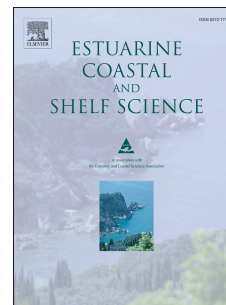# Accepted Manuscript

The role of interdisciplinary collaboration for stated preference methods to value marine environmental goods and ecosystem services

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1 **The role of interdisciplinary collaboration for stated preference methods to value**

2 **marine environmental goods and ecosystem services**

3

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14

15 **Abstract**: With the increasing use of environmental valuation methods in coastal, marine and

16 deep-sea settings, there is a growing need for the collaboration of natural scientists and

17 environmental economists. Stated preference valuation methods in particular need to be based

18 on sound natural science information and translate such information to be used in social surveys.

19 This paper uses three applications to make explicit the flow of information between different

20 disciplines in the preparation and implementation of stated preference studies. One approach

21 for facilitating this flow is to increase knowledge and understanding of natural scientists on these

22 methods. To address this, this paper highlights key opportunities and pitfalls and demonstrates

23 those in the context of three case studies. It therefore provides guidance on stated preference

24 valuation for natural scientists rather than for economists.

25

1. Introduction

A rising demand for cost-benefit analyses of coastal and marine management measures, driven by national and international legislation, has recently been stimulating increasing efforts in environmental valuation in this field (Hanley et al. 2015, Börger et al. 2014a). Efficient use of public funds for marine environmental policy requires the assessment of costs and benefits of management measures (Oinonen et al. 2016, Scharin et al. 2016). Such management measures are a response to an increasing number of directly and indirectly human-induced stressors, such as climate change, fishing, maritime transport, land-based pollution and tourism. These stressors are leading to changes in the state of the marine environment and consequently impact human welfare (Halpern et al. 2015, Wolanski and Elliott 2015). Beyond their direct and indirect influence on economic activity, such as the production of goods and services, there are a variety of impacts that are not directly accounted for in observable market transactions. Their value (for use in environmental cost-benefit analyses) cannot be assessed through the analysis of market data, necessitating the use of non-market valuation techniques. These can be divided into two main groups: revealed preference and stated preference (SP) methods. Other methods exist, such as cost-based approaches and value transfer (Johnston and Rosenberger 2010), but as they do not employ survey methods, they are beyond the remit of this paper. Revealed preference methods, such as the travel cost method (e.g. Whitehead et al. 2008, Söderqvist et al. 2005, Bhat 2003) or hedonic pricing (e.g. Gopalakrishnan et al. 2011, Samarasinghe and Sharp 2010), use available data on market transactions or individual behaviour to infer the value of non-market goods. These methods are limited to the assessment of use values. Total economic value, potentially consisting of use and non-use value, can only be assessed by means of SP methods. The two most prominent of the latter are the contingent valuation method (CVM) (Carson and Hanemann 2005, Mitchell and Carson 1989) and discrete choice experiments (DCE) (Louviere et al. 2000).

In recent years, there has been an increase in the application of SP valuation studies in coastal locations (e.g. Hynes et al. 2013, Taylor and Longo 2010, Hanley et al. 2003), the intertidal zone (e.g.

1

27 Nunes et al. 2009, Bulte et al. 2005) and offshore resources (e.g. Brouwer et al. 2016, Aanesen et al.

28 2015, Börger et al. 2015, Jobstvogt et al. 2014a, Norton and Hynes 2014, Wattage et al. 2011, Glenn

29 et al. 2010, Liu and Wirtz 2010, McVittie and Moran 2010, Eggert and Olsson 2009). Nevertheless,

30 the number of high-quality primary valuation studies in the marine realm remains low compared to

31 terrestrial environments as can be seen in the existing valuation databases such as that of the

32 Marine Ecosystem Services Partnership (MSEP)[1] or the Environmental Valuation Reference Inventory

33 (EVRI)[2].

34   The stimulation for further marine valuation already exists due to increasing activity within

35 marine policy and management domains (for example, the EU Marine Strategy Framework Directive

36 (2008/56/EC), the development of marine plans and growing interest in the promotion of the blue

37 economy (Spalding 2016)). To ensure that environmental valuation is robust, of high quality, and

38 useable in the decision-making process, what needs to be fostered is increased collaboration

39 between natural scientists and environmental economists. This requires contributions from different

40 disciplines at different stages of the valuation process. On a practical level, the valuation of

41 environmental goods and ecosystem services entails four steps (Freeman 2002): (1) determining

42 (and quantifying) the size of the environmental change to be valued and its effect on ecosystem

43 structure and function; (2) determining (and quantifying) the impact of these effects on the

44 provision of ecosystem services to humans; (3) assessing changes in human welfare in monetary

45 terms, i.e. valuation; and (4) aggregating individual valuations over the affected population. While

46 steps (3) and (4) have received considerable attention from environmental economists and relevant

47 manuals are available (e.g. Johnston et al. forthcoming, Kanninen 2006, Champ et al. 2003, Bateman

48 et al. 2002, Haab and McConnell 2002), there is no standardised way to translate natural science

49 information into a valuation scenario in steps (1) and (2). It is evident that these steps depend

50 heavily on the specific survey topic. Interdisciplinary teams are indispensable to ensure that the links

[1] www.marineecosystemservices.org

[2] www.evri.ca

2

51 between environmental changes and ecosystem services affected are presented to survey

52 respondents in a correct, succinct and understandable, yet neutral and non-leading way. This

53 involves a trade-off between the provision of more detail to increase ecological accuracy and realism

54 of the environmental changes to be valued and the risk of overburdening respondents on a cognitive

55 level. Against this backdrop, this paper explores how natural science knowledge and data can be

56 best translated for the use in SP studies by making the information flow in this interdisciplinary type

57 of research explicit. One approach for facilitating this information flow is to increase the

58 understanding of natural scientists of practical SP environmental valuation. In addition, while biases

59 and procedural problems still challenge valuation practitioners (Hoyos 2010, Venkatachalam 2004,

60 Mitchell and Carson 1989), the application of CVM and DCE in the marine environment has its own

61 recognised set of difficulties (Hanley et al. 2015). Therefore, key opportunities and pitfalls in the use

62 of SP valuation in the marine environment are highlighted by means of three recently conducted

63 valuation surveys in Poland, the Netherlands and the UK in the framework of the EU FP7 project

64 VECTORS (www.marine-vectors.eu). Consequently this paper is intentionally aimed predominantly at

65 a natural science readership rather than environmental economists. This focus will enable the

66 former to better assess the quality of existing valuation studies and generally to improve the

67 translation of environmental information for valuation purposes. Using the three applications of the

68 DCE approach as examples, this paper examines the approach and its application to value ecological

69 changes in the coastal and marine environment and thereby intends to raise awareness amongst

70 natural scientists for the particular requirements of interdisciplinary research around environmental

71 valuation.

72

73 **2. Using stated preferences to value non-market environmental goods**

74 **2.1. Introduction to the concept of value in economics and stated preference methods**

75 In economics, value can be expressed through exchange, and as such is instrumental and

76 anthropocentric (Freeman 2002, Turner 1999). Instrumental (as opposed to intrinsic) values relate to

77 individual preferences and needs. Something has value to the extent that it satisfies existing human

78 preferences. Value can be thought of as the value of the good as a whole, which underpins the

79 conceptualisation in the CVM, or made up of the value of the different characteristics of the good,

80 which is the foundation of the DCE approach. Values are relative in the sense that the value of good

81 A relates and is comparable to the value of good B (Turner 1999). Consequently, in economics value

82 is usually assessed by employing the concept of willingness to pay (WTP), which implies a

83 comparison between the value of a good and money. This concept attempts to assess welfare

84 changes by quantifying how much of an individual's current income or wealth he is willing to trade

85 for the provision of a good or service (or to prevent the cessation or reduction of this provision). An

86 alternative to this is the concept of willingness to accept (WTA) compensation to go without an

87 improvement or to endure deterioration of environmental quality. The majority of practical

88 applications, however, employ the WTP concept. In other words, what is the amount of money

89 forgone that leaves an individual exactly as well off, in terms of welfare, as before a positive change

90 in environmental quality occurred? This establishes a substitution relationship between the

91 provision of environmental quality and money. WTP can therefore be interpreted as an indicator of

92 the change in welfare that this individual expects from the change in provision or quality expressed

93 in monetary terms.

94   When goods or services are traded in markets, market data can usually be used to infer WTP

95 and hence the value of the goods in question.[3] For the case of non-market goods this is not possible,

96 but SP valuation methods can be used to assess how much people *would* be willing to pay if there

97 was a market for these goods. While the beginnings of the CVM go back to the middle of the 20th

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[3] Note that there is a difference between WTP and market prices in that the amount a person is willing to pay for a good might be more than she actually needs to pay in the market, i.e. the market price. Valuation is therefore concerned with WTP, which is associated with the concept of consumer surplus (Bateman et al. 2002, Morse-Jones et al. 2011). However, in well-functioning markets (and only there), market prices are usually a good approximation of WTP.

