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Analysis

Valuing conservation benefits of an offshore marine protected area

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ABSTRACT

Increasing anthropogenic pressure in the offshore marine environment highlights the need for improved management and conservation of offshore ecosystems. This study scrutinises the applicability of a discrete choice experiment to value the expected benefits arising from the conservation of an offshore sandbank in UK waters. The valuation scenario refers to the UK part of the Dogger Bank, in the southern North Sea, and is based on real-world management options for fisheries, wind farms and marine protection currently under discussion for the site. It is assessed to what extent the general public perceive and value conservation benefits arising from an offshore marine protected area. The survey reveals support for marine conservation measures despite the general public's limited prior knowledge of current marine planning. Results further show significant values for an increase in species diversity, the protection of certain charismatic species and a restriction in the spread of invasive species across the site. Implications for policy and management with respect to commercial fishing, wind farm construction and nature conservation are discussed.

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1. Introduction

With recent technological developments and an expanding global economy, there is increasing pressure from human activities on the offshore environment (Stojanovic and Farmer, 2013). Offshore waters are typically considered to be those outside territorial waters (i.e. beyond 12 nautical miles from the coast, including international waters) and have traditionally been exploited by the commercial fishing, oil and gas, and aggregate sectors. However, the expanding blue economy, which is considered to offer "smart, sustainable and inclusive economic and employment growth from the oceans, seas and coasts" (EC, 2012), exemplifies a growing interest in the offshore marine environment. It reflects a wider range of activities including: marine energy extraction; aquaculture; maritime, coastal and cruise tourism; marine mineral resources; and blue biotechnology (DG MARE, 2012; EC, 2012). With the resulting pressures on offshore sites, the challenges for the management of remote parts of the marine environment become far greater. These developments require more informed planning and management to ensure sustainable use of offshore marine resources. While marine planning has been effective in reaching out to particular user groups, such planning is increasingly required by legislation to engage all stakeholders including non-user groups such as the general public (cf. EC, 2001; Jobstvogt et al., 2014). This demand for wider engagement recognises that the marine environment provides ecosystem services which are fundamental to human well-being (Beaumont et al., 2007; Atkins et al., 2011; Börger et al., 2014).

While the economic benefits of offshore activities such as fisheries are widely discussed (e.g. Sumaila et al., 2007), evidence on the wider societal benefits of the marine environment, in which these offshore activities take place, is less well known (Pendleton et al., 2007; Armstrong et al., 2010). Few published studies have explored the benefits provided by the offshore marine environment (Glenn et al., 2010; McVittie and Moran, 2010; Ressurreição et al., 2011, 2012; Jobstvogt et al., 2014). Much greater attention has focused on coastal areas (e.g. Atkins et al., 2007; Eggert and Olsson, 2009; Taylor and Longo, 2010; Hynes et al., 2013). Other studies have used benefit transfer to value the benefits of offshore sites (Hussain et al., 2010; Londoño and Johnston, 2012), but are limited by the scarcity of primary valuation data. Environmental impact assessments associated with the creation of wind farms or the designation of marine protected areas (MPAs) are starting to increase the offshore evidence base (e.g. Talisman Energy, 2006; Defra, 2012), but valuation evidence still remains limited. This paper focuses on gaining greater insight into how the general public perceive and value the benefits of the offshore marine environment. For this purpose a case study assessment is made employing a discrete choice experiment (DCE) to value benefits provided by the conservation of an offshore sandbank under UK jurisdiction.

1.1. Management of an Offshore MPA: The Dogger Bank

The Dogger Bank is the largest offshore sandbank in the North Sea, covering a total area of approximately 17,600 km^2 (Diesing et al., 2009) (Fig. 1). The waters surrounding the Dogger Bank are relatively shallow (Diesing et al., 2009), are highly productive (Kröncke, 2011),

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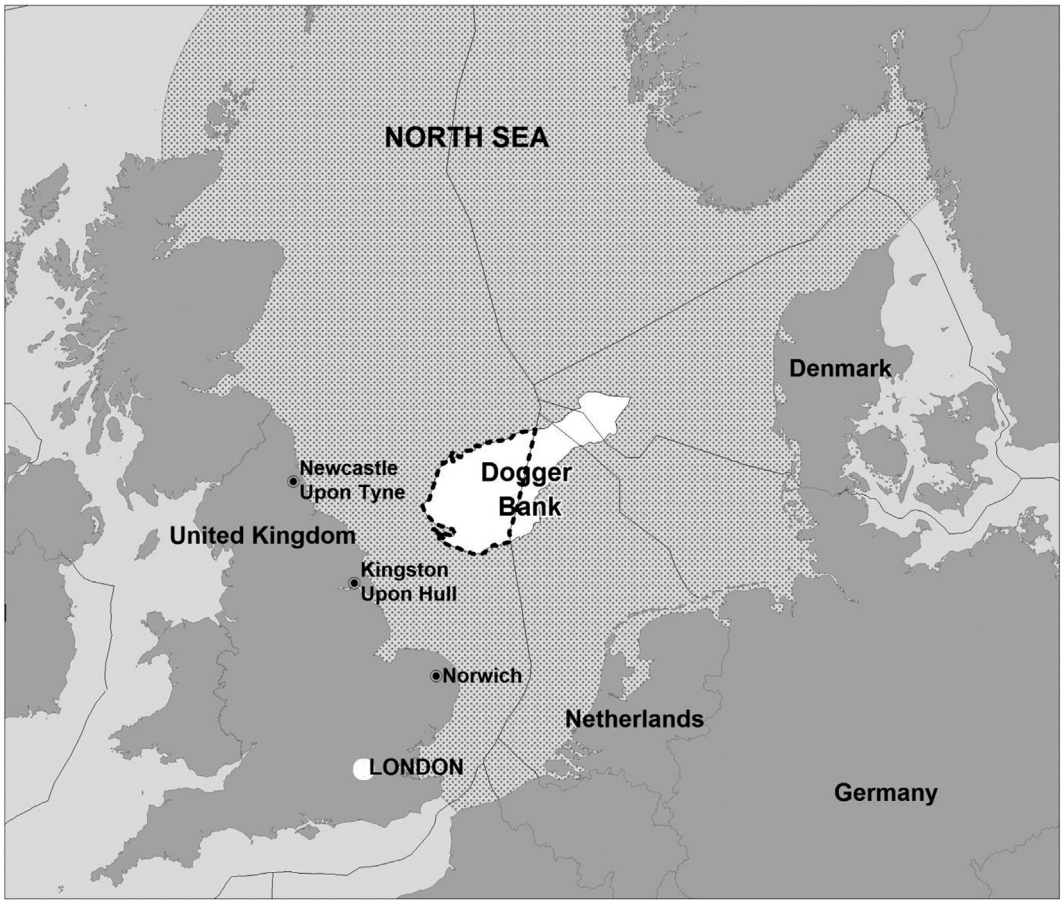

