



PARTICIPATORY MAPPING OF NATURAL CAPITAL AND BENEFITS: METHOD GUIDANCE DOCUMENT

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Marine Management Organisation & Suffolk Marine Pioneer

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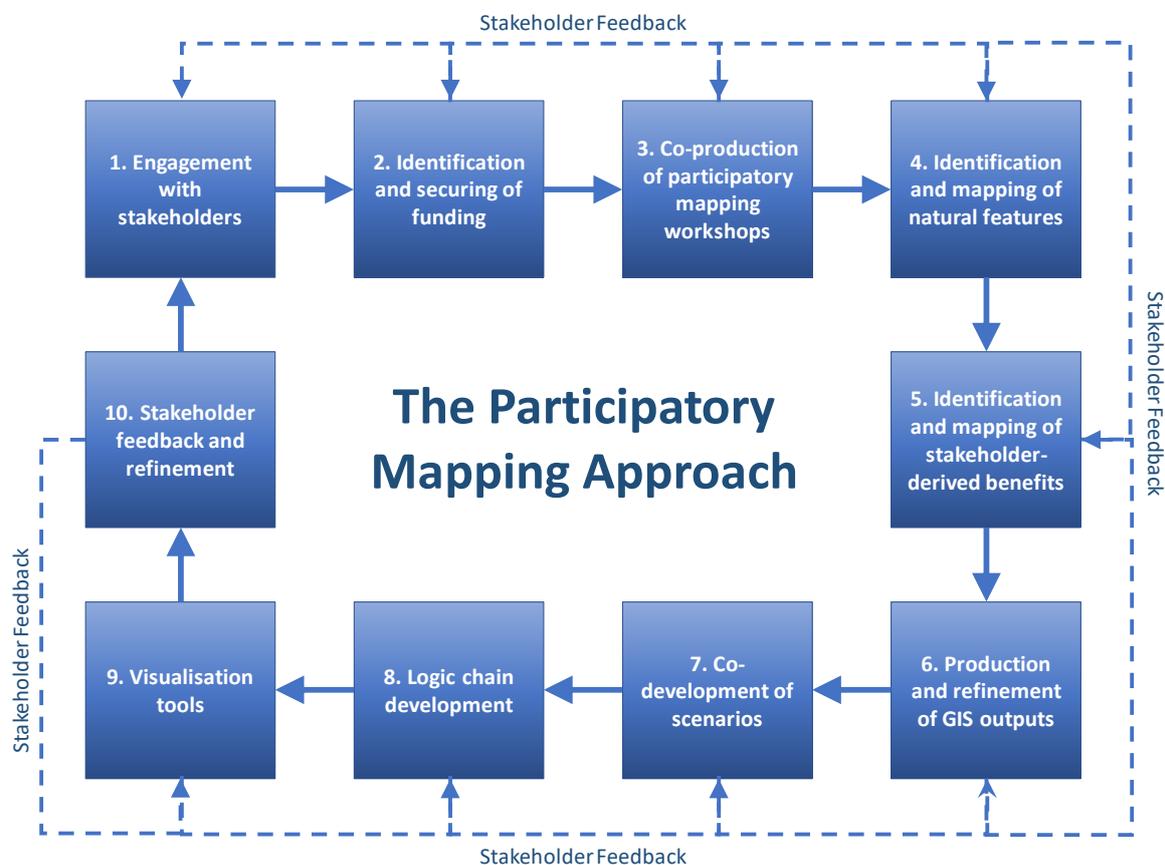
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Summary



- The **UK Government's 25 Year Environment Plan** highlights our need to understand the full value of the marine environment and incorporate that into decision-making which is key to applying the natural capital approach. Participatory mapping can make a significant contribution towards this.
- **Participatory mapping** is a direct means of co-producing knowledge with stakeholders and communities which facilitates local spatial mapping of features, benefits and values. It can provide rich data on the distribution of natural capital features, benefits, values and trade-offs.
- In the context of **ecosystem services valuation**, stakeholders provide local, spatially explicit information about ecosystem services and benefits, use and value (both monetary and non-monetary), negating the need to use proxy data derived from literature or modelling.
- There is currently an **evidence gap** as to how benefits are identified at the local scale, where benefits are provided and to whom, identifying trade-offs in development decisions, and understanding how natural capital and benefits support well-being. This supports a place-based approach to natural capital.

PARTICIPATORY MAPPING METHOD



APPLICATIONS TO DATE

Pilot Studies

- Four pilot studies (East Caithness, Aberdeen Bay, Humber Estuary, The Wash) were undertaken to test and refine the participatory mapping method following extensive stakeholder feedback.
- The pilot studies engaged over 60 local stakeholders who are actively engaged within one of the four local coastal partnerships (Moray Firth Coastal Partnership, East Grampian Coastal Partnership, Humber Nature Partnership and The Wash and North Norfolk Marine Partnership).
- The workshop methods, results and discussion are presented in full in Burdon et al. (2019)¹.

Suffolk Marine Pioneer

- The Suffolk Marine Pioneer was established by Defra to test the application of a natural capital approach in practice and to inform the implementation and iteration of the 25YEP.
- The aim of a series of three participatory mapping workshops was to expand the role of this method for the enhancement of natural capital within the Deben Estuary.
- Outputs from the three workshops can be accessed via the Suffolk Coasts and Heaths website².

SWOT ANALYSIS OF THE PARTICIPATORY MAPPING APPROACH

- A critique of the Participatory Mapping Approach was undertaken by senior marine planners, policy-makers and nature conservation bodies using a SWOT analysis framework. A brief summary is provided below with further details provided in Burdon and Potts (2020)³.

<p style="text-align: center;">CURRENT STRENGTHS</p> <ul style="list-style-type: none"> • Empowers local stakeholders. • Local detail scale of the approach. • Includes the full range of benefits. • Powerful communication tool. • Knowledge sharing and co-production. • Captures local knowledge. • Does not rely on existing data. 	<p style="text-align: center;">CURRENT WEAKNESSES</p> <ul style="list-style-type: none"> • Scalability to regional or national level is challenging. • Workshops are subjective. • Small sample sizes may not reflect whole community so requires mitigation. • Stakeholder fatigue requires managing. • Current system low on time and staff. • Does not weigh up or value the benefits.
<p style="text-align: center;">FUTURE OPPORTUNITIES</p> <ul style="list-style-type: none"> • Provide evidence to inform new national and place-based policy. • Designation and management of MPAs and HPAs. • Application to the offshore environment e.g. offshore wind. • Provides spatial baseline information. • Raise awareness and communicate natural capital, climate change, net gain etc. 	<p style="text-align: center;">FUTURE THREATS</p> <ul style="list-style-type: none"> • Current lack of spatial baseline data. • Investment in people's time if rolled out across the UK. • Challenge to inform regional and national policy from local scale. • Lack of join-up between jurisdiction and ecosystems. • Scepticism to transferring power/control to stakeholders.

For further information on the Participatory Mapping Approach please contact: Dr Daryl Burdon (darylburdon@gmail.com) and/or Dr Tavis Potts (Tavis.Potts@abdn.ac.uk).

¹ Burdon et al. (2019). <https://doi.org/10.1016/j.ecoser.2019.101009>.

² Suffolk Marine Pioneer Outputs. <https://www.suffolkcoastandheaths.org/managing/projects/marine-pioneer/>

³ Burdon & Potts, 2020. *Participatory mapping of natural capital and benefits: method guidance document*. Report to Marine Management Organisation and Suffolk Marine Pioneer by Daryl Burdon Ltd., Willerby UK.

1. Introduction

1.1 Background to Natural Capital, Ecosystem Services and Benefits

For the purposes of this report the definitions from the Natural Capital Committee (2017) are advocated:

- **Natural Capital:** “The elements of nature that directly or indirectly produce value to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions”.
- **Ecosystem Services:** “Functions and products from nature that can be turned into benefits with varying degrees of human input”.
- **Benefits:** “Changes in human welfare (or well-being) that result from the use or consumption of goods, or from the knowledge that something exists”.

There has been **increasing international** effort to better understand the diversity and quality of marine natural capital, services and societal benefits. For example:

- Costanza et al. (1997) attempted to **value the world’s ecosystem services and natural capital** and identified coastal ecosystems as providing 38% of the total value.
- The Millennium Ecosystem Assessment identified four categories of ecosystem services (MA, 2005): **Provisioning services:** the products obtained from the ecosystem; **Regulating services:** the benefits obtained from the regulation of ecosystem processes; **Cultural services:** the nonmaterial benefits people obtain from ecosystems, and **Supporting services:** those that are necessary for the production of all other ecosystem services, but do not yield direct benefits to humans.
- The **UK National Ecosystem Assessment** which focused on the processes that link human society and well-being to the natural environment and applied a generic ecosystem services framework to a wide range of terrestrial and aquatic habitats (UKNEA, 2011).
- The **UK National Ecosystem Assessment Follow-On Project** tailored the approach specifically for the marine environment focussing on the relationships between marine components and processes, intermediate and final ecosystem services and goods/benefits (UKNEAFO, 2014).
- The **Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services** Global Assessment recognises the need to consider multiple values of ecosystem functions and nature’s contributions to people (IPBES, 2019).
- The UK Government released the **Enabling a Natural Capital Approach** document for those who are looking to learn more about natural capital and environmental valuation and need practical guidance (Defra, 2020).

1.2 Policy Drivers

- There are an increasing number of high level policy drivers and regulatory mechanisms for delivery of a natural capital and ecosystem services approach (Table 1), with drivers being articulated at a UK and devolved administration scale.
- High level policy drivers, while indicating support for natural capital and ecosystem service approaches, lack operational mechanisms and resources for delivery.
- These policy drivers increase the emphasis on place-based approaches and integrating natural capital with well-being, planning, licencing and conservation.

Table 1: Policy drivers and their relevance to natural capital.

Policy Driver	Jurisdiction	Relevance to Natural Capital
OSPAR	International	Delivering OSPAR ecosystem approach across OSPAR's activities in monitoring and assessment, communication, guidelines on management, or policy and Quality Status Report 2023.
Sustainable Development Goals CBD Aichi Targets	UK	Integrated approach to achieving the SDGs and provide useful information for policy decisions. Supporting green economy and poverty reduction.
UK Government's 25 Year Environment Plan (25YEP)	UK	Take a natural capital approach to understand the full value of the marine environment; incorporate natural capital into marine decision making.
Marine and Coastal Access Act	UK	Potential to include natural capital in marine planning, licencing & management. Incorporate natural capital in new / existing MPAs & management of inshore fishing and marine stewardship.
HM Treasury: The Green Book & ENCA	UK	Incorporating natural capital concepts into policy appraisal, evaluation and supporting policy goals. Supported by Enabling a Natural Capital Approach (ENCA) Jan 2020.
The UK Marine Strategy	UK	Marine Online Assessment tool reports against Marine Strategy Framework Directive and Good Environmental Status. Scope for natural capital indicators.
The Environment Bill (2020)	UK / England	Applying natural capital to Net gain, Nature Recovery Networks and Local Nature Recovery Strategies. Reorientation of MPAs towards natural capital.
The Fisheries Bill (2020)	UK / England	Further powers / objectives for fisheries including restoration, habitat and natural capital considerations mirroring UK Agriculture Bill.
Marine Scotland Act (2011)	Scotland	Potential to include natural capital in marine planning, licencing & management. Legal duty to consider social, economic, environmental aspects of marine systems. Options for research and demonstration MPAs.
National Marine Plan 2015	Scotland	High level objectives reference an ecosystem services approach. Planning to address: The species, habitats and functionsto ensure ecosystem health and continued delivery of ecosystem services; The impacts of decision making on ecosystems and the services they provide.
Scotland's Environment Strategy 2020	Scotland	Understand the impacts of economic activities on Scotland's natural capital, and to design business models to regenerate rather than deplete it.
Well-being of Future Generations Act 2015	Wales	Improving the economic, social, environmental and cultural well-being of Wales by taking action, in accordance with sustainable development principles. Link natural capital and ecosystem services with improving the economic, social, environmental and cultural well-being.
Environment (Wales) Act 2016	Wales	Action to build resilience into Wales' ecosystems so that the ecosystem services they provide are available now, for future generations, and contribute to the achievement of the well-being goals. Emphasis on nature-based solutions and place based approaches relevant to participatory natural capital.
Welsh National Marine Plan 2019	Wales	Adopts an ecosystem approach to natural resources management, marine planning and licencing in the Welsh marine area.
(Draft) Northern Ireland Environment Strategy 2020	Northern Ireland	Recognises importance of natural capital, integrating into the policy making process is a priority and requires improved data. Disaggregation of UK accounts to support local applications.
Marine Act (Northern Ireland) 2013	Northern Ireland	Potential to include natural capital as consideration in marine planning process.
Draft Marine Plan for Northern Ireland 2020	Northern Ireland	Ecosystem services will inform key activity policies.

