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# 1 Expanding the role of participatory mapping to assess ecosystem 2 service provision in local coastal environments

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## 8 **Abstract:**

9 There has been increasing international effort to better understand the diversity and quality of marine  
10 natural capital, ecosystem services and their associated societal benefits. However, there is an  
11 evidence gap as to how these benefits are identified at the local scale, where benefits are provided  
12 and to whom, trade-offs in development decisions, and understanding how benefits support well-  
13 being. Often the benefits of conservation are poorly understood at the local scale, are not effectively  
14 integrated into policy and are rarely included meaningfully in public discourse. This paper addresses  
15 this disjuncture and responds to the demand for improving dialogue with local communities and  
16 stakeholders. Participatory GIS mapping is used as a direct means of co-producing knowledge with  
17 stakeholder and community interests. This paper drives a shift from development of participatory  
18 approaches to adaptive applications in real-world case studies of local, national and international  
19 policy relevance. The results from four sites along the UK North Sea coast are presented. This paper  
20 showcases a robust stakeholder-driven approach that can be used to inform marine planning,  
21 conservation management and coastal development. Although the demonstration sites are UK-  
22 focused, the methodology presented is of global significance and can be applied across spatial and  
23 temporal scales.

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24 **Keywords:** ecosystem services; societal benefits; co-production of knowledge; participatory  
25 mapping; marine protected areas; coastal developments

## 27 **Research Highlights**

- 28 • Adaptive stakeholder-driven approach to participatory mapping and engagement.
- 29 • Satellite imagery used to engage stakeholders in natural capital discussions.
- 30 • Workshop outputs can be used for marine planning and conservation management.
- 31 • Contributes to the wider discussion with a focus on socio-cultural value.

## 33 1. Introduction

34 International scientific efforts, such as the Millennium Ecosystem Assessment (MA, 2005), have  
35 focused on furthering our understanding of the diversity and quality of ecosystem services provided  
36 by the environment and how these can benefit society. The MA (2005) first separated ecosystem  
37 services into four distinct categories: provisioning (the products obtained from the ecosystem);  
38 regulating (the benefits obtained from the regulation of ecosystem processes); supporting (those that  
39 are necessary for the production of all other ecosystem services, but do not yield direct benefits to  
40 humans); and cultural (the nonmaterial benefits people obtain from ecosystems) services. Within  
41 Europe, The Economics of Ecosystems and Biodiversity (TEEB) project developed an ecosystem  
42 services framework (de Groot et al., 2010), which was based upon a conceptual model adapted from  
43 Haines-Young and Potschin (2010) and Maltby (2009) and, similarly to the MA, was applied to a range  
44 of ecosystems (including marine/open ocean, coastal systems, wetlands, rivers/lakes, forest, deserts  
45 and urban areas). Whilst, the Common International Classification of Ecosystem Services (CICES)  
46 formed part of the analytical framework for ecosystem service assessments under Action 5 of the EU  
47 Biodiversity Strategy (Maes et al., 2014) and was also adapted for application at a local level within  
48 Belgium (Turkelboom et al., 2013). More recently, the dialogue around this has evolved to encompass  
49 the concept of natural capital, which can be defined as the stock and flow of both renewable and non-  
50 renewable natural resources (e.g. water, biodiversity, air) that provide benefits to society (NCC, 2019).  
51 Within the UK, a number of studies have attempted to categorise the links between ecosystem  
52 services, societal benefits and well-being across a broad spectrum of ecosystems that make up natural  
53 capital (e.g. UKNEA, 2011), including more specifically with respect to the marine environment (e.g.  
54 Beaumont et al., 2007; UKNEAFO, 2014; Friedrich et al., 2015; Turner et al., 2015; CoastWEB<sup>1</sup>). Further  
55 scientific effort has focussed on the identification of indicators to assess state, behaviour and  
56 trajectory of marine ecosystem services (Hattam et al., 2015a; Atkins et al., 2015) and how important  
57 designated marine habitats and species at a national scale are in delivering individual services and/or  
58 benefits (Fletcher et al., 2012; Potts et al., 2014; Saunders et al., 2015; Burdon et al., 2017).

59 Coastal waters, and the diverse habitats and species they sustain, provide society with food to eat  
60 (provisioning service), regulate the climate we live in, break down the waste we produce and protect  
61 us from coastal erosion and flooding (regulating services) (MA, 2005; Turner et al., 2015). They provide  
62 an inspirational seascape that allows us to play, contemplate and create (cultural services), and are  
63 essential for our individual and social well-being. The continued delivery of these ecosystem services,  
64 however, is under increasing pressure as a result of both human activities and the ongoing impacts of  
65 climate change. In addition, the advancement of Blue Growth (i.e. the long term strategy to support  
66 sustainable growth in the marine and maritime sectors as a whole) has led to further opportunities  
67 for maritime (and supporting) industries, resulting in increased pressure along the coastal zone, and  
68 has more recently led to a shift in activities further offshore (e.g. aquaculture, renewable energy  
69 development) (Börger et al., 2014; OECD, 2016).

70 Although a relatively recent addition to the conversation around ecosystem services and their value,  
71 there exists a myriad of recognised methods and approaches to assess socio-cultural values (e.g. Klain  
72 & Chan, 2012; Börger et al., 2014; Kenter et al., 2015; Cooper et al., 2016; Kenter et al., 2016) and  
73 their inclusion in ongoing conversations around marine natural capital. These range from quantitative,  
74 deductive approaches employed through large-scale questionnaires using Likert scale style questions  
75 as a method of assessing non-monetary values, through to more inductive, qualitative approaches of  
76 data gathering, including interviews, focus groups, workshops and an increasing use of art to elucidate

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<sup>1</sup> <http://valuing-nature.net/coastweb>

77 values, through methods such as photo elicitation and visual mapping (Andrews et al., 2018). Mapping  
78 ecosystem services and the values (both monetary and non-monetary) attributed to them provides  
79 decision makers with the ability to design management grounded in a spatial understanding of the  
80 ecosystem e.g. mapping can identify spatial variation in ecosystem service supply and value (Martinez-  
81 Harms & Balvanera, 2012; Brown & Fagerholm, 2015). Despite a recent growth in research effort  
82 around community-based mapping approaches (Raymond et al., 2009), there remains a significant  
83 knowledge gap regarding the socio-cultural value associated with natural capital and ecosystem  
84 services, as well as the social deliberation that determines trade-offs and exchanges between these  
85 services in the determination of societal welfare. As a counterbalance, this paper shifts the spotlight  
86 onto methods of socio-cultural valuation, specifically examining the role of participatory mapping as  
87 a tool through which socio-cultural values can be elucidated.

88 Participatory mapping is a direct means of co-producing knowledge with stakeholder and community  
89 interests, often in contrast to the simplifications and technocratic approaches of traditional  
90 Geographical Information Systems (GIS) that avoid social complexity and political negotiation.  
91 Participatory mapping approaches refer to a range of methodologies to capture spatially explicit data  
92 in a participatory way (Brown & Fagerholm, 2015), underpinned by effective stakeholder and  
93 community engagement processes (Damastuti & de Groot, 2019), producing knowledge and  
94 understanding of place and use on a local scale (Brown & Reed, 2012). In the context of ecosystem  
95 services valuation and mapping, relevant actors provide local, spatially explicit information about  
96 ecosystem service provision, use and value (both monetary and non-monetary, where possible),  
97 negating the need to use proxy data derived from literature or modelling (Brown & Fagerholm, 2015).  
98 Building on participatory mapping approaches, actively engaging stakeholders and local communities  
99 with a Participatory Geographical Information System (PGIS) approach (Elwood, 2006) allows more  
100 accurate spatial mapping of ecosystem uses and values on a local scale to be undertaken and can  
101 provide a rich data set relating to values (Klain & Chan, 2012). Participatory mapping (GIS) projects  
102 have gained status in recent years, particularly with the recognition that social-ecological systems tend  
103 to be 'messy' and complex, knowledge is diverse and contested and spatial representations have  
104 inherently political elements (Cutts et al., 2011); all of which may be avoided by traditional GIS  
105 approaches. Furthermore, participatory mapping results in a more comprehensive understanding of  
106 spatial variation in valuation and provides a platform for the consideration of multiple values, as well  
107 as providing a potential mechanism for conflict resolution when addressing potential trade-offs  
108 between ecosystem services and users (Ruiz-Frau et al., 2011; Brown et al., 2014; Brown & Fagerholm,  
109 2015; Moore et al., 2017).

110 As with all methods, there are potential limitations of participatory mapping as a way of engaging  
111 stakeholders. For the process to be effective and representative, it is necessary to ensure stakeholders  
112 with varying levels of influence, interest, knowledge and spatial relationships with the environment  
113 are given an opportunity to participate (Elwood, 2006; Brown & Kyttä, 2014; García-Nieto et al., 2015),  
114 which can be logistically complex and challenging. Providing this equal opportunity for engagement  
115 refers not only to inviting stakeholders to participate, but also to ensuring participants have a clear  
116 understanding of the aims and objectives and are contributing to the discussion from a similar  
117 knowledge baseline (Elwood, 2006). Further, design of any participatory process must be sensitive to  
118 any cultural, political or social tensions within the stakeholder group and the local context (Elwood,  
119 2006). There is, therefore, considerable onus on the design and facilitation of the participatory  
120 mapping process to ensure it does not inadvertently exclude, which could potentially lead to bias,  
121 impact the validity and integrity of the data collected and undermine the wider stakeholder  
122 engagement process.

123 Despite these potential limitations, participatory approaches are increasingly considered best practice  
124 for eliciting meaningful values relating to the natural world. However, valuing the non-tangible and  
125 subjective personal-spatial nature of many of these (e.g. sense of place, peacefulness, tranquillity)  
126 remains a challenge, resulting in a limited understanding of many socio-cultural values (Klain & Chan,  
127 2012; Brown & Fagerholm, 2015). Our approach seeks to address this by working closely with  
128 stakeholders across a series of workshops, actively encouraging participants to include spatially  
129 bounded information about how and where they use the coastal and marine environment, in addition  
130 to the valuing information. While participatory mapping and GIS approaches are becoming  
131 increasingly commonplace, their use in a marine and coastal context remains limited (Moore et al.,  
132 2017). This paper builds on existing work examining social-cultural values and the inclusion of  
133 community views and local environmental knowledge (see for example Berkes et al., 2007; Klain &  
134 Chan, 2012; Chan et al., 2012a,b; Nursery-Bray et al., 2014), and presents a flexible and adaptive  
135 methodology that can be applied across a range of coastal contexts, contributing to the growing  
136 literature base around the applicability of, and indeed the need for, participatory mapping to support  
137 effective and sustainable coastal management.

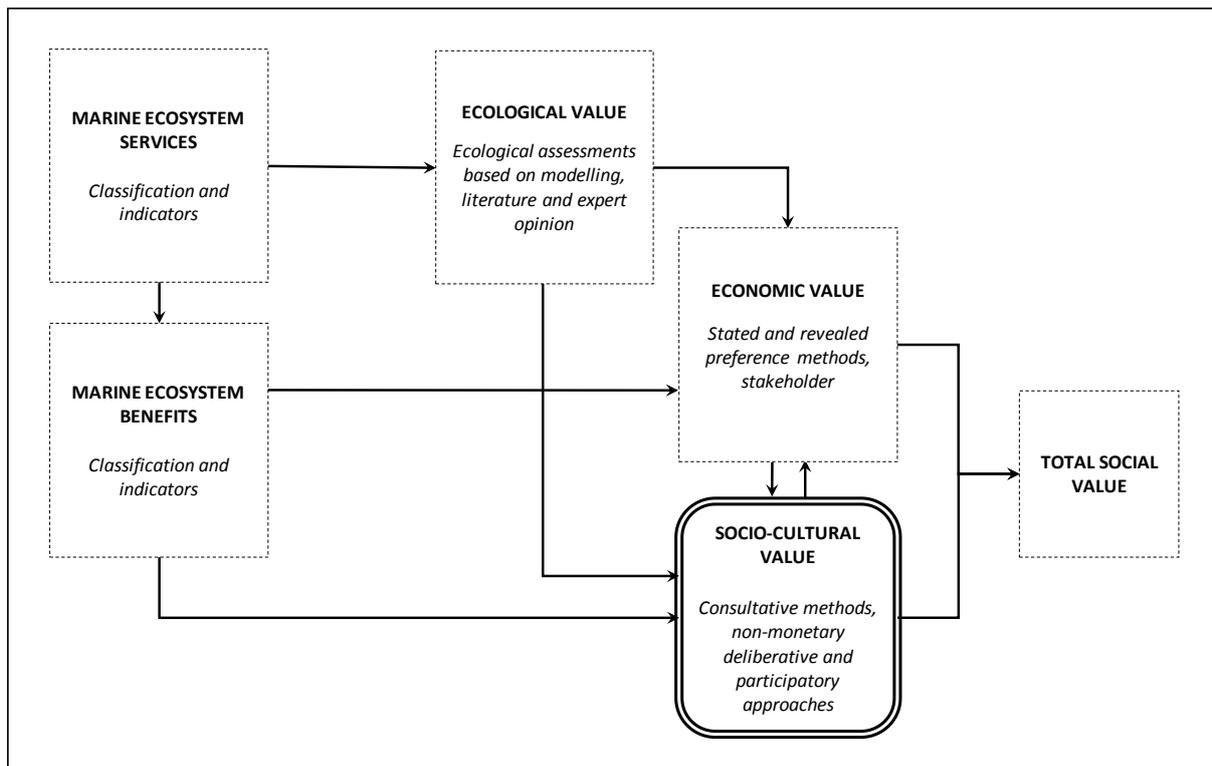
138 Despite a rapidly developing evidence base, there remains an evidence gap as to how ecosystem  
139 services are identified at the local scale, what benefits are provided and to whom, how trade-offs  
140 between services and benefits are negotiated in planning, and how benefits support positive social  
141 well-being. This paper addresses this disjuncture and responds to the demand for improving dialogue,  
142 understanding and access to ecosystem services and linking these services to the emerging well-being  
143 agenda. Using the observations from four stakeholder workshops, this paper examines the potential  
144 for participatory mapping to capture socio-cultural values in a local or regional context and influence  
145 coastal decision-making. In so doing, this paper drives a shift from the development of such  
146 approaches to real-world application and testing at the local community scale.