Fig. 1. Location of the Dogger Bank (the dotted outline shows the area under UK jurisdiction).

and support an important seabed community (Wieking and Kröncke, 2003; Kröncke, 2011) which provides a vital food resource for the diverse fish assemblage (Sell and Kröncke, 2013). The Dogger Bank is also an economically important area. Historically it has been used as a rich fishing ground primarily by Dutch, German, Danish and UK fleets, and competition for space is intense and increasing. This area of the southern North Sea has further been used for natural gas exploration with five platforms still present across the site (JNCC, 2011). There are also two small areas which are licensed for aggregate extraction (JNCC, 2011). More recently, plans have been submitted for the development of the largest wind farm in Europe on the UK sector of the Dogger Bank, covering an area of 8660 km^2 (Forewind, 2010). Given the shallow depth of water found above the Dogger Bank, very little commercial shipping takes place (JNCC, 2011), however the wrecks found on and around the Bank provide for a limited amount of recreational angling and diving (Forewind, 2013).

1.2. Current Governance

The Dogger Bank is located within the exclusive economic zones (EEZ)[1] of four European Union (EU) Member States (Fig. 1). Three of these Member States (the UK, Germany and the Netherlands) are in the process of designating the sandbank under their jurisdiction as a Special Area of Conservation (SAC), a form of MPA, under the EU Habitats Directive (EC, 1992). Within the EU, the establishment of a network of MPAs is driven by both international obligations (e.g. the OSPAR Convention in the North East Atlantic) and the implementation of European Directives (e.g. Good Environmental Status under the Marine Strategy Framework Directive (2008/56/EC) and Favourable Conservation Status for habitats and species under the Habitats Directive (92/43/EEC) and Birds Directive (2009/147/EC) (Potts et al., 2014).

In the UK, the Joint Nature Conservation Committee (JNCC) is responsible for the identification of SACs in offshore marine waters for designation by the Government. The JNCC is therefore responsible for establishing conservation objectives for offshore SACs. The Dogger Bank was recommended by JNCC to the UK Government as a candidate SAC (cSAC) for the protection of 'sandbanks which are slightly covered by seawater all the time' (EC, 1992). Following a baseline assessment, JNCC reported the Dogger Bank as being in unfavourable conservation status. The site is vulnerable to physical disturbance or abrasion (e.g. from bottom trawl fishing gear[2] and pipeline burial), selective extraction of species (e.g. by bottom trawl fishing), and physical loss by obstruction (e.g. permanent construction of wind farms) (JNCC, 2011). Its vulnerability to the introduction of non-native species has not been possible to asses (JNCC, 2011). To restore the site and achieve favourable conservation status, the establishment of a management plan is required to provide the basis for determining what current or future activities may have an impact on the overall health of the site.

To develop such a management plan, the UK, Germany and the Netherlands formed the transnational Dogger Bank Steering Group (DBSG), in which the European Commission and Denmark have an observer status. In 2011, the DBSG invited the North Sea Regional Advisory Council (NS RAC), which consists mainly of representatives from the fisheries and wind farm industries and environmental non-governmental organisations (ENGOs), to develop a proposal for a

[1] An exclusive economic zone (EEZ) is defined by the United Nations Convention on the Law of the Sea (UNCLOS, 1982) as an area beyond and adjacent to the territorial sea, under which the rights and jurisdiction of the coastal State and the rights and freedoms of other States are governed by the relevant provisions of the UNCLOS.

[2] Bottom trawl fishing, also known as demersal fishing, involves the towing of heavy fishing gear along the seabed.

fisheries management plan for the Dogger Bank (NS RAC, 2012). This novel bottom-up decision-making process was welcomed by most stakeholders and policy-makers. The process eventually stalled, however, because fishing representatives and ENGOs were unable to adopt a compromise proposal regarding habitat protection (NS RAC, 2012). This situation results in part from the lack of evidence on species, habitats and fisheries impacts on the Dogger Bank, and on what percentage of the Dogger Bank would need to be protected to achieve the conservation objectives set for the respective cSACs.

Based on the above considerations, the main purpose of this study is to test the applicability of the DCE methodology to the valuation of the expected benefits of an offshore site as a result of management options currently under discussion. More specifically, the research objectives are to:

1. Assess the general public's level of concern regarding the environmental consequences of offshore marine activities and potential support for marine management plans.
2. Assess the social benefits of proposed management plans to an offshore sandbank (specifically the Dogger Bank).
3. Determine the value of the potential outcomes of management plans that target specific aspects of biodiversity (both positive and negative attributes, such as species diversity, charismatic species and invasive species).
4. Identify determinants of respondents' preferences for different aspects of the proposed management plans.

Consequently, this paper contributes to the literature on the valuation of the offshore marine environment and, in particular, ecosystem services associated with protected offshore sandbanks. The remainder of the paper is structured as follows: Section 2 describes the DCE approach and survey development; Section 3 presents the results; and Section 4 provides the discussion and policy implications.

