Title: **Integrating stakeholder knowledge through modular cooperative participatory processes for marine spatial planning outcomes (CORPORATES)**

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Highlights:

- Participatory exercises fostered meaningful dialogue across stakeholder sectors
- Innovative process for knowledge exchange facilitated equal participation
- Approach to link science with policy development and implementation

- Conceptual systems maps provide awareness of trade-offs
- Decision making tool for marine spatial planning
- Transferable implementation of meaningful stakeholder engagement

Abstract

Management of the sea is increasingly complex, riddled with uncertainty and necessitates involvement from researchers across disciplines and stakeholders from multiple policy and practice sectors. This article discusses "The Cooperative Participatory Evaluation of Renewable Technologies on Ecosystem Services" (CORPORATES) research project, which developed an innovative and practical method of linking ecological processes, ecosystem services and benefits. The research was conducted in the context of licensing decisions for offshore wind farms in the North Sea (Scotland, UK).

A set of linked, modular participatory processes were developed to foster cross-sector stakeholder engagement. It employed an exchange of ecological, legal, social, economic and cultural knowledge around marine ecosystem services. Workshop exercises included participatory mapping, benefit identification, and developing an understanding of linkages between ecosystem services, benefits, stakeholders' activities and policy drivers through co-development of conceptual systems maps of the study area.

The participatory exercises fostered meaningful dialogue across sectors and an ability to participate equally, despite initial differences in knowledge about ecosystem services. The development of conceptual systems maps facilitated productive discussion about trade-offs in relation to different policies. Reflective discussion identifies ways in which the developed processes could be integrated into future decision making.

An assessment of the approach revealed that it operationalised a post normal science framework in terms of process oversight, multiple knowledge claims, and managing uncertainty. It developed a process that linked understanding of ecosystem functioning with the creation and implementation of policy thereby creating an ecosystem approach to marine spatial planning and licensing decisions, as required by law.

This approach has extensive transferability to situations where stakeholder engagement is required to develop policy and provide feedback as part of a decision-making process. It is an engagement, outreach tool for communities and can help teach methods and processes for stakeholder engagement which enable new insights.

Keywords: marine protected areas, transdisciplinary research, decision support tool, ecosystem services, conceptual systems modelling, offshore renewables

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1.0 Introduction[1]

Managing the environmental impacts of marine activities is characterised as increasingly complex and important to society. Governments worldwide are progressively promoting an ecosystems approach to balance new development with intersecting social, economic and environmental impacts on land and sea (Alexander et al., 2015). To achieve this, it is critical for effective development of public policy to improve the link between ecological science and ecosystem services (ES) (Wong et al., 2014). As a concept, ES is an innovative and appropriate vehicle for policy and decision making at all scales and environments (Turner et al., 2015). It is also widely acknowledged that stakeholder engagement is an essential element of ecosystem-based marine management (e.g. Friedrich et al., 2020; Oates and Dodds, 2017; Ritchie and Ellis, 2010). However, although Burden et al. (2019) report that there has been an increasing international effort to better understand the diversity and quality of ES and their associated societal benefits at a local level, there is often a lack of understanding of the connectivity, dynamic complexity and biological diversity of the marine environment or the roles of marine ecosystems in supporting human well-being (Friedrich et al 2020; Jefferson et al., 2014; Mason et al 2014). Ecosystem assessments are frequently undertaken in situations that have high uncertainty, are value laden and necessitate quick decisions, situations (Ainscough et al., 2018). Finding ways for meaningful engagement across research, policy and practice is urgently needed.

A post normal science (PNS) framework provides a useful lens through which to consider engagement in such situations. This framework adopts a complex systems perspective, engages a plurality of knowledges and embraces the importance of extended peer review beyond the scientific community, including the local community and industry stakeholders

[1] Acronyms: Ecosystem Services = ES Post normal science = PNS Marine Protected Area = MPA

(Ainscough et al., 2018). A PNS approach is valuable because it helps to address the complexity of issues associated with, for example, marine spatial planning where standard approaches to knowledge generation and decision making are no longer appropriate (Douvere and Ehler 2009; European Commission, 2014). Many studies have implicitly used elements of PNS in studying and valuing ecosystem services, however, to date, few have explicitly considered ES from the perspective of a fixed PNS frame (Ainscough et al., 2018).

This paper discusses findings from the "Cooperative Participatory Evaluation of Renewable Technologies on Ecosystem Services" (CORPORATES) research project which sought to develop an innovative, practice-focused, way of linking ecological processes, ES and benefits (Scott et al., 2016). This paper additionally uses the PNS framework for a reflective critique of the process as a tool for stakeholder engagement to support effective implementation of an ecosystem services approach for marine spatial planning outcomes.

The transdisciplinary research team included ecologists, lawyers, oceanographers, economists, social scientists and policy representatives. The work was undertaken in the context of licensing decisions for offshore wind farms in the North Sea, off the East coast of Scotland, UK. The site was chosen as an example of complexity in co-location of different uses (MUSES, 2018). This included commercial fishing, tourism and recreational uses, along with the designation of Marine Protected Areas (MPAs) and a potential new use - offshore wind turbines to produce renewable energy. The multiple uses of the site generated potential conflict from uncertainty over social-ecological impact of the proposed changes. The central aim was to develop a process for exchange of ecological, legal, social, economic and cultural knowledge around marine ES, involving researchers and a wide range of public and private sector stakeholders, that could serve as a decision support tool for marine spatial planning. Using a participatory approach, we sought to:

1. map key elements of spatially explicit marine activities and biodiversity in the wider case study region that contribute to spatially identifiable provisioning, regulating and cultural ES;
2. identify locally important benefits provided by ecosystem services, considering multiple domains of evidence and values (ecological, economic, social, cultural);

3. explore the stakeholder evaluation of the impacts of ecosystem services on different scenarios of change through wind farm development, MPA designation and climate change (including their combined impacts); and
4. evaluate the knowledge exchange process as a decision support tool to improve stakeholder engagement and uptake of ecosystem knowledge in marine spatial planning outcomes, particularly in relation to planning marine renewable energy.

2.0 CORPORATES Approach

The research was designed to facilitate the implementation of the ecosystem approach in decision-making and policy development within marine environments. It aimed to provide a 'tool kit' of activities to assist policy makers, planners and decision makers operationalise the ecosystem approach. Key to this was drawing on social science methods to foster sharing of different knowledges and to co-create a conceptual systems map. This enabled a wide range of stakeholders to first share their opinions of the benefits of a real location and then explore together how human systems are interrelated with the ecological processes. The final outcome was a shared appreciation across stakeholders of the trade-offs of different policy drivers on local ES. This section describes the study area (section 2.1) and the need for a PNS approach to managing the seas from the perspective of three relevant disciplines – ecology, social and, law and policy (section 2.2).

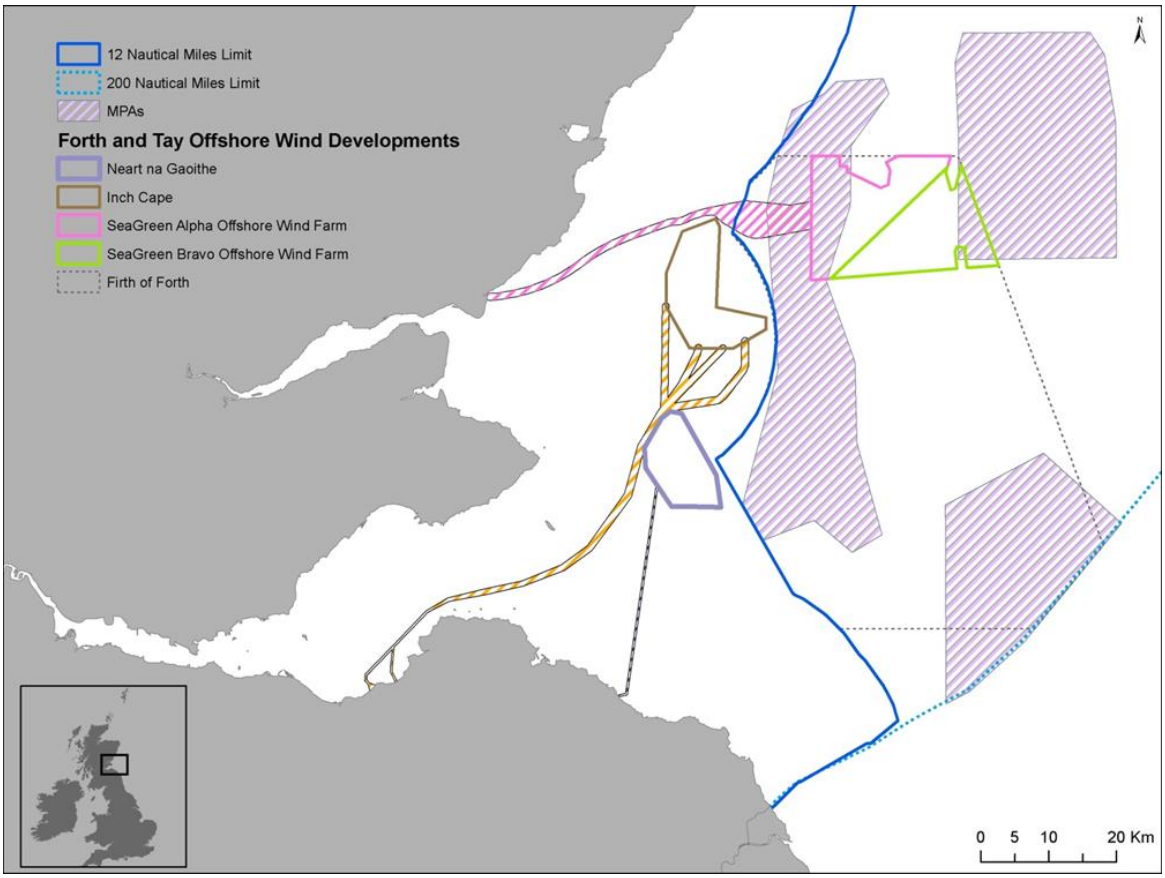
2.1 Study Area

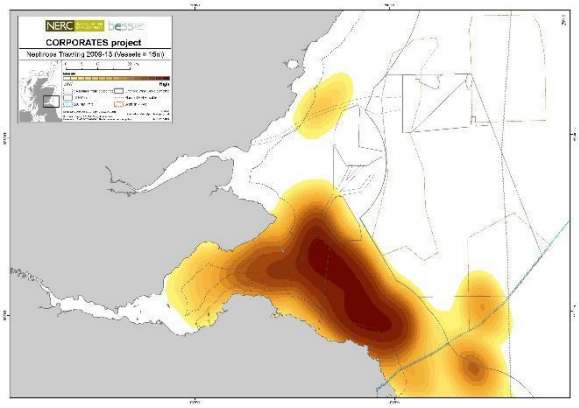
The study area is of international ecological significance as well as national economic and societal importance (Fig. 1). It includes designated MPAs (JNCC, 2019), EU Special Protected Areas (Special Protected Areas (SPAs) (SNH, 2019)) and Special Areas of Conservation (SACs) (SACs) (JNCC, 2019)). The area is intensively used for commercial and recreational fishing, merchant shipping, defence, tourism (e.g. bird watching tours) and other recreational uses, including diving, sailing and kayaking. It was also within an extensive site identified by the UK and Scottish Government as suitable for the development of offshore wind farms (Scotland's Offshore Wind Route Map 2010 and 2013).