## 147 **2. Background**

148 Ecosystem services have the potential to lead to diverse benefits for society; therefore, it is  
149 appropriate to consider their broader value (Atkins et al., 2013). There has been increasing attention  
150 given to the valuation of ecosystem service approaches in science, and this has recently been followed  
151 by an uptake and use by stakeholders (Tallis et al., 2008; Norgaard, 2010; de Groot et al., 2010;  
152 Dempsey & Robertson, 2012; Beery et al., 2016; Willcock et al., 2016). For example, at the EU-level,  
153 an assessment of the value of ecosystem services is called for under the EU 2020 Biodiversity Strategy  
154 (EU, 2011), which emphasises the need 'to value ecosystem services and to integrate these values into  
155 accounting systems as a basis for more sustainable policies'. Additionally, the EU's Water Framework  
156 Directive and Marine Strategy Framework Directive both explicitly call for the integration of valuation  
157 into the environmental management process (Burdon et al., 2016). Furthermore, at a UK scale, the  
158 importance of ecosystem services and natural capital was recently highlighted within the UK  
159 Government's 25-Year Plan to Improve the Environment (HM Government, 2018), which recognises  
160 the need to take a natural capital approach to understand the full value of the marine environment  
161 and incorporate it within decision-making in England. Similar efforts are being taken across the UK's  
162 devolved administrations. For example, the Scottish Government is currently developing a draft  
163 'Environment Strategy for Scotland' which incorporates natural capital thinking into the national  
164 policy context. It is developing a series of 'knowledge accounts' to guide implementation on  
165 safeguarding natural capital (Scottish Government, 2018). The concept of 'full value' is interpreted in  
166 these cases to mean not only the economic values of the coastal and marine environment but also the  
167 broader social, cultural and ecological values of the system.

168 There is an increasing emphasis in the marine sciences on the importance of understanding how  
 169 society interacts with the natural environment (McKinley & Fletcher, 2010, 2012; Fletcher et al., 2012;  
 170 Jefferson et al., 2015; Potts et al., 2015; Bennett, 2016; Bennett et al., 2017). This is matched by an  
 171 emerging interest by decision-makers on how social–ecological interactions can be operationalised in  
 172 a policy, planning and management context. An example is the emphasis in the green economy  
 173 domain on the integration of natural capital within an inclusive green economy (Lok et al., 2018).  
 174 Expanding local partnerships with the communities who directly use a range of ecosystem services  
 175 should deepen the understanding of these benefits and promote local biodiversity conservation.  
 176 Furthermore, linking social and ecological systems and developing novel models of governance and  
 177 assessment help to deliver an ecosystem approach under the UN Sustainable Development Goals and  
 178 the Aichi Targets (Geijzendorffer et al., 2017).

179 When considering valuation of natural resources ‘Total Social Value’ is one of many concepts that can  
 180 be used to incorporate the views of both individuals and society as a whole and their values associated  
 181 with ecosystem service provision into the decision-making process to support the determination of  
 182 policy options and management measures (MA, 2003). This holistic approach recognises the  
 183 importance of considering both ecological value and socio-cultural value, alongside the more  
 184 traditionally recognised economic values (Figure 1).



185  
 186 **Figure 1: Valuation of marine ecosystem services, including socio-cultural values (adapted from**  
 187 **Burdon et al., 2018).**

188 There is a growing evidence base relating to marine ecosystem services which consider these three  
 189 elements, assessing ecological value (e.g. Derous et al., 2007; Pascual et al., 2011), economic value  
 190 (e.g. Börger et al., 2014; Jobstvogt et al., 2014a) and socio-cultural value (e.g. Jobstvogt et al., 2014b;  
 191 Hattam et al., 2015b; Kenter et al., 2015). More recently, the need to ensure valuation takes account  
 192 of those benefits that are intangible or immaterial has garnered increasing attention from both the  
 193 research and policy communities (see for example, Chan et al., 2012a; Chan et al., 2012b; Pike et al.,  
 194 2010), with participatory processes highlighted as being crucial to successfully elucidating these

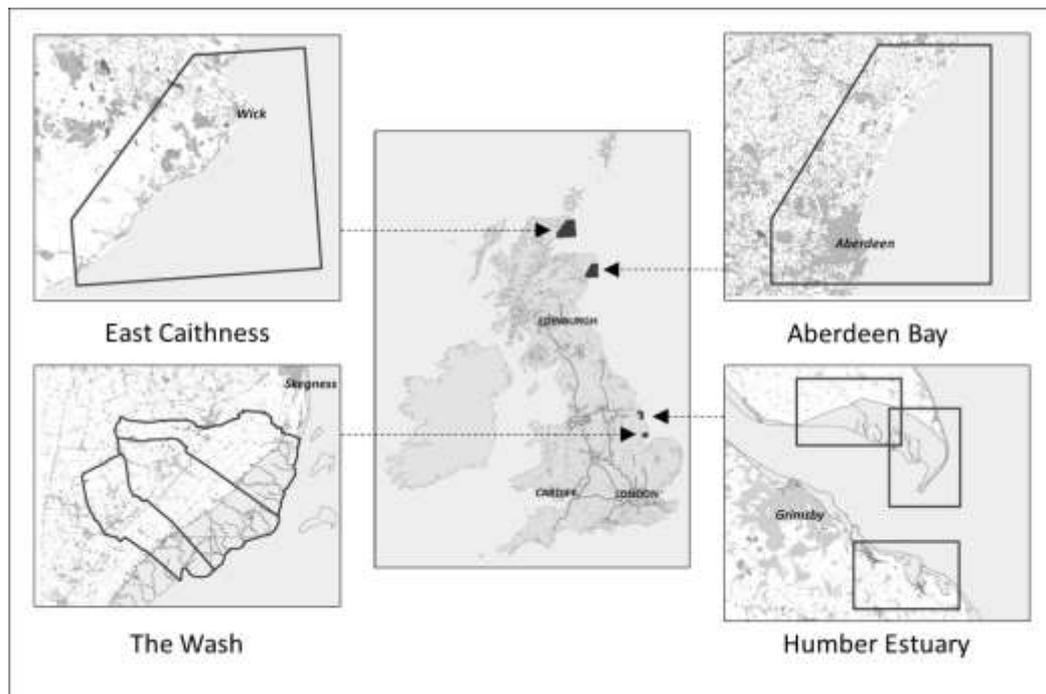
195 harder to measure values (Klain & Chan, 2012; Martin et al., 2016). However, at present, the majority  
196 of valuation studies focus on a small range of provisioning services (e.g. fisheries - Fonseca, 2009),  
197 regulating services (e.g. carbon sequestration and flood defence - Luisetti et al., 2015) and cultural  
198 services (e.g. recreation - Bhatia, 2012), with an emphasis on economic valuation using stated and  
199 revealed preference methods (see Cooper et al., 2013 for a review of methods applied in the marine  
200 environment). This paper contributes to the wider discussion around total value with a focus on the  
201 socio-cultural value (as presented in Figure 1).

### 202 3. Methods

203 This paper has developed an adaptive approach to participatory mapping, whereby community and  
204 stakeholder activities, perceptions and experiences can be directly captured, digitised and used to  
205 inform local coastal and marine planning initiatives that improve the management of biodiversity and  
206 the benefits that flow from natural capital. This approach engages local coastal stakeholders to discuss  
207 the social benefits derived from local ecosystems, how those benefits are spatially distributed and  
208 how they trade-off against other uses of the marine environment.

#### 209 3.1 Demonstration Sites

210 Four demonstration sites were selected to reflect a diversity of anthropogenic activities, natural  
211 features, and coastal communities along the North Sea east coast in Scotland and England (Figure 2).  
212 Workshops were co-designed and co-delivered with the relevant local coastal partnership (Table 1) to  
213 ensure that the aims and objectives of the workshop were appropriate at the local scale and that  
214 relevant stakeholders were identified and enrolled for participation from an existing network of local  
215 stakeholders. The two Scottish workshops focussed on coastal stretches and interactions between  
216 human activities and marine protected areas, whereas the two English workshops adopted a case  
217 study approach focussing on areas of interest as identified by The Wash and North Norfolk Marine  
218 Partnership, and the Humber Nature Partnership as part of their Natural Capital Vision for the Humber  
219 (HNP, 2017).



220  
221 **Figure 2: Locations of the four demonstration sites.**

222 **Table 1: Summary of demonstration sites.**

<b>Features</b>	<b>East Caithness</b>	<b>Aberdeen Bay</b>	<b>Humber Estuary</b>	<b>The Wash</b>
<b>Nearest Cities/Towns</b>	Wick	Aberdeen, Peterhead	Hull, Goole, Cleethorpes, Grimsby,	King’s Lynn, Hunstanton, Boston, Skegness, Spalding, Wisbech
<b>Main tributaries</b>	River Wick	Dee, Don and Ythan	Aire, Derwent, Don, Hull, Ouse, Trent and Wharf	The Great Ouse, Nene, Welland, Witham
<b>Activities</b>	Industry, Fishing, Shipping, Renewables, Infrastructure & Ports, Tourism, Recreation	Industry, Oil & Gas, Renewables, Shipping, Recreation; Infrastructure & Ports	Shipping, Industry, Renewables, Tourism, Recreation, Infrastructure & Ports	Agriculture, Fishing, Infrastructure & Ports, Mariculture, Tourism, Recreation
<b>Marine Protected Areas (MPAs)</b>	East Caithness Cliffs Nature Conservation MPA, East Caithness Cliffs SPA and Noss Head Nature Conservation MPA.	Forvie NNR, Foveran Links SSSI, Ythan Estuary and Meikle Loch Ramsar site, Ythan Estuary, Sands of Forvie and Meikle Loch SPA, Buchan Ness to Collieston Coast SPA, Bullers of Buchan Coast SSSI, Collieston to Whinniefold SSSI, and Sands of Forvie and Ythan Estuary SSSI	Humber Estuary SAC, SPA, EMS, Ramsar, SSSI	The Wash and Gibraltar Point SPA, The Wash and North Norfolk coast SAC, Ramsar, SSSI, NNR
<b>Local Coastal Partnership</b>	Moray Firth Coastal Partnership	East Grampian Coastal Partnership	Humber Nature Partnership	The Wash and North Norfolk Marine Partnership
<b>Workshop Coverage</b>	Wick in the north to Lybster in the south	Peterhead in the north to Aberdeen in the south	3 case study sites – Welwick, Spurn and South Bank (Cleethorpes to Donna Nook)	3 case study sites – Wainfleet, Friskney & Wrangle coastal parishes

223 NOTE: MPA=Marine Protected Area; SSSI=Site of Special Scientific Interest; SAC=Special Area of Conservation; SPA=Special  
 224 Protection Area; NNR=National Nature Reserve; EMS=European Marine Site.

225 **3.2 Workshop Aims and Objectives**

226 After collaborative discussions with the relevant local coastal partnerships, the two workshops in the  
 227 north east of Scotland focussed on human activities within East Caithness and Aberdeen Bay. The  
 228 workshops identified and mapped the multiple sectoral activities which occurred within these sites  
 229 and how protected marine features (i.e. habitats and species) could support activities via the provision  
 230 of ecosystem services and ‘benefits’. The facilitators did not define the term ‘benefits’ as the  
 231 workshops aimed to capture the full range of perceived benefits from the marine environment from  
 232 the stakeholders perspective.