98   century (Randall et al. 1974, Davis 1963, Ciriacy-Wantrup 1947), DCE originate in the 1980s in

99   marketing and transport research (Louviere 1988, Louviere and Woodworth 1983) with first

100   applications in the environmental field appearing in the 1990s (Hanley et al. 1998, Boxall et al. 1996,

101   Adamowicz et al. 1994). Both methods are survey-based and present respondents with hypothetical

102   environmental management measures, the 'valuation scenario'. These scenarios detail a proposed,

103   hypothetical environmental management project, which will lead to changes in specific aspects of a

104   non-market good or service. It is further specified that the proposed management measures can

105   only be implemented at a certain cost, which will have to be incurred by the potential beneficiaries

106   of the resulting changes, typically the households surveyed. As part of the valuation scenario, a

107   payment vehicle, the specific way respondents are asked to contribute to support the proposed

108   scenario, has to be specified. Typically coercive payment vehicles, such as taxes or fees are

109   preferable to voluntary vehicles such as donations (Carson and Groves 2007, Mitchell and Carson

110   1989). The payment vehicle also determines the frequency and duration of the hypothetical

111   payments. In DCE, both the changing aspects of the ecosystem and the payment vehicle details are

112   expressed in the choice attributes that describe a certain choice option. As an example, Figure 1

113   displays the valuation scenario used in one of the DCEs examined in this paper (the Dogger Bank

114   survey; Section 3.1) introducing all choice attributes ('Diversity of species', 'Protection of porpoises,

115   seals and seabirds' and 'Invasive species' and the need to pay for this programme and the payment

116   vehicle, an 'Additional tax'). Subsequently, respondents are presented with the valuation task. In the

117   CVM this is usually a single question directly eliciting the WTP for a change in environmental quality

118   proposed in the valuation scenario. Common formats of the elicitation question are the

119   dichotomous-choice question, in which respondents are simply prompted to indicate whether they

120   are willing to pay a certain amount for the proposed environmental change. This format has been

121   shown to make truthful responding in the best interest of the respondent (and hence more likely to

122   occur) if the WTP response really influences the chance of the proposed scenario to be implemented

123   or not (Carson and Groves 2007). Another format often used is the payment card approach, in which

5

124   they are asked to state their maximum WTP on a list of monetary amounts (or intervals) (Cameron

125   and Huppert 1989).

126

127   *- Figure 1 -*

128

129   While the CVM assesses the value of the entirety of attributes of a good in monetary terms,

130   the DCE conceptualises a good as consisting of a number of attributes which all contribute to its

131   value. As two of these attributes are usually environmental quality and the price of the good, the

132   comparison with money is less direct in the DCE. Therefore, DCE are somewhat more flexible than

133   the CVM because instead of eliciting the WTP for the hypothetical management measures they

134   present respondents with a series of choices between two or more specifications of measures. These

135   choice options are described in terms of a set of attributes, the levels of which vary across options.

136   Each option displays how the management measure leads to different quantities or quality levels of

137   the specific non-market goods described (i.e. the choice attributes) at different costs. Respondents

138   are then asked to indicate their most preferred option. Typically a respondent answers several such

139   choice tasks with varying levels of the choice attributes. The use of the cost attribute allows for the

140   computation of respondents' WTP for changes in the non-monetary choice attributes. As an example,

141   Figure 2 displays the choice card from one of the case studies. Respondents are asked to state their

142   preferred alternative between the current ('Plan A') and two hypothetical management plans ('Plan

143   B' and 'Plan C') (Section 3.1).

144

145   *- Figure 2 -*

146

147   In both CVM and DCE, if the survey sample is representative of the whole population affected

148   by the proposed environmental management measures, estimated mean WTP in the sample can be

149   multiplied with the total number of households affected. This yields the total value of the change

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150 under study, which in welfare economics is referred to as the social value of this change. Both

151 approaches assume that respondents have clear and stable preferences regarding the goods and

152 services provided so that they can express their WTP (in CVM) or indicate their preferred choice

153 alternative(s) (in DCE) during the survey interview. In turn, respondents need to have all the

154 necessary information to complete this task. However, an increasing number of studies have shown

155 that preferences are often formed during the valuation interview (e.g. Kingsley and Brown 2010,

156 Holmes and Boyle 2005). Consequently, the way information is presented and what information is

157 provided is crucial if respondents are to accurately express their WTP or preferences. This is

158 especially important when the good to be valued is unfamiliar to respondents, which is often the

159 case in applications to coastal or marine environmental goods (Aanesen et al. 2015; McVittie and

160 Moran 2010).

161

162 **2.2. Stated preference valuation in practice**

163 Considerable research has gone into the different steps of developing a survey questionnaire,

164 preparing and administering the survey, and analysing collected data. In addition to a vast literature

165 in this field (Carson 2012a, Hoyos 2010), a number of manuals and textbooks are available (e.g.

166 Johnston et al. forthcoming, Kanninen 2006, Champ et al. 2003, Bateman et al. 2002). The

167 development of the valuation scenario and survey questionnaire is often informed by policy

168 requirements (Hanley et al. 2015), consultation with the scientific literature and natural scientists

169 with expertise in the area under study, and semi-structured interviews and focus groups with

170 members of the general public (Figure 3). The latter two help the researchers gauge the level of

171 concern, knowledge and understanding that potential survey respondents have for the specific topic.

172 It also helps identify suitable cost levels that can be incorporated into the choice exercise and the

173 payment scenario. The former helps identify how the proposed measures will be financed, the

174 responsible institution and the payment vehicle. The choice of an appropriate payment vehicle

175 requires substantial consideration to maximise the level of realism of the scenario and to help

7

176   respondents relate the proposed changes to their household budget. The last crucial component of

177   questionnaire construction is the experimental design. In the case of the CVM, the experimental

178   design involves the selection of payment amounts for the dichotomous-choice format or the

179   specification of a payment card. For DCE, the experimental design is the combination of attribute

180   levels and costs into choice alternative that appear on the choice cards (e.g. Figure 2). In practical

181   applications the number of all possible attribute combinations is typically too large to present them

182   to respondents. Efficient experimental designs generate that combination of attribute levels in a

183   limited number of choice occasions, which is able to produce accurate estimates of the model

184   parameters in the analysis stage of the DCE while taking into account a number of additional criteria,

185   such as balancing the occurrence of each attribute level (Johnson et al. 2006, 2013, Street et al. 2005,

186   Ferrini and Scarpa 2007).

187

188   *- Figure 3 -*

189

190   Figure 3 illustrates the further survey process. Preliminary questionnaires are tested in waves

191   of pilot surveys using face-to-face interviews or the mode to be applied in the main survey (e.g.

192   postal, e-mail or online). This is an essential iterative process in which the scenario and

193   questionnaire are refined based on insights from pilot interviews, and the importance of this stage

194   should not be underestimated. During this stage, repeated meetings with natural scientists are

195   typically necessary regarding the use of factual information and its clear and concise, yet

196   understandable, representation in the survey materials (e.g. the use of illustrative materials, such as

197   photos, charts, graphs or maps in the questionnaire to support respondent comprehension). For

198   DCEs, typically the pilot surveys produce choice data that can be used to further inform the

199   experimental design (Scarpa and Rose 2008). The development of a survey and a questionnaire can

200   take up considerable amounts of time; a year or 18 months is not uncommon in academic

201   applications, whereas valuation studies for consulting purposes can be conducted in as little as six

202   months. With the fully developed questionnaire and an experimental design the main survey can be

203   conducted and resulting choice data analysed. The three case study surveys reported below were

204   developed and conducted following this procedure.

205

206   **3. Translating and presenting natural science knowledge in SP surveys**

207   In the framework of the VECTORS project, three stated preference surveys were conducted to value

208   changes in the provision of goods and services from selected marine ecosystems. These case studies

209   cover two European regional seas, the North and Baltic Seas, and both coastal and offshore sites.

210   These case studies illustrate the practical steps and considerations necessary to use SP surveys to

211   value changes in the marine environment. To reach this point, Figure 3 indicates that understanding

212   and quantifying these environmental changes requires close cooperation between environmental

213   economists and natural scientists, such as marine biologists and ecologists. However, there is

214   frequently a mismatch between the types of data and knowledge available to natural scientists and

215   the type of information required for a valuation survey. Therefore, this section first sketches out the

216   practical implementation of valuation surveys in the case studies. It subsequently uses these cases to

217   highlight the challenges of translating natural science information into SP surveys and links these

218   challenges to relevant procedural issues and ongoing research on SP methods.[4] This discussion is

219   structured into three parts: (1) valuation scenarios, (2) endpoints of environmental change to be

220   valued and (3) the importance of letting policy and management issues guide survey development.

221   The use of realistic and believable scenarios based on accurate natural scientific evidence is an

222   essential requirement to obtain valid valuation estimates. While substantial methodological research

223   on these approaches in environmental economics focuses on removing or minimising biases in the

---

[4] General overviews of methodological issues under study for stated preference valuations can be found in Hoyos (2010), Venkatachalam (2004) and Mitchell and Carson (1989). Continuing methodological controversies are discussed by Carson (2012b), Hausman (2012) and Kling et al. (2012).

224 survey responses and resulting WTP estimates (Rakotonarivo et al. 2016), the subsequent discussion

225 emphasises the role of cooperation between the natural sciences and economics in this effort.