Four applications to construct and operate large scale wind farms – Inch Cape Offshore, Neart Na Gaoithe, Seagreen Alpha and Seagreen Bravo submitted on 15th October 2012 – were still

under consideration at the start of the CORPORATES project. The combined developments would have the capacity to provide 2.284 GW of power and up to 335 turbines; a significant contribution to the UK's low carbon economy and a marked increase to its renewable energy supply (Scotland's Offshore Wind Route Map 2010 and 2013). These applications gained consent in 2014. During the project, the research licensing decisions were challenged by way of judicial review, based on procedure, science and method by a non-governmental organisation (RSPB v Scottish Ministers (2017). This was ultimately unsuccessful and new applications for revised developments to benefit from advances in turbine technology were submitted to the regulator.

a)





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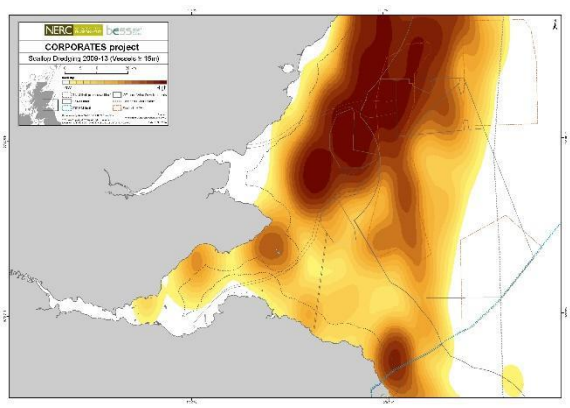

c)

Figure 1. a, b, c. a) Study location with the consented wind developments and Marine Protected Areas (MPAs), b) Nephrops trawling densities from vessel monitoring data (VMS) on vessels ≥ 15 m, c) Scallop dredging densities from VMS on vessels ≥ 15 m.

2.2 The need for an interdisciplinary approach to ecosystem services

The research commenced with detailed consideration of existing decision making and policy formulation mechanisms for marine spatial planning from the separate discipline perspectives of ecological studies, social processes, and law and policy. This enabled shared knowledge for the transdisciplinary work to collectively co-design and implement a decision support tool for marine spatial planning as an output from the research. It underlined the need to facilitate a process of oversight for marine decisions and emphasised that effective policy development required multiple knowledge sources. Furthermore, it highlighted that an extended peer assessment process is essential to manage the uncertainty of the implications of policy direction and its relationship to decisions. This examination and analysis clearly illustrated that existing processes were problematic but could be addressed by adopting the interdisciplinary developed approach. Next, a summary of this analysis through each disciplinary lens is provided.

2.2.1 Ecological Perspective

From an ecological perspective, the research was designed to develop an understanding by all stakeholders, regardless of background, of a whole marine ecosystem perspective. The main local ecological issues are typical of anthropogenic use of shelf sea ecosystems around the world, where traditional fishing areas now have a range of recently introduced protected sites (MPAs) as well as the prospect of very large-scale wind farm developments. The ecological effects of the introduction of wind farms include the possible changes in habitat, species diversity and abundance (Van der Molen et al., 2014; Cazenave et al., 2016) as well as the displacement of fishermen (Kafas et al., 2018). Additionally, within the shallow sea pelagic habitats, in which many of the ecosystem changes will occur due to wind farms, there are some locations ('hotspots') that may be more ecologically important than others (Scott et al., 2010; Benoit-Bird and McManus, 2012). Pelagic habitats are not yet as well represented in Marine Strategy Framework Directive policy (European Commission, 2008) and Good Environmental Status indicators as they should be (Dickey-Collas et al., 2017). Therefore aspects about the ecology of pelagic habitats needed to be highlighted when discussions about the trade-offs of ES effects on policy direction were debated. All of these issues also need to be put in the context of predicted regional climate change with the possible trade-offs of decreases in CO_2 emissions and the increased probability of climate stability via the uptake of large-scale developments of marine renewables.

The ecological emphasis on the interconnectedness of ES was also favoured to improve on what has become a software limited approach to policy development and decisions in the marine environment. The use of Geographical Information Systems allows information to be presented for each 'layer' of the marine system; for example, layers separately produced for species of fish, seabirds, mammals and human activities. This separation of layers has led to a lack of appreciation of how connected the marine ecosystem can be and how ES are produced. Due to all these stated factors, across a range of industries and regulators, there is a rising concern that existing marine spatial planning decision-making processes are not fit for purpose (Chambers et al. 2012; MMO, 2014; Howard, 2018). Thus, from the ecological perspective, a challenge is how to ensure that all stakeholders had the opportunity to appreciate, via participatory processes, the role that different spatial usage (fishing, protection, wind farms) of the seas could have on local ecological changes and ecosystem level effects.

2.2.2 Social Deliberative Perspective

The research conceived and implemented an output that involved engaging a range of stakeholders, academic experts and policy makers in a deliberative process to frame, identify and explore the multiple ways that society is connected to marine ecosystems. It responds to the increasing demand for participatory approaches that identify, map and value the contributions that ecosystems make to human welfare, recognising the tautology of knowledge and experience that shape the coastal domain (Damasuti and de Groot, 2019). This multi-stakeholder perspective and deliberative approach has been shaped by international conventions such as the Convention on Biological Diversity (1992) and the supplementary agreements and targets that have been developed by the Conference of Parties thereunder. For example, the Aichi Targets which were developed in 2010 (COP 10 Decision X/2 Strategic Plan for Biodiversity 2011-2020).

Under this Strategic Plan, Aichi Target 14 stipulates that "By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable" (COP 10 Decision X/2 Strategic Plan for Biodiversity 2011-2020). Key to achieving this target is to engage communities and stakeholders in a process of 'joint fact finding' that allows for a stake in identifying relevant

ecosystem services, how they are traded off and how they are to be managed (Potts et al., 2013).

Two forces have contributed to increasing social deliberation around ES and the rationale of a PNS based approach to ecosystem assessments. The first, at an international level, was the emergence of what is termed the 'ecosystem approach' being brought to the management of biological diversity, as set out in the Malawi Principles of the Convention of Biodiversity (UNEP/CBD/COP/4/Inf.9 20 March 1998). The 12 principles were then developed by the Convention in 2002 and highlight the central importance of societal engagement as the mechanism that delivers an ecosystem approach across multiple knowledge domains ((UNEP/CBD/COP/DEC/VII/11 13 April 2004). Three of the Malawi Principles are built around social engagement and knowledge domains, including Principle 1 - *The objectives of management of land, water and living resources are a matter of societal choices*; Principle 2 - *Management should be decentralized to the lowest appropriate level*; and Principle 12 –*involve all relevant sectors of society and scientific disciplines*). These universal international principles have now framed the broader development of ES strategies at national scales (Orchard-Webb et al., 2016).

The second, more structural, driving force has shaped the emergence of deliberative governance. Over the past two decades, a trend of 'collaborative governance' has emerged in public policy circles. This mode of governance shifts from centralised and adversarial forms of engagement to more participatory structures where stakeholders engage in deliberative decision making (Ansell and Gash, 2008), drawing together a plurality of knowledges often necessary when addressing complex environmental issues. Such participatory approaches have been lacking in marine planning, which tend to employ technocratic approaches that create adversarial forms of governance that can increase conflict and decision stasis (Ranger et al., 2016). Several of the mechanisms identified by Ansell and Gash (2008) for successful collaborative governance were integrated into this research including face-to-face dialogue, trust building and the development of commitment and shared understanding. In the marine environment, the use of ES as part of participatory processes is developing (Hattam et al., 2015; Friedrich, 2020), as is an adaptive stakeholder approach to participatory mapping (Burden et al., 2019). Our research, however, specifically focused on stakeholder

understanding of the social-ecological relationships with the sea to implement effective marine spatial planning outcomes in policy and decision making.

2.2.3 Legal and policy perspective

The UK has a sophisticated marine spatial planning system founded on legislation and policy (Marine and Coastal Access Act 2009, Marine Policy Statement, 2011). Devolution of powers within the UK has resulted in the transfer of specific matters, including the competence for marine management from the UK Government to the Scottish Government (Scotland Act 1998; Marine and Coastal Access Act 2009). These new powers, however, built upon existing sea use management regimes for different sectoral activities, 'the spatial allocation elements… [of which] are not insubstantial' (Smith et al., 2012) These laws are not limited to marine legislation and, depending upon the activity, they can incorporate a multitude of laws including terrestrial planning legislation, land and property laws (Slater and MacDonald, 2018).

Scotland's first statutory marine plan was adopted by Scottish Ministers, March 2015 (Scotland's National Marine Plan, 2015). Prior to this, non-statutory sectoral marine plans existed for offshore wind, wave and tidal energy in Scotland. These plans specified the 'Scottish Government policies, including their spatial strategy, to steer commercial scale offshore renewable energy development' (Scotland's National Marine Plan, 2015, p. 83 para 11.11). Although marine planning and licensing are separate processes, marine plans are implemented by decisions on various uses (Douvere, 2008; Douvere and Ehler, 2009). These decisions are based on the objectives set out in the plan but governed by existing legal frameworks that regulate the activity (Douvere, 2008). In the study area, therefore, the licensing system includes environmental impact assessment, public participation, appropriate assessment and consultation, under marine spatial planning legislation with licensing decisions made based on statutory marine plans (Slater and MacDonald, 2018).

Scottish Government policy has actively promoted the potential for offshore renewable energy due to *inter alia* the extensive shoreline and the natural conditions in Scottish waters (Wood, 2017). Marine spatial planning and offshore renewable energy initiatives have, therefore, developed simultaneously (Scottish Government, 2011a; 2011b; 2017; 2018). The system has been implemented through pre-existing and separate licensing processes and procedures. It is designed to include marine plans and policies to guide licensing decisions

which are statutorily required to adopt an ecosystem approach under the Marine Acts. This was introduced to balance extensive and complex technical and epistemic data from a range of experts and stakeholders as part of the marine spatial planning process.