233 Designed similarly, following discussions with the relevant local nature/marine partnerships, the two  
 234 workshops on the English east coast focussed on:

- 235 • Identifying and mapping natural features of interest within the Humber Estuary (focussing on  
 236 all intertidal features) and The Wash (focussing on saltmarsh);
- 237 • Identifying and mapping the benefits provided by these features; and
- 238 • Discussing the use of both satellite imagery and participatory mapping in the future  
 239 management of these designated sites.

### 240 3.3 Stakeholder Engagement

241 The range of organisations represented at each workshop reflected the aims and objectives of the  
 242 workshop (Table 2). Each workshop consisted of three groups of 4-5 stakeholders plus a facilitator  
 243 (except for East Caithness where a lower turnout resulted in only one group on the day) to ensure an  
 244 even balance between the representation of organisations, and that each stakeholder had an  
 245 opportunity to participate in the discussions and mapping exercises. Through discussions with the  
 246 local project teams, stakeholders were identified and contacted by the local coastal partnership to  
 247 ensure that the full range of local voices were represented at each workshop.

248 **Table 2: Summary of organisations represented at each workshop.**

	<b>Aberdeen Bay</b>	<b>East Caithness</b>	<b>The Humber</b>	<b>The Wash</b>
<b>Date</b>	6 July 2017	7 September 2017	22 May 2018	20 February 2018
<b>Location</b>	Forvie National Nature Reserve Visitor Centre, Collieston	The Pulteny Community Centre, Wick	Water’s Edge Visitors Centre, Barton Upon Humber	Lincolnshire Wildlife Trust’s Coastguard Centre, Gibraltar Point, Skegness
<b>Local Partnership</b>	East Grampian Coastal Partnership	Moray Firth Coastal Partnership	Humber Nature Partnership	The Wash and North Norfolk Marine Partnership
<b>Stakeholders</b>	Aberdeen City Council; Scottish Natural Heritage; Royal Society for the Protection of Birds; University of Aberdeen; Vattenfall Windfarms Ltd.	Caithness Seacoast Ltd.; Independent participant; The Environmental Research Institute (the University of the Highlands and Islands); The Highland Council; The Wick Society	University of Hull; Yorkshire Wildlife Trust; East Riding Council; North East Inshore Fisheries and Conservation Authority; Natural England; Environment Agency; Lincolnshire Wildlife Trust; North East Lincolnshire Council; Royal Society for the Protection of Birds; Marine Management Organisation	Natural England, Eastern Inshore Fisheries and Conservation Authority; Environment Agency; Wildfowlers; Lincolnshire Wildlife Trust; Graziers and land owners
<b>Total attendees</b>	12	7	15	14

249 **3.4 Workshop Activities**

250 While all four case study sites (Figure 1) have broadly similar features and the methodology has  
 251 common activities, an adaptive approach was adopted throughout the workshops. This enabled the  
 252 research team to test different approaches, obtain feedback from the stakeholders, review and adapt  
 253 the methodology in response to the needs and interests of stakeholders at each case study site. All  
 254 four workshops were designed with a consistent structure, comprising a series of introductory  
 255 presentations at the start of the day, a series of interactive identification and mapping sessions  
 256 throughout the day, and ending the day with a plenary discussion and stakeholder feedback.

257 The workshops were all stand-alone exercises, which complemented existing work undertaken by the  
 258 respective local coastal partnerships. The specific activities undertaken and discussion topics covered  
 259 were co-developed by the local coastal partnership and the project team in order to reflect the specific  
 260 aims and objectives of each workshop (Table 3). In the case of the East Caithness and Aberdeen Bay,  
 261 workshop design centred on identifying coastal and marine activities and how activities can be  
 262 influenced by the ecosystem services that are provided by marine protected areas. In the Humber  
 263 Estuary these discussions focussed around the Natural Capital Vision for the Humber (HNP, 2017)  
 264 whereas the discussion in The Wash workshop centred around findings from the Common Ground  
 265 Project (MCS, 2017). In order to ensure consistency in the workshops, the lead author of this paper  
 266 facilitated all four workshops, with the second author facilitating three out of the four workshops.

267 **Table 3: Summary of activities, materials and outputs from each workshop**

<b>Activities</b>	<b>East Caithness</b>	<b>Aberdeen Bay</b>	<b>Humber Estuary</b>	<b>The Wash</b>
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	✓	✓	✓	✓
<b>Materials</b>	<b>East Caithness</b>	<b>Aberdeen Bay</b>	<b>Humber Estuary</b>	<b>The Wash</b>
Flipcharts	✓	✓	✓	✓
Industry maps	✓	✓		
Tourism/recreation maps	✓	✓		
Site designation maps	✓	✓		
Bathymetry maps	✓	✓		
Local ecosystem service matrices	✓	✓		
Aerial images (Sentinel-2)			✓	✓
<b>Outputs</b>	<b>East Caithness</b>	<b>Aberdeen Bay</b>	<b>Humber Estuary</b>	<b>The Wash</b>

Workshop report (including stakeholder feedback)	✓	✓	✓	✓
Online interactive maps	✓	✓		
Interactive pdf files			✓	✓

268

### 269 3.5 Workshop Materials

270 Given the focus of the East Caithness and Aberdeen Bay workshops on anthropogenic activities and  
 271 protected sites, the stakeholders were provided with three A0 scale maps which presented (1) the  
 272 recreational activities which occur within the case study site; (2) the extent of maritime industries in  
 273 the case study site (e.g. fishing, pipelines, renewable energy); and (3) the designated features within  
 274 each case study site (e.g. EU Special Areas of Conservation, Scottish Nature Conservation MPAs). The  
 275 three maps were composites of relevant spatial data sets from the Marine Scotland National Marine  
 276 Plan Interactive (NMPi) (Marine Scotland, 2018). Each map included broad scale habitats derived from  
 277 NMPi and Scottish Natural Heritage SiteLink (SNH, 2018) and included bathymetry. For the  
 278 participatory mapping exercises, stakeholders on each table could choose which of the three A0 maps  
 279 they wished to annotate, providing information for inclusion in the final GIS output which would  
 280 contain individual layers for each of the three maps as well as the stakeholder input. At the East  
 281 Caithness workshop only one annotated map was produced as a result of the smaller group size and  
 282 representation of stakeholders. At the Aberdeen Bay workshop, duplicates of each of the three A0  
 283 maps were provided on each of three tables, with each table producing its own independent  
 284 annotated map. The annotated maps from the three tables were integrated post-workshop producing  
 285 a single output in GIS.

286 After the mapping exercises, the stakeholders at the East Caithness and Aberdeen Bay workshops  
 287 were provided with edited versions of the ecosystem service matrices, developed by Potts et al. (2014)  
 288 for UK habitats and species and by Burdon et al. (2017) for UK seabirds. The Matrix Approach  
 289 recognises the relative importance of protected UK marine features in delivering ecosystem services  
 290 and societal benefits (as defined by the UKNEAFO, 2014), highlights the confidence in the relationship  
 291 between a particular feature and the ecosystem services they deliver, and thus provides a valuable  
 292 visual tool for stakeholder engagement. An example of the Matrix for Aberdeen Bay designated  
 293 habitats is provided in Figure 3. The matrix activity formed part of the discussion at the two Scottish  
 294 workshops as a means to compare local observations against the broader (UK) assessments within the  
 295 matrix.



298 Given the focus of the Humber Estuary and The Wash workshops on mapping features, satellite  
299 imagery was used to generate maps for each demonstration site. True-colour composite images from  
300 bands 2 (blue), 3 (green) and 4 (red) of cloud-free Sentinel-2 satellite images at 10 m pixel resolution  
301 were projected into British National Grid coordinates and printed on A1 scale paper, which required  
302 less meeting room space than the A0 maps used in the Scottish workshops. For the Humber Estuary,  
303 three coastal sites (Welwick, Spurn, Cleethorpes to Donna Nook) were selected based on sites  
304 previously identified within the Humber Nature Partnership’s natural capital vision for the Humber  
305 (HNP, 2017). The image for the Humber was taken on 17 January 2018 from Sentinel-2. For The Wash,  
306 three adjacent coastal parishes (Wrangle, Friskney and Wainfleet) were selected based on the extent  
307 of saltmarsh habitat present and particular management interests associated with the saltmarsh. The  
308 image for The Wash was taken on 9 April 2017 from Sentinel-2. At the Humber Estuary workshop,  
309 each table focused on a different geographical case study from the mouth of the Humber Estuary  
310 (three in total), whilst at The Wash workshop the stakeholders focussed on one of three adjacent  
311 coastal parishes per table. At both workshops stakeholders were provided with the opportunity to  
312 move around tables and thus sense-check the mapping undertaken by others at the workshop.

313 In addition to the maps, each workshop used a range of flip-charts, pens, post-it notes, and sticky dot  
314 based activities to capture the information from the stakeholders. To support data collection, each  
315 workshop facilitator took their own notes of discussions, which were verified by the participants after  
316 the workshop.

### 317 **3.6 Analysis and Reporting**

318 The annotated maps were photographed at the end of each workshop, and then digitised using GIS  
319 software ARC GIS. In the East Caithness and Aberdeen Bay workshops, the activities data was hand  
320 drawn over the top of the formal spatial data. This approach allowed for sense checking of local  
321 perspectives against the national data sets. Hand drawn data were discussed by the stakeholders and  
322 were digitised into vector layers using the Android mapping application GIS Pro. The layers were then  
323 imported to ARC GIS for scaling and clean-up before being imported as layers onto ESRI Web Apps  
324 (ARC GIS online) which was made publicly available via a web link. The maps from the Humber Estuary  
325 and The Wash workshops were digitised using ARC GIS software and were then converted into  
326 interactive Pdfs which were circulated to the stakeholders for sense-checking and feedback. The  
327 advantages of an interactive Pdf are that stakeholders do not require GIS software, GIS expertise or  
328 internet access to interrogate the data layers making them more accessible and user-friendly.

### 329 **3.7 Stakeholder Feedback**

330 In order to facilitate a co-productive and adaptive approach, stakeholders who attended the  
331 workshops were asked to complete a short workshop evaluation questionnaire. The questionnaire  
332 consisted of five questions, using a mix of both open (qualitative data) and closed (quantitative data)  
333 questions. These aimed to collect stakeholder feedback on: (i) the usefulness of the workshop overall,  
334 (ii) the usefulness of each of the workshop activities (e.g. mapping exercises as described above), (iii)  
335 the quality of the materials used in the workshop exercises, (iv) the quality of the venue and catering,  
336 and; (v) an opportunity for stakeholders to provide suggestions as to how the workshops and/or the  
337 process could be improved. In total, 36 responses were received across the four workshops, with the  
338 stakeholder comments collated, analysed and used to review and adapt the final workshop process  
339 presented in this paper. For the closed, quantitative questions, descriptive statistical analysis was used  
340 to examine overall trends in the responses obtained. This gave the research team an indication of  
341 stakeholder views across all four workshops, and allowed any differences between cases to be  
342 identified. Open, qualitative questions were analysed using a manual thematic coding approach

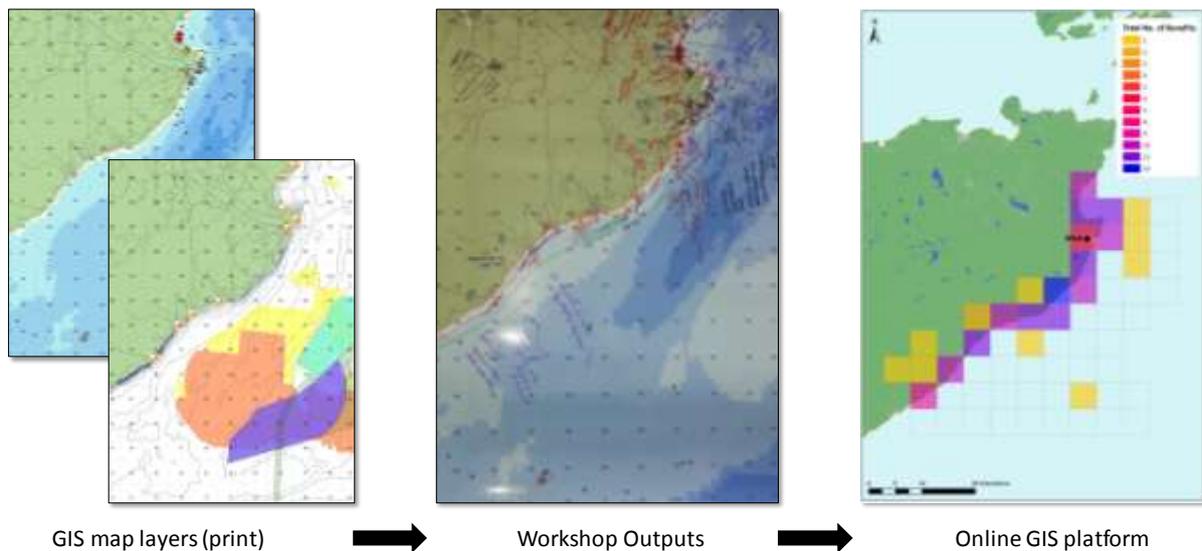
343 whereby the responses to open questions were reviewed by the research team to identify emergent  
344 themes. The data were reviewed numerous times to ensure confidence in the final thematic codes  
345 assigned. Where appropriate, italicised quotes taken from the stakeholder feedback are used to  
346 support the presentation of results.