226

227 **3.1. Stated preference valuation in the marine environment – The cases**

228 *3.1.1. Conservation benefits on the Dogger Bank (North Sea)*

229 The Dogger Bank is a shallow sea area in the southern North Sea traversing the exclusive economic

230 zones of Denmark, Germany, the Netherlands and the UK. Due to its shallowness the area is

231 characterised by high primary production, which supports substantial fish assemblages (Sell and

232 Kröncke 2013). Consequently, the Dogger Bank has long been an important fishing ground. In recent

233 years the site has also been used for natural gas and aggregate extraction (JNCC 2011). More

234 recently, plans for Europe's largest wind farm have been developed for the Dogger Bank (Forewind

235 2010). The valuation scenario for this DCE survey was framed around ongoing negotiations between

236 stakeholders about a management plan for the Dogger Bank, a requirement of its recent designation

237 as a candidate special area of conservation (cSAC) under the EU Habitats and Species Directive

238 (92/43/EEC) (Burdon et al. in press, Hattam et al. 2015b). The valuation scenario introduced to

239 respondents focused on the regulation of the two main commercial activities on the site –

240 commercial fishing and wind farm development. Respondents were informed that by introducing

241 different regulations regarding permissible fishing gear and construction of the wind farm, several

242 aspects of the local ecosystem would be affected. These aspects are captured in the resulting choice

243 attributes, which were general species diversity, protection of some charismatic species (porpoises,

244 seals and seabirds), restrictions of the spread of invasive species and an annual household tax (Table

245 1). While ecosystem service categories were not directly used as attributes, the idea of capturing

246 diversity of species as a regulating service and the protection of particular species as a cultural

247 service guided attribute selection. As the survey was to be conducted in the UK, all described

248 changes refer to the UK section of the Dogger Bank area. The survey was conducted online in

249 December 2013 with respondents sampled across the UK. In total, 1,022 completed questionnaires

250   were obtained (Table 1), 973 of which were used for analysis. Survey preparation took

251   approximately one year and drew upon continual interaction between members of the survey team

252   (two natural scientists and three environmental economists) and multiple interactions with

253   members of the public: 29 semi-structured in-person interviews in the Southwest and Northeast of

254   England, 19 test interviews using a draft questionnaire and finally an online pilot survey ($n = 60$).

255   WTP estimates and further details can be found in Börger et al. (2014b).

256

257   - Table 1 -

258

259   *3.1.2. Climate change impacts in the Dutch Wadden Sea (North Sea)*

260   The Dutch Wadden Sea is an intertidal zone in the south eastern part of the North Sea enclosed by

261   the Frisian Islands. It comprises deep basins, tidal gullies, sand and mudflats and saltmarshes (Wang

262   et al. 2012), which accommodate several habitats and a variety of species, including shellfish, birds,

263   fish and seals. This distinctive ecological system makes the Wadden Sea area attractive for tourism

264   and recreation, with activities concentrated on the five Dutch Wadden Sea islands and alongside

265   some parts of the mainland coast. With approximately 2.15 million visitors and a turnover of around

266   €450 million per year, tourism is one of the most important economic sectors of this region (Stenden

267   Instituut Service Management 2010, Statistics Netherlands 2010). Changing ecosystems may impact

268   the Wadden Sea area and the tourism industry it sustains. Two challenges that the Wadden Sea may

269   encounter are: (1) mud flats may disappear, which may substantially influence the ecological system

270   potentially threatening the habitat of several species, such as birds and seals (van Goor et al. 2003,

271   Wang et al. 2012); and (2) growing sea transport and rising temperatures will facilitate more

272   introductions of southern warm water species, such as the invasive pacific oyster *Crassostrea gigas*,

273   into the area (Ravel and Olden 2008).

274   A DCE survey was conducted to assess the values held by tourists to the Wadden Sea for the

275   prevention of these impacts. Choice attributes were selected to reflect the changing conditions, such

276   as the presence of beach and sea, nature and an open view (Sijtsma et al. 2012, Raad voor de

277   Wadden 2008). Five climate change related attributes, which potentially impact the value of the

278   Wadden Sea to tourists, were chosen: (1) changes in the abundance of the 'Pacific Oyster' that may

279   limit recreation possibilities on the mud flats; (2) numbers of 'Birds' and (3) numbers of 'Seals' as

280   charismatic species; (4) 'Wind turbines' as a landscape feature that may affect the open view of the

281   sea; and (5) a tourist tax, which was selected as the most realistic payment vehicle (Table 1). This

282   selection was based on three indicators: (1) the importance of the attribute for tourists, (2) the

283   potential impact of climate change on the attributes and (3) the lack of a proven management

284   strategy that may reduce the potential impact. Beach width seemed to be another relevant indicator.

285   However, the Netherlands already have a successful sand nourishment strategy, which will reduce

286   the potential impact (Giardino et al. 2011). Hence this characteristic was not included.

287   Attribute levels were based on the present situation and potential future changes resulting

288   from the International Panel on Climate Change (IPCC) emission scenarios A1F1 (high CO_2 emissions)

289   and B1 (lower CO_2 emissions) (Nakićenović et al. 2000). Due to limited literature regarding the extent

290   of the potential impacts on the Wadden Sea (Markham et al. 2016), expert judgment was used to

291   derive attribute levels reflecting the possible future impacts on the selected attributes. Assumptions

292   were made on the potential vectors of change based on the climate change scenarios resulting from

293   a literature review. This review was subsequently checked by eight experts and practitioners in the

294   field including ecologists, policy makers, tourism experts and a morphologist. After several semi-

295   structured interviews with amongst others environmental economists, ecologists, geologists,

296   sociologists and Wadden Sea experts a draft questionnaire was set up. This questionnaire was tested

297   during two pilot surveys with residents ($n = 50$) and tourists ($n = 25$) on the Wadden Island

298   Ameland (Table 1). After both pilots the feedback was included in the questionnaire. The attribute

299   levels of the payment vehicle were also set based on these tests. The final questionnaire consisted of

300   six choice cards including a test choice card and an introduction of the different attributes. After the

301   set of choice tasks a question was included to identify protest respondents. Between April and May

12

302   2012 a combination of 550 face-to-face and take-home interviews were undertaken in Ameland. The

303   sample consisted of 121 German and 429 Dutch tourists.

304

305   *3.1.3. Ecosystem benefits of seagrass in the Gulf of Gdańsk (Baltic Sea)*

306   The Gulf of Gdańsk in Northern Poland is part of the Southern Baltic Sea. This shallow and sheltered

307   sea has witnessed a sharp decline in seagrass (*Zostera marina*) from the 1950s, but recently there

308   have been measures to protect and recover the seagrass meadows (Boström et al. 2003, Jankowska

309   et al. 2014). This DCE was concerned with benefits resulting from seagrass restoration. Choice

310   attributes were a reduction of the amount of filamentous algae (*Ectocarpus* and *pilyaella*) in the

311   water and on the shore (ecosystem service: biological control), access to seagrass meadows for

312   boaters and divers (opportunities for recreation and tourism) and improved water clarity through

313   water purification (waste treatment/water purification). The cost attribute was specified as a waste

314   water treatment fee that all households in the region would have to pay (Table 1). The preparation

315   of this survey took just under one year and comprised regular interactions between members of the

316   survey team (two economists and three seagrass ecologists) and between the survey team and the

317   public, including: 19 semi-structured interviews with residents in the Gdańsk area, three focus group

318   meetings as well as two face-to-face pilot surveys with $n = 50$ completed interviews each (Table 1).

319   After each of these steps, the survey questions, valuation scenario and attribute description were

320   modified based on findings. In the main survey, 500 interviews were completed face-to-face with

321   residents in the coastal areas of the Pomeranian Province in Northern Poland between November

322   2013 and January 2014. Börger and Piwowarczyk (2016) provide detailed WTP estimates and

323   additional results.

324

325   **3.2. Valuation scenarios**

326   The effect of scenario realism has been assessed in several studies (e.g. Cameron et al. 2011, Kataria

327   et al. 2012). The extent to which respondents believe the presented status quo and proposed

328 change and their level of agreement with them have been demonstrated to affected the elicited

329 preferences. To ensure that lay respondents understand the survey task and can accurately state

330 their preferences, valuation scenarios, the provision of information on the environmental change to

331 be valued, how it will be caused (i.e. the management measure) and what its consequences will be,

332 therefore need to be presented in an understandable way. This can be problematic for marine

333 settings as the marine environment has been shown to be perceived as remote and unfamiliar (Rose

334 et al. 2008, Steel et al. 2005). While it is crucial to present realistic scenarios of change to ensure

335 respondents interpret scenarios as credible and to induce them to take the (hypothetical) valuation

336 task seriously it is equally important to simplify ecological relationships to ensure they are

337 understood. Scenarios which are hardly credible will result in random stated choices and

338 consequently uninformative WTP estimates. The valuation scenario must demonstrate how the

339 environmental changes under study will affect the welfare of the interviewed population. Practically

340 this means repeated interactions between specialists on the environmental change of interest,

341 survey designers, other members of the valuation team and members of the target survey

342 population (e.g. members of the public in the three cases presented here). For example, in the Dutch

343 case, the different ecosystem impacts had to be made specific to the Wadden Sea (Table 2). This

344 required ecological, climate-related and morphological expert knowledge, including a pilot survey to

345 examine the understanding of the scenarios by the general public. Experts of Pacific oysters

346 indicated the possible spreading of this invasive species, while mud flat walking agencies could add

347 information on the impact of this spread for tourists. Another example of expert input into scenario

348 design concerned the possibility of replanting of seagrass in the Polish survey. While participants of

349 the preparatory focus groups believed that active replanting of seagrass was the easiest mitigation

350 strategy, expert interviews revealed that such initiatives have so far proved to be technically

351 unsuccessful. As a result of this information the restoration scenario included in the survey

352 questionnaire clearly explains why seagrass planting is not the solution.

353   Once a preliminary questionnaire has been developed, multiple rounds of questionnaire

354   testing commence. This can be undertaken in many ways, including through interviews, focus groups

355   and self-completion activities. One of the approaches used in the development of the Dogger Bank

356   survey was the use of think-aloud interviews whereby respondents were asked to vocalise their

357   thoughts are they completed the questionnaire. This enabled the survey development team to

358   detect unclear wording and overly complex attribute description (Ryan et al. 2009, Schkade and

359   Payne 1994). By gaining insight into how respondents take up and process the information

360   presented, refinements of the questionnaire were undertaken with the aim of increasing respondent

361   engagement and the stating of informed preferences. This process of testing and refinement should

362   be employed routinely, especially when remote and unfamiliar goods are to be valued.