A textual examination of the law and policy in Scotland revealed that although there are multiple mentions of the 'ecosystem approach' within the Marine Acts and marine planning policy documents, nowhere is the approach explicitly translated into a process (Slater and MacDonald, 2018). For example, renewable energy developments appear to be encouraged through marine plans, as the policy of promoting the offshore renewable energy and adopting marine spatial planning processes requiring an ecosystem approach, have evolved separately, but cross reference each (Scotland's National Marine Plan, 2015).

This step change in priorities and formalisation of policy can create uncertainty for existing users (Smith and Brennan, 2012), for example, by appearing to jeopardise long-standing access to fishing grounds (Jantoft and Knol, 2014). The legal process can also give the impression of non-transparent decision-making processes, resulting in increased regulation imposed through marine planning. However, marine plans are designed to provide certainty and guide developers in respect of investment decisions to areas where impacts can be managed such that these plans can also protect and conserve marine habitats and wildlife. These marine plans and the decisions based on them require effective connectivity between local stakeholders and the process of policy development and implementation. From a legal and policy perspective, a key research output was a process that effectively bridges that gap between public engagement and marine plan implementation at national and local level.

Having set out the existing processes from an ecological, social deliberative and legal / policy perspective, it is considered that these requirements for consultation and decisions exhibit characteristics that a new approach could address.

3.0 Method

3.1 Stakeholders

Stakeholders were identified as groups that had a vested interest in the study area inclusive of financial/livelihood, governance/management and personal reasons drawing from public and private sectors. An initial list drew from a stakeholder analysis for an ES valuation project

in the study area (Kenter, 2014) and individual contacts of the research team. This was expanded using internet searches and phone inquiries to increase often underrepresented sectors, e.g. recreation and tourism. The list was also cross referenced with the licence application consultation process to ensure we had representatives of both statutory and non-statutory consultees for offshore renewable developments. Most of the stakeholders, apart from some of the recreational groups, were well accustomed to the Environmental Impact Assessment process for this region. Stakeholders were drawn from the following sectors: Marine Renewable Energy, Fishery, Conservation, and Recreational/Tourism Stakeholders. Several additional stakeholders were invited due to their direct relevance to the study area (e.g. government, landowners, community groups).

3.2 Workshop Exercises

The participatory stakeholder engagement process described in this paper consisted of a set of modular activities to facilitate dialogue and knowledge exchange to inform decision making underpinned by an ecosystem approach. These were implemented through two paired workshops (30-person upper limit) set three months apart; Fig. 2 provides an overview. The five core exercises considered in this paper include participatory mapping (Exercise 1.1), benefits identification (Exercise 1.2), benefits-ES linking (Exercise 2.1), conceptual systems modelling (Exercise 2.2) and decision-making processes (Exercises 2.3 & 2.4).

These activities were accompanied by knowledge exchange ‘interludes’ on both ecological and legal issues to provide a common knowledge base for all participants. Each workshop also incorporated opportunities for stakeholder feedback - verbally during activities and in written form with an end-of-workshop questionnaire containing both open and closed-ended questions. Below we provide details of the methods for these core activities.

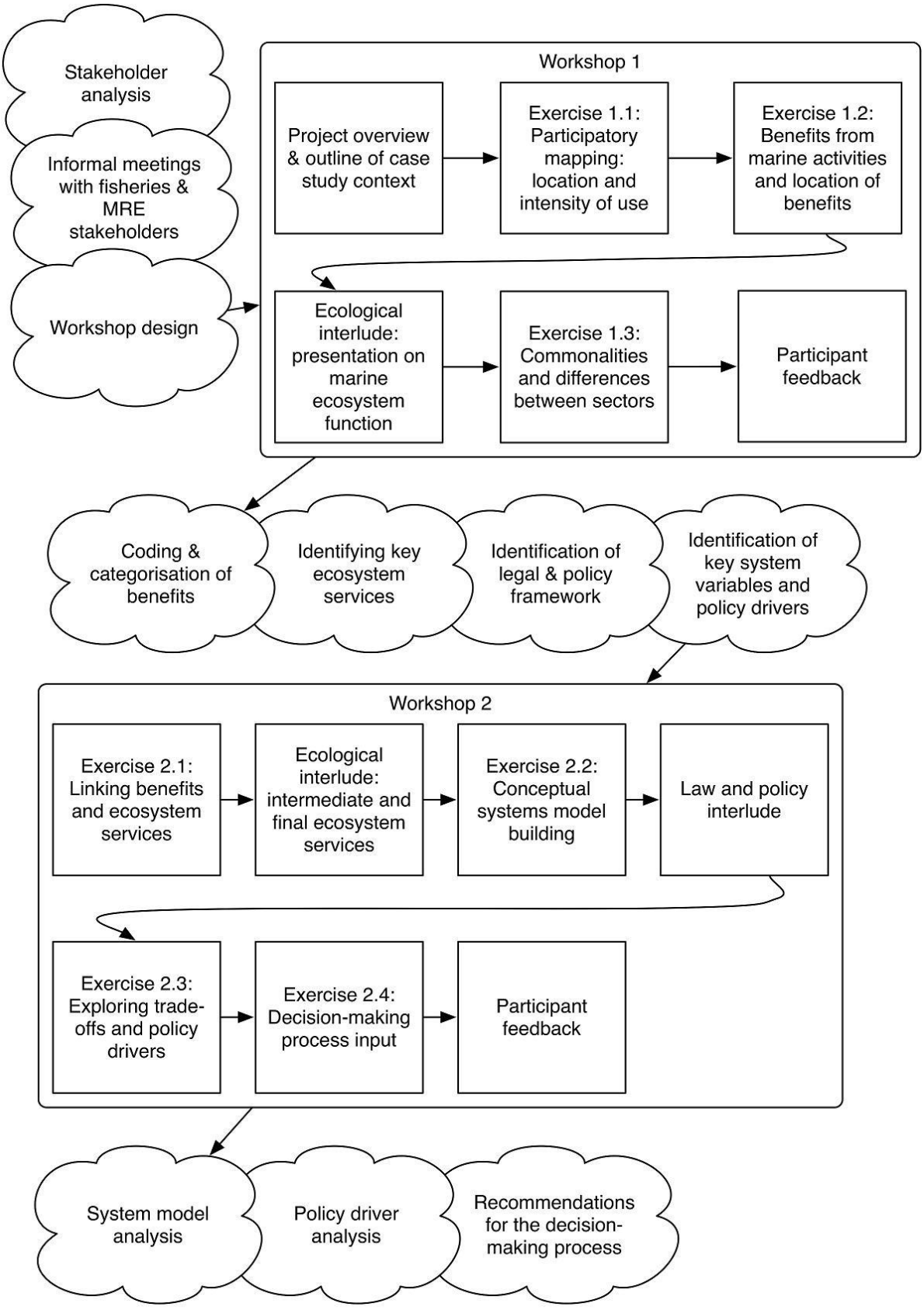

Figure 2. Details of the workshop activities (in boxes) and the 'behind the scenes' work by the research team (in cloud bubbles).

3.2.1 Participatory Mapping

Participatory mapping (Workshop 1, Exercise 1.1) was used to develop a common understanding amongst stakeholders from different sectors and to allow a sharing of their experiences and knowledge of the study area. This first exercise clustered stakeholders into three sector/interest-specific groupings: Fishing & Maritime, Recreation & Tourism (including recreational fishers), Conservation, Heritage & Community, with the addition of a Marine Renewable Energy sector stakeholder in each group. By having a within-sector discussion, and people of similar vested interest at the same table, we hoped that conversation would flow easily and go into greater detail for discussion and mapping of the important activities and locations in the region.

The main aim was to explore the location and spatial footprint of local activities by sector. Mapping included ground truthing and revising existing data, identifying additional uses of the region and providing insight on the intensity of use. A focus for the mapping process was to increase discussion and awareness across stakeholders and prepare for further mapping of benefits and interactions. Each group was provided with a hard copy of A0 admiralty charts showing the location of proposed wind farms, cables sites and MPA designations (developed from existing data for the workshop) along with supplementary A1 size maps of existing spatial information by sector. To facilitate provision of information about use intensity, stakeholders used a 5-point scale (very infrequently to very frequently). The design of this exercise is grounded in participatory mapping methods developed for landscapes (e.g. Fagerholm et al., 2012).

3.2.2 Benefit Identification

The aim of this exercise (Workshop 1, Exercise 1.2) was to identify the benefits that local stakeholders derive from marine activities. Stakeholders remained in the same sector/interest-specific groupings. Everyone wrote benefits linked to their sector-specific activities on post-it notes. Benefits were defined as important ecological, economic and cultural/social benefits and ecosystem services (i.e. the food, recreation and energy resources) that the study area provides. Stakeholders then shared their identified benefits with the others

in their group. The post-it notes were then clustered according to different sector-based activities; a process that was stakeholder led. Following this deliberation, stakeholders could add further benefits from a pre-prepared list of benefits drawn from existing literature (e.g. Irvine et al., 2013). (The list of benefits created from workshop 1: Appendix A). Stakeholders were then asked to indicate which, if any, of the identified benefits linked to particular spatial locations or habitats (using the admiralty charts from Exercise 1.1). The development of this exercise was also informed by previous participatory mapping research (e.g. Fagerholm et al., 2012), particularly those that take a more qualitative approach (e.g. Klain and Chan, 2012), and research on greenspace using participant-led approaches to identification of benefits (Irvine et al., 2013). Outputs were combined with spatial data about activities (exercise 1.1) to create updated digitized maps; this was done by the research team between workshops.

3.2.3 Benefits-Ecosystem Services Linkages

The aim of this exercise (Workshop 2, Exercise 2.1) was to promote learning about the links between the identified ES and benefits. The process enabled stakeholders to re-engage with the benefits they had identified in Workshop 1 and to contextualise the broad ES definitions into the reality of the study area. The mixed-sector groups were provided with a pre-printed A1 sheet with 3 ES (in the centre) and 12 benefits (around the edges). Stakeholders worked as a group to draw arrows to indicate how benefits link to different ES and their features. The number of links were counted and then divided by the number of benefits within the 4 main groups to create a ratio of links to benefits value.