1.3 Valuation

- In order to meet the ambitions of the UK Government's 25YEP, the full value of the marine environment must be understood and incorporated into decision-making.
- In this context, value can be defined in terms of ecological value (the health of the system measured using ecological indicators), economic value (including both use and non-use values identified using market or non-market techniques) and/or socio-cultural value (for example relating to cultural identity and the degree to which that is related to ecosystem services and well-being) (MA, 2003).
- The concept of 'total social value' can be used to incorporate the views of society and their values associated with ecosystem service provision into the decision making process in order to determine policy options and management measures and comprises these three domains (Figure 1).

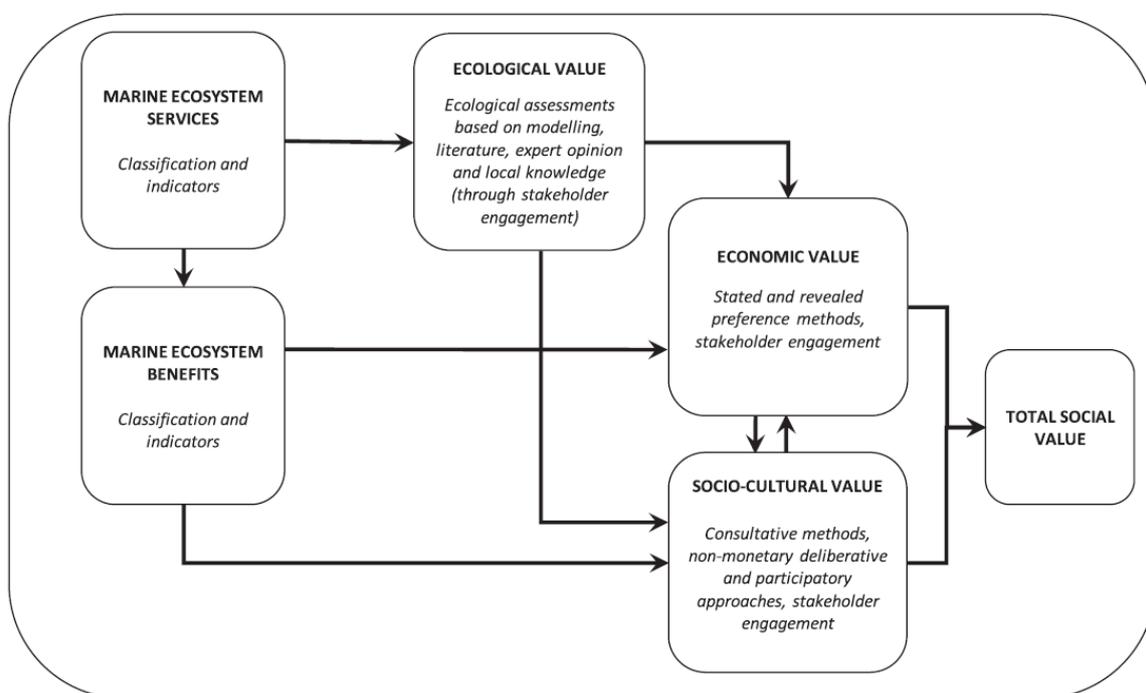


Figure 1: Total social value comprising ecological value, economic value and socio-cultural value (Burdon et al., 2019).

- A range of methods are available to assess ecological value, economic value and socio-cultural value. Examples of such methods, and their application within the marine environment, are presented in Table 2.
- Whilst numerous studies have attempted to value components of the marine environment, particularly focussing on ecological and economic value, there are currently data gaps regarding socio-cultural value which need to be addressed to fully meet the ambitions of the UK Government's 25YEP.
- Of particular relevance to the current project is the development and application of Participatory Mapping Approaches which can be used to qualify socio-cultural value.

Table 2: Example methods used to assess ecological, economic and socio-cultural value in the marine environment.

Value Domain	Method	Description	Example References
Ecological	Biological valuation	Marine biological valuation is based on a literature review of existing valuation criteria and the consensus reached by a discussion group of experts.	Derous et al., 2007; Pascual et al., 2011
	Ecological indicators	Indicators can be identified and populated to show changes in state, trajectory and behaviour of ecosystem services over time.	Burkhard et al., 2012; Hattam et al., 2015a; Atkins et al., 2015
Economic	Contingent valuation	Creates a hypothetical market by direct surveying of a sample of individuals and aggregation to encompass the relevant population.	Ressurreição et al., 2012; Atkins et al., 2007.
	Discrete choice experiment	Uses experiments to reveal factors that influence choice. Discrete choice models assume the respondent has perfect discrimination capability.	Jobstvogt et al., 2014; Borger et al., 2014
	Market analysis	Where market prices of outputs (and inputs) are available. Could approximate with market price of close substitute. May require shadow pricing where prices do not reflect social valuations.	Cooper et al., 2013; Luisetti et al., 2011; Rees et al., 2010
	Benefit transfer	Uses primary valuation research results from one area (the study site) to make secondary predictions about values at a different area (the policy site).	Luisetti et al., 2015; Costanza et al., 2014
Socio-cultural	Participatory mapping	The gathering and mapping of spatial information to help communities learn, discuss, build consensus, and make decisions about their communities and associated natural resources.	Burdon et al., 2019; Damastuti & de Groot, 2018; NOAA, 2015
	Citizen's Jury	Expert witnesses are invited to state their case to a group of jurors from the general public. After hearing all the witnesses' accounts, the jurors deliberate on the issue in attempt to reach a common 'verdict' or conclusion.	Hattam et al., 2014; 2015b
	Q method	Provides insights into the range of opinions that exist about some issues within a sample population, and how those opinions differ and converge. It turns qualitative deliberations with individuals into quantitative data.	Sy et al., 2018; Pike et al., 2014
	Community Voice	A participatory method which uses filmmaking to engage stakeholders to foster more inclusive, informed, and ongoing social dialogue in local communities.	Ranger et al., 2016
	Travel Cost	Cost incurred in reaching a recreation site as a proxy for the value of recreation.	Hanley et al., 2003; Chae et al., 2012
	Photo Elicitation	A qualitative interview method for eliciting comments, feelings and memories based on images such as photographs, cartoons, paintings and adverts.	Harper, 2002; Andrews et al., 2018
	Means-End & Chains Model, Laddering theory	A structured interview process for eliciting goals and personal values in relation to products / phenomena. Applied in the psychology and economics domain.	Reynolds & Gutman, 1988; Gutman, 1982
	Longitudinal values surveys	An approach that creates large scale data sets exploring and classifying public perceptions, values and priorities around environmental issues.	Potts et al., 2016

1.4 Aims and Objectives

This project aims to outline how to apply the Participatory Mapping Approach, where it can be applied, who it can be applied by and what evidence it can generate.

In order to achieve this aim, this project has two objectives:

- To engage with senior marine planners, policy-makers and nature conservation bodies to provide a critique of the Participatory Mapping Approach to date and to discuss potential opportunities and threats to its future applications.
- To produce a guidance methods document and a 2-page policy briefing on the use of the Participatory Mapping Approach for engaging marine stakeholders in natural capital discussions.

2. Participatory Mapping - Development and Results

2.1 Background

- Participatory mapping is a direct means of co-producing knowledge with stakeholders and communities which allows spatial mapping of ecosystem features, benefits and values on a local scale (Burdon et al., 2019).
- Participatory Mapping can provide a rich data set relating to ecosystem service distribution, values and trade-offs.
- Stakeholders provide local, spatially explicit information about ecosystem service provision, use and value (both monetary and non-monetary), negating the need to use proxy data derived from literature or modelling (Brown & Fagerholm, 2015).
- There is currently an evidence gap in place based approaches supporting how benefits are identified at the local scale, where benefits are provided and to whom, trade-offs in development decisions, and understanding how benefits support well-being (Burdon et al., 2019).

2.2 Pilot Studies

- Four pilot studies (East Caithness, Aberdeen Bay, Humber Estuary, The Wash) were undertaken to enable the participatory mapping method to be tested and refined following stakeholder feedback (Figure 1).
- The pilot studies engaged over 60 local stakeholders who are actively engaged within one of the four local coastal partnerships (Moray Firth Coastal Partnership, East Grampian Coastal Partnership, Humber Nature Partnership and The Wash and North Norfolk Marine Partnership).

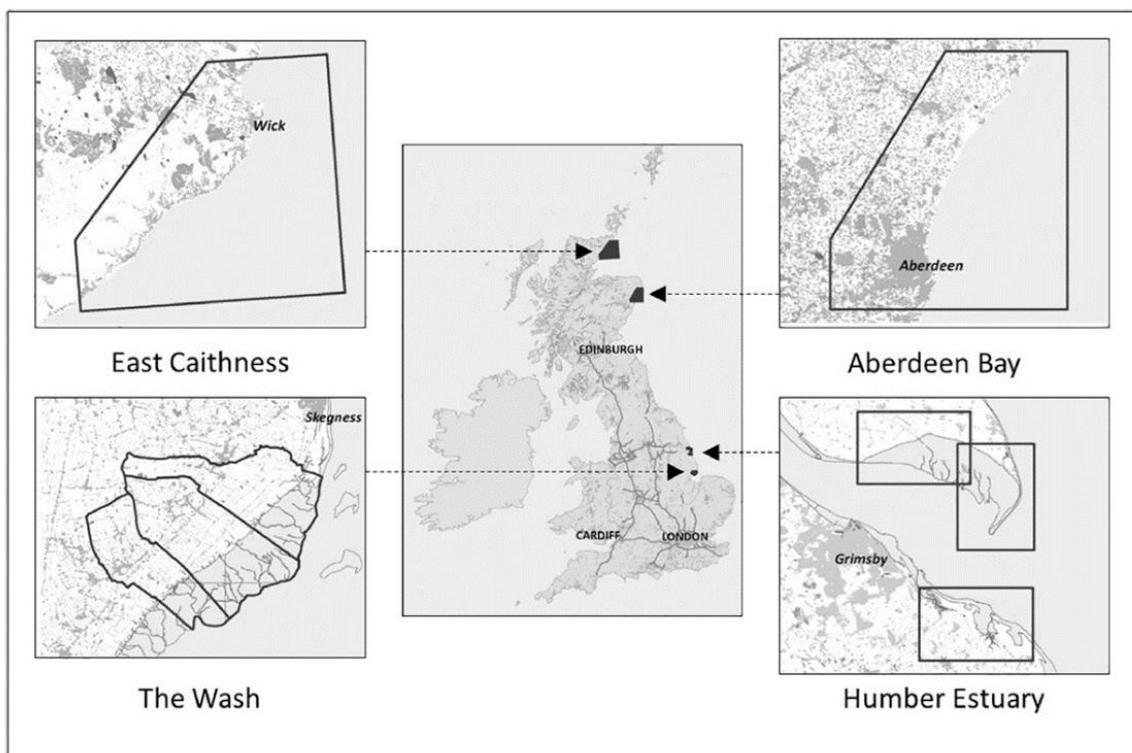


Figure 1: Location of the four Pilot Studies (Burdon et al., 2019).

Funding was secured from a range of sources to undertake a single one-day workshop at each of the four pilot study locations. A standardised structure was applied across the pilot studies which was based around three core elements (Figure 2):

- **A series of Introductory Presentations:** These presentations provided stakeholders with a background to the case study site (delivered by the local coastal partnership manager or equivalent), an introduction to satellite imagery (or other relevant mapping technique), an introduction to participatory mapping, an introduction to natural capital and ecosystem services, and outlined the aims and objectives of the workshop which were co-developed with the local coastal partnerships.
- **Identification and Mapping Exercises:** The majority of time at each workshop was taken up with a series of interactive mapping exercises undertaken in groups and included identifying and mapping features, activities and benefits. In order to show the relative importance of natural features in providing ecosystem services and benefits the Matrix Approach is introduced to the participants (Potts et al., 2014⁴). The type of exercises undertaken is tailored to the needs of the local coastal community and the exercises are co-designed with the stakeholders. A summary of the exercises undertaken at each workshop in addition to the workshop outputs is presented in Table 3 with outputs from Aberdeen Bay and the Humber Estuary presented in Figure 3 and Figure 4 respectively.
- **Deliberation, Discussion and Feedback:** Each workshop concluded with a plenary discussion where the stakeholders discussed the exercises they had participated in, potential local management issues (which can be addressed in follow-up workshops), and to provide feedback on the workshop methodology. Feedback from these pilot studies was used to refine the Participatory Mapping Approach (Table 4).