#### 347 **4. Results**

348 The workshops results are presented below with respect to the mapping of activities, features and  
349 benefits, workshop outputs and stakeholder feedback.

#### 350 **4.1 Activities Mapping**

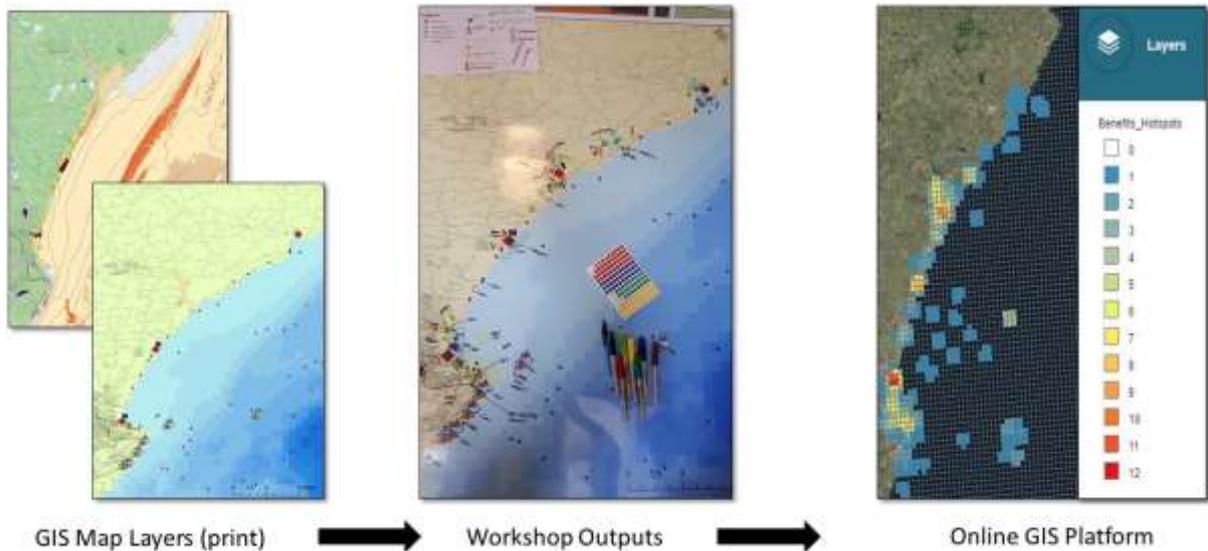
351 Stakeholders at the East Caithness workshop identified a range of recreational and commercial  
352 activities and designations, including several not mapped onto, or in contrasting intensity to those on  
353 national marine database layers (Figure 4). Stakeholders were enthusiastic to discuss and map  
354 activities, requesting more detailed maps at a finer scale. The low intensity of activities in East  
355 Caithness reflects the low population in the area, although a diverse range of activities were identified.  
356 Activities of cultural importance including historic sites, castles and wrecks were discussed, reflecting  
357 the regions strong connection to their cultural heritage. Inconsistencies and inaccuracies of existing  
358 data in East Caithness were highlighted including the spatial distribution of wrecks and dive sites.



360 **Figure 4: Mapping process and outputs from the East Caithness workshop.**

361 Activities mapping (Figure 5) in Aberdeen Bay revealed many small-scale low impact activities,  
362 particularly in the tourism and recreation sector, were not captured at a local scale or were not present  
363 in the national marine database. Recreational activities including board sports (surfing, windsurfing,  
364 paddle boarding), walking, recreational fishing, horse riding and wildlife watching, despite local  
365 importance, were not represented in the formal layers and amended by participants. The mapping  
366 recognised the importance of a range of activities around wildlife watching, photography, and  
367 education that reinforce cultural benefits associated with sense of place, well-being and health.  
368 Recreational activities were distributed along the open beach systems of Aberdeen city beach and  
369 Balmedie beach but rely on public access points such as car parks and roads. A range of recreational  
370 activities were identified, from easily accessible beach walks in an urban environment to more remote  
371 'wilderness' experiences on Balmedie Beach and Black Dog. The wildlife watching sector was clustered  
372 around access points and ecological features, in particular at the points where the river systems meet

373 the coast. This in itself ranges from highly modified habitats and harbours (the Dee mouth), locally  
 374 noted for Bottlenose Dolphins to estuarine systems such as Donmouth and the Ythan Estuary with its  
 375 mudflats and saltmarsh habitat attracting wildlife including waders and seals. Multiple overlapping  
 376 activities were identified and mapped, particularly across recreation and tourism. While overlapping  
 377 activities contribute to multiple benefits (e.g. sense of place and physical and mental health)  
 378 stakeholders highlighted examples where activities have impacted local sites. In Aberdeen,  
 379 overlapping activities such as salmon netting, wildlife watching, coastal walks and boating have  
 380 interacted with protected sites for seals; popular areas for ‘consumption’ of ecosystem services have  
 381 a lack of infrastructure to support higher visitor numbers; and golf course development has  
 382 undermined the integrity of dune systems and impacted cultural services such as sense of place.



383

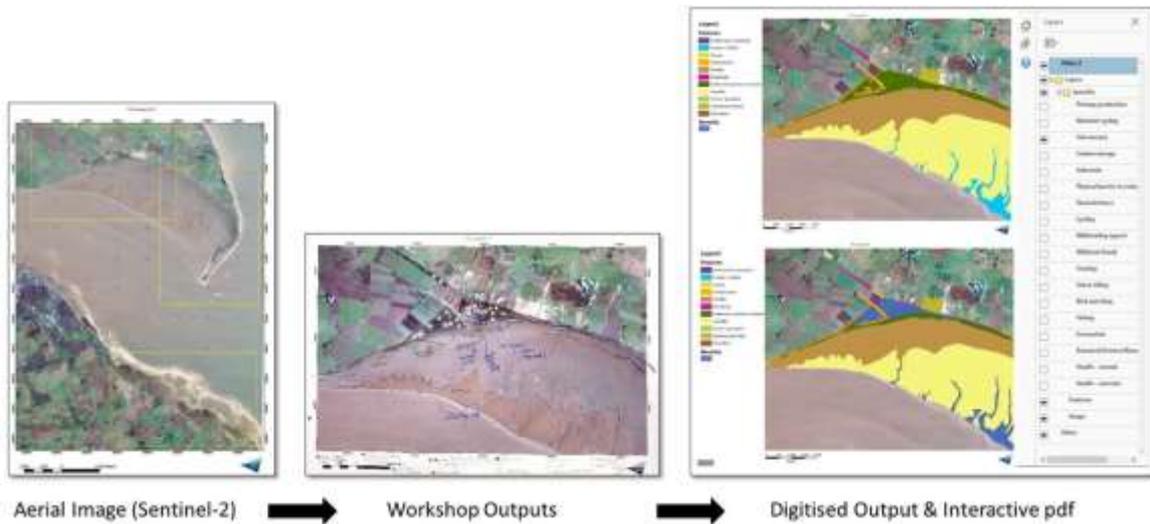
384 **Figure 5: Mapping process and outputs from the Aberdeen Bay workshop.**

385 Stakeholders commented that it was useful to learn about activities, with one stakeholder  
 386 commenting that it was useful to “[understand] the extent of what is available on our local coasts and  
 387 sea”. A view from an industry representative noted “[the approach] is very useful for providing  
 388 information on the local area and the services and goods provided by the local ecosystems. Important  
 389 for industry to consider these wider services so as to prevent knock-on effects”. Local government  
 390 noted that “the discussion with local stakeholders take ideas [on ecosystem services] into a wider field”  
 391 and “allows for good overview of the services provided and their importance within a specific area”.  
 392 The activity mapping highlighted the diversity of local coastal use, but importantly indicated that  
 393 overlapping activities can place pressures on natural capital and that both activities and benefits can  
 394 be socially contested.

395 **4.2 Features Mapping**

396 Features were mapped in the Humber Estuary, focussing on three case study areas (Welwick, Spurn  
 397 and Cleethorpes to Donna Nook). The activity started with the stakeholders identifying the types of  
 398 features that can be identified from the satellite image of their case study site. The number of features  
 399 identified varied between sites (e.g. Welwick n=19; Spurn n=23; and Cleethorpes to Donna Nook n=12)  
 400 and included a range of both natural features such as broad scale habitats (mudflats, sandflats and  
 401 saltmarsh) to man-made structures (managed realignment sites, flood banks and pipelines). Once a  
 402 list was produced, the stakeholders drew the features on to the A1 scale paper map produced using a  
 403 satellite image, and generated their own colour-coded key for each feature. This exercise required

404 local knowledge to accurately map and sense-check the features which were visible from the satellite  
405 image and also enhanced the level of stakeholder buy-in to the process given that the stakeholders  
406 were responsible for all lines drawn on the map. An example of the map generated for the Welwick  
407 site is shown in Figure 6. After the workshop the lines drawn by the stakeholders were digitised, with  
408 the colour coding and feature types being standardised across the three Humber Estuary sites,  
409 resulting in a digital image of features (Figure 6).

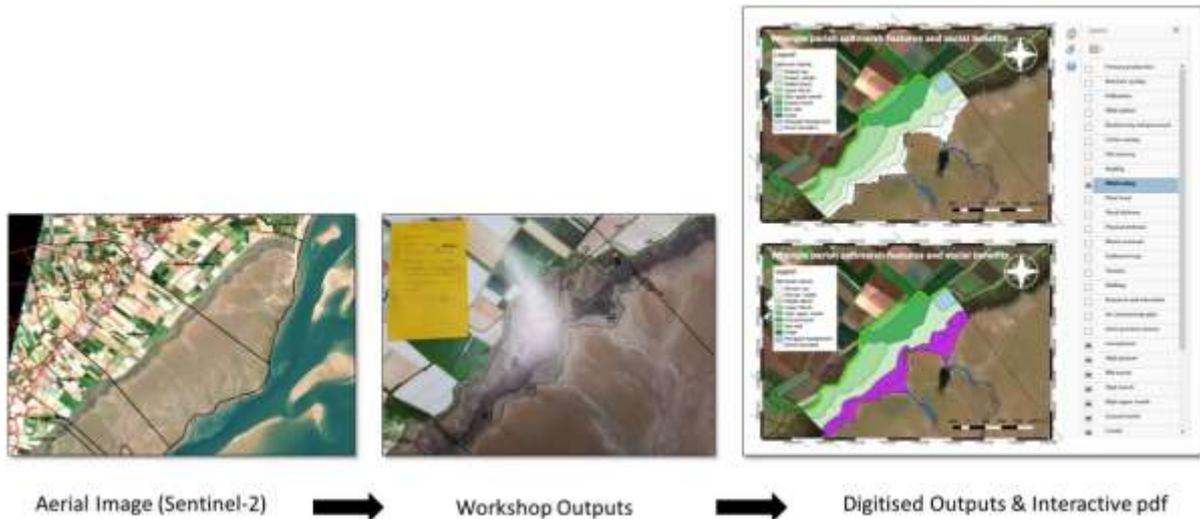


410

411 **Figure 6: Mapping process and outputs from the Humber Estuary workshop. Example shown is for**  
412 **the Welwick case study site.**

413 Features were mapped at The Wash workshop, focussing on three coastal parishes (Wainfleet,  
414 Friskney and Wrangle). Given the focus of The Wash workshop on saltmarsh, the features identified  
415 were all sub-features of saltmarsh. A total of 7 sub-features of saltmarsh were identified, which  
416 included pioneer low, pioneer middle, middle marsh, upper marsh, high upper marsh and grazed  
417 marsh. In addition, infrastructure were also identified which included sea walls and a managed  
418 realignment site. The stakeholders identified these sub-features on A1 scale paper copies of the  
419 satellite images by drawing around the extent of each sub-feature (Figure 7). Following the workshop,  
420 the extent of each sub-feature was digitised using GIS software and converted into an interactive pdf  
421 which allows the different sub-features to be turned on and off by the user (Figure 7).

422



423

424 **Figure 7: Mapping process and outputs from The Wash workshop. Example shown is for the Wrangle**  
 425 **coastal parish.**

426 **4.3 Benefits Mapping**

427 All stakeholders were asked to identify the benefits they receive from the marine and coastal  
 428 environment. No definition of benefits was provided in order to capture the full range of benefits that  
 429 the stakeholders identify being gained from the marine environment. The full range of benefits  
 430 identified by each workshop is presented in Table 4.