2. Methodology

2.1. Discrete Choice Experiments (DCEs)

Besides the contingent valuation method (CVM), discrete choice experiments (DCEs) (Hanley et al., 1998; Louviere et al., 2000) are one of the most popular approaches to assess the total economic value (TEV) of non-market environmental goods. These methods use surveys to elicit the willingness-to-pay (WTP) of respondents for securing some future positive environmental change (or to prevent some negative change from happening). WTP estimates are interpreted as indicators of the change in utility that respondents expect from the specific environmental change. Aggregated over the representative sample of the affected population, WTP estimates provide quantification of the benefits of environmental changes for that population, e.g. for users and non-users of a particular area.[3]

Few non-coastal marine valuation studies have used quantifiable attributes. Glenn et al. (2010) and Wattage et al. (2011) report on a DCE on MPAs around cold-water coral reefs in Irish waters but do not provide any monetary values for the protection of corals or the banning of fishing activities. The CVM study in Ressurreição et al. (2011, 2012) reports significantly positive WTP of respondents in the Azores for the preservation of species diversity in waters around the archipelago. McVittie and Moran (2010) conducted a DCE survey to value the provision of ecosystem services resulting from the network of UK marine conservation zones. While these authors base their valuation scenarios entirely on a real-world management measure (the UK Marine Bill), the attribute levels are described qualitatively. This makes it very difficult to link changes in the underlying ecological indicators to the elicited values. The only non-coastal DCE study reporting WTP for the protection of deep-sea biodiversity and using quantifiable attributes is Jobstvogt et al. (2014). Their survey elicits WTP of Scottish households for additional MPAs in the Scottish deep-sea. They focus on two value categories of biodiversity: the existence value for deep-sea species and the option value of deep-sea organisms as a source of future medicinal products. Given the scarcity of evidence in this field, the present study implements a DCE that is firmly linked to real-world management measures for offshore marine sites. It also uses quantifiable attributes, which can be directly linked to measurable changes resulting from the proposed management. The use of clearly quantifiable attributes makes resulting value estimates suitable for benefit transfer (Loomis and Rosenberger, 2006; Richardson et al., 2014).

2.2. Development of Valuation Scenarios and Choice Attributes

The development of valuation scenarios was based upon the discussions of the DBSG regarding the management of the Dogger Bank. The range of management proposals brought forward by the different parties leave considerable scope for the development of relevant choice attributes. At the same time attributes represented certain ecosystem service categories. The two sectors likely responsible for the greatest current and potential future impact on the Dogger Bank are commercial fishing and offshore wind farm development (JNCC, 2011). Fishing regulations could affect a multitude of ecosystem services associated with the conservation of biodiversity, in addition to food provision. For example, the Dogger Bank has historically been important for sandeels (Cefas, 2007). They are important prey for other commercial fish species (e.g. whiting, plaice, mackerel and cod), seabirds (e.g. fulmar and kittiwake) and cetaceans, especially the harbour porpoise (Diesing et al., 2009). Prohibiting bottom trawling activities on part of the Dogger Bank would conserve the sandeel populations, as well as improve the health and diversity of the wider marine community (Kaiser et al., 2006; Olsgard et al., 2008). Seabed communities are also known to play a role in a number of regulating ecosystem services (Snelgrove, 1999; Austen et al., 2011), such as carbon sequestration and storage and the regulation of waste products. They also provide supporting services including nursery grounds for commercially important fish species. The Dogger Bank acts as a nursery ground for plaice, providing suitable habitat for foraging and maturing fish (Diesing et al., 2009; Hufnagl et al., 2013). In addition, by excluding fishing activities on part of the Dogger Bank, porpoises, seals and seabirds, charismatic species with cultural significance, are less likely to be caught as by-catch in the area (Vinther and Larsen, 2004; Zydelis et al., 2009; Sonntag et al., 2012; Brown et al., 2013). Changes in species diversity and protection of porpoises, seals and seabirds were therefore selected as choice attributes (Table 1). Recognising that a species is rare or endangered may lead to respondents stating a higher WTP for their protection (Christie et al., 2006), the conservation status of porpoises, seals and seabirds was therefore not mentioned.

The attribute levels for species diversity and protection of porpoises, seals and seabirds were chosen based on the areas for closure proposed by the different stakeholders for the Dogger Bank and scaled to the UK section. The ENGOs and Germany are seeking closure of 50% of the area to all fishing activities, while the fishing industry would prefer a maximum of 25% of the area to be closed. Taking these as attribute levels, under the conservation scenario porpoises, seals and seabirds would be protected on 50% of the Dogger Bank by preventing potential by-catch by the fishing industry (e.g. Brown et al., 2013), but only on 25% under the fishing industry proposal. The link between the cessation of a particular type of fishing gear, namely bottom trawling, and change in species diversity is less clear. Drawing from correlations in Kaiser et al. (2006) suggests, however, that it is reasonable to assume that removal of trawling on 25% of the area could lead to a 10% increase in species diversity, while removal from 50% of the area could lead to an increase in species diversity of approximately 25%.

[3] Alternatively, the willingness to accept (WTA) compensation to forgo a positive change or to accept a negative change can be assessed. Most applications use the WTP concept.

Table 1
Choice attributes (*status quo* in italics).