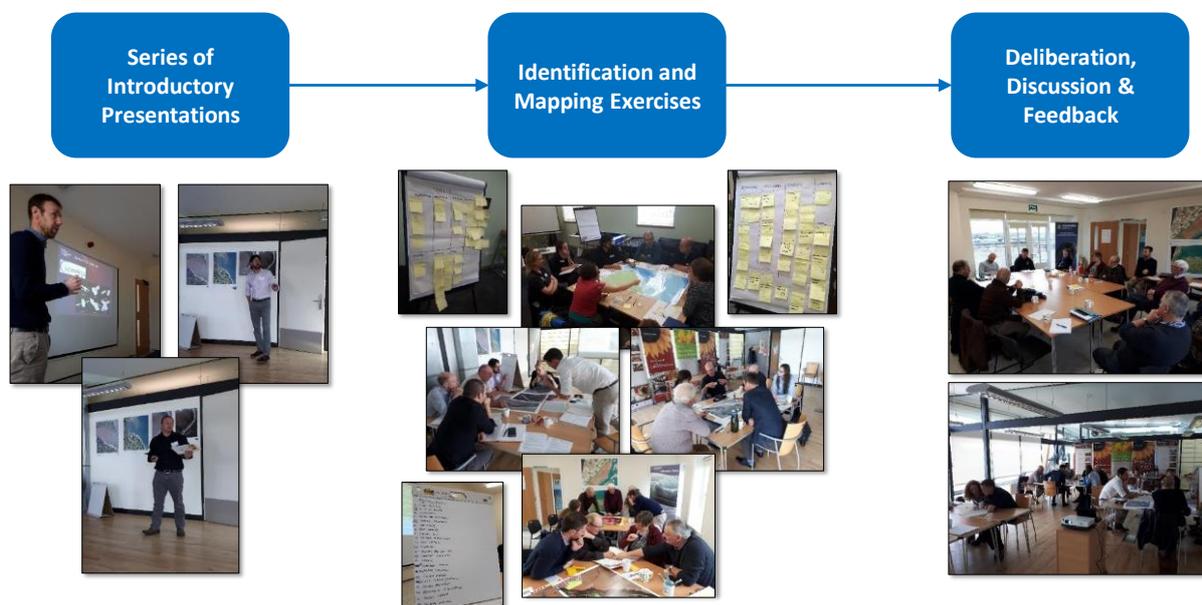


Figure 2: Application of the Participatory Mapping Approach to the Pilot Studies.

⁴ Potts et al., 2014. Do marine protected areas deliver flows of ecosystem services to support human welfare? <https://doi.org/10.1016/j.marpol.2013.08.011>

Table 3: Summary of activities, materials and outputs from each workshop (Burdon et al., 2019).

Activities	East Caithness	Aberdeen Bay	Humber Estuary	The Wash
Introduction to the workshop	✓	✓	✓	✓
Introduction to the local nature/coastal partnership	✓	✓	✓	✓
Introduction to participatory mapping	✓	✓	✓	✓
Introduction to natural capital / ecosystem services	✓	✓	✓	✓
Introduction to satellite imagery			✓	✓
Identifying and mapping maritime activities	✓	✓		
Identifying and mapping features			✓	✓
Identifying and mapping benefits	✓	✓	✓	✓
Local application of the matrix approach	✓	✓		
Plenary discussions	✓	✓	✓	✓
Stakeholder feedback	✓	✓	✓	✓
Materials	East Caithness	Aberdeen Bay	Humber Estuary	The Wash
Flipcharts	✓	✓	✓	✓
Industry maps	✓	✓		
Tourism/recreation maps	✓	✓		
Site designation maps	✓	✓		
Bathymetry maps	✓	✓		
Local ecosystem service matrices	✓	✓		
Satellite images (Sentinel-2)			✓	✓
Outputs	East Caithness	Aberdeen Bay	Humber Estuary	The Wash
Workshop report (including stakeholder feedback)	✓	✓	✓	✓
Online interactive maps	✓	✓		
Interactive pdf files			✓	✓

- Outputs from the Aberdeen Bay pilot study are presented in Figure 3. The hand drawn maps from the workshop were digitised using GIS with outputs presented via an online GIS platform. This method provides the outputs in an accessible format for stakeholders to access without the requirement for the end-user to have access to GIS software or expertise. Hotspots of benefit provision (based on the number of benefits provided within each cell of a pre-defined grid) can be identified around areas of highest population (e.g. Aberdeen City) or around nature reserves (e.g. the mouth of the Ythan Estuary at Newburgh).
- Outputs from the Humber Estuary pilot study are presented in Figure 4. The hand drawn maps from the workshop were digitised using GIS with outputs presented in an interactive pdf format. This format allows the end-user to select a particular benefit which will then be automatically mapped thus not requiring web access, or GIS software or expertise. In the example shown, the benefit 'fish nursery' has been selected which results in areas of 'saltmarsh' and 'creeks' changing colour thus indicating that they provide this benefit.
- Detailed methods, results and discussion from the pilot studies are presented in Burdon et al. (2019)⁵.

⁵ Burdon et al., 2019. Expanding the role of participatory mapping to assess ecosystem service provision in local coastal environments. <https://doi.org/10.1016/j.ecoser.2019.101009>

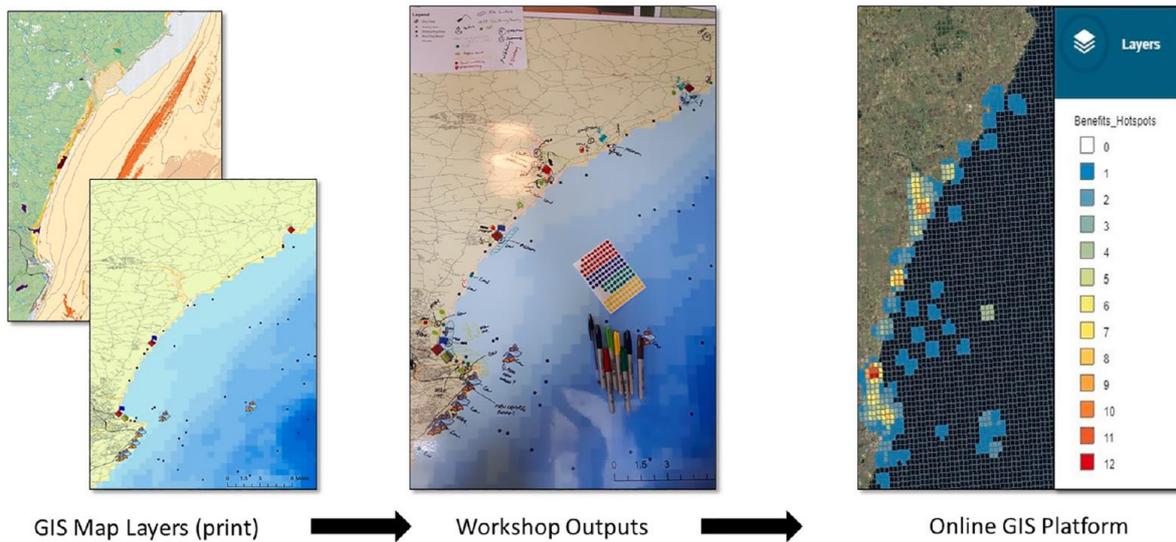


Figure 3: Outputs from the Aberdeen Bay pilot study (Burdon et al., 2019).

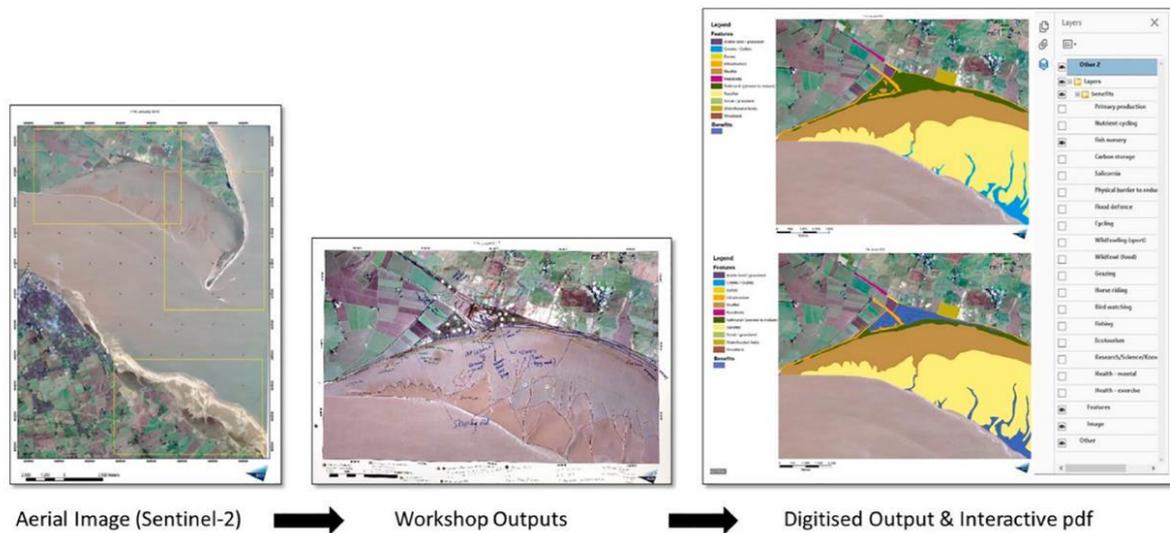


Figure 4: Outputs from the Humber Estuary pilot study (Burdon et al., 2019).

Table 4: Summary of stakeholder feedback and how it refined the workshop methodology (adapted from Burdon et al., 2019).

Stakeholder Feedback	Workshop(s)	Refined Methodology
Pre-reading in the form of information and background for the specific locations, as well as workshop activities, would be more efficient and lead to more effective engagement from attendees.	Aberdeen Bay & Humber Estuary	A more detailed background document to be circulated prior to each workshop to outline the workshop aims and objectives, but also to state which case studies will be covered within the workshop.
The scale of the maps used at the workshops was not sufficiently detailed to capture activities at a local scale.	East Caithness	Move to using maps derived from Satellite imagery for both the Humber Estuary and The Wash and which resulted in habitats being mapped down to a 10m scale.

Stakeholder Feedback	Workshop(s)	Refined Methodology
To ensure representation from as many relevant stakeholders as possible, it was suggested that extending the invitation out more widely would be beneficial.	Aberdeen Bay, East Caithness	For future workshops, invitations will be sent to key stakeholders as early in the process as possible. However, it must be recognised that participation is voluntary and it may not always be possible to have representation from every group.
Stakeholders made recommendations regarding the materials used during the workshops, including the provision of multiple maps to support high volumes of data and avoid confusion ('maps became messy/confusing due to volume of information') or providing maps for both summer and winter to allow for seasonal comparisons to be made.	Aberdeen Bay, Humber Estuary, The Wash	Incorporating satellite imagery into the stakeholder-driven methodology allows for comparison between maps over time. This allows seasonal or historic comparisons to be made if that is of interest to the stakeholders at the local scale. For example, The Wash workshop used images from different seasons.
It would be useful to try and plot where humans go around the estuary. Data can be obtained for activities such as cycling but we could also build on the access and activity mapping undertaken under other projects.	Humber Estuary	A mapping activity is included within the proposed methodology to capture the activities as well as the features and benefits. Such mapping activities have recently been applied on behalf of the MMO (Project 1136 ⁶) for non-licensable activities.
Stakeholders suggested that an iterative process of 3-4 workshops would be valuable.	East Caithness	A series of 3 workshops is proposed which can be tailored to meet the needs of particular local groups.
Stakeholders expressed a desire to know more about the outputs of the workshop and how these might be used in the future to support decision making and coastal management in their local areas.	Humber Estuary, The Wash	It is proposed that a series of workshops would be developed so that the second workshop would start with the output of the first, and so forth. For example, a second workshop could start to use the interactive pdfs developed in Workshop 1.
The ecosystem service matrix approach was seen as a valuable tool which could be used to assess trade-offs under different scenarios; however more time was needed to understand the approach.	Aberdeen Bay, East Caithness	The ecosystem service matrix approach was omitted from subsequent workshops (Humber Estuary, The Wash) due to time constraints but it is seen as a valuable approach for understanding trade-offs.