363   Realistic, credible and understandable valuation scenarios are also required to help mitigate a

364   procedural problem that continues to trouble SP surveys: Protest responses (Venkatachalam 2004;

365   Meyerhoff and Liebe 2008). In the CVM some respondents might state a WTP of zero not because

366   they truly expect no change in welfare but because they want to express protest, dissatisfaction or

367   anger regarding the valuation scenario, the payment vehicle, the institution responsible for the

368   proposed measures or the valuation survey as a whole. This type of respondent has to be identified

369   so that only true zero WTP statements are used for welfare analysis. In DCE studies, protest

370   respondents might be those who prefer the no-cost status quo in all choice occasions even though

371   they would in fact experience a change in welfare from the proposed changes. Attitudinal follow-up

372   questions are used to distinguish these respondents from those who choose the no-cost option

373   because they truly do not value the described changes. In the Wadden Sea study, for example, all

374   respondents consistently choosing the status quo were asked why they were not willing to pay to

375   avoid environmental changes in the Wadden Sea. Most of these respondents stated that the

376   Wadden Sea needs to be protected by law or that such measures should be paid out of current taxes.

377   This indicates that their choices of the status quo do not mean that they do not value the

378   management measures, but simply that they did not want to pay even though they would value the

379   proposed changes. Based on these answers 33 respondents were discarded from the survey sample.

380

381   *- Table 2 -*

382

383   **3.3. Endpoints of valuation scenarios: Definition and range of choice attributes**

384   Valuation scenarios need to clearly specify the endpoints of the proposed environmental change.

385   Such endpoints are described in terms of the different ways through which the environmental

386   changes will affect societal welfare. In CVM scenarios, typically only a one-off change from a current

387   status or business-as-usual scenario to a future change scenario covering all possible impacts is

388   presented. In DCE, the different impacts may find expression in the choice attributes which can be

389   varied and valued independently based on the collected choice data. Determining realistic ranges for

390   each attribute and ensuring that combinations of different attribute levels are ecologically

391   meaningful are crucial to the interpretability of valuation results.

392   A helpful tool to specify choice attributes and their ranges proved to be the ecosystem service

393   framework, which facilitates the translation of ecosystem changes to services and eventually

394   benefits that affect human welfare (de Groot et al. 2010). Böhnke-Henrichs et al. (2013) call for

395   valuation studies to clearly describe which ecosystem service categories are being valued and "how

396   much of a particular service has been valued" (p. 144). However, ecosystem service categories may

397   have a greater role than just as a communication tool in the valuation scenario. They can also help

398   guide the development of choice attributes by the researchers, as applied in both the Polish and the

399   Dogger Bank case studies (Table 2). If indicators for ecosystem service change exist (e.g. Hattam et al.

400   2015a, Liquete et al. 2013), such metrics can be used in the valuation scenario. This allows the

401   changes in the marine environment to clearly map to the values elicited in the survey. In the case of

402   the Gulf of Gdańsk survey, the ecosystem service framework was used to structure preparatory

403   focus group discussions (Table 2). The emphasis on all channels through which seagrass potentially

                                              16

404 affects individual welfare proved helpful in guiding participants' discussions of the role of this

405 ecosystem. Consequently, the use of clear-cut ecosystem service categories as choice attributes was

406 retained in the main survey. While ecosystem service categories guided the initial considerations

407 about the choice attributes to be used in the Dogger Bank survey, they were not used in the final

408 survey due to a lack of required ecosystem data at the appropriate spatial scale for the ecosystem

409 services in the case study area and lack of familiarity with these services by the respondents (e.g.

410 waste remediation, carbon sequestration and gene pool protection).

411   The selection of choice attributes, however, is always influenced by both the scientific

412 evidence and the perception of respondents. In the Polish survey, ecological expert knowledge was

413 necessary to translate the quantitative – but still relatively scarce – information about projected

414 filamentous algae abundance into spatial terms meaningful to respondents. In a series of work

415 meetings, economists and seagrass ecologists developed the description of the attribute and its

416 levels, which were then tested on members of the public and subsequently refined. Focus groups

417 can serve to detect potential interaction effects between attributes which should be taken into

418 account in the experimental design (Hoyos 2010). While clarification from a natural science

419 perspective is needed about which services are delivered jointly by the same ecological processes

420 (e.g. carbon sequestration and bioremediation of waste) and hence cannot be independently varied,

421 the perception of respondents on service interactions also needs to be assessed. It is possible that

422 the value of a benefit from a certain service depends on the level of another service. This

423 information needs also to be incorporated into the experimental design of the DCE. For example,

424 participants in the Polish focus groups explicitly discussed which seagrass ecosystem services they

425 perceive as related and being provided jointly. Since no relationships between the three attributes

426 were perceived, they were varied independently in the experimental design used in the main survey.

427

428 **3.4. The importance of policy and management in survey design and evaluation**

429   Supporting natural science knowledge is required to facilitate the use of value estimates and

430   particularly environmental cost-benefit analysis (informed by valuation) in policy and management

431   (Scharin et al. 2016). Natural science knowledge provides the context for result interpretation but

432   also makes valuation outputs useful beyond the specific context of the study. As stated, a well-

433   designed survey not only improves the credibility of the scenario for respondents, ensuring scenario

434   realism, but is also more likely to elicit credible values. The presentation of SP valuation findings by

435   interdisciplinary teams is necessary as it has been shown that decision-makers have limited

436   knowledge about the economic aspect of these valuation techniques in particular (Guo and Kildow

437   2015). The use of interdisciplinary language to present results may therefore help to remedy this

438   situation and facilitate the take-up of these values by policy- and decision-makers. Values assessed

439   through SP surveys provide indications about the societal desirability of environmental change, but

440   natural scientific knowledge is needed to devise the management measures that will lead to these

441   changes.

442   Guo and Kildow (2015) emphasise that valuation studies need to address specific

443   environmental management problems if they are to be relevant for policy-making. This idea has

444   guided the Dogger Bank study, which looked at the specific need to develop a management plan for

445   the area. This study's scenario was entirely based on ongoing negotiations about a management

446   plan for the Dogger Bank cSAC under the EU Habitats and Birds Directive. Different attribute levels

447   represented the anticipated outcomes of different management measures proposed by the

448   stakeholders involved in these negotiations. Similarly the Gdańsk study was framed by the need for

449   management to support local implementation of local targets for the EU Marine Strategy Framework

450   Directive. In the Wadden Sea study scenarios were linked to global rather than national or local

451   policy by using official IPCC scenarios from which to derive the anticipated environmental change in

452   the study area (Table 2). This step attempts to close the gap between SP valuation and policy-making

453   (Guo and Kildow 2015) and address the lack of uptake of valuation results by decision-makers

454   (Laurans et al. 2013, Billé et al. 2012).

455

456   **4. Discussion and conclusions**

457   The above discussions illustrate how valuation studies can incorporate natural science knowledge to

458   improve scenario realism, attribute definition and valuation surveys and findings for policy and

459   management. This is achieved through the establishment of the causal links between the

460   applications of certain environmental management measure(s), the impact on ecosystems, the

461   resulting effects on human welfare and associated values. Establishing these links and conducting

462   policy-driven valuation is essential if the needs of marine legislation and policy, such as the EU

463   Marine Strategy Framework Directive or for marine planning are to be met (Börger et al. 2014a).

464   Despite the use of state-of-the-art survey development techniques in the above studies, the

465   presentation of information about the marine environment remains challenging. Self-reported

466   knowledge of respondents about the survey topic is often gathered in such surveys and commonly

467   shown to be low. For example, in the Dogger Bank survey, while approximately half of the

468   respondents stated they had heard of the Dogger Bank, 80.3% of these had done so in the shipping

469   weather forecast on national radio. After completing the choice tasks, 57.2% of respondents

470   indicated that they did not have enough information about the Dogger Bank to know what the

471   proposed measures are worth to them. Looking beyond the three case studies, this share is equally

472   high (56.2%) in a similar survey about ecological and amenity impacts of an offshore windfarm in

473   Northwest England (Börger et al. 2015) and higher in the Gulf of Gdańsk survey (63.0%). In a

474   valuation study of deep-sea ecosystem services in Scotland, 63.0% of respondents indicated they

475   knew only half or less of the presented information (Jobstvogt et al. 2014a). In the Dogger Bank

476   study, 59.6% of respondents stated they had known none of the information presented. These

477   numbers demonstrate that providing respondents with accurate, succinct and neutral information

478   about the good to be valued is crucial and yet still challenging. Many DCE studies, but particularly

479   those valuing offshore environmental goods, such as Börger et al. (2014b), Jobstvogt et al. (2014a) or

480   Wattage et al. (2011), have to reduce complexity of information and also the number of choice

481 attributes to keep the survey manageable for respondents. Methodological research has recently

482 been studying how exactly respondents receive and process information in stated preference

483 surveys (Czajkowski et al. 2014, LaRiviere et al. 2014). Given the low level of prior knowledge

484 regarding many marine ecosystems, this is an important field for further research.