Attribute	Description in the questionnaire	Levels
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)	*No change*, 10% increase in species diversity, 25% increase in species diversity
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.	*Not protected*, protected on 25% of the Dogger Bank area, protected on 50% of the Dogger Bank area
Invasive species	The construction of wind turbines on the Dogger Bank provides space for invasive species, increasing the 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.	*Restricted spread*, wide spread
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.	*£0*, £5, £10, £20, £30, £40, £60

The third attribute selected was the spread of invasive species across the North Sea as a potential outcome of the installation of offshore wind turbines. Many species are extending their ranges northwards due to increasing sea temperatures caused by climate change (Perry et al., 2005; Tasker, 2008; Rijnsdorp et al., 2009; Edwards et al., 2013; Mieszkowska et al., 2013). For hard substrate dwelling species the introduction of permanent hard structures into what is a dynamic, mobile sandbank has the potential to provide new habitat for species that are currently unable to colonise the locality (Petersen and Malm, 2006; Glasby et al., 2007; Bulleri and Chapman, 2010). This increases their potential to survive and, with the turbines acting as stepping stones, spread throughout the North Sea. Once established invasive species may compete with native species for resources such as food and space (e.g. Arenas et al., 2006). Invasive species are already found in the North Sea, e.g. the sea walnut (*Mnemiopsis leidyi*), colonial sea squirts such as *Botrylloides violaceus*, Atlantic blue crab (*Callinectes sapidus*), Japanese skeleton shrimp (*Caprella mutica*) (Galil et al., 2014). Of particular relevance in this case are the spread of species such as the colonial sea squirt and the Japanese skeleton shrimp which are both known to colonise artificial (man-made) hard substrata in shallow waters (Arenas et al., 2006; Page et al., 2007; Turcotte and Sainte-Marie, 2009) as well as the potential for the proliferation of those invasive jellyfish that require hard substrate for part of their life cycle (Purcell, 2012). Consequently, the attribute levels chosen for the spread of invasive species were 'restricted' and 'wide spread' across the North Sea, which reflects the fact that invasive species are already present in the North Sea.

The valuation scenarios further specify that the implementation, monitoring and enforcement of the Dogger Bank management plan will come at a cost. Marine management within the UK is the responsibility of the Marine Management Organisation (MMO), funded ultimately by the taxpayer. The payment vehicle used was therefore an increase in annual tax for UK households over the next five years.[4] This attribute was given seven levels (Table 1).

[4] The payment vehicle was not specified as an increase in income tax or council tax. Income tax is a personal tax and could not justifiably apply to a household. The generic household tax in the UK, the council tax, is paid to local authorities. As local authorities are not responsible for marine management, a generic household tax was chosen as the payment vehicle. A five year period was proposed to fall within the reporting timeframe required for assessing the status of all SAC sites after which management measures may need to be reassessed.

2.3. Development of the Survey Questionnaire and Design of Choice Tasks

To develop the survey questionnaire 29 semi-structured interviews were conducted by the project team (an interdisciplinary team comprising marine ecologists and economists) with members of the general public. Interviews were completed in Hull (Northeast England) and Plymouth and Exeter (Southwest England) to sample respondents living close to and far from the North Sea. Based on insights from these interviews a preliminary choice questionnaire was tested in 19 face-to-face interviews with members of the public following a workshop on management of the Dogger Bank (held in Newcastle, Northeast England). Respondents were asked to think aloud while they completed the choice tasks (Ryan et al., 2009). This helped to detect inconsistencies and unclear wording in the scenario and attribute description. The same questionnaire was tested online with respondents from across the UK ($n = 60$). Findings from both pilot surveys were used to modify the questionnaire wording and additional pictograms were included to describe the choice attributes (Fig. 2). The results from the online pilot survey also informed the experimental design of the main survey. Coefficients indicating the influence of the choice attributes on choices from a mixed logit model (cf. next section) were used as priors when generating a Bayesian D-efficient design (Scarpa and Rose, 2008) in the software package Ngene (ChoiceMetrics, 2012). Unrealistic survey scenarios were excluded, such as choice options which yield the *status quo* for each attribute at positive cost, since these options would be dominated by the *status quo*. The final set included 24 choice tasks separated into four blocks of six tasks. Respondents were randomly allocated to one block and complete the six choice tasks in that respective block. Each choice task contained two alternative management plans at different cost levels and a 'no change' or *status quo* option at zero cost (Fig. 2).

The final questionnaire consisted of four parts: part one contains 19 questions regarding the respondent's general knowledge of and experience with the North Sea and the Dogger Bank. Part two introduced the valuation scenarios, the hypothetical 'Dogger Bank Management Plan', and included the description of the choice attributes and the payment method (Table 1). Part three contained the actual choice experiment. Following each choice task, respondents were asked to indicate how certain they were of their choice on a 5-point scale from 1 "Not certain at all" to 5 "100% certain". Part four contained a series of attitudinal questions, some of which are used to identify protest respondents. These are respondents who chose the costless *status quo* option in all