431 **Table 4: Benefit categories as identified by the stakeholders at each of the four workshop**

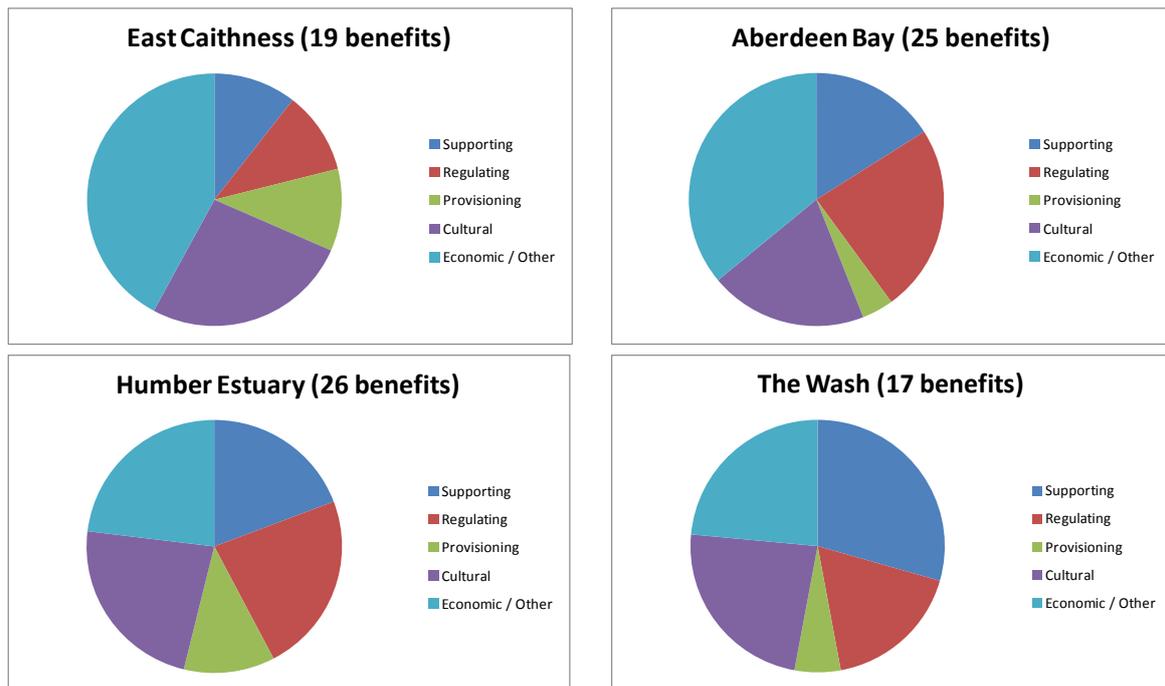
Cumulative List of Benefits	East Caithness	Aberdeen Bay	Humber Estuary	The Wash
Primary production		1	1	1
Nutrient cycling	1	1	1	1
Pollination				1
Formation of species habitats		1	1	1
Formation of physical barriers			1	1
Formation of seascape / soundscape	1	1	1	
Biological control		1		
Carbon sequestration		1	1	
Food for human consumption	1	1	1	1
Food for fish/birds	1		1	
Fertiliser and biofuel			1	
Climate regulation	1	1	1	
Prevention of coastal erosion		1	1	
Sea defence		1	1	1
Waste burial			1	1
Waste breakdown	1	1	1	1
Tourism and nature watching	1	1	1	1
Spiritual & cultural wellbeing	1	1	1	1
Aesthetic benefits			1	
Education and research	1	1	1	1

Physical health	1	1	1	
Mental health	1	1	1	
Renewable energy	1	1	1	
Sediment transport		1		1
Shipping		1	1	
Historical culture	1	1	1	
Improved farming / grazing			1	1
Employment	1	1		
Improved local economy	1	1	1	
Emergency services			1	
MOD training		1		
Interactions between sectors	1			
Natural systems		1		
Community cohesion (social)	1	1		
Biodiversity	1			1
Personal safety	1			
Art and photography				1
Semi-precious stones				1
<b>Total Number of Benefits</b>	<b>19</b>	<b>25</b>	<b>26</b>	<b>17</b>

432

433 Once identified by the stakeholders, the benefits were each assigned a reference number and were  
434 then mapped onto the activity maps (Figures 4 & 5) or the feature maps (Figures 5 & 6) using sticky  
435 dots on which the reference number is written. Following the East Caithness and Aberdeen Bay  
436 workshops, the benefits were digitised, with outputs being presented either using an online platform  
437 to illustrate where benefits are produced. This can be displayed as heat maps of benefits (Figures 4 &  
438 5) or be converted into an interactive pdf file (Figures 6 & 7) in which benefits can be selected in  
439 relation to the feature which provides that particular benefit. For example, Figure 6 shows the  
440 importance of creeks and managed realignment in providing fish nursery (supporting ecosystem  
441 service), whereas Figure 7 shows the importance of the pioneer low and middle saltmarsh for  
442 wildfowling (cultural benefit). In addition to the digitised outputs, a brief workshop report was  
443 produced following each workshop which was circulated to all the stakeholders who attended the  
444 workshops.

445 Following the workshops, the benefits identified by the stakeholders (Table 4) were categorised using  
446 the marine ecosystem service categories developed in the framework for the UK coasts (Turner et al.,  
447 2015) i.e. identifying the proportion of supporting, regulating, provisioning and cultural benefits  
448 identified (Figure 8). For mapping purposes, some of these services were further sub-divided. For  
449 example, tourism and nature watching was broken down by the stakeholders into sub-categories such  
450 as bird watching, cetacean watching, dog walking, kayaking, and surfing. Benefits from all four  
451 Millennium Ecosystem Assessment categories (MA, 2005) were identified at each workshop, thus  
452 recognising the importance of coastal systems in delivering supporting, regulating, provisioning and  
453 cultural benefits. Although outside the scope of the MA (2005), economic activities were also noted,  
454 including those related to employment (e.g. employment income or job creation) or abiotic benefits  
455 (e.g. shipping, renewable energy generation).



456 **Figure 8: Summary of benefit categories identified by stakeholders at all four workshops.**

#### 457 **4.4 Stakeholder feedback**

458 Qualitative analysis was carried out on the text-based responses collected through open-ended  
 459 questions included in the evaluation forms at each workshop to provide a more in-depth  
 460 understanding of stakeholder perceptions towards the workshops and their activities. Analysis found  
 461 that bringing together a range of stakeholders and providing an opportunity to hear from ‘*other*  
 462 *interested parties*’ and to ‘*see other people’s views...*’ were commonly mentioned by stakeholders as  
 463 being one of the primary benefits of this workshop approach. This was further emphasised by one  
 464 workshop attendee (The Wash) who stated that the process and ‘*the benefits mapping [activity] really*  
 465 *opened my eyes to the natural resources and the benefits of saltmarsh*’. The location specific, multi-  
 466 modular approach of having multiple workshop sessions was identified as an advantage of the process,  
 467 with one stakeholder stating that it was ‘*good to have the opportunity to develop discussions and*  
 468 *themes, [in a way that was not] unduly rushed*’, highlighting the potential value of this approach as an  
 469 effective stakeholder engagement tool. Furthermore, as the concepts of ecosystem services and  
 470 natural capital continue to dominate the conversation around natural resource management, the  
 471 workshops were seen as a valuable introduction to the application of the natural capital concept and  
 472 approach at a local scale.

473 Stakeholders at the Scottish workshops believed that the ecosystem service matrices (adapted from  
 474 Potts et al., 2014) would be a useful tool in MPA designation and management, particularly the latter,  
 475 and for use in stakeholder engagement. Feedback suggests that stakeholders saw the matrices as a  
 476 good visual tool to condense large volumes of data into an accessible format, but that the ability to  
 477 see the data sources behind the scoring would strengthen the validity of the approach. Stakeholders  
 478 felt that more time would be required to fully understand and then apply the matrix approach at the  
 479 local scale; however, they saw value in local adaptations of the matrices to interrogate changes in  
 480 ecosystem service provision resulting from different management scenarios.

481 The feedback received from the stakeholders was used by the authors to refine the methodology for  
 482 subsequent workshops (Table 5). This resulted in the development of a co-produced adaptive,  
 483 modular structure for marine stakeholder participatory mapping workshops (Figure 9).

**Table 5: Summary of stakeholder feedback and how it refined the workshop methodology.**

<b>Stakeholder Feedback</b>	<b>Workshop(s)</b>	<b>Refined Methodology</b>
The provision of pre-reading in the form of contextual information and background for the specific locations, as well as workshop activities, would be more efficient and lead to more effective engagement from workshop 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 (Figure 9).
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 (Figure 5) and The Wash (Figure 6) and which resulted in habitats being mapped down to a 10m scale.
To ensure representation from as many relevant stakeholders at workshops 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 in these workshops is voluntary and it may not always be possible to have representation from every stakeholder organisation or 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 (e.g. using the STRAVA app.) but we could also build on the access and activity mapping undertaken under other projects.	Humber Estuary	A mapping activity (Task 7, Figure 9) 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 <sup>2</sup> ) 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 (Figure 9)
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 (Figure 9).
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 (Task 11, Figure 9).

485

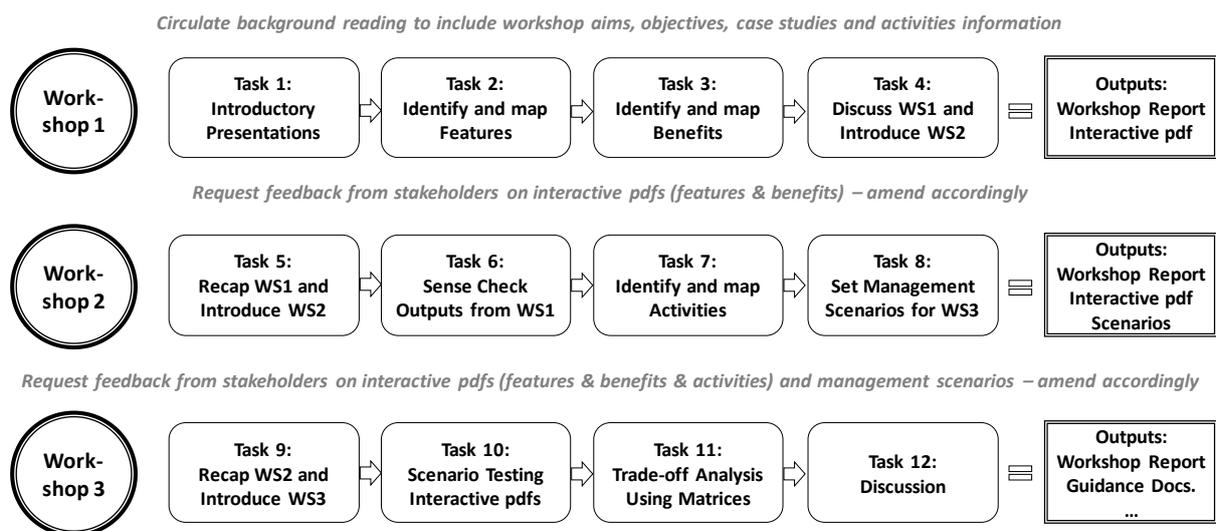
### 486 3.5 Adaptive methodology for future workshops

487 This paper has applied a locally-focused stakeholder-based participatory methodology which  
 488 integrates different kinds of knowledge into a more nuanced local understanding of ecosystem  
 489 services. Its application can assist coastal communities in understanding what natural capital features  
 490 are present in their localities and how these features produce a diverse range of services and benefits

<sup>2</sup> The intensity and impacts of non-licensable activity on MPAs (MMO Evidence Project 1136)  
<https://www.gov.uk/government/publications/evidence-and-the-marine-management-organisation-mmo/evidence-projects-register>

491 and how these benefits interact to shape human engagement in coastal environments. Future  
 492 application of the methodology has the potential to influence how coastal communities engage in  
 493 planning with local authorities and how communities respond to increasing policy interest in  
 494 developing natural capital strategies under the UK 25 Environment Plan and the draft ‘Environment  
 495 Strategy for Scotland’. As the UK and all devolved administrations progress marine spatial planning  
 496 under their respective national marine strategies, there will be increasing demand for improved local  
 497 data on ecosystem services and how they are used and contested in coastal communities, particularly  
 498 when trade-offs will need to be made across overlapping or competing activities. It is also applicable  
 499 to other UK and international coastal contexts where natural capital assessments are becoming more  
 500 commonplace and demonstrating the multiple benefits of healthy ecosystems and marine protected  
 501 areas is becoming a key part of marine planning.