485   To further facilitate the presentation of ecological information in SP surveys, the use of

486 ecosystem principles has been proposed (Jobstvogt et al. 2014b), which systematically extracts

487 expert knowledge on ecosystem processes to express these in a set of comprehensive principles in a

488 survey setting. Other research on SP surveys has pointed out the role of using maps, both as

489 overview maps and individualised maps, to facilitate the respondent's understanding of the

490 environmental good and its exact location or spatial distribution (Johnston et al. 2016). Another area

491 of research that has consequences for nature of natural science information to be included and the

492 way how it can be presented concerns survey modes. While face-to-face surveys are regarded as the

493 'gold standard' (Arrow et al. 1993) and allow for presentation of complex information and even

494 additional explanations from the interviewer, other modes are usually employed to save costs and

495 time.[5] Online surveys (Olsen 2009) are comparably cheap and allow access to a wide range of

496 respondents (in countries where there is a high level of internet penetration in the population) but

497 are also vulnerable to "professional respondents" who regularly take surveys and might rush

498 through the questionnaire and might not be easy to identify (Börger 2016). As an alternative, some

499 studies valuing hard-to-understand or remote environmental goods employ workshops to collect

500 data (Aanesen et al. 2015, Christie and Rayment 2012). This approach increases survey costs and

501 limits the geographical reach of the survey sample, but it facilitates the provision of complex

502 ecological information and offers more room for deliberation and contemplation before WTP or

503 choices are stated. It is important that social and natural scientists work cooperatively on the

[5] It should be noted that the presentation of choice cards needs to be randomised, which is difficult in face-to-face interviews. While computer-assisted personal interviewing (CAPI) is a way to solve this problem, this mode also increase survey costs compared to traditional paper-and-pencil surveys.

504   preparation and implementation of valuation surveys to ensure that the information provided and

505   the materials used are in line with the particular requirements of the survey mode.

506   Many changes in the marine environment cannot be described in quantitative terms due to

507   the lack of relevant data at appropriate spatial and/or temporal scales. Indicators of ecosystem

508   services and their changes as developed by e.g. Hattam et al. (2015a) will play an important role in

509   overcoming this challenge, as may ecological and ecosystem modelling outputs (Hyder et al. 2015,

510   Peck et al. in press). Some degree of uncertainty therefore exists around ecosystem change and

511   responses to ecosystem management. How this uncertainty is presented in SP surveys remains a

512   challenge and is an under-researched issue. Although natural science information is often associated

513   with uncertainty, valuation surveys often present respondents with future changes that occur with

514   certainty. This mismatch would not be problematic if preferences were unaffected by this, but it has

515   been shown that presenting environmental change in valuation scenarios as certain or uncertain

516   affects elicited preferences (Roberts et al. 2008). Consequently, better communication of

517   uncertainty about future environmental states in surveys and understanding its effect on values is an

518   important field of research. This requires better information from natural scientists about the extent

519   and the type of uncertainty related to a particular environmental change.

520   In addition, ecological expertise is usually required for value transfer to ensure that elicited

521   values from one site are only applied to other sites which are ecologically equivalent in

522   characteristics (Richardson et al. 2015, Johnston and Rosenberger 2010). Value transfer is analogous

523   to the process by which a marine ecologist might infer that the marine species in one location where

524   sampling has been undertaken will be similar to those in another location because they share key

525   environmental characteristics. The pitfalls for an economist using value transfer with limited data

526   availability are familiar to those faced by the natural scientists. Can it be reasonably assumed that

527   the two sites are sufficiently similar in the characteristics that affect economic choices to be certain

528   that value transfer is a valid process? However, this technique is developing rapidly (e.g. Czajkowski

529   et al. 2017, Bateman et al. 2011), and the involvement of natural scientists in the design of the three

530   case studies and the use of ecosystem service categories guiding the selection of choice attributes

531   could further facilitate the use of the elicited values in value transfer. The values could, therefore,

532   support management decisions in these other locations. For example, in the Polish seagrass study

533   values for the reduction of algae abundance and improved water clarity can be transferred to other

534   sites independent of their link to seagrass beds, but ecologists and biologists are required in this

535   transfer to ensure the equivalence of ecological conditions between the study site and the transfer

536   site.

537   Several conclusions can be drawn from the above discussion of challenges of SP valuation in

538   marine and coastal settings. First, interdisciplinary teams are a necessity, consisting at least of

539   marine scientists (particularly biologists and ecologists), environmental economists and survey

540   methodology experts. Furthermore, the handling of DCE data and the related field of choice

541   modelling (also relevant to applications to health and transport policy) have seen rapid progress in

542   recent years and methods are now available to extract increasingly detailed information from choice

543   data (Hensher et al. 2015, Train 2009). Second, the ecosystem service approach should be more

544   extensively applied in valuation studies as a way of describing the consequences of change in the

545   marine environment and guiding the selection of choice attributes as highlighted in the Dogger Bank

546   and Gulf of Gdańsk cases. Future research is needed to strengthen this link between what is being

547   valued and established ecosystem service categories so that ecosystem service values can be used to

548   support marine planning and general marine management. This is also necessary if valuation outputs

549   are to be used as input to larger ecosystem or bioeconomic models that consider multiple ecosystem

550   services (e.g. Punt et al. 2009, Hyder et al. 2015). Third, defining best practice for questionnaire

551   development for SP surveys is challenging. While there are detailed manuals available for the

552   development of an appropriate survey instrument, some trade-off between clarity and realism

553   within the survey and the potential overburdening of respondents with information will always exist.

554   Against this background, the cases in this paper show that (and how) natural scientists can

555   contribute to different steps throughout a SP study. The cases also highlight that close collaboration

22

556 between natural scientists and environmental economists adds a further layer of complexity to

557 survey preparation and implementation and therefore requires time during survey development but

558 results in greater survey quality. For the natural scientists who are willing to contribute to

559 interdisciplinary SP valuation the reward is that their research can directly support policy

560 development and management decisions in the marine and coastal environment.

561

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566

567 **References**

568 Aanesen M, Armstrong C, Czaijkowski M, Falk-Petersen J, Hanley N, Navrud S (2015) Willingness to

569   pay for unfamiliar public goods: Preserving cold-water coral in Norway. Ecological Economics,

570   112, 53-67.

571 Adamowicz W, Louviere J, Williams M (1994) Combining Revealed and Stated Preference Methods

572   for Valuing Environmental Amenities. Journal of Environmental Economics and Management,

573   26 (3), 271-292.

574 Arrow KJ, Solow RM, Portney PR, Leamer EE, Radner R, Schuman H (1993) Report of the NOAA Panel

575   on Contingent Valuation: Natural resource damage assessment under the oil pollution act.

576   Federal Register 58.

577 Bateman IJ, Carson RT, Day B, Hanemann M, Hanley N, Hett T, Jones-Lee M, Loomes G, Mourato S,

578   Özdemiroglu E (2002) Economic valuation with stated preference techniques: A manual. Edward

579   Elgar, Cheltenham.

580 Bateman IJ, Brouwer R, Ferrini S, Schaafsma M, Barton DN, Dubgaard A, Hasler B, Hime S, Liekens I,

581   Navrud S, De Nocker L, Ščeponavičiūtė R, Semėnienė D (2011) Making benefit transfers work:

23

582   Deriving and testing principles for value transfers for similar and dissimilar sites using a case

583   study of the non-market benefits of water quality improvements across Europe. Environmental

584   and Resource Economics, 50 (3), 365-387.

585 Bhat MG (2003) Application of non-market valuation to the Florida Keys marine reserve

586   management. Journal of Environmental Management, 67 (4), 315-325.

587 Billé R, Laurans Y, Mermet L, Pirard R, Rankovic A (2012) Valuation without action? On the use o

588   economic valuations of ecosystem services. IDDRI Policy Brief 07/12, 1-4.

589 Böhnke-Henrichs A, Baulcomb C, Koss R, Hussain SS, de Groot RS (2013) Typology and indicators of

590   ecosystem services for marine spatial planning and management. Journal of Environmental

591   Management, 130, 135-145.

592 Börger T (2016) Are fast responses more random? Testing the effect of response time on scale in an

593   online choice experiment. Environmental and Resource Economics, 65 (2), 389-413.

594 Börger T, Beaumont NJ, Pendleton L, Boyle KJ, Cooper P, Fletcher S, Haab T, Hanemann M, Hooper

595   TL, Hussain SS, Portela R, Stithou M, Stockill J, Taylor T, Austen MC (2014a) Incorporating

596   ecosystem services in marine planning: The role of valuation. Marine Policy, 46 (C), 161-170.

597 Börger T, Hattam C, Burdon D, Atkins JP, Austen MC (2014b) Valuing conservation benefits of an

598   offshore marine protected area. Ecological Economics, 108 (0), 229-241.

599 Börger T, Hooper TL, Austen MC (2015) Valuation of ecological and amenity impacts of an offshore

600   windfarm as a factor in marine planning. Environmental Science & Policy, 54, 126-133.

601 Börger T, Piwowarczyk J (2016) Assessing non-market benefits of seagrass restoration in the Gulf of

602   Gdansk. Journal of Ocean and Coastal Economics, 3, Article 1.

603 Boström C, Baden S, Krause-Jensen D (2003) The seagrass of Scandinavia and the Baltic Sea. In:

604   Green EP, Short FT (eds.) The world atlas of seagrasses, University of California Press, Berkeley

605   and Los Angeles, 27-37.

606 Boxall PC, Adamowicz WL, Swait J, Williams M, Louviere J (1996) A comparison of stated preference

607   methods for environmental valuation. Ecological Economics, 18 (3), 243-253.