2.3 Suffolk Marine Pioneer Project

- The Suffolk Marine Pioneer Project⁷ was established by Defra to test the application of a natural capital approach in practice and to inform the implementation and iteration of the Government's 25YEP.
- The aim of a series of three Participatory Mapping workshops was to expand the role of this method for the enhancement of natural capital within the Deben Estuary, Suffolk.
- The Participatory Mapping Approach applied to the Deben Estuary comprised 10 key interlinked stages (Figure 5). Solid lines represent linkages between stages, dashed lines represent opportunities for stakeholder feedback.

⁶ The intensity and impacts of non-licensable activity on MPAs (MMO Evidence Project 1136) <https://www.gov.uk/government/publications/non-licensable-activity-impacts-on-marine-protected-areas-mmo1136>

⁷ Suffolk Marine Pioneer Outputs. <https://www.suffolkcoastandheaths.org/managing/projects/marine-pioneer/>

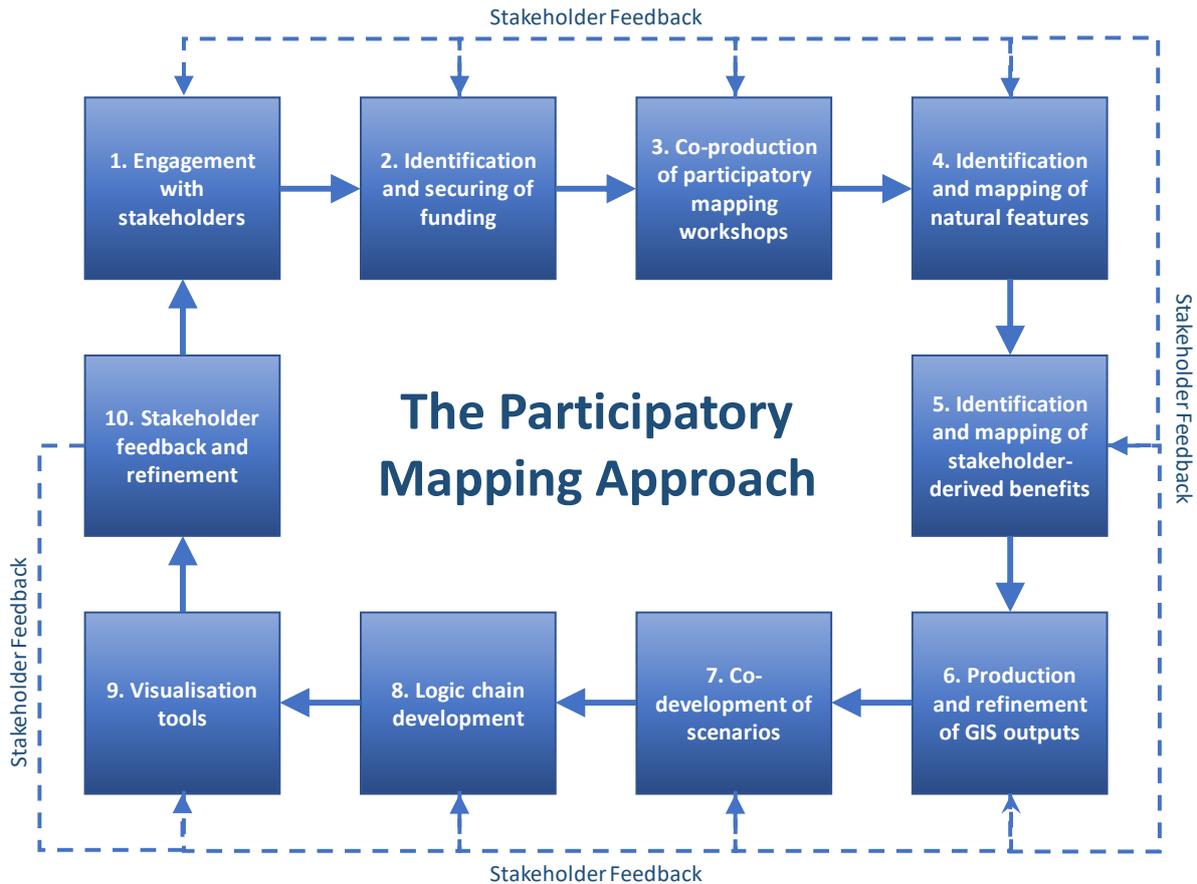


Figure 5: Schematic of the Participatory Mapping Approach.

The application of the 10-stage process (Figure 5) to the Deben Estuary, as part of the Suffolk Marine Pioneer Project, is described below.

1. **Engagement with stakeholders:** Early contact with the MMO Marine Pioneer Programme Lead and the Suffolk Pioneer Project Manager identified and engaged local stakeholders with an active interest in the management of the Deben Estuary thus ensuring that local issues were fully understood. Stakeholder engagement started at the project proposal phase and continued throughout the full duration of the study. The series of three workshops engaged a total of 33 individual stakeholders representing 26 organisations.
2. **Identification and securing of funding:** Relevant funding streams should be identified in collaboration with the local partnerships and local stakeholders. This ensures that the stakeholders have buy-in from the project proposal stage but also has the potential to access a wider range of funding streams e.g. research councils, Universities, charitable foundations, local authorities, government, etc. There is substantial potential for long term continual engagement and improvement of natural capital in localities e.g. infrastructure funding. Funding for the Deben Estuary workshops was funded by the Marine Management Organisation under the Suffolk Marine Pioneer Project.
3. **Co-production of participatory mapping workshops:** The three Deben Estuary workshops were co-produced by the project team, the MMO Marine Pioneer Programme Lead and the Suffolk Marine Pioneer Project Manager with additional input from local stakeholders. Aims and objectives for each workshop were agreed (Table 5) in addition to the structure of the workshop

(including the introductory presentations and the interactive activities). This ensures that the interactive activities that were undertaken were fit-for-purpose and the outputs from the workshops were of added value to the local community.

Table 5: Co-produced aims of the three Deben Estuary workshops.

Workshop	Aims
1	To expand the role of participatory mapping and deliberation for the enhancement of natural capital within the Deben Estuary.
2	To investigate trade-offs between the delivery of benefits in the Deben Estuary using future scenarios assessments.
3	To demonstrate the multi-directional logic chain sequence between natural capital, benefits and beneficiaries of the Deben Estuary.

4. **Identification and mapping of natural features:** A satellite image of the Deben Estuary, captured by Sentinel-2 satellite on 20 February 2019, was used for the mapping exercises. Detailed instructions for processing satellite images are provided in Lew (2018)⁸. Stakeholders were asked to identify a list of features they would expect to see within the Deben Estuary, before identifying and drawing around all of the features visible on printed maps and generating their own key. 27 features were identified comprising 16 natural features (e.g. intertidal mud), 6 modified/managed features (e.g. golf courses) and 5 built features (e.g. housing developments). Three tables of stakeholders focussed on the upper, middle and lower Deben but were given the opportunity to swap tables and thus feed into the three maps (Figure 6).

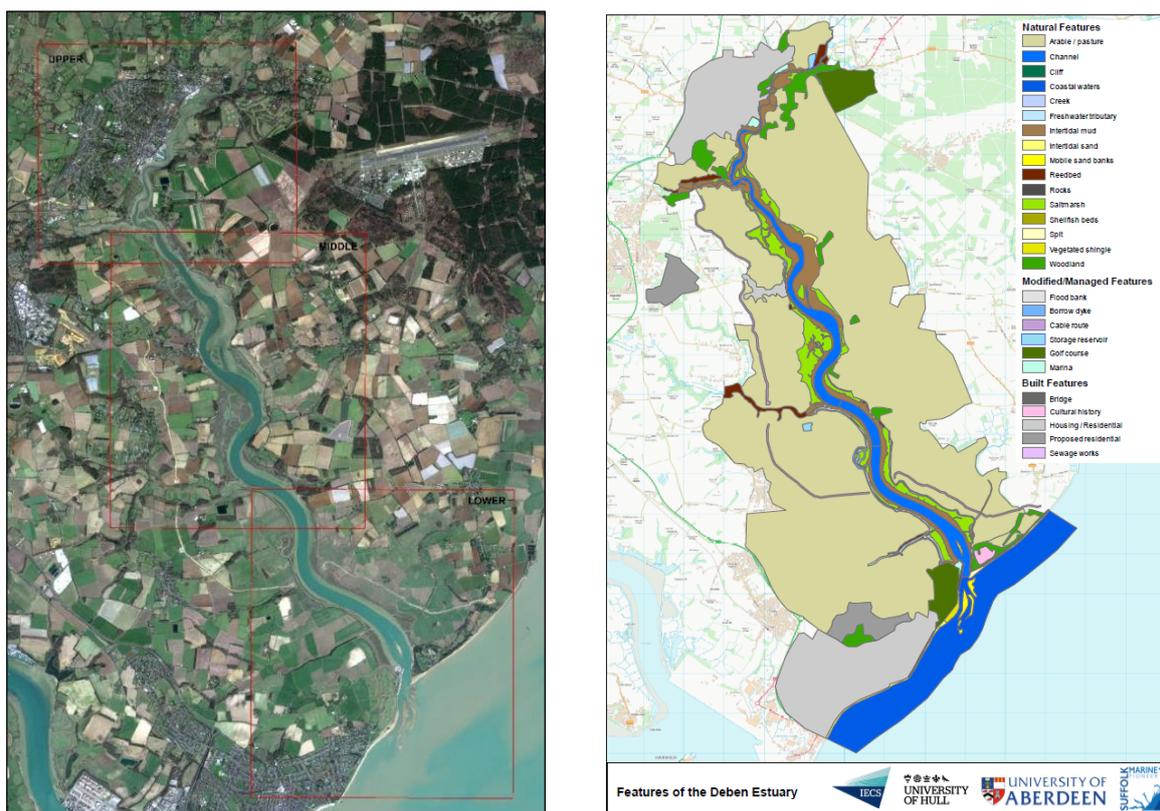


Figure 6: Sentinel-2 image of the Deben Estuary, Suffolk (left) and GIS output from the Participatory Mapping workshop (right) (Burdon et al., 2019b).

⁸ Lew., S., 2018. Annex 1 Toolkit for satellite mapping.

<https://wnmp.co.uk/wp-content/uploads/sites/29/2018/04/Appendix-1-satellite-mapping-toolkit-3.pdf>

5. **Identification and mapping of stakeholder-derived benefits:** Benefits were identified and defined by the Deben Estuary stakeholders. This enabled them to develop a shared language and understanding. A total of 26 benefits were identified by the Deben Estuary stakeholders (Table 4). Once identified, the benefits were numbered and then mapped using sticky dots on the map of features of the system which deliver them (as identified in Stage 4). Benefits can include both material (e.g. food, flood protection) and non-material (e.g. health, sense of community / place) elements.

Table 4: Benefits identified by stakeholders in the Deben Estuary workshops.

Benefits	
Primary production	Spiritual and cultural wellbeing
Nutrient cycling	Aesthetic benefits
Formation of species habitat	Education, Research
Formation of seascape	Physical health benefits
Natural hazard regulation	Psychological health benefits
Waste breakdown and detoxification	Renewable energy
Carbon sequestration	Sand supply (process)
Food (wild, farmed)	Dredging materials (product)
Wildlife feed (wild, farmed, bait)	Water resources (quantity and quality)
Healthy climate	Archaeology / Geology / Geomorphology
Prevention of coastal erosion	Place to live
Sea defence	Place to work / Employment
Tourism/nature watching (general)	Biodiversity

6. **Production and refinement of GIS outputs:** All hand-drawn maps of features and benefits from the Deben Estuary workshop were digitised post-workshop using GIS software so that they can be shared, refined and manipulated for future scenarios assessments (Stage 7). The mapping process can be identified as six distinct tasks which are undertaken before (Task 1), during (Tasks 2-3) and after (Task 4-6) the Participatory Mapping workshop (Figure 7). All workshop outputs generated in Workshop #1 were subsequently refined by the stakeholders at the start of Workshop #2 before the interactive pdfs were finalised and delivered to the Suffolk Marine Pioneer Project Manager.

