its Scottish Marine Renewables Research Group has completed 15 scientific research projects to date, with a further 19 ongoing and additional projects planned for the future.[17]

2.6.2. SEA in Nova Scotia, Canada

The government of Nova Scotia Department of Energy, foreseeing the potential for tidal energy development in the highly prospective Bay of Fundy area in Nova Scotia (NS), requested the Ocean Energy and Environment Research Association (OEER) to undertake a SEA process to inform the development of the resource. As with the Scottish SEA, the objective was to assess the social, economic and environmental effects of MRE deployment in the region to inform decisions regarding the MRE industry (OEER, 2008, p. 3).

One of the co-chairs of the NS SEA process notes that a high level of agreement was agreed on key issues, but that time and resource limitation precluded deeper agreement on substantive issues (Doelle, 2009). A further limitation caused by the small level of funding available is that knowledge gaps were identified, but generally not filled as part of the SEA process.

The NS SEA did however demonstrate that considerable new knowledge can be generated and shared through mutual learning. During the process, developers provided insight into ideal conditions for development of a variety of technologies, while the fishing industry provided information on local conditions.

2.6.3. Improving scientific knowledge through SEA: lessons learned

Though the experience with SEA in the MRE context is limited, the two above examples provide some lessons learned in terms of improving scientific knowledge.

Though it may be some time before the effect of the SEAs is known, the role of the SEAs in improving the science is clearly much stronger in the Scottish SEA. The NS SEA focussed much more on high-level identification of impacts, without also providing sufficient detail at the lower levels to benefit developers and encourage specific additional research. As a result, the SEA's recommendations are general in nature. By contrast, the Scottish SEA was more explicitly undertaken to identify knowledge gaps and act as part of the foundation for a much broader planning framework for MRE. As such, the Scottish SEA, enters into a much higher level of detail.

It was however noted that in NS the SEA process itself was effective at bringing to light existing research and knowledge. The NS SEA was conducted as a 'roundtable' type process, inviting various stakeholder groups to participate. Through this process, it transpired that a wide range of scientific knowledge already existed, but that this was often sector-specific, unpublished, or drawn from practical experience. This knowledge, though potentially very valuable, was therefore not yet part of the broader discussion.

A further lesson learned is the need for follow-up actions to give effect to the SEA and its recommendations. The Scottish Government has given lasting influence and effect to the SEA by initiating a comprehensive research program to fill in the knowledge gaps identified. By contrast, the NS Government has not since followed the SEA with additional research, though this may of course change as the industry further develops in this region.

3. Conclusion

The experience of the MRE industry with existing EIA frameworks suggest that substantial reform is required if the economic, social and environmental goals of the 'Blue Economy' agenda are to be adequately balanced. It is essential that innovative new marine-based technologies are supported by complementary regulatory frameworks and strong scientific evidence as to their environmental interactions. EIA can play a part in providing both. Firstly, EIA processes must do more to incorporate all available knowledge into regulatory decisions to the fullest extent possible. Secondly, EIA and broader marine governance initiatives must be a conduit for the dissemination of knowledge generated during their respective processes. Thirdly, marine governance frameworks must complement project-level EIA processes by identifying knowledge gaps and providing for the advancement of scientific knowledge.

A risk-based approach is clearly needed in order to make the best use of existing scientific knowledge and to permit deployment of devices that can generate new knowledge. The SDM Guidance provides one model for factoring in a certain level of risk in project-level decision-making, as does the experience with the Rochdale Envelope. Over time, the EIA framework can transition to one based on Adaptive Management, providing a collaborative environment in which developers and regulators can progress scientific knowledge.

The experience in Scotland and Nova Scotia with SEA suggests that a detailed SEA process can help to identify knowledge gaps and provide a foundation for this risk-based approach, however sufficient political will and funding must be available to the SEA process and follow-up action must be taken to fill identified knowledge gaps.

This paper has necessarily only provided a brief overview, and further research is required to improve marine governance structures, especially where the new technologies or industries are likely to have a small environmental impact. In particular, research is needed into the practical effects of EIA regimes on the sustainable development of MRE, and other, technologies. Further research is also required regarding jurisdictions that have begun to use some of the regulatory mechanisms discussed above to assess whether they are having the desired impact, what are the best practices in implementing them, and how other jurisdictions might successfully follow these examples.

With further research, reform, and experience with implementation, EIA processes can contribute to emerging marine

[16] See http://www.scotland.gov.uk/Topics/marine/marineenergy/Research.

[17] See http://www.scotland.gov.uk/Topics/marine/marine-environment/smrrg.

governance frameworks, advance scientific knowledge, and help progress the 'Blue Economy' agenda.

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