608   Brouwer R, Brouwer S, Eleveld MA, Verbraak M, Wagtendonk AJ, van der Woerd HJ (2016) Public

609   willingness to pay for alternative management regimes of remote marine protected areas in the

610   North Sea. Marine Policy, 68, 195-204.

611   Bulte E, Gerking S, List JA, de Zeeuw A (2005) The effect of varying the causes of environmental

612   problems on stated WTP values: Evidence from a field study. Journal of Environmental

613   Economics and Management, 49 (2), 330-342.

614   Burdon D, Boyes SJ, Elliott M, Smyth K, Atkins JP, Barnes RA, Wurzel RK (in press) Integrating natural

615   and social sciences to manage sustainably vectors of change in the marine environment: Dogger

616   Bank   transnational   case   study.   Estuarine,   Coastal   and   Shelf   Science,

617   doi:http://dx.doi.org/10.1016/j.ecss.2015.09.012.

618   Cameron TA, DeShazo JR, Holmes Johnson E (2011) Scenario adjustment in stated preferences

619   research. Journal of Choice Modelling, 4 (1), 9-43.

620   Cameron TA, Huppert DD (1989) OLS versus ML estimation of non-market resource values with

621   payment card interval data. Journal of Environmental Economics and Management, 17 (3), 230-

622   246.

623   Carson RT (2012a) Contingent valuation: A comprehensive bibliographic history. Edward Elgar,

624   Cheltenham.

625   Carson RT (2012b) Contingent valuation: A practical alternative when prices aren't available. Journal

626   of Economic Perspectives 26 (4), 27-42.

627   Carson RT, Groves T (2007) Incentive and informational properties of preference questions.

628   Environmental and Resource Economics, 37 (1), 181-210.

629   Carson RT, Hanemann WM (2005) Contingent valuation. In: Mäler K-G, Vincent JR (eds.) Handbook

630   of Environmental Economics, vol 2. Elsevier, Amsterdam, 821-936.

631   Champ PA, Boyle KJ, Brown TC (2003) A primer on nonmarket valuation, vol 3., Springer, York.

632 Christie M, Rayment M (2012) An economic assessment of the ecosystem service benefits derived

633   from the SSSI biodiversity conservation policy in England and Wales. Ecosystem Services, 1 (1),

634   70-84.

635 Ciriacy-Wantrup Sv (1947) Capital returns from soil-conservation practices. Journal of Farm

636   Economics, 29 (4 (II)), 1181-1196.

637 Czajkowski M, Hanley N, LaRiviere J, Simpson K (2014) What is the causal effect of information and

638   learning about a public good on willingness to pay? Stirling Economics Discussion Papers 2014-

639   05, University of Stirling, Stirling.

640 Czajkowski M, Ahtiainen H, Artell J, Meyerhoff J (2017) Choosing a functional form for an

641   international benefit transfer: Evidence from a nine-country valuation experiment. Ecological

642   Economics, 134, 104-113.

643 Davis RK (1963) The value of outdoor recreation: An economic study of the Maine woods. Ph.D.

644   disseration, Harvard University.

645 de Groot RS, Fisher B, Christie M, Aronson J, Braat L, Gowdy JM, Haines-Young R, Maltby E, Neuville

646   A, Polasky S, Portela R, Ring I (2010) Integrating the ecological and economic dimensions in

647   biodiversity and ecosystem service valuation. In: Kumar P (ed.) The Economics of Ecosystems

648   and Biodiversity. Ecological and Economic Foundations. Earthscan, London and Washington, 9-

649   40.

650 Eggert H, Olsson B (2009) Valuing multi-attribute marine water quality. Marine Policy, 33 (2), 201-

651   206.

652 Ferrini S, Scarpa R (2007) Designs with a priori information for nonmarket valuation with choice

653   experiments: A Monte Carlo study. Journal of Environmental Economics and Management, 53

654   (3), 342-363.

655 Forewind (2010) Dogger Bank zonal characterisation report. Version 4, October 2011, Reading.

656 Freeman AM (2002) How much is nature really worth? An economic perspective. The Shipman

657   Workshop Papers. Bowdoin College, Brunswick.

658 Giardino A, Mulde, J, Ronde JD, Stronkhorst J (2011) Sustainable development of the Dutch coast:

659   Present and future. Journal of Coastal Research, 61, 166-172.

660 Glenn H, Wattage P, Mardle S, Rensburg TV, Grehan A, Foley N (2010) Marine protected areas—

661   substantiating their worth. Marine Policy, 34 (3), 421-430.

662 Gopalakrishnan S, Smith MD, Slott JM, Murray AB (2011) The value of disappearing beaches: A

663   hedonic pricing model with endogenous beach width. Journal of Environmental Economics and

664   Management, 61 (3), 297-310.

665 Guo J, Kildow J (2015) The gap between science and policy: Assessing the use of nonmarket

666   valuation in estuarine management based on a case study of US federally managed estuaries.

667   Ocean & Coastal Management, 108 (0), 20-26.

668 Haab TC, McConnell KE (2002) Valuing environmental resources. New Horizons in Environmental

669   Economics. Edward Elgar, Cheltenham.

670 Halpern BS, Frazier M, Potapenko J, Casey KS, Koenig K, Longo C, Lowndes JS, Rockwood RC, Selig ER,

671   Selkoe KA, Walbridge S (2015) Spatial and temporal changes in cumulative human impacts on

672   the world's ocean. Nature Communications 6.

673 Hanley N, Bell D, Alvarez-Farizo B (2003) Valuing the Benefits of Coastal Water Quality

674   Improvements Using Contingent and Real Behaviour. Environmental and Resource Economics,

675   24 (3), 273-285.

676 Hanley N, Hynes S, Patterson D, Jobstvogt N (2015) Economic valuation of marine and coastal

677   ecosystems: Is it currently fit for purpose? Journal of Ocean and Coastal Economics 2.

678 Hanley N, Wright RE, Adamowicz V (1998) Using choice experiments to value the environment.

679   Environmental and Resource Economics 11 (3-4), 413-428.

680 Hattam C, Atkins JP, Beaumont N, Börger T, Böhnke-Henrichs A, Burdon D, de Groot R, Hoefnagel E,

681   Nunes PALD, Piwowarczyk J, Sastre S, Austen MC (2015a) Marine ecosystem services: Linking

682   indicators to their classification. Ecological Indicators, 49 (0), 61-75.

683 Hattam C, Böhnke-Henrichs A, Börger T, Burdon D, Hadjimichael M, Delaney A, Atkins JP, Garrard S,

684   Austen MC (2015b) Integrating methods for ecosystem service assessment and valuation:

685   Mixed methods or mixed messages? Ecological Economics, 120, 126-138.

686 Hausman J (2012) Contingent Valuation: From Dubious to Hopeless. Journal of Economic

687   Perspectives 26 (4), 43-56.

688 Hensher DA, Rose JM, Greene WH (2015) Applied choice analysis. Cambridge University Press,

689   Cambridge.

690 Holmes TP, Boyle KJ (2005) Dynamic learning and context-dependence in sequential, attribute-based,

691   stated-preference valuation questions. Land Economics, 81 (1), 114-126.

692 Hoyos D (2010) The state of the art of environmental valuation with discrete choice experiments.

693   Ecological Economics, 69 (8), 1595-1603.

694 Hyder K, Rossberg AG, Allen JI, Austen MC, Barciela RM, Bannister HJ, Blackwell PG, Blanchard JL,

695   Burrows MT, Defriez E (2015) Making modelling count-increasing the contribution of shelf-seas

696   community and ecosystem models to policy development and management. Marine Policy 61,

697   291-302.

698 Hynes S, Tinch D, Hanley N (2013) Valuing improvements to coastal waters using choice experiments:

699   An application to revisions of the EU Bathing Waters Directive. Marine Policy, 40 (0), 137-144.

700 Jankowska E, Włodarska-Kowalczuk M, Kotwicki L, Bałazy P, Kuliński K (2014) Seasonality in

701   vegetation biometrics and its effects on sediment characteristics and meiofauna in Baltic

702   seagrass meadows. Estuarine and Coastal and Shelf Science, 139, 159-170.

703 JNCC (2011) Dogger Bank SAC final impact assessment. Joint Nature Conservation Committee,

704   Peterborough, UK.

705 Jobstvogt N, Hanley N, Hynes S, Kenter J, Witte U (2014a) Twenty thousand sterling under the sea:

706   Estimating the value of protecting deep-sea biodiversity. Ecological Economics, 97 (0), 10-19.

707 Jobstvogt N, Townsend M, Witte U, Hanley N (2014b) How can we identify and communicate the

708   ecological value of deep-sea ecosystem services? PLoS One 9 (7), e100646.

709   Johnson FR, Kanninen B, Bingham M, Ozdemir S (2006) Experimental designs for stated choice

710   studies. In: Kanninen BJ (ed.) Valuing environmental amenities using stated choice studies, vol 8.

711   The economics of non-market goods and resources. Springer, Dordrecht, 159-202.

712   Johnson FR, Lancsar E, Marshall D, Kilambi V, Muhlbacher A, Regier DA, Bresnahan BW, Kanninen B,

713   Bridges JFP (2013) Constructing experimental designs for discrete-choice experiments: Report

714   of the ISPOR Conjoint Analysis Experimental Design Good Research Practices Task Force. Value

715   in Health 16, 3-13.

716   Johnston RJ, Rosenberger RS (2010) Methods, trends and controversies in contemporary benefit

717   transfer. Journal of Economic Surveys, 24 (3), 479-510.