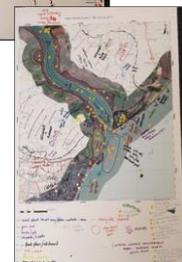
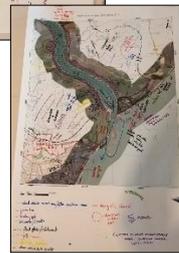
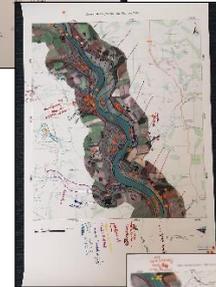
1. Satellite Image



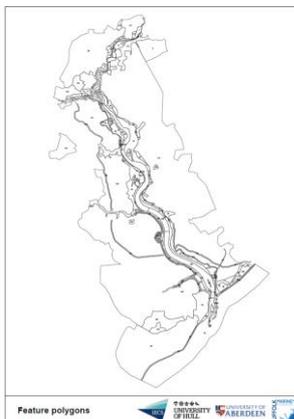
2. Features Mapping



3. Benefits Mapping



4. Created GIS Polygons



5. Produced Features Map



6. Interactive PDF of Features & Benefits

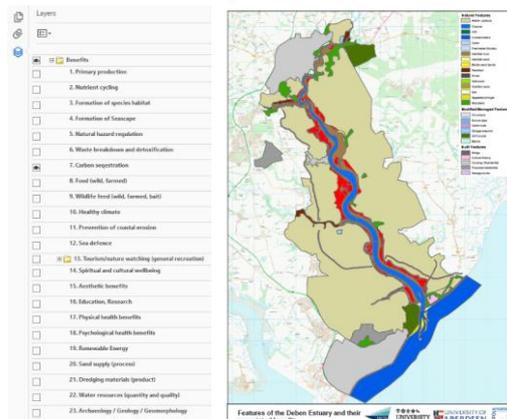


Figure 7: Mapping process undertaken during the Deben Estuary workshops and post-workshop GIS processing.

- Co-development of scenarios:** Future scenarios can be used to identify where natural capital is changing in response to a range of natural or anthropogenic drivers and assess the loss or gain in the delivery of benefits and the potential impact on different groups of stakeholders. These scenarios should always be co-developed with the stakeholders and agreement sought over the range and parameters of the scenario. In the case of the Deben Estuary, Workshop #2 focussed on two scenarios: (1) 'Sea Level Rise' - 31 ha of saltmarsh in the middle Deben Estuary is lost as a result of sea level rise and is replaced by mudflat and (2) 'Land-use Change' – 500 ha of agricultural land is lost through a managed realignment and is replaced by saltmarsh. The Matrix Approach was used as part of the trade-off assessment as it demonstrated the relative importance of these different features in delivering the different benefits (Figure 11).

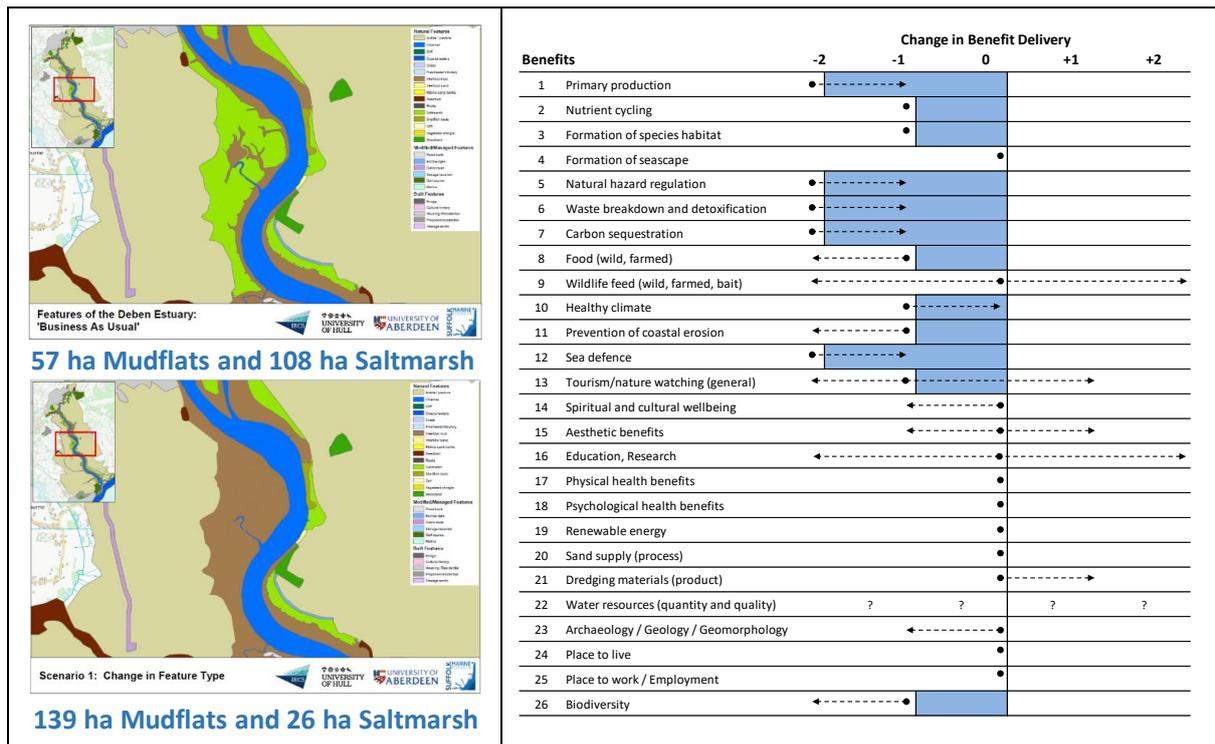


Figure 8: Scenario 1: Sea Level Rise (left). Output from the trade-off assessment (right). The blue bars with black dot represent the mean change (large loss --, small loss -, small gain +, large gain ++) from the 'Business As Usual' (represented as 0). The variance of responses across the three tables is represented by the dashed line.

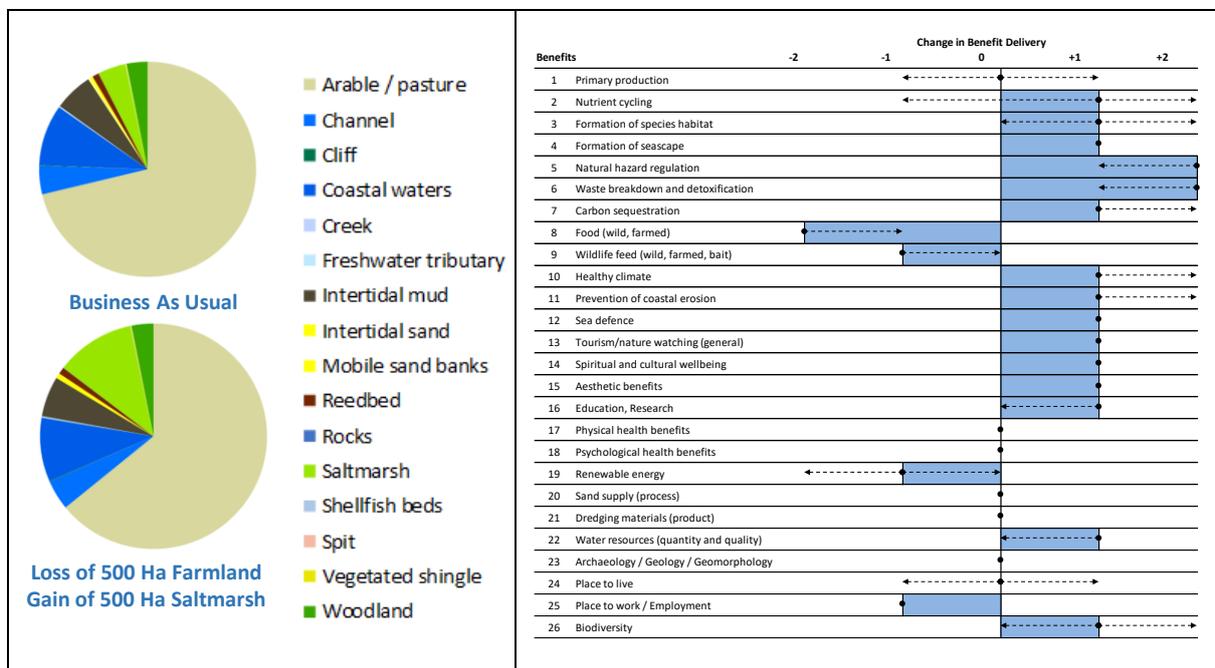


Figure 9: Scenario 2: Change in land-use type calculated using GIS from the features mapping (left). Output from the trade-off assessment (right). The blue bars with black dot represent the mean change (large loss --, small loss -, small gain +, large gain ++) from the 'Business As Usual' (represented as 0). The variance of responses across the three tables is represented by the dashed line.

8. **Logic chain development:** Stakeholders can identify and assess the relative importance of multi-directional relationships between natural capital, benefits and beneficiaries. Such logic chains can be used by individuals or groups of stakeholders to assess their reliance, or that of other stakeholders, on the natural capital and features provided by the case study site. Deben Estuary Workshop #1 established the links between 16 natural features ('natural capital') and the 26 stakeholder-derived 'benefits'. Deben Estuary Workshop #3 focussed on identifying the links between a range of 15 beneficiaries and the 26 benefits. The example presented in Figure 10 focuses on the benefit of 'sea defence'. The logic chain can be viewed through either a natural capital lens (read left to right) with the narrative focussing on the 'importance' of linkages or a beneficiaries lens (read right to left) with the narrative focussing on 'reliance / dependence'. By taking a logic chain approach, the relative importance and/or reliance of linkages within the chain can easily be identified using both the Matrix Tool (Figure 11) and the Beneficiaries Tool (Figure 12) which were developed specifically for the Deben Estuary. Full details of the development and application of the logic chain approach in the Deben Estuary are provided in Burdon et al. (2020).

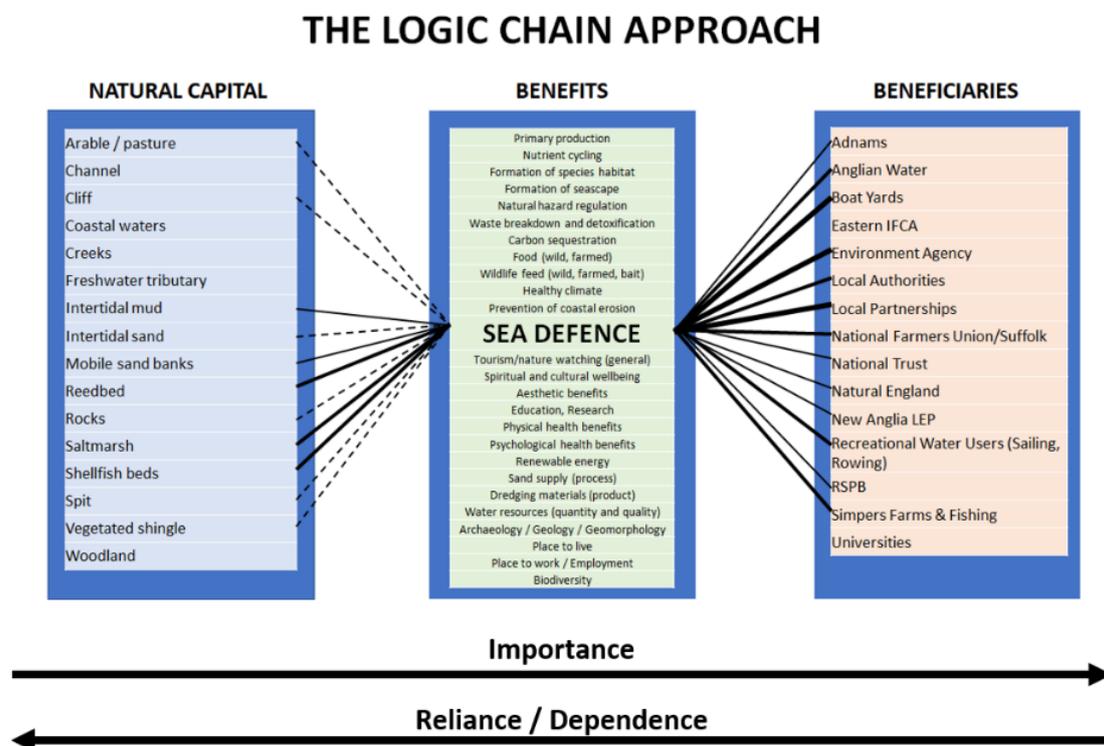


Figure 10: Deben Estuary logic chain (Burdon et al., 2020). The thickness of line represents the importance of the relationship (low, medium, high). Dashed lines represent that there is a relationship but its relative importance has not been assessed.

9. **Visualisation:** Bespoke visualisation tools can be developed which clearly illustrate the relative importance of the linkages between natural capital, benefits and beneficiaries. These tools are an essential component of the Participatory Mapping approach as they enable stakeholders to fully engage the process and can be used in real-time. For the Suffolk Marine Pioneer Project, visualisation tools were developed to illustrate the relative importance of the natural features (identified in Stage 4) in delivering benefits (Figure 11) and for the reliance of beneficiaries on the 26 benefits (identified in Stage 5) delivered by the Deben Estuary (Figure 12). These tools form part of the Suffolk Pioneer Project legacy and are available for the Deben Stakeholders to use in the future.