502 Feedback from the stakeholders on each activity has resulted in refinement of the methodology  
 503 employed at subsequent workshops, with the overall feedback and testing of the activities at multiple  
 504 sites resulting in the development of a co-produced adaptive methodology (Figure 9). This  
 505 methodology has a flexible structure, providing opportunity for bespoke workshops to be co-  
 506 developed with local marine stakeholders. Working in collaboration with local coastal partnerships  
 507 was a major strength in the approach. Depending on the issues of interest at the local scale, a series  
 508 of workshops can be co-designed to ensure local specificity and application (if required). For example,  
 509 where a local coastal partnership is interested in only identifying features (Task 2), mapping benefits  
 510 (Task 3) and having a general discussion around management issues (Task 4), then a one-day workshop  
 511 would be sufficient for their needs. Where stakeholder groups wish to develop and apply the tools  
 512 further (i.e. interactive pdfs, ecosystem service matrices, etc.) then a bespoke series of workshops can  
 513 be tailored to meet their needs. As a further example, where site features have already been identified  
 514 and mapped, then a shorter (half-day) workshop could be co-developed which jumps straight from  
 515 Task 1 to Task 3, where the focus would be on the identification and mapping of the benefits provided  
 516 by the features which have previously been mapped. Likewise, where activities have already been  
 517 mapped (i.e. Task 7) then this stage would not need to be repeated but could be included within the  
 518 interactive pdfs after workshop 1. Finally, where management options exist for an area, Task 8 can be  
 519 skipped and the final workshop can focus on trade-offs associated with the different management  
 520 options.



521

522 **Figure 9: Flexible, modular structure for marine stakeholder participatory mapping workshops.**

523

524 **4. Discussion**

525 In the UK, the implementation of a natural capital and ecosystem services approach is gaining traction  
526 at the national scale and has yet to filter down to the practical realities of implementation in use in  
527 coastal communities. This is also reflected in the domain of policy, where implementation of the  
528 Sustainable Development Goals (UN-DESA, 2019), the UN Aichi Targets for Biodiversity (CBD, 2019)  
529 and an inclusive green economy (Altenburg & Assmann, 2017) refer to natural capital and ecosystem  
530 services as a strategic influence in macro-economic and sector wide reform. Recent efforts to  
531 incorporate natural capital into mainstream policy practice include the construction of national  
532 natural capital accounting systems and asset registers. For example, the UK Office of National Statistics  
533 has developed a system of natural capital reports specifying the economic contribution of ecosystem  
534 services (ONS, 2017), while Scottish Natural Heritage (the nature conservation agency in Scotland) has  
535 developed a Natural Capital Index that focuses on the contribution of terrestrial ecosystems to social  
536 wellbeing (SNH, 2017). Similar approaches to understanding ecosystem services across a range of  
537 Welsh environments have been applied in the recent Welsh State of Natural Resources Report (NRW,  
538 2016), while the link between the natural environmental and societal well-being is more explicitly  
539 supported through the recent Well-being of Future Generations (Wales) Act (2015). While we note  
540 the utility of these recent advances, approaches at the international and national policy scale should  
541 be supplemented by implementation at the local scale (as set out in this paper) where identification  
542 and understanding of the extent and quality of local ecosystem services can support policy delivery  
543 and community aspirations for local environmental planning and quality.

544 This research has highlighted how the perceptions of the benefits provided by the coastal environment  
545 can differ between the national and local scale, between official policy documents such as marine  
546 evidence databases and the 'on the water' reality for coastal communities. It is this scale mismatch  
547 that hides the often overlapping, entwined, contested and complex reality of services at the local scale.  
548 With mapping activities, stakeholders commented that it was useful to learn about anthropogenic  
549 activities, with one stakeholder commenting that it was useful to "[understand] the extent of what is  
550 available on our local coasts and sea". A common interpretation by participants was that the larger  
551 scale data sets did not represent local realities, particularly in sectors such as recreation. An example  
552 from the Scottish case illustrates this point. It is evident from the National Marine Plan for Scotland  
553 that there is consensus for increasing recreation and tourism activity in the coastal zone. While  
554 national databases specify, in broad terms, where activities occur, we discovered that at the local scale  
555 many activities were missing (e.g. horse-riding, small boating activity, board sports) or were  
556 considered inaccurate (e.g. dive sites or paths that were not used). Stakeholders at the East Caithness  
557 workshop indicated a preference for more fine scale and detailed maps to allow mapping of activities  
558 that were locally significant, given that the national databases did not reflect the situation at the local  
559 level and supporting local culture was integral to economic development. It is through a participatory  
560 mapping process that the fine-scale and locally relevant activities and overlaps are documented,  
561 supporting future planning and assessments. While it was beyond the scope of this research to  
562 develop policy pathways, a number of options for using participatory mapping data were highlighted  
563 during discussions with coastal stakeholders including supporting project and policy assessment (EIA  
564 and SEA), community wellbeing planning indicators, local environmental strategies (e.g. recreational  
565 and parks strategies; catchment and river plans) and civic strategies for improving natural capital e.g.  
566 the Humber Nature Forum Natural Capital Strategy (HNP, 2017). Benefits mapping activities in each  
567 workshop followed the same methodology. All four demonstration sites identified a range of benefits  
568 they get from the marine environment, covering all four MA (2005) categories (regulating, supporting,  
569 provisioning and cultural), in addition, to a range of economic / other categories of benefits. It was  
570 interesting to note that the two Scottish workshops, which focussed on mapping anthropogenic

571 activities, identified a much larger proportion of abiotic benefits within this category. In Aberdeen Bay,  
572 benefits ‘hotspots’ were evident where there was appropriate coastal access, focussing around the  
573 City of Aberdeen in the south, accessible beaches and nature reserves present around the Ythan  
574 Estuary in the north. Discussion over the ‘constellations’ of benefits in this case increased the  
575 recognition amongst stakeholders that coastal systems are integral for supporting the wellbeing of  
576 residents in the North East of Scotland and that this should be included in future planning initiatives  
577 and the management of coastal protected sites. The benefits identified by East Caithness stakeholders  
578 represented cultural and economic benefits gained from the environment and including the built /  
579 cultural environment including historical sites and visitor centres. Although some of the identified  
580 benefits such as ‘community cohesion (social)’, ‘employment’ and ‘improved local economy’ do not  
581 correspond with the MA (2005) ecosystem service framework, this reflects the values of the region in  
582 maintaining the local economy and population and the importance of community cohesion in a  
583 relatively sparsely populated and economically vulnerable area. It underlies the importance of cultural  
584 heritage, both tangible and intangible, in creating lived seascapes that support community wellbeing.  
585 The historical human culture in East Caithness combined with the modern maritime industrial context,  
586 represent a strong link between people and the sea, and the importance of benefits from both the  
587 ‘ecosystem’ and abiotic factors such as wind, space and infrastructure.

588 In contrast, the two English workshops focussed more on the benefits relating to the biotic features  
589 of the system, possibly reflecting the focus of the workshop on identifying features from high-  
590 definition satellite images. It is also of note that there were fewer benefits identified in The Wash  
591 (n=17) than in the Humber Estuary (n=26). However, this likely reflects the focus of the workshop on  
592 multiple features in the Humber Estuary, whereas The Wash workshop focussed solely on saltmarsh.  
593 Focus on different aspects of the wider ecosystem illustrates an attempt to assign value to all  
594 components of the ecosystem, including those included in the supporting services category. This has  
595 commonly been attributed the lowest level of social value, and as stated by Klain and Chan (2012),  
596 participatory mapping approaches have often omitted this level of detail.

597 The strength of this research is the co-production of ecosystem services data and awareness within  
598 coastal partnerships and networks of stakeholders. By co-producing the research aims and objectives,  
599 methodologies and workshops with established networks of individuals or organisations, it ensures  
600 that the outputs and outcomes of the research are fit-for-purpose and improve legitimacy with  
601 stakeholders (Hattam et al., 2015b; Burdon et al., 2018). Each of the four workshops held space for an  
602 open discussion regarding workshop activities, the direction of subsequent workshops and to identify  
603 and openly discuss potential management issues currently faced by coastal communities. A positive  
604 example of this came out of The Wash workshop, where issues regarding public access to the  
605 foreshore were raised and discussed relating to a recent increase in fly-tipping, vehicle access and  
606 disturbance. Following these discussions, a local working group was created, including representatives  
607 from the Ministry of Defence, Natural England, Witham Forth Drainage Board, farmers/landowners,  
608 Lincolnshire Wildlife Trust and The Wash and North Norfolk Marine Partnership, which has now  
609 actioned the installation of gates and concrete blocks to restrict vehicle access, but still ensure that  
610 pedestrians still have public right of way. In Aberdeen, discussions on the social wellbeing benefits of  
611 the coast have influenced new developments around establishing marine wildlife watching facilities  
612 and cemented concerns about the expansion of golf courses that undermine services from sand dune  
613 systems. Engaging a range of marine stakeholders in a workshop setting has not only resulted in the  
614 expansion of the role of participatory mapping for natural capital but has also enhanced discussion for  
615 management of the coastal and marine environment.

616 By taking a stakeholder-driven approach, where the outputs of the research are generated by the  
617 stakeholders themselves, it ensures buy-in from the start and provides a product legacy for use by the  
618 stakeholders at the end of the research. Our approach has focused on the development and  
619 application of a methodology, and with future iterations, will be applied in different coastal localities  
620 and incorporating additions such as trade-off analysis and future scenarios. For example, the method  
621 is currently been applied within a series of stakeholder workshops for the Suffolk Marine Pioneer  
622 project (Burdon et al., in preparation). Our focus on using coastal partnerships enabled researchers to  
623 identify and connect with those stakeholders who directly benefit ecosystem services and to those  
624 who manage, protect and educate about the marine environment and are at the forefront of policy  
625 change. A clear signal from all four workshops is that current coastal planning and policy mechanisms  
626 at the local scale are poorly equipped to deal with the policy challenge of natural capital and  
627 ecosystem services. We recommend a state change in effort and focus from the national scale (e.g.  
628 Natural Capital registers) to the community scale accommodating multiple stakeholders, interests and  
629 viewpoints around coastal system benefits. Our view is that a range of direct and indirect benefits are  
630 produced and consumed at the local scale and that this pattern of spatial heterogeneity across coastal  
631 regions should be reflected in UK, national and local policy. The UK is fortunate to have a national  
632 network of coastal partnerships, which are a highly valuable, but often under-used resource, to learn  
633 more about and implement the natural capital agenda (CPN, 2019). A review of the different  
634 management structures of UK coastal partnerships has recently been undertaken, providing a valuable  
635 resource for identifying how to determine governance requirements and structures for MPAs (Bennet  
636 & Morris, 2017). Future research can build on and facilitate new reforms to deliver the natural capital  
637 agenda at the local scale co-produced with community interests and expertise.

638 Participatory mapping offers a route for engagement in the process of knowledge production linking  
639 national initiatives and data with local knowledge, a critical component of an ecosystem approach to  
640 management. This research has demonstrated through the production of locally evaluated service /  
641 benefits maps that there is a disconnect between the findings of national evaluations and the social  
642 reality of diverse, contested and contextual ecosystem services. The outputs indicate that services in  
643 the domains of regulatory, provisioning and cultural, are consumed or experienced at the local scale  
644 (e.g. shoreline protection, sense of place, recreation and food gathering). The distribution, access to  
645 and beneficiaries of these services are subject to social deliberation and negotiation, particularly at  
646 times of change when development or bio-physical changes in the local environment drive shifts in  
647 the patterns of access or changes in benefits. During the four workshops, participants were engaged  
648 in the identification, spatial mapping and discussion of local activities, natural and modified features  
649 and the full range of ecosystem service benefits. The project took a strong approach to refinement  
650 and adaptation, improving the methodology in response to feedback and incorporating innovative  
651 new designs such as the use of satellite imagery to derive feature / benefit relationships. One of the  
652 insights of this demonstration work is that attempts to value natural capital and ecosystem services  
653 may have been premature, particularly in the context of local understanding and policy. What we have  
654 explored in these cases is that the local distribution and understanding of ecosystem services is  
655 complex, variable and subject to interpretation. While valuation is a necessary and important tool,  
656 this should be preceded by rigorous and detailed understanding of the services that exist in the local  
657 context before any valuations are undertaken.