718   Johnston RJ, Boyle KJ, Adamowicz W, Bennett J, Brouwer R, Cameron TA, Hanemann WM, Hanley N,

719   Ryan M, Scarpa R, Tourangeau R, Vossler CA (forthcoming) Contemporary guide for stated

720   preference studies. Journal of the Association of Environmental and Resource Economists.

721   Kanninen BJ (2006) Valuing environmental amenities using stated choice studies, vol 8. The

722   economics of non-market goods and resources. Springer, Dordrecht.

723   Kataria M, Bateman I, Christensen T, Dubgaard A, Hasler B, Hime S, Ladenburg J, Levin G, Martinsen

724   L, Nissen C (2012) Scenario realism and welfare estimates in choice experiments – A non-market

725   valuation study on the European Water Framework Directive. Journal of Environmental

726   Management, 94 (1), 25-33.

727   Kingsley DC, Brown TC (2010) Preference uncertainty, preference learning, and paired comparison

728   experiments. Land Economics, 86 (3), 530-544.

729   Kling CL, Phaneuf DJ, Zhao J (2012) From Exxon to BP: Has Some Number Become Better Than No

730   Number? Journal of Economic Perspectives 26 (4), 3-26.

731   LaRiviere J, Czajkowski M, Hanley N, Aanesen M, Falk-Petersen J, Tinch D (2014) The value of

732   familiarity: Effects of knowledge and objective signals on willingness to pay for a public good.

733   Journal of Environmental Economics and Management, 68 (2), 376-389.

734   Laurans Y, Rankovic A, Bille R, Pirard R, Mermet L (2013) Use of ecosystem services economic

735   valuation for decision making: Questioning a literature blindspot. Journal of Environmental

736   Management 119, 208-219.

737   Liquete C, Piroddi C, Drakou EG, Gurney L, Katsanevakis S, Charef A, Egoh B (2013) Current status

738   and future prospects for the assessment of marine and coastal ecosystem services: A systematic

739   review. PLoS One, 8 (7), e67737.

740   Liu X, Wirtz KW (2010) Managing coastal area resources by stated choice experiments. Estuarine,

741   Coastal and Shelf Science 86 (3), 512-517.

742   Louviere JJ (1988) Conjoint analysis modelling of stated preferences: A review of theory, methods,

743   recent developments and external validity. Journal of Transport Economics and Policy 22 (1),

744   93-119.

745   Louviere JJ, Hensher DA, Swait JD (2000) Stated choice models. Analysis and application. Cambridge

746   University Press, Cambridge.

747   Louviere JJ, Woodworth G (1983) Design and analysis of simulated consumer choice or allocation

748   experiments: An approach based on aggregate data. Journal of Marketing Research, 20, 350-

749   367.

750   Markham A, Osipova E, Lafrenz Samuels K, Caldas A (2016) World heritage and tourism in a changing

751   climate. United Nations Environment Programme, Nairobi, Kenya and United Nations

752   Educational, Scientific and Cultural Organization, Paris, France.

753   McVittie A, Moran D (2010) Valuing the non-use benefits of marine conservation zones: An

754   application to the UK Marine Bill. Ecological Economics, 70 (2), 413-424.

755   Meyerhoff J, Liebe U (2008) Do protest responses to a contingent valuation question and a choice

756   experiment differ? Environmental and Resource Economics 39 (4), 433-446.

757   Mitchell RC, Carson RT (1989) Using surveys to value public goods: The contingent valuation method.

758   Resources for the Future, Washington.

759 Morse-Jones S, Luisetti T, Turner RK, Fisher B (2011) Ecosystem valuation: some principles and a

760   partial application. Environmetrics, 22 (5), 675-685.

761 Nakićenović N, Alcamo J, Davis G, de Vries B, Fenhann J, Gaffin S, Gregory K, Grübler A, Jung TY,

762   Kram T, Lebre La Rovere E, Michaelis L, Mori S, Morita T, Pepper W, Pitcher H, Price L, Riahi K,

763   Roehrl A, Rogner H-H, Sankovski A, Schlesinger M, Shukla P, Smith S, Swart R, van Rooijen S,

764   Victor N, Zhou D (2000) Special report on emissions scenarios: A special report of Working

765   Group III of the Intergovernmental Panel on Climate Change. Cambridge University Press,

766   Cambridge, UK.

767 Norton D, Hynes S (2014) Valuing the non-market benefits arising from the implementation of the

768   EU Marine Strategy Framework Directive. Ecosystem Services, 10 (0), 84-96.

769 Nunes PALD, de Blaeij AT, van den Bergh JCJM (2009) Decomposition of warm glow for multiple

770   stakeholders: Stated choice valuation of shellfishery policy. Land Economics, 85 (3), 485-499.

771 Oinonen S, Börger T, Hynes S, Buchs AK, Heiskanen A-S, Hyytiäinen K, Luisetti T, van der Veeren R

772   (2016) The role of economics in ecosystem based management: The case of the EU Marine

773   Strategy Framework Directive; First lessons learnt and way forward. Journal of Ocean and

774   Coastal Economics 2 (Article 3). doi:http://dx.doi.org/10.15351/2373-8456.1038.

775 Olsen SB (2009) Choosing between internet and mail survey modes for choice experiment surveys

776   considering non-market goods. Environmental and Resource Economics, 44 (4), 591-610.

777 Peck MA, Arvanitidis C, Butenschön M, Canu DM, Chatzinikolaou E, Cucco A, Domenici P, Fernandes

778   JA, Gasche L, Huebert KB, Hufnagl M, Jones MC, Kempf A, Keyl F, Maar M, Mahévas S, Marchal P,

779   Nicolas D, Pinnegar JK, Rivot E, Rochette S, Sell AF, Sinerchia M, Solidoro C, Somerfield PJ, Teal

780   LR, Travers-Trolet M, van de Wolfshaar KE (in press) Projecting changes in the distribution and

781   productivity of living marine resources: A critical review of the suite of modelling approaches

782   used in the large European project VECTORS. Estuarine, Coastal and Shelf Science. doi:

783   http://dx.doi.org/10.1016/j.ecss.2016.05.019.

784 Punt MJ, Groeneveld RA, van Ierland EC, Stel JH (2009) Spatial planning of offshore wind farms: A

785   windfall to marine environmental protection? Ecological Economics, 69, 93-103.

786 Raad voor de Wadden (2008) Recreatie en toerisme in het Waddengebied, toekomstige

787   ontwikkelingsmogelijkheden en hun effecten op economie, duurzaamheid en identiteit.

788   Analyserapport behorende bij advies 2008/05.

789 Rakotonarivo OS, Schaafsma M, Hockley N (2016) A systematic review of the reliability and validity

790   of discrete choice experiments in valuing non-market environmental goods. Journal of

791   Environmental Management, 83(1), 98-109.

792 Randall A, Ives B, Eastman C (1974) Bidding games for valuation of aesthetic environmental

793   improvements. Journal of Environmental Economics and Management, 1 (2), 132-149,

794 Ravel FJ, Olden JD (2008) Assessing the effects of climate change on aquatic invasive species.

795   Conservation Biology, 22(3), 521-533.

796 Richardson L, Loomis J, Kroeger T, Casey F (2015) The role of benefit transfer in ecosystem service

797   valuation. Ecological Economics, 115, 51-58.

798 Roberts DC, Boyer TA, Lusk JL (2008) Preferences for environmental quality under uncertainty.

799   Ecological Economics, 66 (4), 584-593.

800 Rose C, Dade P, Scott J (2008) Qualitative and quantitative research into public engangement with

801   the undersea landscape in England. Natural England, Sheffield.

802 Ryan M, Watson V, Entwistle V (2009) Rationalising the 'irrational': a think aloud study of discrete

803   choice experiment responses. Health Economics, 18 (3), 321-336.

804 Samarasinghe O, Sharp B (2010) Flood prone risk and amenity values: A spatial hedonic analysis.

805   Australian Journal of Agricultural and Resource Economics, 54 (4), 457-475.

806 Scarpa R, Rose JM (2008) Design efficiency for non-market valuation with choice modelling: How to

807   measure it, what to report and why. Australian Journal of Agricultural and Resource Economics,

808   52 (3), 253-282.

809   Scharin H, Ericsdotter S, Elliott M, Turner RK, Niiranen S, Blenckner T, Hyytiäinen K, Ahlvik L,

810   Ahtiainen H, Artell J, Hasselström L, Söderqvist T, Rockström J (2016) Processes for the

811   sustainable stewardship of marine environments. Ecological Economics, 128, 55-67.

812   Schkade DA, Payne JW (1994) How people respond to contingent valuation questions: A verbal

813   protocol analysis of willingness to pay for an environmental regulation. Journal of

814   Environmental Economics and Management, 26 (1), 88-109.

815   Sell AF, Kröncke I (2013) Correlations between benthic habitats and demersal fish assemblages — A

816   case study on the Dogger Bank (North Sea). Journal of Sea Research, 80 (0), 12-24.

817   Sijtsma FJ, Daams MN, Farjon H, Buijs AE (2012) Deep feelings around a shallow coast. A spatial

818   analysis of tourism jobs and the attractivity of nature in the Dutch Wadden area. Ocean &

819   Coastal Management, 68, 138-148.

820   Söderqvist T, Eggert H, Olsson B, Soutukorva Å (2005) Economic valuation for sustainable

821   development in the Swedish coastal zone. AMBIO: A Journal of the Human Environment 34 (2),

822   169-175.