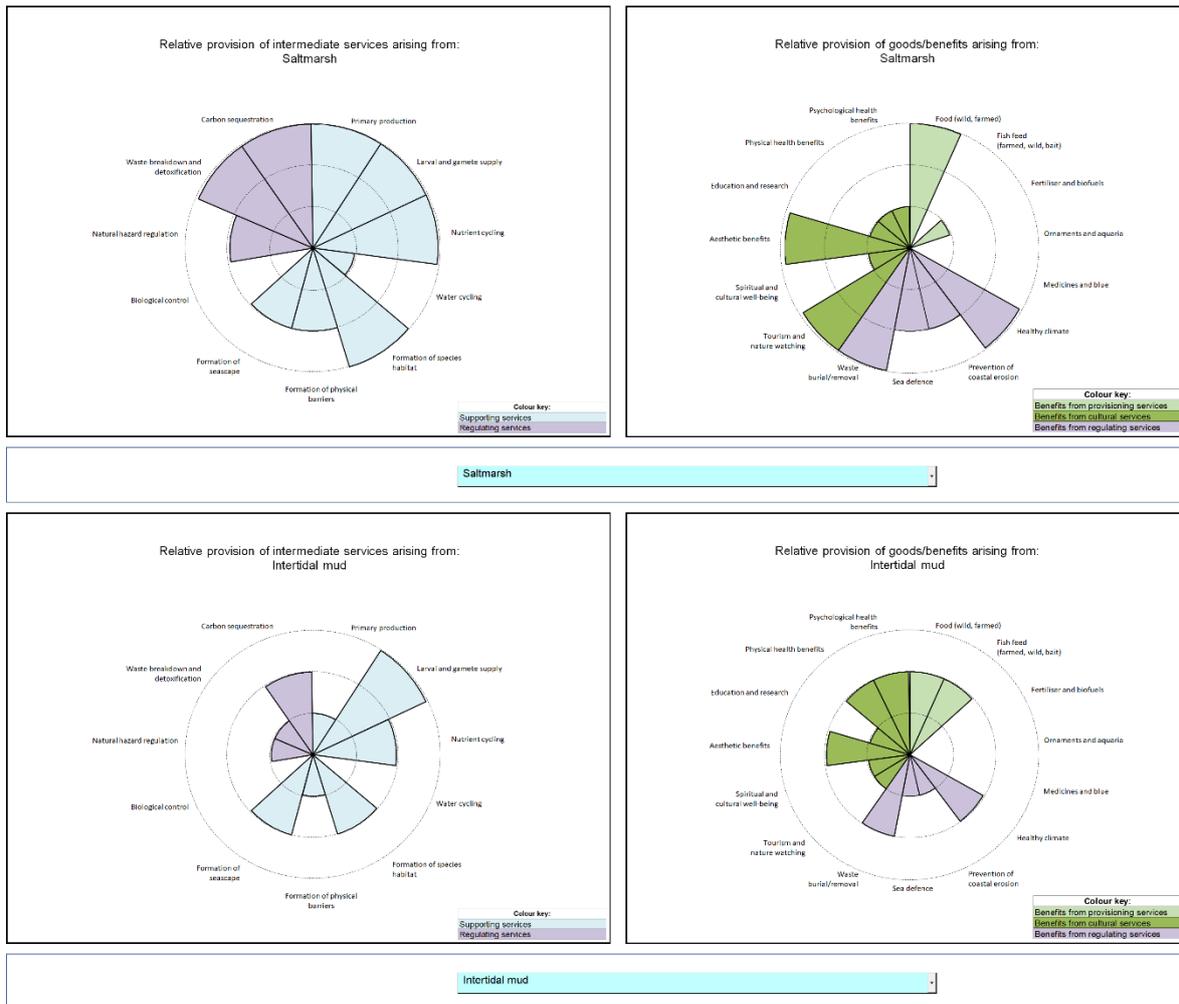


Figure 11: Matrix Tool: Examples shown for Saltmarsh (top) and Intertidal mud (bottom). Concentric circles represent high, medium and low importance. Underpinning data taken from Potts et al. (2014). Tool design © Steve Barnard.

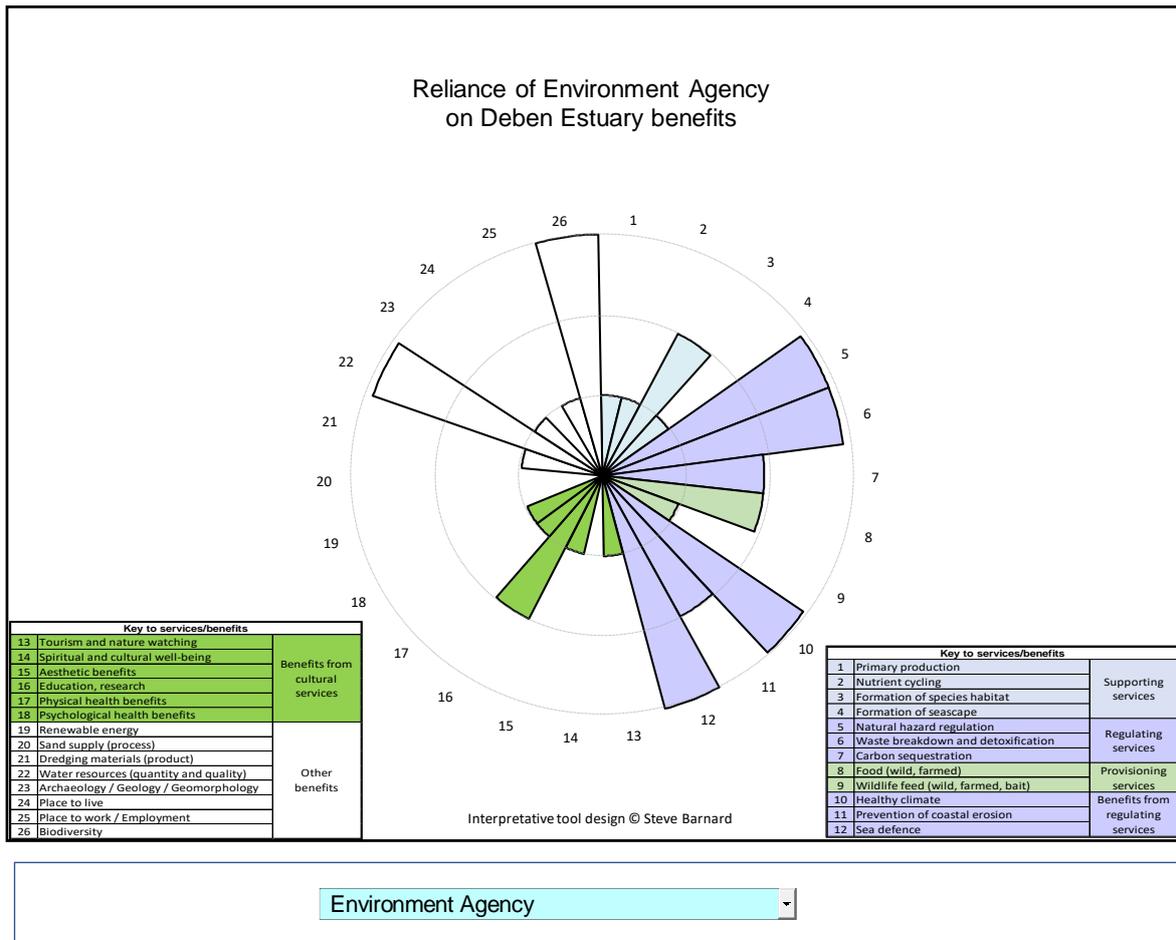


Figure 12: Beneficiaries Tool developed by the Deben Estuary stakeholders: Example shown for the Environment Agency. Concentric circles represent high, medium and low importance/reliance. Tool design © Steve Barnard.

10. **Stakeholder feedback and refinement:** Being a stakeholder-driven approach, feedback from the stakeholders is essential and should be sought at all stages of the process to ensure outputs are fit-for-purpose and to enable the project team to refine the approach. Opportunities for stakeholder feedback are represented as the dashed lines in Figure 5. Stakeholder feedback was obtained and analysed following each of the three Deben Estuary workshops (Burdon et al., 2019a,b, 2020). Feedback was used to refine the Deben Estuary workshops and will also be taken on board for future applications of the Participatory Mapping Approach.

All Suffolk Marine Pioneer Project outputs (workshop reports and tools) can be accessed via the Suffolk Coasts and Heaths website⁹.

⁹ Suffolk Marine Pioneer Outputs. <https://www.suffolkcoastandheaths.org/managing/projects/marine-pioneer/>

3. Critique of the Participatory Mapping Approach

In order to review and critique the current development and applications of the Participatory Mapping Approach, and to investigate future applications of the method, a workshop was designed and delivered with senior marine planners, policy-makers and nature conservation bodies from across the UK¹⁰. In order to capture the opinions of the workshop participants, a questionnaire was completed by the participants during the workshop. The questionnaire was structured around a SWOT analysis.

3.1 SWOT Analysis

The SWOT analysis focussed on the strengths (Pros) and weaknesses (Cons) of the Participatory Mapping Approach to date, and the opportunities (Pros) and threats (Cons) of applying the Participatory Mapping Approach in the future (Figure 13). As such the participants were asked to respond to four questions:

1. What are the CURRENT STRENGTHS of the Participatory Mapping Approach?
2. What are the CURRENT WEAKNESSES of the Participatory Mapping Approach?
3. What are the FUTURE OPPORTUNITIES of using the Participatory Mapping Approach?
4. What are the FUTURE THREATS of using the Participatory Mapping Approach?

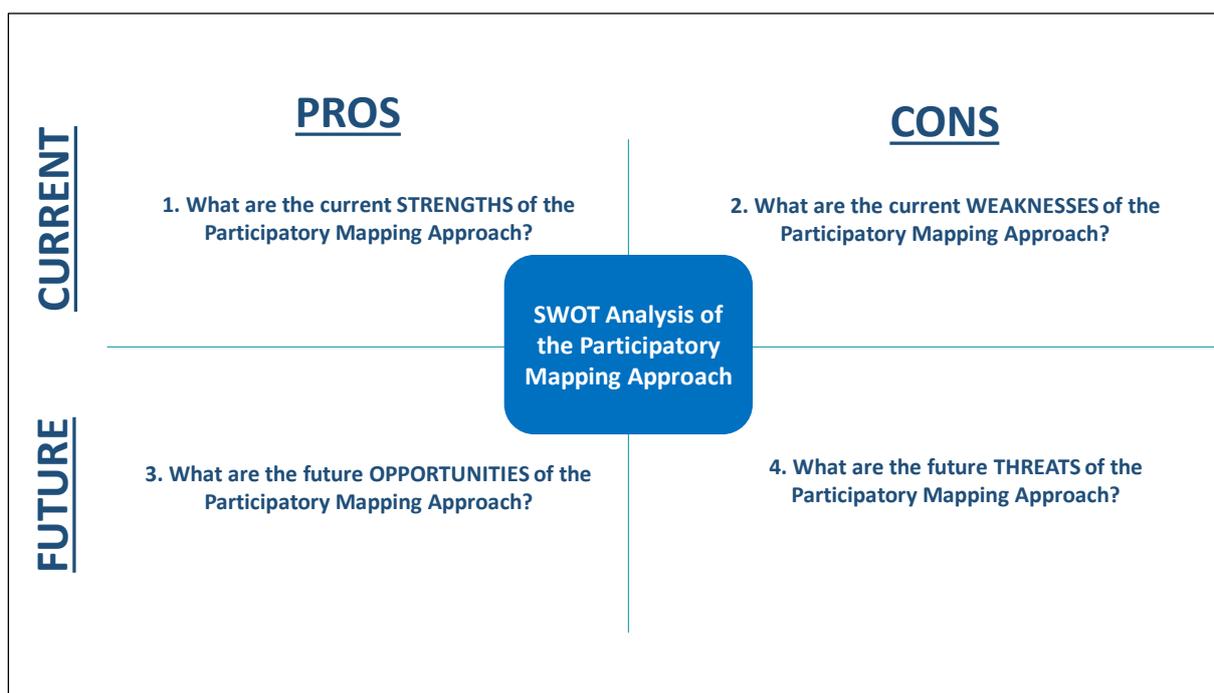


Figure 13: SWOT analysis structure used during the workshop.