3.2.4 Conceptual Systems Modelling

The aim of this exercise (Workshop 2, Exercise 2.2) was to develop a conceptual system map of the study area around the key ES to enable stakeholders to consolidate knowledge of the links between ecosystem services, benefits and socio-economic drivers. Each mixed sector group undertook a facilitated, participatory conceptual systems modelling process where a range of connections and feedbacks were identified, discussed and organised into a shared, co-created conceptual systems map. The process allows for a group understanding of the social-ecological system to emerge and for exploration of system connections. The emphasis was on process and learning about ecosystem services, as much as outputs. Participatory conceptual systems modelling has been used in a wide array of contexts, as summarised by

Kenter et al. (2014). This was one of the first applications to the marine renewables or knowledge exchange around marine biodiversity and ES.

To develop the conceptual systems map, the facilitator used a set of 17 cards (see Appendix B and C) depicting in words and images ecosystem services, benefits and action which were identified by the researchers drawing on output from workshop 1 and existing literature. Two cards were initially placed on the table and participants were asked to consider the relationship between them. The definitions of relationships included:

- A positive relationship (+) means that if A goes up, B also goes up, whereas if A goes down, B goes down.
- A negative relationship (-) means that if A goes up, B goes down, and if A goes down, B goes up.
- An ambiguous relationship (±) means that if A goes up, in some cases B may go up, and in others it can go down.
- An uncertain relationship (?) means that we don't know what happens to B if A goes up or down.

Additional cards were added one by one and stakeholders continued to link the cards either directly or indirectly to the others to explore how the connections between ecosystem services, benefits and actions interacted and changed in the context of the study area and how these complex systems are woven together. At the conclusion of the exercise, stakeholders were asked to consider how the four overarching benefits (derived from Exercise 2.1: local economic benefit, cultural heritage & identity, ecosystem health & resilience, personal well-being) link to other parts of the system and what they are dependent on and or influenced by. The resulting conceptual maps identified key relationships and feedback loops of relevance to the stakeholders and were used to help inform discussion about the impacts of different policy drivers (Exercise 2.3). A network analysis was also performed on the outcomes of this exercise; methods, outcomes and results can be found in Scott et al. (2016).

3.2.5 Decision Making Process

Three activities in Workshop 2 focused on decision making processes through an exploration of trade-offs (Exercise 2.3) and an evaluation of the workshops' activities as tools for decision making (Exercise 2.4). The trade-off focused activities were designed to enable stakeholders to consider how the different sectors and activities will change in response to key policy and legal drivers and how these changes will impact intermediate ES and benefits. Working in mixed sector groups and using the conceptual maps from the conceptual systems modelling process, each group was asked to explore how different activities (i.e. MPAs, fishing, wind farms, recreation/tourism) will respond to future policy drivers in conservation (e.g. EU Marine Strategy Framework Directive and Habitats Directive), fisheries (e.g. Common Fisheries Policy) and climate (e.g. Renewables Directive, Climate Framework 2030). The purpose was to advance understanding of what trade-offs are involved through increasing/decreasing an action in response to policy drivers using the group's conceptual map as a guide.

The group was then asked to consider how the discussed conceptual and broad scale issues impact upon individuals through the development of 'personal narratives'. This provided an opportunity for integration of 'first hand' ideas, stories, causes and consequences that could impact decision making, but may have been missed through the previous, conceptually-focused, exercise. Each stakeholder was asked to consider how an individual working within their given sector might respond to the drivers and trade-offs just identified. The focus for the narrative development was: How do the potential changes from these drivers and trade-offs affect this individual's activity, livelihood, values and perspectives in the short (2020) and long (2050) and how might this individual engage in decision-making? Each participant had 15 minutes to write a story of up to 1 page; narratives were then discussed within the mixed sector groups.

The final exercise (Exercise 2.4) was a focused plenary reflective discussion on the CORPORATES approach as a whole to inform the parameters of a decision-support tool/mechanism. Discussion considered: what activities should be included in decision-making process, how and at what points, and who should be involved?

3.2.6 Application of post normal science framework to the developed workshop process

A subset of the original research team undertook an evaluation of the process through a post normal science (PNS) lens. The evaluation considered the strengths, weaknesses, limitations

and lessons learnt in terms of: process oversight, managing multiple knowledge claims and managing uncertainty. Table 1 outlines the questions used in our evaluative critique which forms the structure for the discussion section.

Table 1. Evaluation Questions (from Ainscough et al., 2018)

Process Oversight ● Which stakeholders should be included and when? ● What format will engagement with and participation of stakeholders take? ● What is the degree to which stakeholders have the capacity to understand and maintain oversight of different elements of the process? ● What training / capacity building is necessary to ensure stakeholders can meaningfully contribute and maintain oversight? ● Can the process be adjusted to enhance participation? What are the constraints (time, resources, other)?
Dealing with multiple knowledge claims ● What knowledge is pertinent to this context and how / with whom is it held? ● How will different knowledge claims be validated? ● How will different knowledge types be integrated? ● What differences in understanding might exist, and how will they be dealt with? ● What knowledge will be excluded (e.g. due to constraints in scope, time, resources, capacity)? ● What assumptions are made when answering these questions, how can they be made transparent to all involved?
Managing uncertainty ● What level of technical and epistemic uncertainty exist? ● How are these types of uncertainty addressed within the process? ● What trade-offs result from the chosen research design? ● How can uncertainty and trade-offs be made transparent to all involved?

4.0 Results

Figure 3 provides an overview of the four core workshop exercises discussed in this paper which informed the fifth core exercise focused on decision-making processes. It identifies the key outputs, possible advantages and potential application for each exercise as derived from the implementation of and feedback about the CORPORATES process.

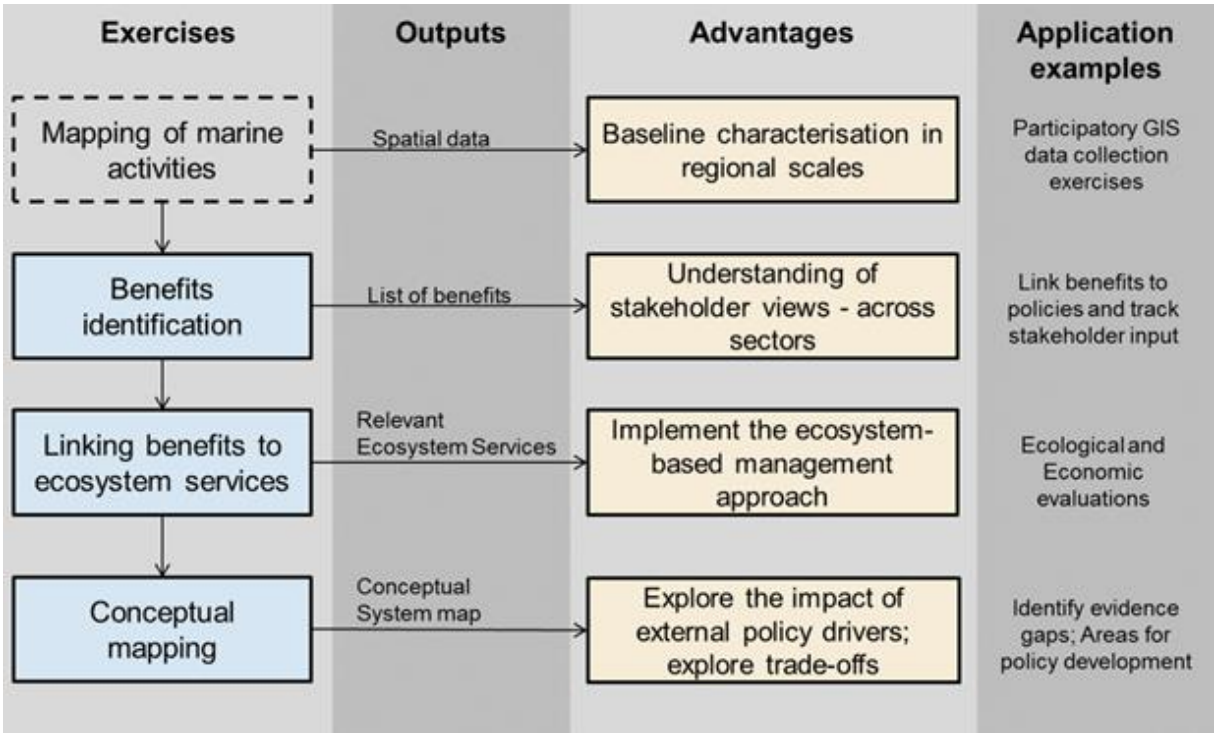

Figure 3. Overview of main workshop activities and their outputs and uses

4.1 Participatory Mapping Results (Workshop 1, Exercise 1.1)

The within-sector groups generated detailed maps and rich discussions on data missing from existing and official maps and why it was important. The expectation that clustering stakeholders of similar vested interest could facilitate conversation and deep engagement was supported by the outcome of this exercise. Information about the spatial location and the importance of location for specific activities was combined with the spatial data about the intensity of activities, to create updated digitized, electronically available maps.

4.2 Benefit Identification (Workshop 1, Exercise 1.2)

Each stakeholder group generated several sector-specific benefits with, unsurprisingly, overlap within the group. Detailed discussion occurred around efforts to spatially locate benefits within the marine environment and identify the importance of place. Some benefits were considered place-specific (e.g. the 'high' one gets from a specific dive location) while others were less so (e.g. the generational sense of identity from commercial fishing). Data on the relative importance of particular places for benefits, were combined with spatial data from the participatory mapping exercise (exercise 1.1) into a single representation for the sector groups (as an example see Fig. 4).

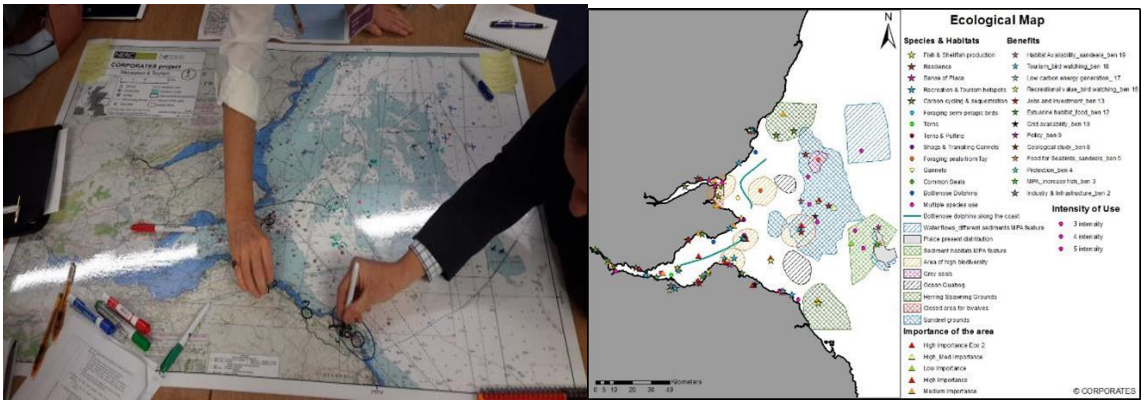

Figure 4: Stakeholders identifying location of sector-specific activities (left) to incorporate their knowledge onto existing spatial information for the study area. Intensity of activities and the specificity and relative importance of particular places for benefits were combined across stakeholder groups (right: NGO and Conservation output example)

Stakeholders generated 100+ benefits in their sector-specific groups (see Appendix A for a list of all identified Benefits). The compiled list was briefly shared between sectors to identify commonalities, however, the sheer volume precluded substantive discussion. Between workshops, the researchers clustered the identified benefits into a set of 12 categories, which were further summarised to four benefit domains: Local Economic Benefits, Cultural Heritage & Identity (which includes Social Bonding), Ecosystem Health & Resilience and Personal Wellbeing from Nature (see Fig. 5).