823   Spalding MJ (2016) The new blue economy: The future of sustainability. Journal of Ocean and

824   Coastal Economics 2 (2).

825   Statistics Netherlands (2010) Toerisme in Nederland, het gebruik van logiesaccomodaties 2009. Den

826   Haag/Heerlen.

827   Steel BS, Smith C, Opsommer L, Curiel S, Warner-Steel R (2005) Public ocean literacy in the United

828   States. Ocean & Coastal Management, 48 (2), 97-114.

829   Stenden instituut Service Management (2010) Consumentenonderzoek toerisme 2009. Stenden

830   hogeschool, Leeuwarden.

831   Street DJ, Burgess L, Louviere JJ (2005) Quick and easy choice sets: Constructing optimal and nearly

832   optimal stated choice experiments. International Journal of Research in Marketing, 22 (4), 459-

833   470.

834   Taylor T, Longo A (2010) Valuing algal bloom in the Black Sea coast of Bulgaria: A choice experiments

835   approach. Journal of Environmental Management, 91, 1963-1971.

836   Train KE (2009) Discrete choice models with simulation. 2nd edn. Cambridge University Press,

837   Cambridge.

838   Turner RK (1999) The place of economic values in environmental valuation. In: Bateman IJ, Willis KG

839   (eds.) Valuing environmental preferences. Theory and practice of the contingent valuation

840   method in the US, EU, and developing countries. Oxford University Press, Oxford, 17-41.

841   van Goor MA, Zitman TJ, Wang ZW, Stive MJF (2003) Impact of sea-level rise on the morphological

842   equilibrium state of tidal inlets. Marine Geology, 202, 211-227.

843   Venkatachalam L (2004) The contingent valuation method: A review. Environmental Impact

844   Assessment Review, 24, 89-124.

845   Wang ZB, Hoekstra P, Burchard H, Ridderinkhof H, De Swart HE, Stive MJF (2012) Morphodynamics

846   of the Wadden Sea and its barrier island system. Ocean & Coastal Management, 68, 39-57.

847   Wattage P, Glenn H, Mardle S, Van Rensburg T, Grehan A, Foley N (2011) Economic value of

848   conserving deep-sea corals in Irish waters: A choice experiment study on marine protected

849   areas. Fisheries Research, 107 (1–3), 59-67.

850   Whitehead JC, Dumas CF, Herstine J, Hill J, Buerger R (2008) Valuing beach access and width with

851   revealed and stated preference data. Marine Resource Economics, 23 (2), 119-135.

852   Wolanski E, Elliott M (2015) Estuarine ecohydrology, 2nd edition. Elsevier Science, Amsterdam.

Table 1: Choice attributes and main characteristics of the three case study surveys

	Case study		
	Dogger Bank	**Wadden Sea**	**Gulf of Gdańsk**
Attributes	- General species diversity	- Changes in the abundance of the Pacific oyster	- Reduction of the amount of filamentous algae
	- Protection of porpoises, seals and seabirds	- Numbers of birds	- Access to seagrass areas
	- Spread of invasive species	- Numbers of seals	- Improved water clarity
		- Presence of wind turbines	
Payment vehicle	Household tax	Tourist tax	Waste water fee
Survey mode	Online	Face-to-face	Face-to-face
Sample size	1,022	550	500
Questionnaire preparation and testing	Semi-structured interviews (*n=29*)	Resident pilot survey (*n=50*)	Focus groups (three meetings)
	Test interviews using think-aloud protocol (*n=19*)	Tourist pilot survey (n=25)	Semi-structured interviews (*n=19*)
	Online pilot survey (*n=60*)		Two face-to-face pilot surveys (*n=50* each)

Table 2: Matching natural science knowledge with information requirements for SP surveys

Type of natural science information	How are different types of information matched in case studies		
	Dogger Bank	**Wadden Sea**	**Gulf of Gdańsk**
Expert knowledge on environmental change	- Translation into choice attributes guided by ecosystem service and benefit categories	- Experts' indication of potential changes in IPCC emission scenarios translated into choice attributes	- Ecosystem services provided by seagrass used to select the choice attributes, and to discuss the importance of seagrass meadows with focus groups participants
Scenarios of environmental and ecosystem change	- Translation of effects of management discussed in stakeholder negotiations	- Breakdown of IPCC scenarios to local conditions	- Definition of possible protection and restoration initiatives and assessment of their effectiveness
Assessment of biophysical indicators	n/a	n/a	- Translation of information about algae abundance into approximate spatial patterns of distribution - Translation of the optical properties of the water into improvements in water clarity
Ecosystem modelling	n/a	- Outputs from ecosystem and ecological models indicated potential changes in the ecosystem	- Used to define the potential distribution of *Zostera marina* beds

Notes: IPCC – International Panel on Climate Change; n/a – not applied

Regulating fishing activities and changing windfarm design could determine the state of Dogger Bank habitat and the ecological functions Dogger Bank is able to perform.

In the next set of questions, we want to explore your opinions about the potential outcomes of the Dogger Bank management plan and the costs of monitoring and enforcing the plan:
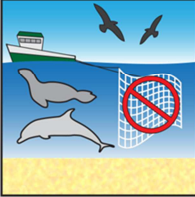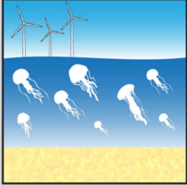
Diversity of species

Reducing or removing trawling in some parts of the Dogger Bank will:
- increase the diversity of fish, invertebrates and other marine species
- Enhance the natural functions provided by the Dogger Bank (contributing to the regulation of climate, maintenance of clean water and support of fish populations).

Protection of porpoises, seals and seabirds

The Dogger Bank provides a natural home for porpoises and seals, and is a feeding ground for seabirds.
- These animals and birds are sometimes accidentally caught in fishing nets.
- The use of harmful nets will be regulated or forbidden on some parts of the Dogger Bank meaning these animals will be better protected.
- Fishing vessels will not be banned from the whole area

Invasive species

The construction of wind turbines on the Dogger Bank provides space for invasive species, increasing their ability to spread elsewhere.
- They may affect the survival of species normally found there.
- The higher the numbers of turbines and the closer they are, the greater the likelihood of invasive species becoming established.

Additional tax

Monitoring and enforcing the Dogger Bank management plan will be costly. The government therefore needs to raise additional funds through taxes.
- The tax is payable by all households in the UK for the next 5 years.
- If the overall funds people are willing to contribute do not cover the cost of monitoring and enforcement, the plan cannot be put into action.

Figure 1: Valuation scenario, including choice attributes and payment vehicle, of the Dogger Bank study

Please choose the one you prefer by selecting the button in the appropriate box.

Description	Dogger Bank Management Plan A "no change"	Dogger Bank Management Plan B	Dogger Bank Management Plan C
Diversity of species	**No change** in species diversity	**25% increase** in species diversity	**10% increase** in species diversity
Protection of porpoises, seals and seabirds	Porpoises, seals and seabirds **Not Protected**	Porpoises, seals and seabirds **Protected on 50% of area**	Porpoises, seals and seabirds **Not Protected**
Invasive species	**Restricted spread** of invasive species	**Wide spread** of invasive species	**Wide spread** of invasive species
Additional tax £	Additional tax **£0** per household per year	Additional tax **£20** per household per year	Additional tax **£5** per household per year
Please select your answer here:	○	○	○

Figure 2: Choice card used in the Dogger Bank survey (from Börger et al. 2014b)
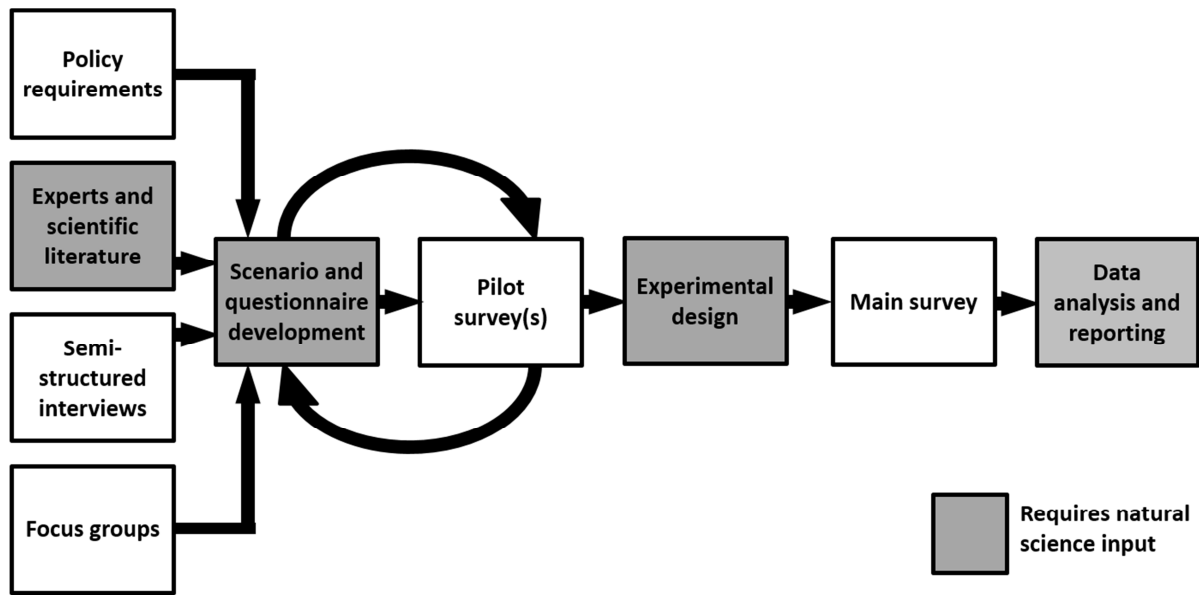
Figure 3: Typical preparatory steps of a SP survey and input requirements from the natural sciences and survey methodology