¹⁰ The workshop was planned to be hosted at Defra Offices, Nobel House, London at 13:00-17:00 on Thursday 19 March 2020. However due to the Covid-19 pandemic the workshop was run remotely by Dr Daryl Burdon and Dr Tavis Potts using Zoom. The workshop was attended by 25 senior marine planners, policy-makers and nature conservation bodies.

3.1.1 Strengths

A summary of the main themes (in no particular order) that came out of the analysis of current strengths of the Participatory Mapping Approach include:

Methods

- The local specificity is a real strength as it can draw upon very accurate and detailed data.
- Participatory methods and co-design are gaining momentum and this approach may help to aid best practice/guidelines for use.
- Maps are a very useful visual tool for stakeholders to understand where assets and ecosystem services are located and to understand the development of the scenarios.
- Use of visuals such as satellite images is very powerful and helps to avoid anyone leading or biasing the process.
- Identification of the relative importance and significance of the different benefits is far more meaningful than simply mapping the presence and number of features or ecosystem services in spatial grids.
- Considers the full range of benefits rather than just those that can have an economic valuation assigned to them.
- Transparency and partnership is mediated through sharing and co-creating tools and knowledge which is usually confined to policy/statutory organisations or stakeholders.
- Use of simple scenarios encourages wider and longer-term perspectives.
- Applying a logic chain approach enables mapping of the connections between features, benefits and beneficiaries and the relative importance of these.
- Workshops generate outputs in a format (e.g. interactive pdfs) which ensures that the evidence and tools can be taken forward by the stakeholders.

Stakeholder Engagement and Communication

- The approach not only obtains stakeholder buy-in but also results in genuine collaboration and co-production.
- Useful for policy and decision-makers to see that there are different views amongst stakeholders which can be used to challenge bias about what is 'important'.
- Taking a mapping approach results in a great communication tool with good visual outputs.
- Ensuring that stakeholders are included early in the study and buy-in to the process can help increase the acceptance of ultimate decisions.
- Knowledge sharing and co-production is a real strength of the approach.
- Documenting non-monetary value and non-quantitative value in a way that can be visualised and easily digested.
- Mapping allows stakeholders to have ownership over their input and are a really good communication tool.
- Exposure of stakeholders to processes which are undertaken by government departments and agencies help them to understand the issues and restrictions that they face.

- Engagement with local stakeholders ensures that local knowledge on historical issues is included within the dialogue which may not be documented elsewhere.
- Transparent and inclusive approach will make stakeholders and local communities feel involved and their opinions/knowledge valued.
- Deepens and strengthens the relationship with and amongst stakeholders which results in a high quality dialogue.
- Production of a shared understanding gained by getting all stakeholders in the same room working together.
- Wider awareness amongst people of others peoples view and priorities, allows exploration of options/differences of opinions in a controlled and structured fashion.

Data and Resources

- By generating quantitative data, this approach allows meaningful discussions on specific trade-offs, which would otherwise be very qualitative and subjective.
- The matrix approach contains an assessment of confidence which is very important when it comes to policy and decision making.
- Participatory mapping provides more up to date and refined data on activities than previously known.

3.1.2 Weaknesses

A summary of the main themes that came out of the analysis of current weaknesses of the Participatory Mapping Approach include (in no particular order):

Scale of the Approach

- Highly localised nature of the mapping approach means it is not easily scalable to a regional or national level and findings cannot be extrapolated.
- The scale of the map could be a weakness if it is not appropriate for the case study area.
- Not been applied yet to highly controversial situations or in the offshore marine environment.

Stakeholder Engagement

- Workshops are subjective and have the potential for strident lobby or interest groups to influence the discussion and conclusions.
- Representativeness - Small sample sizes selected from existing partnerships engages those who may have already bought into such processes and may not reflect the values of the wider community – how could it engage the wider community and marginalised groups (e.g. BAME, disabled groups, low income families).
- Potential for stakeholder fatigue if this is rolled out across the UK at the same time as other stakeholder engagement events.
- Need to ensure that everyone has an equal voice and people are not too biased from what is said by others.

Data and Resources

- Time and staffing resources required to successfully undertake the approach on a UK wide scale rather than at individual case study levels.

- The underlying matrix approach only includes protected habitats and species so its scope could be widened.
- Reliance of quantitative data generated given the small size of the samples.
- Maps generated by stakeholders knowledge may have some limitations – would be good to use scientific data to verify the locally produced maps.

Methodology

- For decision-making, the approach needs to be further developed to weigh up or value the different benefits and then how do you decide what to prioritise/value most highly.
- Less established than other value-based approaches (e.g. HM Treasury Green Book) so how would it fit with for example the Natural Capital Committee risk register/asset register approaches, citizen's juries, Delphi survey.
- For cultural services, it may need to be topped up by other methods and work with local communities.

3.1.3 Opportunities

A summary of the main themes that came out of the analysis of future opportunities of the Participatory Mapping Approach include (in no particular order):

Government Policy

- Provide evidence to inform future policy e.g. locally you may identify a particular benefit that is valued above others and might want to develop policy to enhance / safeguard that benefit.
- Forming part of a broader suite of tools to consider the value and significance of natural capital features within local planning or policy development.
- Policy-making at the local scale by linking industry and policy-makers with a natural capital approach (place-based policy).

Marine Planning

- Engage stakeholders for the designation and/or management of MPAs, MCZs and HPMAs to ensure that social, cultural and historical aspects are included alongside economic and ecological aspects.
- Further investigate the application of Participatory Mapping and natural capital approaches for the offshore marine environment, e.g. applying them to offshore wind farms and fisheries.
- Useful tool in marine planning to help the broad marine plans to be applied to local areas.
- Used in the blue space planning (e.g. health / well-being / infrastructure).
- Used to locate potential areas for pilot studies for a variety of coastal applications.
- Compliment participatory management currently being considered to manage fisheries.
- The approach is useful for Local Authorities and planning.

Data Generation

- Providing baseline information at the local scale which could be used by Local Authorities to prioritise limited resources and feed into Local Authority planning and monitoring.
- Results from the pilot studies could provide a baseline to compare values and attitudes e.g. after local planning or community challenges or following the Coronavirus pandemic.

- Outputs could feed into wider seascape projects.
- Link with corporate natural capital accounting, generating data for it or for attracting private sector investment to improve natural capital.

Research and Communication

- Powerful tool in raising awareness and communicating the importance of natural capital, climate change, mitigation and ocean literacy.
- Discover opportunities for where local knowledge could be used as a resource in planning and monitoring of our coasts.
- Need to compare the methods and outputs from Participatory Mapping with other approaches currently being applied in the marine environment.
- The matrix, asset and risk approaches for natural capital assessments could be integrated with participatory evidence at local to regional / national scales.
- Outputs (e.g. interactive pdfs) could be used to compare data generated from local knowledge with that generated from existing literature or primary data studies.

3.1.4 Threats

A summary of the main themes that came out of the analysis of future threats of the Participatory Mapping Approach include (in no particular order):

Data and Resources

- A current lack of accurate and detailed underpinning data which would be required for credible mapping and assessments.
- Costs, resources and time needed for the workshops and reporting findings.
- Securing long-term funding to undertake participatory mapping exercises around the UK coasts.

Scale of the Approach

- The local focus of the approach makes it challenging to inform or underpin regional or national strategy of policy approach.
- The requirement to repeat the mapping exercises following severe weather events or developments within the area.
- The method works well in the estuarine and coastal environment but is yet to be tested in an offshore location.
- Lack of join-up between different jurisdictions (e.g. Severn Estuary or Irish Sea) or from terrestrial, through intertidal to coastal and offshore.

Methodology and Stakeholder Engagement

- The highly subjective, and potentially emotive and inconsistent, nature of the outputs generated could be a barrier to their implementation.
- Given the face-to-face nature of the workshops, there is a real threat to such events as a result of extreme events (e.g. localised flooding or Coronavirus outbreak).

- This approach is developing much more slowly in the marine environment and therefore there is the danger that the marine environment will have to play catch up or follow established terrestrial approaches.
- May be difficult to get buy-in from stakeholders or for sufficient stakeholders to be engaged to make the results more reliable.
- Following the current global emergency (Coronavirus) how biased will marine social science surveys be towards the current 'shock' situation and what would 'normal' look like after Coronavirus?

Government Policy

- Changing government policy priorities with respect to the environment (e.g. natural capital, nature-based solutions, net gain etc.).
- Is Natural Capital being seen as 'yesterday's news'?
- Scepticism towards involving / transfer of power / control to stakeholders.
- Getting government / policy colleagues on side / buy-in.
- Acceptance of the process – across communities, and with policy / regulatory bodies.

4. Conclusions and Recommendations

4.1 Conclusions

- A high-level policy agenda for delivering a Natural Capital Approach is evident from the range of drivers in the UK and devolved administrations outlined within this report (Table 1). This is an encouraging development indicating direction of travel, but a challenge still remains over operational delivery, data and resources.
- The Participatory Mapping Approach to natural capital is a peer-reviewed (Burdon et al., 2019), stakeholder-driven and co-produced methodology that has been developed and applied across four pilot studies (East Caithness, Aberdeen Bay, Humber Estuary and The Wash) and throughout a series of workshops for the Suffolk Marine Pioneer Project (Deben Estuary, Suffolk).
- The Participatory Mapping Approach addresses the need for a place-based and stakeholder-driven approach to natural capital which allows spatial mapping of ecosystem features, benefits and values on a local scale and provides pragmatic data relating to natural and man-made features, ecosystem benefits, values and trade-offs.
- The use of satellite images (e.g. Sentinel-2) for intertidal estuarine and coastal Participatory Mapping provides real time data that are free to download and are relatively accessible to all stakeholders. Satellite images enable the user to look at different tidal ranges and during different seasons thus providing a temporal scale to the Participatory Mapping exercises. Satellite images may also provide valuable data for Participatory Mapping offshore, but this would need to be further explored.
- In addition to providing spatial, qualitative and quantitative data of features and benefits, the approach identifies how benefits are distributed amongst stakeholders and communities (the 'beneficiaries'). This provides a novel integrated model linking natural and social systems by focussing on the relationships between the benefits provided by natural capital and specific stakeholders and how this relationship can change over time and in response to both natural and anthropogenic change.
- Participatory Mapping is a flexible and adaptive approach which has already been fully integrated with other complimentary methods such as the Matrix Approach (e.g. Potts et al., 2014). The approach also has great potential to integrate with other methods including ecosystem and climatic modelling (e.g. Sadykova et al., 2020), natural capital asset and risk assessments (e.g. Rees et al., 2019), marine spatial planning (e.g. Friedrich et al., 2020) and monetary and non-monetary valuation approaches (see Table 2).