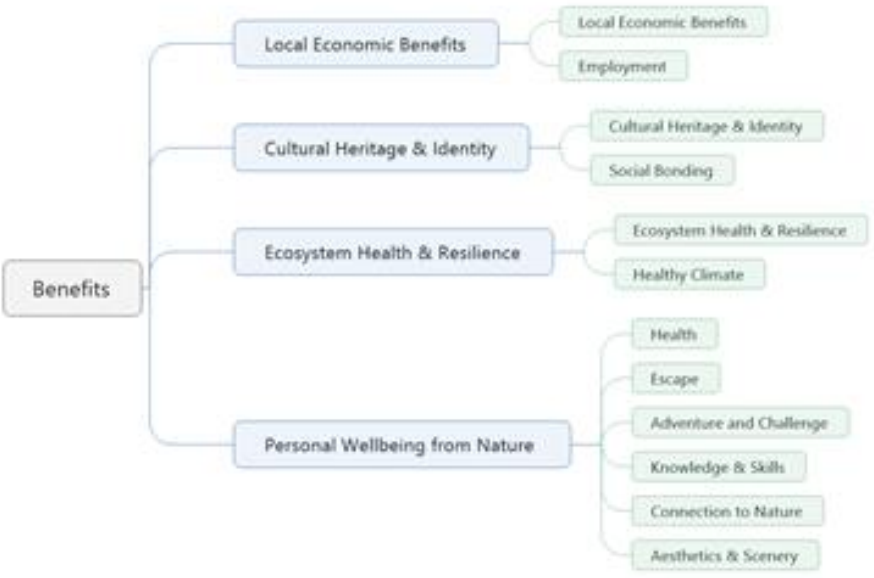

Figure 5: Diagram showing how the benefits were grouped under 4 domains; Local Economic Benefits, Cultural Heritage & Identity (which includes Social Bonding), Ecosystem Health & Resilience and Personal Wellbeing from Nature.

Further analysis assessed how the different stakeholder groups valued the four benefit domains by tracking which sector suggested each benefit. Stakeholders were clustered into the following sectors: Fishing/Maritime, Renewables, Recreation & Tourism, Conservation & Ecological (Human) and Conservation & Ecological (Animal). The sub-categories within the Conservation & Ecological sector indicate that the benefits were identified from the same conservation groups but differentiated as benefits directly to humans or directly to animals. Figure 6 illustrates the relative percentage of interest that sectors had within the 4 benefit domains; this information was shared with stakeholders at the start of the second workshop.

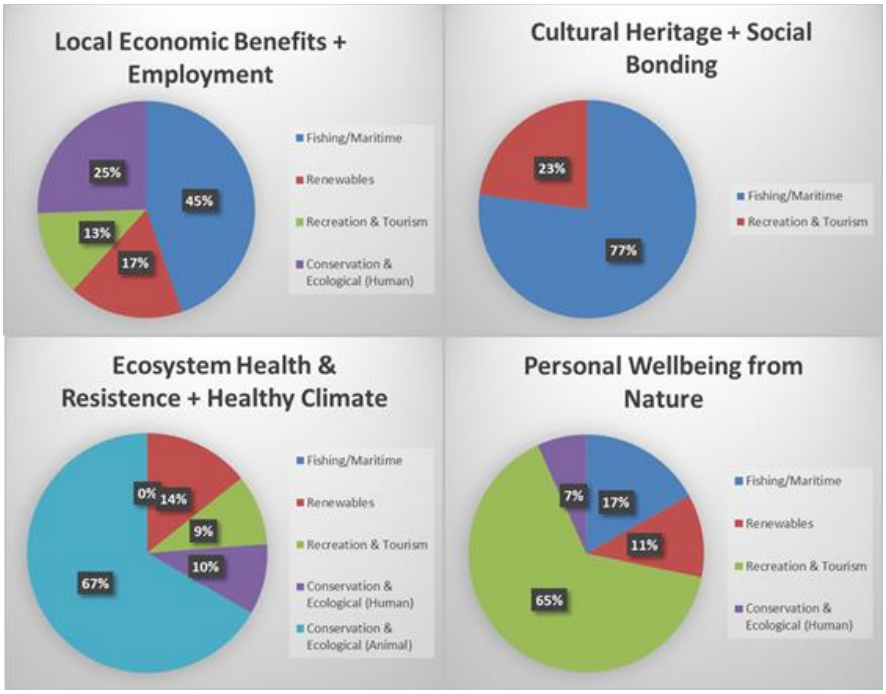

Figure 6. Pie charts showing the number of benefits in the 4 main categories, in percentage, that each stakeholder sector group identified as being of interest. The percentages were standardized for the number of people present in each sector group.

4.3 Benefits-ES linkages (Workshop 2, Exercise 2.1)

The UK National Ecosystem Assessment Follow-On (Albon et al., 2014) was used to define the terminology for ES in the workshops. We identified three ES important for the study area as: Fish and Shellfish, Climate Regulation and Places and Seascapes. For the latter, we also identified 4 relevant Features (Degree of naturalness, wildness and vastness, Habitat diversity, Species diversity and Number of cultural/historical features).

The overall results of quantifying linkages between benefits and ES (Fig. 7) show that stakeholders considered that all three ES were important in all the four summary benefit groups. There is nearly equal use of all three ES in local economic and employment-oriented benefits. Almost all the linkages between cultural heritage and social bonding are nearly equally split between Fish and Shellfish and Seascape. Ecosystem Health is predominantly linked to climate regulation and Personal Wellbeing is predominantly linked to Seascape.

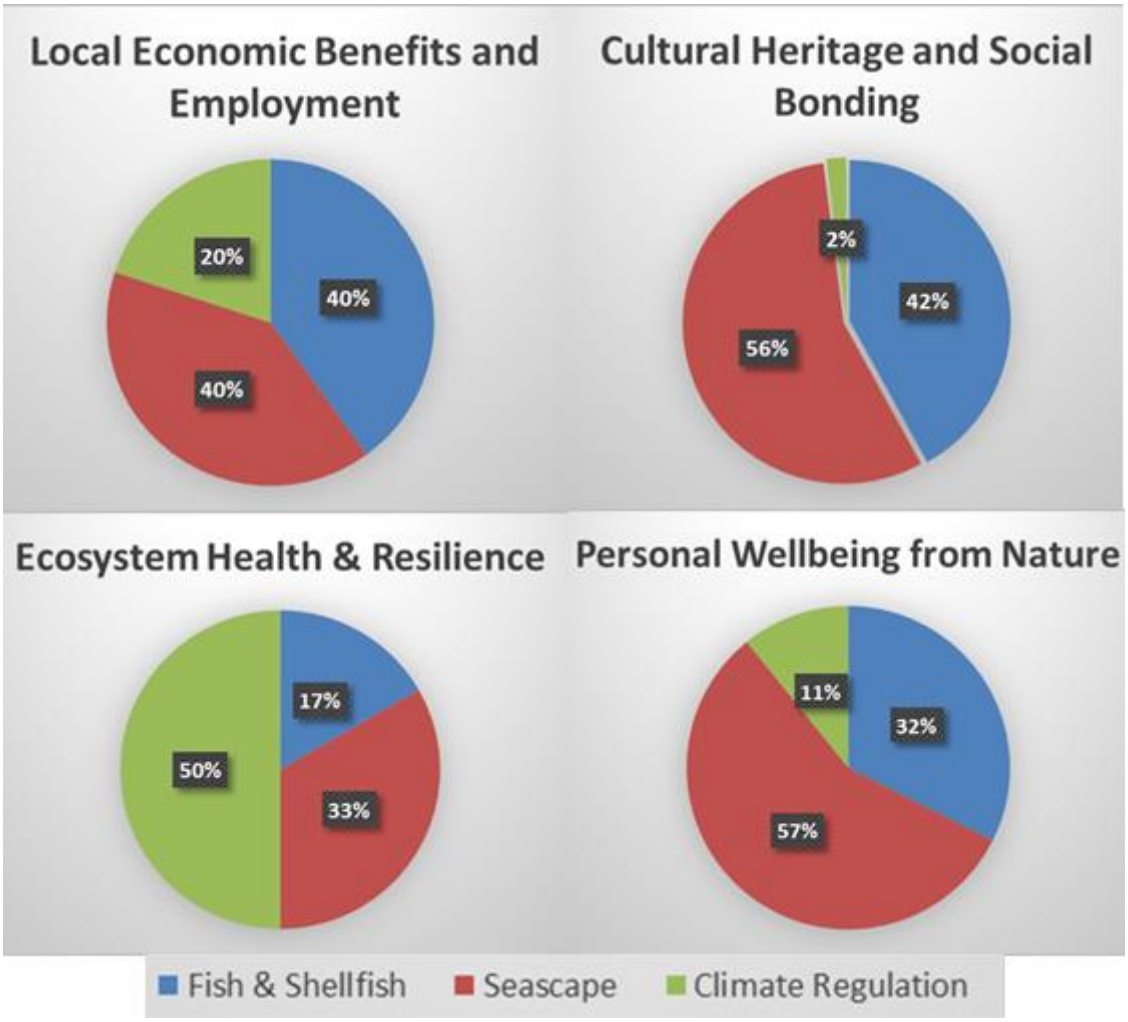

Figure 7. Pie charts showing a comparison of the percentage of links drawn by stakeholders associated with one of the 3 ES (Fish & Shellfish, Seascape and Climate Regulation) and the 4 summary benefit categories.

Cultural Heritage and Social Bonding ES received the most links per benefit category (Fig. 8) with a total of 50 links with 2 categories of benefits, the ratio value was 25. For Personal Wellbeing from Nature, there were 74 links from 6 different benefits, therefore, the ratio was 12.3. Local Economic Benefits and Employment had 30 links, with a ratio of 15 and Ecosystem Health and Resilience had 12 links, with a ratio of 6.