## 658 **5. Conclusions and Future Work**

659 Although there has been a recent rapid development in our understanding of the values (qualitative  
660 and quantitative) of marine ecosystem services, socio-cultural values are often overlooked. This paper  
661 has demonstrated the value of incorporating participatory GIS in the co-production of knowledge

662 about ecosystem services in marine and coastal environments. Positive feedback from all four  
663 workshops has shown support for engagement of stakeholders in the local level discussion of natural  
664 capital and ecosystem services. Looking to the future, this paper has proposed an innovative,  
665 stakeholder-driven, adaptive approach, which has been piloted throughout the workshops, and other  
666 associated projects (e.g. MMO1136), aiming to deliver co-developed tools for use in marine planning,  
667 conservation management and coastal development strategies at a local, national and international  
668 scale. The flexibility in approach enables a bespoke series of workshops to be co-developed with  
669 stakeholders, ensuring that both the outputs and outcomes of the process are fit-for-purpose by the  
670 end-users in the sustainable management of our coasts and seas. Further research should aim to  
671 implement and evaluate the application of the framework to support local decision making at  
672 additional sites within the UK, including application within the UK overseas territories, and to test the  
673 methodology more widely across the globe. As the call for improved and meaningful stakeholder  
674 engagement in marine and coastal decision making continues to grow, this paper demonstrates the  
675 successful application of this co-developed, participatory approach within a UK context. Given the  
676 flexibility in the approach, the framework has the potential to be adapted for broad-scale use outside  
677 the UK, as well as for the management of other ecosystems types (e.g. terrestrial and freshwater  
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#### 691 **References**

- 692 Altenburg, T. & Assmann, C. (Eds.), 2017. *Green Industrial Policy. Concept, Policies, Country*  
693 *Experiences*. Geneva, Bonn: UN Environment; German Development Institute / Deutsches  
694 Institut für Entwicklungspolitik (DIE).
- 695 Andrews, S., Stocker, L. & Oechel, W., 2018. Underwater Photo-Elicitation: A new experiential marine  
696 education technique. *Australian Journal of Environmental Education*, 34, pp. 33-60.
- 697 Atkins, J.P., Banks, E., Burdon, D., Greenhill, L., Hastings, E., & Potts, T., 2013. *An analysis of*  
698 *methodologies for defining ecosystem services in the marine environment*. JNCC Report 491  
699 (Contract number: C12-0170-0612).
- 700 Atkins, J.P., Burdon, D. & Elliott, M., 2015. Chapter 5. Identification of a practicable set of indicators  
701 for coastal and marine ecosystem services. In: Turner, R.K. & Schaafsma, M. (Eds.) *Coastal zones*  
702 *ecosystem services: from science to values and decision making*. Studies in Ecological Economics,  
703 Volume 9, Springer, Switzerland.

- 704 Beaumont, N.J., Austen, M.C., Atkins, J.P., Burdon, D., Degraer, S., Dentinho, T.P., Derous, S., Holm, P.,  
705 Horton, T., Van Ierland, E., Marboe, A.H., Starkey, D.J., Townsend, M. & Zarzycki, T., 2007.  
706 Identification, definition and quantification of goods and services provided by marine  
707 biodiversity: Implications for the ecosystem approach. *Marine Pollution Bulletin*, 54, pp. 253-  
708 265.
- 709 Beery, T., Stalhammer, S., Jonsson, K., I., Wamsler, C., Bramryd, T., Brink, E., Ekelund, N., Johansson,  
710 M., Palo, T. & Schubert, P., 2016. Perceptions of the ecosystem services concept: Opportunities  
711 and challenges in the Swedish municipal context. *Ecosystem Services*, 17, pp. 123-130.
- 712 Bennett, N., 2016. Using perceptions as evidence to improve conservation and environmental  
713 management. *Conservation Biology*, 30, pp. 582-592.
- 714 Bennett, N.J., Roth, R., Klain, S.C., Chan, K., Christie, P., Clark, D.A., Cullman, G., Curran, D., Durbin, T.J.,  
715 Epstein, G., Greenberg, A., Nelson, M.P., Sandlos, J., Stedman, R., Teel, T.L., Thomas, R.,  
716 Verissimo, D. & Wyborn, C., 2017. Conservation social science: Understanding and integrating  
717 human dimensions to improve conservation. *Biological Conservation*, 205, pp. 93-108.
- 718 Bennett, T. & Morris, R., 2017. *How to determine governance requirements and structures for MPAs:  
719 Governance Structure Toolkit*. Report for WWF in Partnership with Natural England, June 2017.
- 720 Berkes, F., Kislalioglu Berkes, M. & Fast, H., 2007. Collaborative Integrated Management in Canada's  
721 North: The Role of Local and Traditional Knowledge and Community-Based Monitoring. *Coastal  
722 Management*, 35, pp. 143-162.
- 723 Bhatia, N., 2012. *Ecological and economic valuation of managed realignment sites, Humber estuary,  
724 UK: benefits for society*. PhD Thesis, University of Hull, UK.
- 725 Börger, T., Hattam, C., Burdon, D., Atkins, J.P. & Austen, M., 2014. Valuing conservation benefits of an  
726 offshore marine protected area. *Ecological Economics*, 108, pp. 229–241.
- 727 Brown, G. & Fagerholm, N., 2015. Empirical PPGIS/PGIS mapping of ecosystem services: A review and  
728 evaluation. *Ecosystem Services*, 13, pp. 119-133.
- 729 Brown, G.G. & Reed, P., 2012. Social Landscape metrics: Measures for understanding place values  
730 from Public Participation Geographic Information Systems (PPGIS). *Landscape Research*, 37, pp.  
731 73-90
- 732 Brown, G., Weber, D. & de Bie, K., 2014. Assessing the value of public lands using public participation  
733 (PPGIS) and social landscape metrics. *Applied Geography*, 53, pp. 77-89.
- 734 Brown, G. & Kytta, M., 2014. Key issues and research priorities for public participation GIS (PPGIS): A  
735 synthesis based on empirical research. *Applied Geography*, 46, pp. 122-136.
- 736 Burdon, D., 2016. *An interdisciplinary approach to marine management: Bridging the divide between  
737 natural and social sciences research*. PhD by Published Work, University of Hull, UK.
- 738 Burdon, D., Boyes, S.J., Elliott, M., Smyth, K., Atkins, J.P., Barnes, R.A. & Wurzel, R.K., 2018. Integrating  
739 natural and social marine science to manage sustainably vectors of change: Dogger Bank  
740 transnational case study. *Estuarine, Coastal and Shelf Science*, 201, pp. 234-247.
- 741 Burdon, D., Potts, T., Barbone, C. & Mander, L., 2017. The matrix revisited: A bird's-eye view of marine  
742 ecosystem service provision. *Marine Policy*, 77, pp. 78-89.

- 743 CBD, 2019. Convention on Biological Diversity - Aichi Biodiversity Targets. Accessed 21 June 2019.  
744 <https://www.cbd.int/sp/targets/>
- 745 Chan, K.M.A., Satterfield, T. & Goldstein, J., 2012a. Rethinking ecosystem services to better address  
746 and navigate cultural values. *Ecological Economics*, 74, pp. 8-18.
- 747 Chan, K.M.A., Guerry, A., Balvanera, P., Klain, S., Satterfield, T., Basurto, X., Bostrom, A., Chuenpagdee,  
748 R., Gould, R., Halpern, B., S., Hannahs, N., Levine, J., Norton, B., Ruckelshaus, M., Russell, R.,  
749 Tam, J. & Woodside, U., 2012b. Where are Cultural and Social in Ecosystem Services? A  
750 Framework for Constructive Engagement. *BioScience*, 62(8), pp. 744–756.
- 751 Cooper, K., Burdon, D., Atkins, J.P., Weiss, L., Somerfield, P., Elliott, M., Turner, K., Ware, S. & Vivian,  
752 C., 2013. Can the benefits of physical seabed restoration justify the costs? An assessment of a  
753 disused aggregate extraction site off the Thames Estuary, UK. *Marine Pollution Bulletin*. 75, pp.  
754 33-45.
- 755 Cooper, N., Brady, E., Steen, H. & Bryce, R. 2016. Aesthetic and spiritual values of ecosystems:  
756 Recognising the ontological and axiological plurality of cultural ecosystem 'services'. *Ecosystem*  
757 *Services*, 21, pp. 218-229.
- 758 CPN, 2019. Coastal Partnerships Network. Accessed 21 June 2019.  
759 <https://www.coastalpartnershipsnetwork.org.uk/>
- 760 Cutts, B.B., White, D. & Kinzig, A.P., 2011. Participatory geographic information systems for the co-  
761 production of science and policy in an emerging boundary organization. *Environmental Science*  
762 *& Policy*, 14, pp. 977-985.
- 763 Damastuti, E. & de Groot, R., 2019. Participatory ecosystem service mapping to enhance community-  
764 based mangrove rehabilitation and management in Demak, Indonesia. *Regional Environmental*  
765 *Change*, 19, pp. 65-78.
- 766 Dempsey, J. & Robertson, M.M., 2012. Ecosystem Services: Tensions, impurities and points of  
767 engagement within neoliberalism. *Progress in Human Geography*, 36, pp. 758-779.
- 768 Derous, S., Agardy, T., Hillewaert, H., Hostens, K., Jamieson, G., Lieberknecht, L., Mees, J., Moolaert,  
769 I., Olenin, S., Paelinckx, D., Rabaut, M., Rachor, E., Roff, J., Stienen, E.W.M., van der Wal, J.T.,  
770 Van Lancker, V., Verfaillie, E., Vincx, M., Weslawski, J.M., Degraer, S., 2007. A concept for  
771 biological valuation in the marine environment. *Oceanologia*, 49, pp. 99-128.
- 772 de Groot, R.S., Fisher, B., Christie, M., Aronson, J., Braat, L., Gowdy, J., Haines-Young, R., Maltby, E.,  
773 Neuville, A., Polasky, S., Portela, R. & Ring, I., 2010. Integrating the ecological and economic  
774 dimensions in biodiversity and ecosystem service valuation, In: Kumar, P. (Ed.). *The Economics*  
775 *of Ecosystems and Biodiversity: Ecological and Economic Foundations*. Earthscan, London and  
776 Washington, pp. 9-40.
- 777 Elwood, S., 2006. Critical issues in participatory GIS: deconstructions, reconstructions and new  
778 research directions. *Transactions in GIS*, 10, pp. 693-708.
- 779 EU, 2011. The EU Biodiversity Strategy to 2020. Publications Office of the European Union, Luxemburg.  
780 [http://ec.europa.eu/environment/nature/info/pubs/docs/brochures/2020%20Biod%20broch](http://ec.europa.eu/environment/nature/info/pubs/docs/brochures/2020%20Biod%20brochure%20final%20lowres.pdf)  
781 [ure%20final%20lowres.pdf](http://ec.europa.eu/environment/nature/info/pubs/docs/brochures/2020%20Biod%20brochure%20final%20lowres.pdf)

- 782 Fletcher, S., Jefferson, R.L. & McKinley, E., 2012. Exploring the shallows: a response to 'Saving the  
783 shallows: focusing marine conservation where people might care'. *Aquatic Conservation Marine  
784 and Freshwater Ecosystems*, 22, pp. 7-10.
- 785 Fletcher, S., Saunders, J., Herbert, R., Roberts, C. & Dawson, K., 2012. *Description of the ecosystem  
786 services provided by broad-scale habitats and features of conservation importance that are  
787 likely to be protected by Marine Protected Areas in the Marine Conservation Zone Project area.*  
788 Natural England Commissioned Reports, Number 088.
- 789 Fonseca, L., 2009. *Fish utilisation of managed realignment areas and saltmarshes in the Blackwater  
790 Estuary, Essex, S.E. England.* PhD Thesis, Queen Mary University of London, UK.
- 791 Friedrich L.A., Dodds W., Philippe M., Glegg G., Fletcher S. & Bailly, D. 2015. *Improving stakeholder  
792 engagement in marine management through ecosystem service assessment. A guide for  
793 practitioners based on experience from the VALMER project.* VALMER project, 6pp.
- 794 García-Nieto, A.P., Quintas-Soriano, C., García-Llorente, M., Palomo, I., Montes, C. & Martín-López, B.,  
795 2015. Collaborative mapping of ecosystem services: The role of stakeholders' profiles.  
796 *Ecosystem Services*, 13, pp. 141-152.
- 797 Geijzendorffer, I.R., Cohen-Shacham, E., Cord, A.F., Cramer, W., Guerra, C. & Martín-López, B., 2017.  
798 Ecosystem services in global sustainability policies. *Environmental Science & Policy*, 74, pp 40-  
799 48.
- 800 Haines-Young, R. & Potschin, M., 2010. The links between biodiversity, ecosystem services and human  
801 well-being. Chapter 6 In: Raffaelli, D. & Frid, C. (Eds.): *Ecosystem Ecology: a new synthesis*. BES  
802 ecological reviews series, Cambridge University Press, Cambridge (31 pp).
- 803 Hattam, C., Atkins, J.P., Beaumont, N., Börger, T., Böhnke-Henrichs, A., Burdon, D., De Groot, R.,  
804 Hoefnagel, E., Nunes, P., Piwowarczyk, J., Sergio, S. & Austen, M., 2015a. Marine ecosystem  
805 services: linking indicators to their classification. *Ecological Indicators*, 49, pp. 61–75.
- 806 Hattam, C., Böhnke-Henrichs, A., Börger, T., Burdon, D., Hajimicheale, M. Delaney, A., Atkins, J.P.,  
807 Garrard, S. & Austen, M., 2015b. Integrating methods for ecosystem service assessment and  
808 valuation: mixed methods or mixed messages? *Ecological Economics*, 120, pp. 126–138.
- 809 HM Government, 2018. A green future: Our 25-year plan to improve the environment.  
810 <https://www.gov.uk/government/publications/25-year-environment-plan>
- 811 HNP, 2017. Investing in Natural Capital: Creating the right environment for economic investment.  
812 Publication of the Humber Nature Partnership, Water's Edge Visitors Centre, Barton Upon  
813 Humber, June 2017. [http://humburnature.co.uk/admin/resources/investing-in-natural-  
814 capital.pdf](http://humburnature.co.uk/admin/resources/investing-in-natural-capital.pdf)
- 815 Jefferson, R., McKinley, E., Capstick, S., Fletcher, S., Griffin, H. & Milanese, M., 2015. Understanding  
816 audiences: making public perceptions research matter to marine conservation. *Ocean and  
817 Coastal Management*, 115, pp. 61-70.
- 818 Jobstvogt, N., Hanley, N., Hynes, S., Kenter, J. & Witte, U., 2014a. Twenty thousand sterling under the  
819 sea: estimating the value of protecting deep-sea biodiversity. *Ecological Economics*, 97, pp. 10–  
820 19.
- 821 Jobstvogt, N., Watson, V. & Kenter, J.O., 2014b. Looking below the surface: The cultural ecosystem  
822 service values of UK marine protected areas (MPAs). *Ecosystem Services*, 10, pp. 97-110.