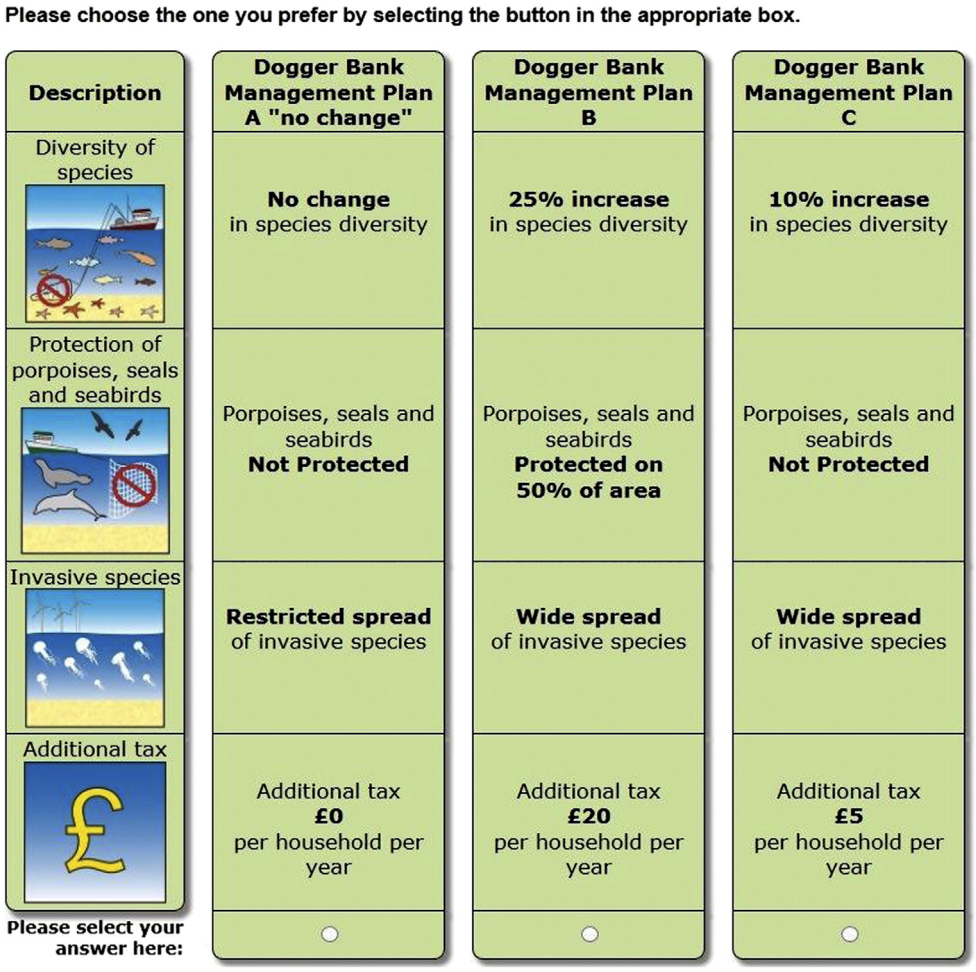

Fig. 2. Example choice card from the online questionnaire.

six choice tasks and agreed to the statements "Taxes and fees are already too high, so there should be no additional financial burden", "I already pay enough for other things", "It is my right to have a well preserved Dogger Bank and I should not have to pay extra for it" and "The government should cut public spending on other things instead of expecting a contribution from me". Answers to these questions were given on a 5-point Likert scale from "Strongly disagree" to "Strongly agree". In the regression models, dummy variables indicating agreement (i.e. "Agree" or "Strongly agree") are used. The questionnaire concluded with a series of socio-demographic questions. Three-digit postcode data (e.g. HU6, PL1) were collected to generate distance variables from the Dogger Bank, the North Sea coast and the nearest coastline using geographical information systems (GIS). Additional dummy variables indicating respondents that live within 1, 2, 4, 6, 10, 25 or 50 miles from a coastline compared to respondents living further inland were computed from these data. These are used to test for distance effects of elicited values.

The survey was conducted online by a market research company with respondents sampled from their existing respondent panel. While online surveys allow researchers to reach a broad survey sample they systematically exclude people without internet connection.[5] However, the problem of hard-to-reach groups also exists for alternative survey modes, such as mail or direct interviews. Regarding stated preference valuation techniques it has been shown that online surveys do not produce significantly different WTP estimates compared to traditional mail surveys (Olsen, 2009; Windle and Rolfe, 2011). Empirical comparisons of WTP estimates of online and face-to-face surveys show mixed results (Canavari et al., 2005; Marta-Pedroso et al., 2007; Nielsen, 2011), but coverage of a large sampling area at justifiable costs can best be achieved by an online survey. The survey aimed to elicit views from a representative sample of the resident population of the UK, in terms of age, gender, and income, to assess potential non-use values held by respondents living far away from the actual study site. Sample characteristics are presented in the Results section.

2.4. Econometric Analysis of Choice Data

The choice data are analysed employing conditional and mixed logit models (Train, 2009), which are based on the random utility model (RUM) (McFadden, 1974; Ben-Akiva and Lerman, 1985). It is assumed that choosing option j out of a set of options $i = 1, \ldots, j, \ldots, J$ in choice situation t generates utility

$$U_{njt} = \beta_n' x_{njt} + \varepsilon_{njt} \quad (1)$$

for respondent n. U_{njt} is the indirect utility of the respondent, x_{njt} a vector of attribute levels of option j and respondent characteristics. β_n denotes a coefficient vector, some elements of which are assumed to be random and thus respondent-specific in the mixed logit, but assumed to be fixed across respondents in the conditional logit model. The unobservable component of utility, ε_{njt}, is assumed to follow a type I extreme

[5] In the UK, 83% of households had internet access (ONS, 2013).

value distribution, so that the probability P_{nit} that respondent n chooses alternative i over all other alternatives $j \neq i$ in choice situation t is

$$P_{nit} = \frac{\exp(\beta_n' x_{nit})}{\sum_{j=1}^{J} \exp(\beta_n' x_{njt})}. \quad (2)$$

Both conditional and mixed logit models produce estimates of the coefficient vector β. The elements of β can be interpreted as the average utility weights of the attributes included in the choice tasks (i.e. the influence of these attributes on stated choices). Both models allow for the analysis of preference variation across respondents. If different respondents have different preferences for a certain attribute, respondent-specific variables can be interacted with attribute-specific variables to account for these different preferences (Train, 2009). As the conditional logit cannot account for unobserved preference heterogeneity, the analysis presented here relies heavily on the mixed logit model. By specifying the distribution of the elements of the coefficient vector β, the latter model can also account for random (i.e. unexplained) preference heterogeneity. The coefficients of all but the cost attribute are assumed to be normally distributed, so both means and standard deviations of coefficients of the respective attributes are reported.[6] Respondent-specific variables are included in the models in interactions with the attribute variables or as a dummy variable indicating whether the *status quo* or one of the policy options was chosen. Both models produce coefficient estimates through maximum likelihood estimation. This study uses the *asclogit* command in Stata (version 12) to compute the conditional logit model. The mixed logit model is estimated using the user-written command developed by Hole (2007).

The dependent variable in all of the above models is the choice that respondents make between the offered alternatives, so the coefficient vector β reports the influence of explanatory variables on choice probabilities. As the choice experiment includes a cost component, WTP for attribute k can be calculated as

$$WTP_k = -\frac{\beta_k}{\beta_{cost}} \quad (3)$$

where β_k and β_{cost} denote the coefficients of the k-th attribute and of the cost attribute, respectively. When the mixed logit model is used β_k represents the mean of the distribution of the coefficient of the k -th attribute.