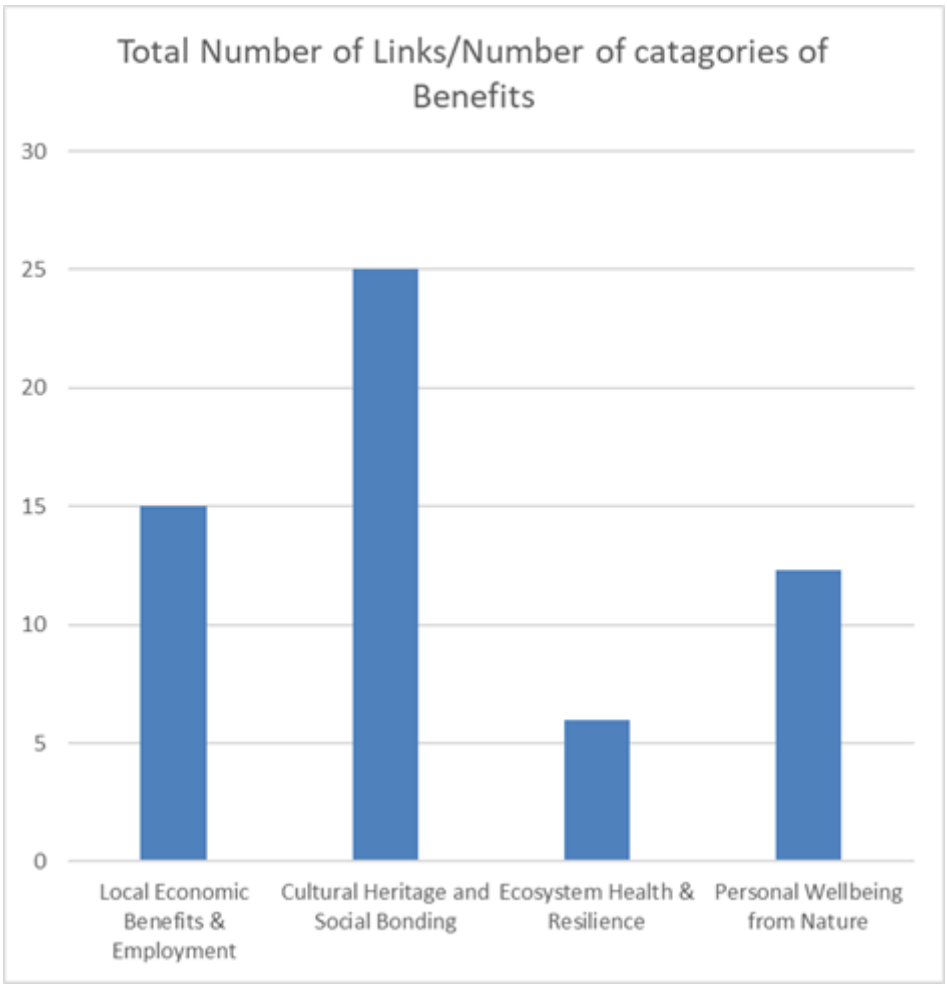

Figure 8. Ratio of links to benefits. The total sum of numbers of links divided by the number of benefit categories is presented to show which ES has the most links to benefits ratio.

4.4 Conceptual Systems Modelling (Workshop 2, Exercise 2.2)

The exercise produced a range of material outputs, including the conceptual systems maps (Fig. 9), data for network analysis (Scott et al., 2016) and outputs that relate to social learning of social-ecological relationships between ES, benefits and actions. The conceptual systems maps produced highlighted the complex and detailed interactions in the study area and increased stakeholder awareness of these interactions.

The participatory conceptual systems modelling outputs highlighted the range of interactions between different services, benefits and actions and the coupled nature of both the social and ecological aspects. This exercise consolidated concepts introduced during the knowledge exchange 'interludes', and built upon the benefits and ES conversations, further improving knowledge of the mechanisms of ecosystem services. It was considered essential for both group and individual learning before tackling the next decision making activities that explore how activities (MPA, Fishing, wind farms, Recreation/tourism) may respond to future policy drivers and what type of trade-offs may need to occur. This exercise was particularly intensive and required considerable focus and energy from the stakeholders, which had ramifications for participation in the remainder of the workshop exercises.

Figure 9: The conceptual maps produced as a result of facilitated mixed sector stakeholder participation.

4.5 Decision Making Process (Workshop 2, Exercises 2.3 & 2.4)

4.5.1 Trade-offs and Policy (Exercise 2.3a)

Each mixed sector group used their conceptual system map as the basis for considering the impact of a specific policy area (i.e. conservation, fisheries, climate change) on the different elements in the social-ecological system. Unsurprisingly, given that each group focused on a different policy driver, discussions between groups diverged. However, a commonality was the recognition of impacts, not only on the sector at which the policy was aimed, but also on how sector-specific policies might affect other sectors. An example here was the erection of offshore wind turbines which was identified as having negative effects on both fisheries and tourism in the short term but potentially positive effects in the long term.

An additional recurring issue across the groups was the uncertainty that accompanies the introduction of new policies. New policies can create problems in relation to investments and efforts to comply with existing policies, and uncertainty regarding the exact details and the implementation can in itself be problematic. For example, uncertainty regarding proposed changes in the EU's Common Fisheries Policy were recognised as having a negative impact on the fishing industry, resulting in people leaving the sector. In one of the groups, the conceptual systems map formed the basis for unpacking how individual items within the system (e.g. fishing catch, tourism) would likely be impacted by the policy being considered.

While this venture engendered a degree of confusion and difficulty, as a whole, the discussions and insight generated through this exercise was rich and detailed. This may reflect the emphasis on exploration of linkages and relationships that was central to all activities in Workshop 2.

4.5.2: Individual Narratives of Future Changes (Exercise 2.3b)

This exercise provided an opportunity for stakeholders to contextualise the conceptual systems map into the reality for individuals and their interests. Narratives were, unsurprisingly, varied in content and focus. One commonality voiced in many of the narratives was a recognition of, and concern over the effect of, the numerous, varied and seemingly disjointed character of existing policy and law contexts. Several such observations are noted in Table 2.

Table 2. Comments from stakeholder narratives reflective of the concern over a context with a plurality of policies, laws and budgetary frameworks.

Policy/regulatory drivers in Scotland are very disjointed… Regulatory processes are reactive, largely change coming too late – failure to understand a need to learn from terrestrial planning process [Marine Renewable Energy sector]

No coherent management of several policies may lead to "consultation fatigue" and confusion as to how all of the various policies will fit together. [Additional Relevant sector]

Progress on both environmental and conservation issues and on (sustainable) development are hampered by bureaucracy and at the moment it feels like bureaucracy is going off the roof. [Conservation sector]

Policy should seek to drive these by being coherent…we are being snowed under by consultations after consultations. [Fisheries sector]

Finance cuts mean consultations being reduced to minimum. [Community sector]

An exemplar comment provides insight into how a more joined-up policy context might facilitate a different scenario:

> *Existing dysfunctional regulation currently leading to marine spatial conflict – more integrated regulation would promote marine spatial planning - better use of the total resource (for everyone!)* [Fishery sector stakeholder]

Additionally, present in the narratives is a sense of passion and commitment. Two examples of this include:

> *Personally, I am long past retirement age but feel I can contribute to the future of the industry I have been part of for almost 60 years…*[Fishery sector stakeholder]

> *We are at an historic juncture in the development of sustainable marine conservation and planning systems for Scotland's seas. A fundamental question from the perspective*

of myself (both individually and professionally) is the degree of ambition of the various processes: MPAs and marine planning. [Conservation sector stakeholder]

An additional dimension present was that of trade-offs, both in terms of what contributes to the decisions (i.e. '*outcome of trade-off discussions depends on the scale, particularly temporal scales at which benefits are evaluated*' [Conservation sector stakeholder]) and the potential for win-win solutions. This latter notion is illustrated by the following two comments:

For me, this is a mixed/complex picture - but we need to see the big picture (spatial plans) to see where (maybe) different activities can exist [Community sector stakeholder]

Opportunities to co-exist are being missed [Marine Renewable Energy sector stakeholder]

4.5.3 Decision-making Process Input (Exercise 2.4)

The plenary discussion identified a number of salient issues associated with the relevance of the workshop exercises for decision making going forward. Table 3 identities which activities they felt should be used in future marine spatial planning.

Table 3. Suggestions from reflective plenary discussion with stakeholders for which workshop exercises to include in decision making for marine spatial planning. Numbers in brackets refers to workshop exercise.

Workshop Exercise	**Comments**
Participatory mapping [1.1]	*Good to gather spatial evidence as the first thing.*
Benefits Identification [1.2]	*Gathering of spatial evidence of Benefits.*

Benefits-ES linkages [2.1] Conceptual systems modelling [2.2]	*Introduction of the ecosystem services framework. It is potentially the way forward*. *There is always the trade-off on balancing between the benefits to society and benefits to individuals with recognition that benefits to a community are not evenly distributed.*
Ecological and Law/Policy knowledge exchange interludes	*[these] highlighted the uncertainty and complexity of the situation.* *Uncertainty needs to be included as uncertainty in one sector increases so too does uncertainty in other sectors.*
Conceptual Systems Modelling [2.2]	*It was good qualitative exercise. However, in order for it to be useful and allow decision makers to use, it has to be quantitative and interactions between nodes should be modelled.*

Additional general observations included: the need to '*start now as marine spatial planning is very sectoral and socio-cultural aspects are missing'*, the applicability of the approach to the development of ecosystem-based plans for regional marine planning, and the 'overall view' of the multiple linkages across drivers (e.g. MPAs, climate change) and sectors that the outputs from exercises could provide.

With respect to who should be involved, stakeholders emphasised bringing different sectors to work together and the importance of including government departments, 'as they are not listening / talking to each other', and smaller companies. Lack of time or resources were noted as potential barriers that need to be addressed to enable representation from the latter.

An overall comment about the way in which the exercises 'fit together' is illustrated by the following observation made during the discussion:

[There is] too much consultation and not enough actual engagement (listening): listening to stakeholders and trying to find solutions was a two-way process [with this one].

5.0 Discussion

In the discussion we use the post normal science (PNS) frame to evaluate the strengths, weaknesses, limitations and lessons learnt from testing the developed participatory approaches in the workshops. We specifically consider process oversight, managing multiple knowledge claims and managing uncertainty as per Ainscough et al. (2018).