- 823 Kenter, J.O., Bryce, R., Christie, M., Cooper, N., Hockley, N., Irvine, K.N., Fazey, I., O'Brien, L., Orchard-  
824 Webb, J., Ravenscroft, N., Raymond, C.M., Reed, M.S., Tett, P. & Watson, V., 2016. Shared values  
825 and deliberative valuation: Future directions. *Ecosystem Services*, 21, pp. 358-371.
- 826 Kenter, J.O., O'Brien, L., Hockley, N., Ravenscroft, N., Fazey, I., Irvine, K.N., Reed, M.S., Christie, M.,  
827 Brady, E., Bryce, R., Church, A., Cooper, N., Davies, A., Evely, A., Everard, M., Fish, R., Fisher, J.A.,  
828 Jobstvogt, N., Molloy, C., Orchard-Webb, J., Ranger, S., Ryan, M., Watson, V. & Williams, S., 2015.  
829 What are shared and social values of ecosystems? *Ecological Economics*, 111, pp. 86-99.
- 830 Klain, S.C. & Chan, K.M.A., 2012. Navigating coastal values: Participatory mapping of ecosystem  
831 services for spatial planning. *Ecological Economics*, 82, pp. 104-113.
- 832 Lok, M., Benson, E., Gough, M., Ahlroth, S., Greenfield, O., Confino, J. & Wormgoor, W., 2018. *Natural  
833 capital for governments: why, what and how*. Draft 1.0, 21 November 2018.  
834 [https://www.greeneconomycoalition.org/news-analysis/natural-capital-for-governments-  
835 draft-dialogue](https://www.greeneconomycoalition.org/news-analysis/natural-capital-for-governments-draft-dialogue).
- 836 Luisetti, T., Turner, R.K., Jickells, T., Andrews, J., Elliott, M., Schaafsma, M., Beaumont, N., Malcolm, S.,  
837 Burdon, D., Adams, C. & Watts, W., 2015. Chapter 11. What future for the English coastline? A  
838 case study exploring managed realignment benefits. In: Turner, R.K. & Schaafsma, M. (Eds.)  
839 Coastal zones ecosystem services: from science to values and decision making. Studies in  
840 Ecological Economics Volume 9, Springer, Switzerland.
- 841 MA, 2003. Ecosystems and human well-being: A framework for assessment. Island Press, Washington.
- 842 MA, 2005. Millennium Ecosystem Assessment – Ecosystems and human well-being biodiversity  
843 synthesis. Island Press, Washington, DC.
- 844 Maes, J., Teller, A., Erhard, M. et al. (45 authors), 2014. *Mapping and Assessment of Ecosystems and  
845 their Services. Indicators for ecosystem assessments under Action 5 of the EU Biodiversity  
846 Strategy 2020*. 2nd final report, European Union, February 2014.
- 847 Maltby, E. (Ed.), 2009. *Functional assessment of wetlands. Towards evaluation of ecosystem services*.  
848 Woodhead Publ., Abington, Cambridge.
- 849 Marine Scotland, 2018. National Marine Plan Interactive. Available from:  
850 <https://marinescotland.atkinsgeospatial.com/nmpi/>
- 851 Martin, C.L., Momtaz, S., Gaston, T. & Moltschaniwskyj, N.A., 2016. A systematic quantitative review  
852 of coastal and marine cultural ecosystem services: Current status and future research. *Marine  
853 Policy*, 74, pp. 25-32.
- 854 Martinez-Harms, M.J. & Balvanera, P., 2012. Methods for mapping ecosystem service supply: A review.  
855 *International Journal of Biodiversity Science, Ecosystem Service and Management*, 8, pp. 17-25.
- 856 McKinley, E. & Fletcher, S., 2010. Individual Responsibility for the Oceans? An Evaluation of Marine  
857 Citizenship by UK Marine Practitioners. *Ocean and Coastal Management*, 53, pp. 379-384.
- 858 McKinley, E. & Fletcher, S., 2012. Improving marine environmental health through marine citizenship:  
859 A call for debate. *Marine Policy*, 36, pp. 839-843.
- 860 MCS, 2017. *Common Ground Report*. Prepared by Marine Conservation Society, Community Voice  
861 Consulting, The Wash and North Norfolk Marine Partnership, Eastern IFCA. 30pp.

- 862 [https://wnmp.co.uk/wp-content/uploads/sites/29/2017/12/Common-Ground-final-](https://wnmp.co.uk/wp-content/uploads/sites/29/2017/12/Common-Ground-final-report.pdf)  
863 [report.pdf](https://wnmp.co.uk/wp-content/uploads/sites/29/2017/12/Common-Ground-final-report.pdf)
- 864 Moore, S.A., Brown, G., Kobryn, H. & Strickland-Munro, J., 2017. Identifying conflict potential in a  
865 coastal and marine environment using participatory mapping. *Journal of Environmental*  
866 *Management*, 197, pp. 706-718.
- 867 NCC, 2019. What is natural capital. Natural Capital Coalition.  
868 <https://naturalcapitalcoalition.org/natural-capital-2/>
- 869 Nursey-Bray, M.,J., Vince, J., Scott, M., Haward, M., O'Toole, K., Smith, T., Harvey, N. & Clarke, B., 2014.  
870 Science into policy? Discourse, coastal management and knowledge. *Environmental Science &*  
871 *Policy*, 38, pp. 107-119.
- 872 NRW, 2016. *The State of Natural Resources Report (SoNaRR)*. Natural Resources Wales  
873 [https://naturalresources.wales/evidence-and-data/research-and-reports/the-state-of-natural-](https://naturalresources.wales/evidence-and-data/research-and-reports/the-state-of-natural-resources-report-assessment-of-the-sustainable-management-of-natural-resources/?lang=en)  
874 [resources-report-assessment-of-the-sustainable-management-of-natural-resources/?lang=en](https://naturalresources.wales/evidence-and-data/research-and-reports/the-state-of-natural-resources-report-assessment-of-the-sustainable-management-of-natural-resources/?lang=en)
- 875 OECD, 2016. *The Ocean Economy in 2030*. OECD Publishing, Paris. [https://read.oecd-](https://read.oecd-ilibrary.org/economics/the-ocean-economy-in-2030_9789264251724-en)  
876 [ilibrary.org/economics/the-ocean-economy-in-2030\\_9789264251724-en](https://read.oecd-ilibrary.org/economics/the-ocean-economy-in-2030_9789264251724-en)
- 877 Office for National Statistics, 2017. *Natural Capital*. Available from:  
878 [https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/methodologies/natur](https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/methodologies/naturalcapital)  
879 [alcapital](https://www.ons.gov.uk/economy/nationalaccounts/uksectoraccounts/methodologies/naturalcapital) (updated 24th February 2017).
- 880 Norgaard, R.B., 2010. Ecosystem services: From eye-opening metaphor to complexity blinder.  
881 *Ecological Economics*, 69, pp. 1219-1227.
- 882 Pascual, M., Borja, A., Eede, S.V., Deneudt, K., Vincx, M. & Galparsoro, I., 2011. Marine biological  
883 valuation mapping of the Basque continental shelf (Bay of Biscay), within the context of marine  
884 spatial planning. *Estuarine, Coastal and Shelf Science*, 95, pp. 186-198.
- 885 Pike, K., Johnson, D., Fletcher, S., Wright, P. & Lee, B., 2010. Social Value of Marine and Coastal  
886 Protected Areas in England and Wales. *Coastal Management*, 38, pp. 412-432.
- 887 Potts, T., Burdon, D., Jackson, E., Atkins, J.P., Saunders, J., Hastings, E. & Langmead, O., 2014. Do  
888 marine protected areas deliver flows of ecosystem services to support human welfare? *Marine*  
889 *Policy*, 44, pp. 139–148.
- 890 Potts, T., O'Higgins, T., Brennan, R., Cinnirella, S., Steiner Brandt, U., De Vivo, J. Beusekom, J., Troost,  
891 T.A., Paltriguera, L. & Hosgor, A., 2015. Detecting critical choke points for achieving Good  
892 Environmental Status in European seas. *Ecology and Society*, 20(1): 29.  
893 <http://dx.doi.org/10.5751/ES-07280-200129>
- 894 Raymond, C.M., Bryan, B., A., MacDonald, D., H., Cast, A., Strathearn, S., Grandgirad, A. & Kalivas, T.,  
895 2009. Mapping community values for natural capital and ecosystem services. *Ecological*  
896 *Economics*, 68, pp. 1301-1315.
- 897 Ruiz-Frau, A., Edwards-Jones, G. & Kaiser, M.J., 2011. Mapping stakeholder values for coastal zone  
898 management. *Marine Ecology Progress Series*, 434, pp. 239-249.
- 899 Saunders, J., Potts, T., Jackson, E., Burdon, D., Atkins, J.P., Hastings, E. & Langmead, O., 2015. Chapter  
900 9. Linking ecosystem services of marine protected areas to benefits in human well-being? In:

- 901 Turner, R.K. & Schaafsma, M. (Eds.) *Coastal zones ecosystem services: from science to values*  
902 *and decision making*. Studies in Ecological Economics Volume 9, Springer, Switzerland.
- 903 Scottish Government, 2018. *Developing an Environment Strategy for Scotland*. Consultation document.  
904 Available from: <https://consult.gov.scot/environment-forestry/environment-strategy>
- 905 Scottish Natural Heritage (SNH), 2017. *Natural Capital Asset Index*. Available from:  
906 [https://www.nature.scot/professional-advice/planning-and-development/valuing-our-](https://www.nature.scot/professional-advice/planning-and-development/valuing-our-environment/natural-capital-asset-index)  
907 [environment/natural-capital-asset-index](https://www.nature.scot/professional-advice/planning-and-development/valuing-our-environment/natural-capital-asset-index)
- 908 Scottish Natural Heritage (SNH), 2018. Scottish Natural Heritage Sitelink; Available from  
909 <<https://sitelink.nature.scot/home>>
- 910 Tallis, H., Kareiva, P., Marvier, M. & Chang, A., 2008. An ecosystem services framework to support  
911 both practical conservation and economic development. *PNAS*, 105, pp. 9457-9464.
- 912 Turkelboom, F., Raquez, P., Dufrêne, M., et al. (19 authors), 2013. CICES going local: Ecosystem  
913 services classification adapted for a highly populated country. In Jacobs, S., Dendoonker, N., and  
914 Keune, H. (eds) *Ecosystem Services*. Chicago, pp. 223-247.
- 915 Turner, R.K., Schaafsma, M., Mee, L., Elliott, M., Burdon, D., Atkins, J.P. & Jickells, T., 2015. Chapter 2.  
916 Conceptual framework. In: Turner, R.K. & Schaafsma, M. (Eds.) *Coastal zones ecosystem services:*  
917 *from science to values and decision making*. Studies in Ecological Economics, Volume 9, Springer,  
918 Switzerland.
- 919 UN–DESA (United Nations Department of Social and Economic Affairs), 2019. The Sustainable  
920 Development Goals. Available <https://sustainabledevelopment.un.org/sdgs>.
- 921 UKNEA, 2011. The UK National Ecosystem Assessment: Synthesis of the key findings. UNEP-WCMC,  
922 Cambridge, UK.
- 923 UKNEAFO, 2014. The UK National Ecosystem Assessment Follow-on: Synthesis of key findings. UNEP-  
924 WCMC, LKWEC, UK.
- 925 Willcock, S., Hoofman, D., Sitas, N., O’Farrell, P., Hudson, M., D., Reyers, B., Eigenbrod, F. & Bullock,  
926 J.M., 2016. Do ecosystem service maps and models meet stakeholders’ needs? A preliminary  
927 survey across sub-Saharan Africa. *Ecosystem Services*, 18, pp. 110-117.