3. Results

3.1. Sample Characteristics

The main survey was conducted in early December 2013. In total 1022 respondents completed the questionnaire. To check whether the sample reflects the structure of the UK population, sample characteristics are compared against population means. Shares of age groups reflect age distribution in the population (Table 2) except for a slight oversampling of respondents aged 65 and over at the expense of the 18–24 and over group. The level of education is somewhat higher in the sample than in the general population. As an education indicator the share of people with at least a university degree is 32.8% in the sample but only 27.0% in the general population. The distribution of occupations closely resembles that of the general UK population. Self-employed and retired respondents are slightly underrepresented compared to the 2011 census figures. Average household size in the sample is 2.64 persons per household compared to 2.37 for the whole country.

Table 2
Means, standard deviation and range of several socio-demographic variables (N = 1022).

	Survey sample	UK population
	Mean/share (std. dev.)	
Male (share)	48.6%	49.1%[a]
Age 18–24 (share)	12.0%	18.1%
Age 25–34 (share)	17.0%	17.3%
Age 35–44 (share)	17.7%	17.1%
Age 45–54 (share)	17.6%	18.8%
Age 55–64 (share)	14.9%	14.4%
Age 65 and above (share)	20.9%	14.3%
Degree or higher (share)	32.8%	27.0%[c]
Employed full-time (share)	39.4%	38.5%[c]
Employed part-time (share)	11.3%	13.7%[c]
Self-employed (share)	5.3%	9.5%[c]
Unemployed (share)	3.9%	4.4%[c]
Retired (share)	17.6%	13.9%[c]
Students (share)	9.9%	9.3%[c]
Household size (members)	2.64 (1.29)	2.37[b]
Monthly household income (£)[d]	2275.93 (1918.31)	2691.67[b]

Sources:
[a] UK Office of National Statistics (ONS) population projections 2012-based.
[b] ONS Labour Force Survey 2013.
[c] ONS 2011 Census.
[d] Income after tax and benefits.

The mean monthly household income of £2275 is lower than average household income for the whole of the UK. Based on these comparisons, the survey sample was considered to reflect the structure of the UK population. The survey findings therefore have significance for the resident population as a whole and can be used in cost-benefit analysis (CBA).

In terms of spatial distribution of the sample across the UK, Fig. 3 shows that respondents from almost all postcode areas of the country were sampled (115 out of 125).

3.2. Knowledge About and Attitudes Towards the Use and Management of Offshore Sites

70.6% of respondents stated that they had previously visited the North Sea coast. About half the respondents had taken a ferry (49.9%) or flight (63.0%) across the North Sea. The more specific topic of the survey, the Dogger Bank, was new to most respondents. Only 50.2% of the respondents stated that they had heard of the Dogger Bank before completing the questionnaire, with the vast majority of them (80.3%) having heard of it in the shipping forecast.[7] After further introduction to the site, only 3.9% of respondents stated that they were previously aware of all the information presented, and 37.0% stated they were aware of some of it. The remaining 59.1% stated that they were unaware of this information before undertaking the survey. Similarly, regarding MPAs, only 19.9% of respondents had heard of the UK government's plans to create a network of MPAs by 2016.

Part one of the questionnaire also elicited the level of support for the two main components of the hypothetical Dogger Bank management plan: regulation of fisheries and future wind farm development. Despite the low level of existing knowledge, the majority of respondents supported regulations both of fisheries and future wind farm development in that area (Table 3). Only a small proportion of respondents directly rejected the plans to regulate fishing and wind farm development introduced in the survey scenarios (3.8% and 6.5% respectively).

3.3. WTP for Environmental Benefits From the Offshore Marine Site

For the analysis of choice data, 49 respondents were identified as protestors based on responses to attitudinal questions and were

[6] It is possible to assume other distributions for the choice attribute coefficients, such as uniform or log-normal, but in this study it is not clear a priori which sign of the coefficients can be expected, so we decided to apply the most commonly used normal distribution. Since, on the contrary, it can be expected that the cost coefficient will be negative, it is assumed to be fixed across respondents.

[7] The shipping forecast is a national institution in the UK. It is a weather forecast for the seas around the British Isles prepared by the Met Office on behalf of the Maritime and Coastguard Agency. It is broadcast four times a day on BBC Radio 4 and published online.