5.1 *Prerequisite assumptions*

A prerequisite for a PNS evaluation included an examination of the assumptions made by the research team (Ainscough et al., 2018). In addition to the normal assumptions for any 'real-world' study: high levels of uncertainty, multiple stakeholders with conflicting interests and a policy / decision-making relevance, five additional assumptions were present that concentrated around the role of shared knowledge development. These include:

1) An assumption the research group members were professionally experienced at stakeholder engagement and that collectively there would be the knowledge and expertise to identify appropriate representative stakeholders for the workshops.

2) An active exchange of knowledge between stakeholders would result in integration of knowledge.

3) Stakeholders identifying benefits together would result in a shared starting point for collaboratively developing the conceptual systems maps.

4) The research team members were 'speaking the same language' when using the same words and terms (e.g. benefits); it became clear that a shared taxonomy was required for clarity and to enhance understanding both within the team and for delivery of the workshops.

5) The research team members were all familiar with the ES framework as a starting point for the research. This was also challenged as there were divergent levels of knowledge on various aspects of the ES framework. The research process therefore incorporated an ongoing and

iterative process to share knowledge and understanding between each other to ensure effective development of the stakeholder engagement process. The role of shared knowledge development clearly emerged from the PNS evaluation.

5.2 Process oversight

5.2.1 Which stakeholders should be included and when?

An essential starting point for development of the approach is to include all stakeholders familiar with the issues, representing the relevant sectors and with an ability to commit to the two-workshop design. Pre-workshop meetings with commercial fishing representatives and marine renewable energy developers were organised to facilitate commitment. Stakeholders were identified who would have the experience and background to appreciate the process, which was developed to specifically encourage transdisciplinary co-creation and interpretation of information for, from and with stakeholders. Training on ES was provided as part of Workshop 1 and the expert knowledge exchange 'interludes' (on ecology and law / policy) provided a shared awareness of specialist information. There was also a requirement amongst research team members to agree a shared language and to develop capacity in applying the concept of ES.

5.2.2 What format will engagement with and participation of stakeholders take?

To assess the level of engagement and participation, the research team role-played the workshop exercises as part of the development process. The output from this was a modular process to enable the workshop exercises to stand alone, yet also build upon one another (see Fig. 3 above). This was especially relevant for the conceptual system map development (see section 4.4) to inform discussion about policy and decision-making (see section 4.5).

Exercises from Workshop 1 (see sections 4.1 and 4.2), which generated a set of collectively identified and geographically mapped benefits from ES (see Fig. 4 above), resulted in positive responses from stakeholders. This feedback, via the plenary reflective discussion and feedback questionnaires, provided reassurance to the research team for the subsequent workshop.

5.2.3 What is the degree to which stakeholders have the capacity to understand and maintain oversight of different elements of the process?

A level of mutual trust and respect was reflected in the stakeholder groups through an open and free flowing exchange of ideas, as well as the shared engagement with difficult processes in subsequent aspects of both workshops (see sections 4.3-4.5). Workshop 2 consisted of a smaller subset of the same stakeholders. Eight people representing recreation and fishing groups did not participate in the second workshop, citing time constraints due to it being scheduled during a busier period for work than the first. Workshop 2 commenced with a reminder overview of the research. Its exercises incorporated material generated in the first workshop which had been analysed by the research team. For example, the identified benefits from ES were thematically classified into 12 categories which were distilled to three important local ES (see section 4.2, Figs. 5 and 6). This condensing of benefits enabled participants to undertake the benefits-ES linking activity (see section 4.3, Figs. 7 and 8). This coupling of activities across the two workshops provided valuable process oversight for the stakeholders and was further enhanced by the two knowledge exchange 'interludes' on intermediate and final ES and key aspects of the law for the development of marine spatial planning policy and decision making. These steps allowed all participants to appreciate how their information was used. It also facilitated a readiness to move to the more involved exercise, the conceptual systems modelling (see section 4.4).

5.2.4 What training / capacity building is necessary to ensure stakeholders can meaningfully contribute and maintain oversight?

The task and responsibilities of the workshop leader and the facilitators have been identified as crucial (Kenter et al., 2016; Devente et al., 2016). In this research they provided scripted explanations to the stakeholder groups, prepared prompts to ensure general understanding at key stages and kept discussion within the established scope and timeframe for the exercise. This facilitated the initial participatory mapping and the subsequent development of the conceptual systems map. A large proportion of both workshops consisted of small group discussions, facilitated for inclusivity.

5.2.5 Process Oversight: Strengths

The research was predicated on the philosophy of shared learning and an atmosphere where all groups could work well together. This was identified as developing linkages between science and stakeholder's local knowledges. It was essential that the format ensured the

researchers were thinking 'back', in other words, reviewing the process as it emerged from theory into practice and amending and adapting the activities for and content of both workshops.

To this end, in terms of process oversight, a main strength of the approach was that it produced effective participation. It provided a forum for mixed sets of stakeholders to actively engage. Additionally, the approach was recognised as a way to apply the ecosystem approach practically and fruitfully. For example, an experienced environmental impact assessment practitioner stated: '*never thought about it this way before.'* Another key strength was the workshop modular exercise approach. These facilitated co-creation and interpretation of information that allowed shared learning and embedded multiple voices into the process. Other strong points were identified as ES training and the development of a shared language amongst the wider group.

The post-workshops questionnaires revealed that attendees found the format and content of the workshops useful to share knowledge and, although some indicated a prior familiarity with the ES concept, the majority considered that the activities contributed to their knowledge. One stakeholder commented: "*It increased knowledge of what other stakeholders value and the complexity of the interconnections. To recognize the interconnectedness of services, activities and benefits, leading to the recognition that trade-offs are a likely component in decision making*". However, another recognised that "*building a conceptual model is a powerful tool provided all participants have the same understanding of exactly what is meant by the components, flows and impacts.*"

5.2.6 Process Oversight: Weaknesses

Limitations in terms of the process oversight were identified as: the need to develop a shared language and the resource demands in terms of stakeholder's time (two 1-day workshops) and staffing and finances. The lessons learnt, in terms of the workshop organisation include seasonal timing was critical for stakeholder involvement; stakeholders would have liked more pre-workshop information; and less time between the workshops could have maintained momentum. Reflection on the lessons learned recognised that trained facilitators were required to ensure equal say between sectors with enough time and/or prompts to enable evolution of ideas. The importance of defining terms was a clear lesson both within the

research group and for the stakeholders as considerable time was spent addressing the lack of a shared and agreed vocabulary, with some talking at cross-purposes. Effective and efficient scribes were also essential to capture the detail of the discussion, as key data for the basis of the conceptual systems map and to ensure representative conclusions.

5.3 Dealing with multiple knowledge claims

5.3.1 What knowledge is pertinent to this context and how / with whom is it held? How will different knowledge claims be validated?

This process engaged researchers and stakeholders from a range of disciplines with enough individual expertise and familiarity with issues in the study area to contribute effectively. Identifying and ensuring attendance and 'buy-in' from relevant stakeholders is an important – and critical – first step. The stakeholders also questioned and challenged the information presented in the knowledge exchange 'interludes'. The cross-sector group exercises allowed an extended peer community to draw conclusions on the combined scientific and local knowledges, including uncertainties. This consensus-based process meant that any knowledge-based claims and conclusions had to be validated by all group participants.

5.3.2 How will different knowledge types be validated?

A key aim for the project was to integrate different knowledge types via engagement between researchers of different disciplines and public and private stakeholders. A mixed set of stakeholders is essential for group assimilation of knowledge from differing perspectives. It was noted in feedback from a participant that the separate sectors were not only in the same room, but they were in the same room and engaging with each other, which does, "*not usually happen as part of regular public participation processes*". The different knowledge types were also integrated by actively working across sectors, as much of the workshop utilised mixed groups. The focus was on real engagement between stakeholders by undertaking a mixture of activities, not just talking. A shared vocabulary around ES was provided to ensure common understanding for all involved.

5.3.3 What differences in understanding might exist, and how will they be dealt with?

Differences in understanding clearly existed between researchers and stakeholders, as *a priori* they were deliberately chosen due to their different backgrounds, experience and depth of

knowledge about relevant aspects of living, working and developing in and around the study area. Differences in understanding within the research team were addressed through extensive online and in-person engagement in pre-workshop and ongoing team communication. The overall aim was for a communicative rationality between experts, policy makers and civil society, with a common goal to manage a specific marine and coastal environment. Differences between stakeholders were dealt with as an active process throughout the workshops in the following ways:

1. Each category of stakeholder was present within each group for all viewpoints to be represented;
2. Everyone 'had their say' by leaving enough time for discussion and utilising 'prompts' for positive evolution of ideas for the group as a whole;
3. After Workshop 1, all data were interrogated to ensure that any differences in understanding was addressed through the facilitation, presentations and knowledge exchange 'interludes' in Workshop 2, which was designed to bridge and reduce differences in levels of knowledge about the study area;
4. Effective facilitation of the workshops as a whole, as well as of the individual groups, ensured any differences in understanding were addressed immediately; and,
5. Workshops were designed to include active participation to draw out individual stakeholders' expert knowledge. The provision of an appropriate environment for all stakeholders to be part of a shared learning experience enabled a step by step approach through workshop exercises and the co-creation of the conceptual systems map.

5.3.4 What knowledge will be excluded (e.g. due to constraints in scope, time, resources, capacity)?

An analysis of the process identifies four specific constraints: scope, time, resources and capacity. In terms of scope, the process was developed and constrained around ecological interactions. While social and economic implications were an important point of discussion, a formal social impact assessment or economic evaluation were not conducted. The research did not extend to detailed consideration of multiple scenarios or options that could be compared. The focus was on understanding the interactions with ES.

In relation to time constraints, some stakeholders did not attend the second workshop. Their knowledge was, therefore, excluded from the development of an understanding of the social-ecological relationships in the study area. Regarding resources, a constraint might have been that the participants were not paid an incentive to attend, potentially reducing participation. Issues of capacity were addressed through the make-up of the transdisciplinary research team, by identification of the wide range of stakeholders, and through the structure and design of the workshops and the knowledge exchange activities.

5.3.5 What assumptions are made when answering these questions, how can they be made transparent to all involved?

The important issue of data collection and analysis transparency was fostered throughout, including: formal stakeholder feedback process after both workshops; a website (http://corporates.moonfruit.com); a Marine Scotland Science Factsheet and sending the research report to all stakeholders (Scott et al., 2016).