4.2 Recommendations

- Place-based approaches are gaining momentum to link higher scale policy developments (e.g. natural capital asset registers, marine planning, blue economy strategies) with community based natural capital planning. Place-based approaches link coastal and marine ecosystems to community well-being and support employment, investment and sustainable coastal regions. **It is recommended that the Participatory Mapping Approach is expanded into priority regions and localities beyond the Marine Pioneer Projects and is incorporated into devolved regions where marine planning is currently being developed and rolled out.**
- The Participatory Mapping Approach can support all phases of the policy process from scoping, design, appraisal, implementation and review. Specific interventions include regional

and local marine and coastal planning; coastal and shoreline management; offshore wind and marine renewable energy development and assessment; marine protected area designation, management and review; and inshore fisheries management. It can help identify local priorities for investment and development, particularly around options for improving sustainability, net gain and well-being. **It is recommended that further work explores integrating the Participatory Mapping Approach with existing and emerging marine policy instruments and processes.**

- The Participatory Mapping Approach fills a gap to engage, educate and empower stakeholders about the links between communities and their coastal and marine systems. It provides visual products and tools that all stakeholders can use to support further natural capital improvement, for example by provision of natural capital plans, supporting existing initiatives and directing community investment. Importantly the approach connects stakeholders from government, civil society and industry with a common language and approach to natural capital. **It is recommended that long term funding mechanisms support continual engagement around coastal and marine natural capital with transparent and rigorous stakeholder engagement, with an emphasis on targeting hard to reach communities or those who do not traditionally engage.**
- At present, the applications of the Participatory Mapping Approach have engaged existing networks of stakeholders through local coastal or nature partnerships. This approach has enabled networks to be easily accessed thus saving time and resources. However it is recognised that this approach may not be representative of the wider community and engages those who already have an interest in natural capital. **It is recommended that further investment is required in engaging the wider community to ensure that marginalised groups (e.g. BAME, disabled groups, low income families) are engaged within the process.**
- A real strength of the Participatory Mapping Approach is the local scale of its application which engages local communities and generates local products based on local knowledge. However a challenge for the approach is how to upscale it for use within regional and national policy and planning. There is great potential for the development of regional scale spatial layers, meta-data, valuations and scenario exercises. **It is recommended that further research is commissioned to develop mechanisms to upscale the Participatory Mapping Approach to regional and national scales.**
- To date the Participatory Mapping Approach has been applied to discrete estuarine and coastal case study sites. **It is recommended that the Participatory Mapping Approach is adapted to map natural capital and benefits across different jurisdictions (e.g. Severn Estuary or Irish Sea) and to map natural capital and benefits across terrestrial, intertidal coastal and offshore case studies.**

References

- Andrews, S., Stocker, L. & Oechel, W., 2018. Underwater Photo-Elicitation: A New Experiential Marine Education Technique. *Australian Journal of Environmental Education*, 34, pp. 33-60.
- Atkins, J.P., Burdon, D. & Allen, J.H., 2007. An application of contingent valuation and decision tree analysis to water quality improvements. *Marine Pollution Bulletin*, 55, pp. 591-602.
- Atkins, J.P., Burdon, D. & Elliott, M., 2015. Chapter 5. Identification of a practicable set of indicators for coastal and marine ecosystem services. In: Turner, R.K. & Schaafsma, M. (Eds.) Coastal zones ecosystem services: from science to values and decision making. Studies in Ecological Economics, Volume 9, Springer, Switzerland.
- Börger, T., Hattam, C., Burdon, D., Atkins, J.P. & Austen, M., 2014. Valuing conservation benefits of an offshore marine protected area. *Ecological Economics*, 108, pp. 229–241.
- Brown, G. & Fagerholm, N., 2015. Empirical PPGIS/PGIS mapping of ecosystem services: A review and evaluation. *Ecosystem Services*, 13, pp. 119-133.
- Burdon, D., Boyes, S.J., Potts, T. & Cosgrove, P., 2019a. Suffolk Marine Pioneer Values and Priorities Workshop #1. Report to Suffolk County Council prepared by IECS, University of Hull, Hull, UK.
- Burdon, D., Boyes, S.J., Potts, T. & Cosgrove, P., 2019b. Suffolk Marine Pioneer Values and Priorities Workshop #2. Report to Suffolk County Council prepared by IECS, University of Hull, Hull, UK.
- Burdon, D., Potts, T. & Barnard, S., 2020. Suffolk Marine Pioneer Natural Capital Logic Chains and Tool Development Workshop Report. Daryl Burdon Ltd., Willerby, UK. February 2020.
- Burdon, D., Potts, T. & Boyes, S.J., 2019c. Suffolk Marine Pioneer Scenarios Assessments. Report to Suffolk County Council prepared by IECS, University of Hull, Hull, UK.
- Burdon, D., Potts, T. McKinley, E.J., Lew, S., Shilland, R., Gormley, K., Thomson, S. & Forster, R., 2019. Expanding the role of participatory mapping to assess ecosystem service provision in local coastal environments. *Ecosystem Services*, 39, October 2019, 101009. <https://doi.org/10.1016/j.ecoser.2019.101009>.
- Burdon, D., Potts, T., Barbone, C. & Mander, L., 2017. The matrix revisited: A bird's-eye view of marine ecosystem service provision. *Marine Policy*, 77, pp. 78-89. <https://doi.org/10.1016/j.marpol.2016.12.015>
- Burkhard, B., Kroll, F., Nedkov, S., Müller, F., 2012. Mapping ecosystem service supply, demand and budgets. *Ecological Indicators*, 21, pp. 17–29.
- Chae, D.R., Wattage, P. & Pascoe, S. 2012. Recreational benefits from a marine protected area: A travel cost analysis of Lundy. *Tourism Management*, 33, pp. 971-977.
- Cooper, K., Burdon, D., Atkins, J.P., Weiss, L., Somerfield, P., Elliott, M., Turner, K., Ware, S. & Vivian, C., 2013. Can the benefits of physical seabed restoration justify the costs? An assessment of a disused aggregate extraction site off the Thames Estuary, UK. *Marine Pollution Bulletin*. 75, pp. 33-45.
- Costanza, R., D'Arge, R., de Groot, R.S., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neil, R.V., Paruelo, J., Raskin, R.G., Sutton, P. & Belt, M.V.D., 1997. The value of the world's ecosystem services and natural capital. *Nature*, 387, pp. 253-260.
- Costanza, R., de Groot, R., Sutton, P.C., van der Ploeg, S., Anderson, S., Kubiszewski, I., Farber, S., Turner, R.K., 2014. Changes in the global value of ecosystem services. *Global Environmental Change*, 26, pp. 152–158.

- Damastuti, E. & de Groot, R., 2018. Participatory ecosystem service mapping to enhance community-based mangrove rehabilitation and management in Demak, Indonesia. *Regional Environmental Change*, 19, pp. 65-78.
- Defra, 2020. Enabling a Natural Capital Approach (ENCA). <https://www.gov.uk/guidance/enabling-a-natural-capital-approach-enca>
- Derous, S., Agardy, T., Hillewaert, H., Hostens, K., Jamieson, G., Lieberknecht, L., Mees, J., Moulaert, I., Olenin, S., Paelinckx, D., Rabaut, M., Rachor, E., Roff, J., Stienen, E.W.M., van der Wal, J.T., Van Lancker, V., Verfaillie, E., Vincx, M., Weslawski, J.M., Degraer, S., 2007. A concept for biological valuation in the marine environment. *Oceanologia* 49 (1), pp. 99-128.
- Friedrich, L.A., Glegg, G., Fletcher, S., Dodds, W., Philippe, M. & Bailly, D., 2020. Using ecosystem service assessments to support participatory marine spatial planning. *Ocean and Coastal Management*, 188 (2020) 105121.
- Gutman, J., 1982. A means-end chain model based on consumer categorization processes. *Journal of Marketing*, 46, pp. 60-72.
- Hanley, N., Bell, D. & Alvarez-Farizo, B., 2003. Valuing the benefits of coastal water quality improvements using contingent and real behaviour. *Environmental and Resource Economics*, 24, pp. 273-285.
- Harper, D., 2002. Talking about pictures: A case for photo elicitation. *Visual Studies*, 17, pp. 13-26.
- Hattam, C., Atkins, J.P., Beaumont, N., Borger, T., Böhnke-Henrichs, A., Burdon, D., De Groot, R., Hoefnagel, E., Nunes, P., Piwowarczyk, J., Sergio, S. & Austen, M., 2015a. Marine ecosystem services: linking indicators to their classification. *Ecological Indicators*, 49, pp. 61–75.
- Hattam, C., Böhnke-Henrichs, A., Börger, T., Burdon, D., Hajimicheale, M. Delaney, A., Atkins, J.P., Garrard, S. & Austen, M., 2015b. Integrating methods for ecosystem service assessment and valuation: mixed methods or mixed messages? *Ecological Economics*, 120, pp. 126–138.
- Hattam, C., Börger, T., Garrard, S., Austen, M., Atkinson, J., Burdon, D., Piwowarczyk, J., Kedra, M., Weslawski, J.M., Delaney, A., Hadjimichael, M., Sastre, S., Canepa, A., Maynou, F., Piñol, L., Nunes, P.A.L.D., Loureiro, M., Voltaire, L., Serra, C., Otrachshenko, V., Bosello, F., Böhnke-Henrichs, A., de Groot, R., 2014. Impacts of change on ecosystem services and their values. FP7 – OCEAN- 2010. Project number 266445, VECTORS of Change in Oceans and Seas Marine Life, Impact on Economic Sectors. Deliverable D32.1 May 2014.
- IPBES, 2019. Global Assessment Report on Biodiversity and Ecosystem Services. <https://ipbes.net/global-assessment>
- Jobstvogt, N., Hanley, N., Hynes, S., Kenter, J., Witte, U., 2014. Twenty thousand sterling under the sea: estimating the value of protecting deep-sea biodiversity. *Ecological Economics*, 97, pp. 10–19.
- Sadykova, D., Scott, B.E., De Dominicis, M., Wakelin, S.L., Wolf, J. & Sadykov, A., 2020. Ecological costs of climate change on marine predator–prey population distributions by 2050. *Ecology and Evolution*, 2020;00:1–18.
- Luisetti, T., Turner, R.K., Andrews, J., Jackson, E., Pamieri, M.G., Sen, A. & Paltriguera, L., 2015. Why value ‘Blue Carbon’? In: Turner, R.K. & Schaafsma, M. (Eds.) Coastal zones ecosystem services: from science to values and decision making. *Studies in Ecological Economics*, Volume 9, Springer, Switzerland.
- Luisetti, T., Turner, R.K., Bateman, I.J., Morse-Jones, S., Adams, C. & Fonseca, L., 2011. Coastal and marine ecosystem services valuation for policy and management: Managed realignment case studies in England. *Ocean & Coastal Management*, 54(3), pp. 212–224.

- MA, 2003. Ecosystems and Human Wellbeing: A Framework for Assessment. Chapter 2: Ecosystems and Their Services. <http://www.millenniumassessment.org/>
- MA, 2005. Millennium Ecosystem Assessment – Ecosystems and human wellbeing biodiversity synthesis. Island Press, Washington, DC.
- Natural Capital Committee, 2017. How to do it: A natural capital workbook.
- NOAA, 2015. Social science tools for coastal programmes: Stakeholder engagement strategies for participatory mapping. Office for Coastal Management. <https://coast.noaa.gov/data/digitalcoast/pdf/participatory-mapping.pdf>
- Pascual, M., Borja, A., Eede, S.V., Deneudt, K., Vincx, M. & Galparsoro, I., 2011. Marine biological valuation mapping of the Basque continental shelf (Bay of Biscay), within the context of marine spatial planning. *Estuarine, Coastal and Shelf Science*, 95, pp. 186-198.
- Pike, K., Wright, P., Wink, B., Fletcher, S., 2014. The assessment of cultural ecosystem services in the marine environment using Q methodology. *Journal of Coastal Conservation*, 19, pp. 667-675.
- Potts, T., Burdon, D., Jackson, E., Atkins, J.P., Saunders, J., Hastings, E. & Langmead, O., 2014. Do marine protected areas deliver flows of ecosystem services to support human welfare? *Marine Policy*, 44, pp. 139–148. <https://doi.org/10.1016/j.marpol.2013.08.011>
- Potts, T., Pita, C., O’Higgins, T., Mee, L. 2016. Who cares? European attitudes towards marine and coastal environments, *Marine Policy*, 72, pp. 59-66.
- Ranger, S., Kenter, J., Bryce, R., Cumming, G., Dapling, T., Lawes, E., & Richardson, P., 2016. Forming shared values in conservation management: An interpretive-deliberative-democratic approach to including community voices. *Ecosystem Services*, 21(B), pp. 344-357.
- Rees, S.E., Rodwell, L.D., Attrill, M.J., Austen, M.C. & Mangi, S.C. 2010. The value of marine biodiversity to the leisure and recreation industry and its application to marine spatial planning. *Marine Policy*, 34, pp. 868–875.
- Rees, S.E., Ashley, M. & Cameron, A., 2019. North Devon Marine Pioneer 2: A Natural Capital Asset and Risk Register. A SWEEP/WWF-UK report by research staff the Marine Institute at the University of Plymouth.
- Ressurreição, A., Gibbons, J., Bentley, C., Burdon, D., Atkins, J.P., Kaiser, M., Austen, M., Santos, R., Dentinho, T.P., Zarzycki, T. & Edwards-Jones, G., 2012. Different cultures, different values: the role of cultural variation in public's willingness to pay for marine species conservation. *Biological Conservation*, 145, pp. 148-159.
- Reynolds, T.J & Gutman, J., 1988. Laddering Theory, Method, Analysis and Interpretation. *Journal of Advertising Research*. Feb/March.
- Sy, M.M., Rey-Valette, H., Simier, M., Pasqualini, V., Figuières, Ch. & De Wit, R., 2018. Identifying consensus on coastal lagoons ecosystem services and conservation priorities for an effective decision making: A Q Approach. *Ecological Economics*, 154, pp. 1-13.
- UKNEA, 2011. The UK National Ecosystem Assessment: Synthesis of the key findings. UNEP-WCMC, Cambridge, UK.
- UKNEAFO, 2014. The UK National Ecosystem Assessment Follow-on: Synthesis of key findings. UNEP-WCMC, LKWE, UK.