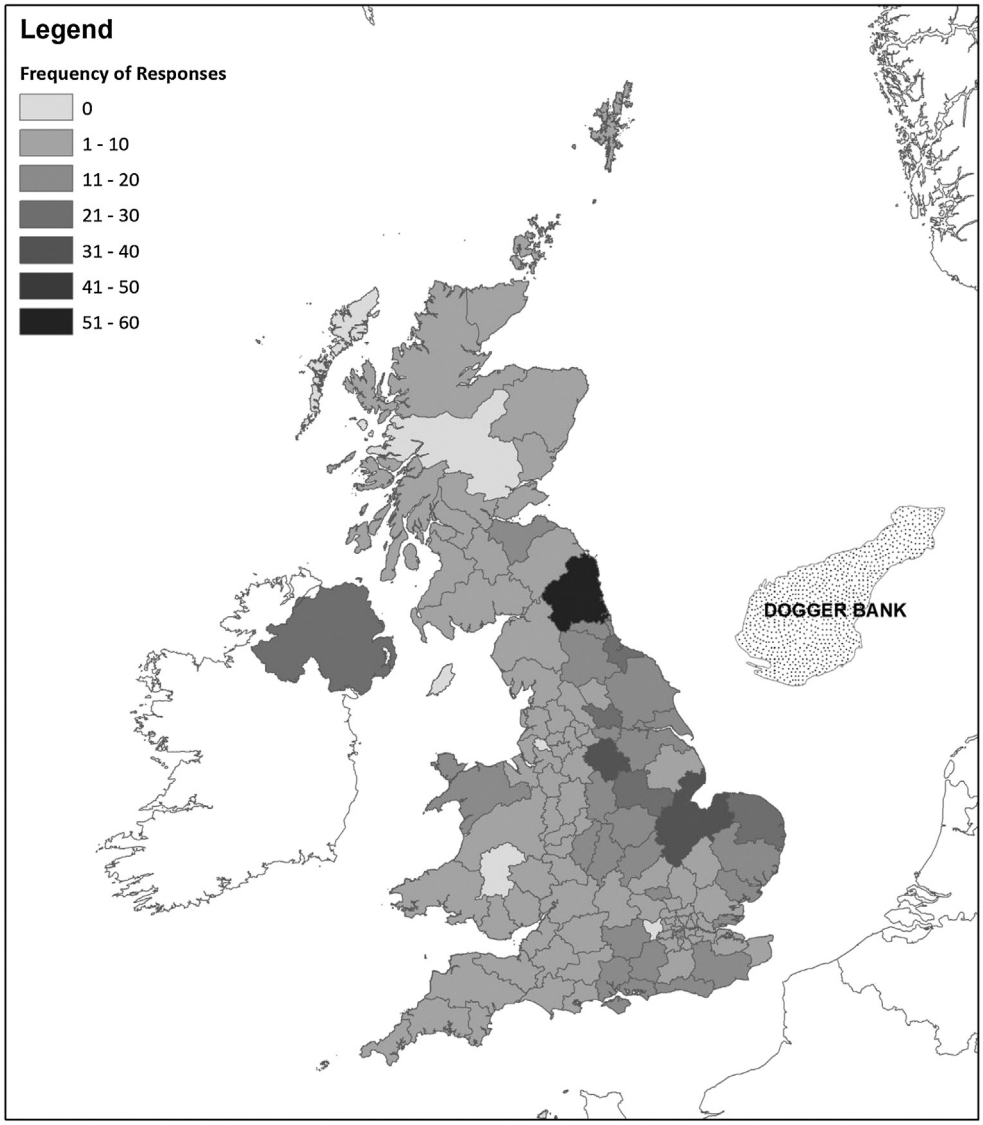

Fig. 3. Spatial distribution of survey responses and location of the Dogger Bank.

subsequently removed from the survey sample.[8] The variables used in all subsequent models and their description are listed in Table 4. In both the conditional and mixed logit models reported in Tables 5a and 5b, coefficients of all attributes were significant and exhibit the expected signs. Changes in species diversity and the protection of charismatic species positively influenced choices (i.e. on average, choice options describing an increase of these attributes had a higher probability of being preferred than those indicating no change). In contrast, the coefficients for wide spread of invasive species (INVASIVE) and the cost attribute were significantly negative in both models. The higher the cost of an option in terms of the household tax the smaller the probability that this option was selected.

Tables 5a and 5b report WTP estimates computed from the conditional and mixed logit models according to Eq. (3). There was no clear pattern that either model produces only higher or lower WTP estimates. The relative importance of the attributes as measured in WTP did not change across models. However, the mixed logit model's fit to the data as indicated by the adjusted ρ^2 and the Bayesian Information Criterion (BIC) was much better compared to the conditional logit model. WTP for the larger change in one attribute (e.g. 25% increase in species diversity) always exceeded WTP for the smaller change (e.g. 10% increase in species diversity). While respondents were willing to pay £4.19 (£5.70 in the conditional logit) per year on average for a 10% increase in species diversity on the Dogger Bank, their average WTP for a 25% increase was £7.76 (£7.22 in the conditional logit). WTP did not appear to increase linearly with the level of this attribute, but indicated decreasing marginal utility of species diversity. Respondents seemed willing to pay for a certain base level of change but their WTP did not increase proportionately for further positive changes. This pattern could also be detected for the protection of porpoises, seals and seabirds. Respondents were willing to pay £24.02 (£26.24 in the conditional logit) on average per year to protect these species on 25% of the UK Dogger Bank area, whereas the WTP for the protection on 50% of the area was £30.32 (£33.07 in the conditional logit). Designing a future wind farm on the Dogger Bank that results in wide spread of invasive species yielded a negative WTP of £−25.39 (£−22.93 in the conditional logit) on average to respondents in this sample. These estimates can be interpreted as an indicator of a negative welfare effect resulting from a decrease in environmental quality as indicated by this attribute.

[8] A share of protesters of about 5% is relatively low. Therefore, we ran additional choice models with samples, from which up to 20% of respondents were removed based on some stricter identification rules. This had very little effect on the coefficient estimates. Given that there is no universal agreement as to the identification of protesters, we decided to take a precautionary approach and keep the number of protest removals as low as possible.

Table 3
Number of respondents supporting or rejecting management measures for the Dogger Bank SAC.

	Do you think fishing activities should be regulated to restore the environmental functions of the Dogger Bank?		Do you think wind farm design should be regulated to prevent further introduction of invasive species to the Dogger Bank?	
	Number of respondents (N)	Share	Number of respondents (N)	Share
No	39	3.8%	66	6.5%
Yes	654	64.0%	632	61.8%
I need more information	253	24.8%	229	22.4%
Don't know	76	7.4%	95	9.3%
Total	1022		1022	

Relating these annual monetary figures to reported monthly household income (after tax and benefits), they make up shares between 0.018% and 0.112%.

As the mixed logit model relaxes the assumption that attribute coefficients are fixed across respondents, the reported coefficients were means of the estimated distribution. An estimate of the standard deviation for each coefficient is reported in Table 5b. While there was no evidence of random preference variation for the coefficient of the protection of charismatic species on 25% of the Dogger Bank (PROT25), all other attribute coefficients modelled had standard deviations significantly different from zero. These results provide evidence of substantial random preference heterogeneity, consequently only the mixed logit model was employed to identify individual specific choice determinants.

Table 4
Description of variables used in the regression models (N = 973).