5.3.6 Dealing with multiple knowledge claims: Strengths

The main strength of the developed approach is its ability to bring all stakeholders to a 'level playing field of knowledge', such that they can use their own knowledge most effectively in the process. This was achieved by inclusion of multiple relevant stakeholders and by effective mixing, ensuring they all had to talk and listen to each other. The 30-person limit for workshop participants created a good working atmosphere enabling effective whole group communication and interaction. It also facilitated small group working, such that individual voices could be clearly heard. Many commented in the feedback questionnaires that the mixing of sectors was a new experience. Feedback revealed that stakeholders considered this as novel, as they did not usually get a chance to talk together; normally the way information is imparted to (or indeed at) them keeps them in their own groups, rather than talking to others. One participant noted that *"…getting all the stakeholders from different organisations with different concerns was almost unique (and) this project managed to get everyone in a room and talking without much conflict and lots of cooperation*."

Other strengths were that existing knowledge was confirmed and verified early in the process. The interactive conversations within and across sectoral groups on activities, benefits and ES exposed similarities in benefits experienced by each sector (see Fig. 6) and contributed to

building a joint understanding of the importance of a sustainable marine system that delivers common benefits (see Figs. 7 and 8). An important lesson learnt in dealing with multiple knowledge claims was that more time was required to share the benefits identified between the single sector stakeholder groups. Feedback suggests that the process should include time during Workshop 1 for participating stakeholders to group the benefits and code them into ES.

The process of agreeing which aspects of the ecosystem were linked to each benefit – cultural, social and ecological – as well as whether the links produced positive or negative impact in the construction of the conceptual systems map, allowed for active participation by all stakeholders. This exercise also focused a step-change in the stakeholder's appreciation of others' views which can be identified as a strength in dealing with multiple knowledge claims.

The conceptual systems modelling exercise consolidated concepts introduced during the knowledge exchange 'interludes' and built upon the benefits and ES conversations, further improving knowledge of the mechanisms of ES (see Fig. 9). It was the base upon which the impacts of activities, climate change and policy options were explored by mixed sector groups, further reinforcing the concept of ES and their reliance on a healthy functioning ecosystem. This also proved to be an effective way of addressing multiple knowledge claims.

Finally, written narratives (see section 4.5.2 and Tables 2 and 3) allowed individual stakeholders to express views and concerns about future changes to ES and to their local benefits and activities that relied on these ES. The conceptual systems modelling outputs (see section 4.4) highlighted the range of interactions between different ES, benefits and actions across the study area and the coupled nature of both the social and ecological aspects. Overall, it was found that once comfortable with the process, stakeholders shared extensive concerns and benefits in both the single and the mixed sector groups.

5.3.7 Dealing with multiple knowledge claims: Weaknesses

In dealing with multiple knowledge claims, three limitations were highlighted. Firstly, once stakeholders started talking freely, the speed and density of information proved challenging to capture. Secondly, as stakeholders were considering the benefits in the abstract and beyond commercial interests, some feedback indicated that if the process had been live (wind farms

actually being built) and had a current effect on livelihood, different views than those presented might have been offered. Thirdly, although exercises considered the impact of existing policy drivers (see section 4.5.1) there was no attempt to link the possible outcomes of changes to ES to future policy development. This last point is explained more fully next.

Once groups each created a shared and agreed conceptual systems map (see Fig 9), the resultant map highlighted to stakeholders the agreed linkages between social, economic, ecological benefits and ES. These do not apportion a 'weight' or impact to any policy change. The approach developed by this research revealed important gaps in knowledge about individual local ES. This lack of general understanding is widespread for marine ES issues (White et al., 2012). While the process enhanced participants' general knowledge on ES, the lack of knowledge about the effect on ES following the development of new policy did not allow an easy link back to existing policy's effects on ES. This limits the ability to link ES to policy changes. However, it should be noted that there was in fact limited existing policy applicable for the study area at the time of the research. Marine Sectoral Plans for offshore wind development were in existence (Marine Scotland, 2013) but Scotland's National Marine Plan (Scottish Government, 2015) was not adopted until after the workshops. The existence of explicit and up-to-date marine spatial planning policies and more knowledge of possible effects on ES would have enabled additional exercises to be undertaken in the workshops to allow discussion on links between ES and policy development.

5.4 Managing Uncertainty

5.4.1 What level of technical and epistemic uncertainty exist and how are these types of uncertainty addressed within the process?

Inherent to effective implementation of an ecosystem approach within marine spatial planning is management of uncertainty stemming from, for example, technological limitations or gaps in knowledge. To address the epistemic uncertainty, this research embedded a shared learning process from the start. The transdisciplinary research team initially derived knowledge from across scientific disciplines and marine regulators and policymakers. This was coupled with stakeholder engagement from across practice sectors through workshop exercises including visualisation, mapping, comparing knowledge and information across and within the specialities. Mixing the stakeholder sectors after the initial workshop exercises also

helped address uncertainty, as the subsequent exercises required discussion and sharing of information which was specifically designed to be done in a supportive environment. For example, comparing the benefits identified by the single sector groups encouraged a sharing of knowledge and information, and revealed many similarities between the findings of the different sector groups (see 4.2, Fig. 6). This promoted discussion and a unity of purpose in discovering shared benefits, such as wellbeing and the relationship between heritage and tourism (see 4.3 Figs. 7 and 8). It was also recognised that it was essential for the research team and the stakeholders to define terms. Talking at cross-purposes by using the same words, but with different meanings was an important early discovery for the research team. It highlighted the importance of a shared and agreed vocabulary across the project.

5.4.2 What trade-offs result from the chosen research design?

The approach has several trade-offs. The time required to gain confidence of the individuals within groups to start talking to the researchers and then to each other via the initial exercises meant that there was less time for the more detailed and high-level conceptual systems map. On the other hand, individual participants provided extensive personal or industry data and information (see section 4.2, Tables 2 and 3). It was recognised that more time than had been allocated was required to discuss the benefits identified by the single sector groups. The workshops turned out to be the first opportunity for many of the stakeholders to share knowledge and information, therefore, should and could not be rushed.

In managing uncertainty, a trade-off is also made in the framing of the activities in the abstract, in order to encourage the sharing of knowledge and developing awareness of ES in the formulation of the conceptual systems map. For example, stakeholders were encouraged to think theoretically, rather than in relation to their own personal circumstances. This had the advantage that it was relatively easy to bridge different interests (cf. Ranger et al., 2016) and support communicative rationality (Habermas, 1984) where force of argument, not force of interest determined outcomes. The trade-off was that it was cognitively challenging and advantaged those who were more experienced in abstract thinking.

Finally, the two-stage workshop design meant some stakeholders were not present to contribute to the conceptual systems map in Workshop 2. The research team needed time to analyse the data from the first workshop and to develop the activities and process for the

second workshop. Moreover, more than three months had passed between workshops which necessitated considerable recap and explanation at the start of Workshop 2, reducing time available.

5.4.3 How can uncertainty and trade-offs be made transparent to all involved?

It was acknowledged that to design a process that supported stakeholders throughout, each stage of the workshops was required to ensure that uncertainty and trade-offs were transparent to all involved. Active facilitation (for group and time management) was essential. The facilitators strove to ensure equal say between stakeholders and specialities. Time was allocated for in-depth discussion and agreed verbal prompts enabled evolution of ideas. Effective note takers were required as data collectors, to capture the detailed interactions within the groups. It was only when stakeholders were at ease with the process and each other that they shared their concerns. Discussing the conceptual systems map within the specific study area, and with self-derived activities and benefits, served to reveal uncertainties in the local context, in contrast to 'general' trends and principles in terms of ecological processes and relationships.

5.4.4 Managing Uncertainty: Strengths

One of the main strengths in managing uncertainty was addressed by the choice of participants – with both specialist expertise and familiarity with the study area and issues therein. To address uncertainty over the course of the project and to begin to develop trust, a 30-person cap was imposed and pre-workshop meetings with specific stakeholder groups reviewed the aims and objectives. Other exercises that effectively manage uncertainty, included visualisations of information during the 'interludes' and all stakeholders able to view and question all knowledge and data. For lessons learnt, the initial verification and sharing of information in the participatory mapping exercise in Workshop 1 (see 4.1) appeared slow to start, particularly when discussion was focused on personal livelihood, for example, fishing locations. However, the research team recognised that the use of confidential commercial information as part of the process required to be managed. Clarity as to the use of the information in terms of the process was vital in managing uncertainty.

5.4.5 Managing Uncertainty: Weakness

The key limitation was the loss of participants between the workshops. The main weakness was stakeholders' concern about getting the conceptual systems maps 'right' and how things would change with different drivers. This tendency pointed towards the need to incorporate time to practice development of conceptual systems maps in future workshops that can be 'played' with. Modelling tools and ecological information on effects of drivers need to be made available to demonstrate the ecological costs of changes in policy.

6.0 Conclusions

This paper offers a step change that forges a clear pathway to link participatory stakeholder engagement with marine spatial planning outcomes. It describes research to create a process that facilitates decisions informed by ES and the effective implementation of marine planning policy.

The overarching aim in the development of this process is that all relevant stakeholders, including those without a background in marine ecology, could participate in the discussions about the impact of anthropogenic changes throughout the marine ecosystem. The development of a modular set of methods and processes for engaging with stakeholders provides an ecosystem services-based decision support model for exchanging social-ecological knowledge and fostering meaningful stakeholder interaction. The process creates an environment for synergy across various knowledges (science, policy, practice), enabling new insights, such as identifying cross-sector concerns and trade-offs between existing and new activities and ecosystem services. It also allows stakeholders, often in conflict, to share concerns and benefits within and across sectors and offers a route for achieving an ecosystem approach to marine planning and licensing decisions, as required by law.

Critically, it offers a practice-based operationalisation of the PNS framework. The analysis, with a focus on the identified areas of process oversight, dealing with multiple knowledge claims and managing uncertainty, suggests that the approach developed through this research successfully bridges social and natural science with practitioner knowledges to effectively link science and practice with the creation and implementation of policy.

Outputs from this research have been adopted to other settings (Burdon et al., 2019, Irvine et al., 2016; Kenter, 2016) which required meaningful stakeholder engagement to both inform

policy and provide feedback as part of a decision-making process. The modular exercises are particularly effective at dealing with multiple knowledge claims. With local modifications, there would be limited barriers to its transferability and adoption in any jurisdiction or the types of environmental issues to be addressed. It is particularly applicable where there is a statutory requirement to engage stakeholders.

Another application is as an engagement / outreach tool to introduce marine spatial planning to communities worldwide. It provides a unique and effective process for data gathering, creating the environment for stakeholder's full participation and collegial interaction by finding agreement on common benefits and providing a process for meaningful input to policy directions. A final outcome is that the approach can be utilized as an educational tool to teach the balancing of ES and benefits at all educational stages and levels.

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