Variable	Description
Variables specific to the choice alternative	
ASC_CHANGE	Alternative-specific constant (0 = no-change option, 1 = management plan B or C)
SPEC10	Increase in species diversity by 10 percent[a]
SPEC25	Increase in species diversity by 25 percent[a]
PROT25	Porpoises, seals and seabirds protected on 25 percent of the UK's Dogger Bank area[a]
PROT50	Porpoises, seals and seabirds protected on 50percent of the UK's Dogger Bank area[a]
INVASIVE	Wide spread of invasive species on the Dogger Bank[a]
COST	Cost of the Dogger Bank management plan as additional tax for the household in £ GBP
Variables specific to the respondent	
AGE	Age of the respondent in years
MALE	Gender of the respondent[a]
UNI	Respondent has got a university degree[a]
INCOME	Monthly household income of the respondent in £ GBP
HHSIZE	Number of household members
ENVORG	Respondent is member of an environmental organisation[a]
NSEA	Respondent lives or works within 10 miles of the North Sea[a]
FERRY	Respondent has taken a boat or ferry trip on the North Sea[a]
FLIGHT	Respondent has flown over the North Sea[a]
ANGLING	Respondent has been recreational sea angling[a]
SCUBA	Respondent has been scuba diving[a]
MARSEC	Respondent has previously worked in a marine sector (fisheries, offshore renewable energy or oil and gas)[a]
DIST_DB	Distance to the Dogger Bank in km
CERTAIN	Sum of six choice certainty questions, each on a 5-point scale from 1 "Not certain at all" to 5 "100% certain"
NOTNEC	"I think a Dogger Bank management plan is not necessary"[b]
BURDEN	"Taxes and fees are already too high, so there should not be an additional financial burden"[b]
ENOUGH	"I already pay enough for other things"[b]
CUT	"The government should cut public spending on other things instead of expecting a contribution from me"[b]
ENJOY	"I enjoy contributing to a good cause no matter what it is"[b]
EXPERTS	"I think it is better to ask experts whether or not to carry out this Dogger Bank management plan"[b]
SPECDIV	"Without a management plan the diversity of species on the Dogger Bank will continue to decrease"[b]
PROTECT	"Porpoises, seals and seabirds need protecting through the management plan"[b]

[a] Dummy variable (1 = yes, 0 = no).
[b] Dummy variable (1 = agree or strongly agree, 0 = strongly disagree, disagree or indifferent).

3.4. Determinants of Preferences and WTP for Offshore Marine Management

To identify determinants of choices, and thus of WTP, and to validate the survey responses, interactions between the management option dummy (ASC_CHANGE) and/or certain choice attributes and a set of respondent-specific variables were included in the mixed logit model. The three models reported in Table 6 contain an increasing number of explanatory variables. Often the number of observations decreases the more explanatory variables are included in the model resulting from the exclusion of respondents with missing values. It should be noted here that the number of observations remained constant across models due to the very high item response rate in this survey.

Model 1 in Table 6 included choice attributes and 13 socio-demographic variables. In Table 6 the top section of the column reports mean estimates of attribute coefficients modelled as random. All attribute coefficients were significant and point in the same direction as in the basic model in Table 5b. Among the respondent-specific variables, the interaction between the ASC_CHANGE and MALE was negative, indicating that male respondents were less likely to choose any of the costly management options. Respondents who were members of an environmental organisation (ENVORG) or had previously taken a ferry (FERRY) or flight across the North Sea (FLIGHT) had a higher WTP for costly management options as indicated by the positive coefficients. The significant effects of MALE, ENVORG and FLIGHT were robust throughout all models in Table 6.

The median response for each of the six choice certainty questions was 4 on the scale from 1 "Not certain at all" to 5 "100% certain". The majority of respondents appeared to be confident to state their

Table 5a
Conditional logit model and WTP estimates.

	Coefficient	Std. Err.	WTP (£)
ASC_CHANGE	−0.476***	(0.101)	
SPEC10	0.227***	(0.075)	5.70
SPEC25	0.288***	(0.055)	7.22
PROT25	1.047***	(0.066)	26.24
PROT50	1.320***	(0.066)	33.07
INVASIVE	−0.915***	(0.051)	−22.93
COST	−0.040***	(0.002)	
Log-likelihood	−5543		
Observations	17,514		
Respondents	973		
Adjusted ρ^2	0.131		
BIC	11,135		

Adjusted ρ^2 is computed as $\rho^2 = 1 - (LL_m - k)/LL_0$, where LL_m and LL_0 are the log-likelihoods of the full model and the intercept-only model respectively, and k the number of parameters. Bayesian Information Criterion (BIC) is calculated as $BIC = -2LL_m + k \cdot \ln(N)$ with N denoting the number of respondents. The use of BIC is preferred to Akaike Information Criterion because it imposes a stronger penalty on the inclusion of more parameters in the model.
*** indicate 1%-level of confidence.

Table 5b
Mixed logit model and WTP estimates.

	Coefficient	Std. Err.	WTP (£)
Mean of random coefficients			
ASC_CHANGE	1.409***	(0.171)	
SPEC10	0.265**	(0.110)	4.19
SPEC25	0.490***	(0.084)	7.76
PROT25	1.517***	(0.096)	24.02
PROT50	1.915***	(0.112)	30.32
INVASIVE	−1.603***	(0.104)	−25.39
Standard deviation of random coefficients			
ASC_CHANGE	2.512***	(0.123)	
SPEC10	0.578***	(0.230)	
SPEC25	0.815***	(0.124)	
PROT25	0.041	(0.569)	
PROT50	1.294***	(0.097)	
INVASIVE	1.932***	(0.117)	
Fixed coefficient			
COST	−0.063***	(0.003)	
Log-likelihood	−4703		
Observations	17,514		
Respondents	973		
Halton draws	5000		
Adjusted ρ^2	0.262		
BIC	9500		

*** and ** indicate 1%- and 5%-level of confidence, respectively. Adjusted ρ^2 is computed as $\rho^2 = 1 - (LL_m - k)/LL_0$, where LL_m and LL_0 are the log-likelihoods of the full model, and the intercept-only model respectively, and k the number of parameters. Bayesian Information Criterion (BIC) is calculated as $BIC = -2LL_m + k \cdot \ln(N)$ with N denoting the number of respondents. The use of BIC is preferred to Akaike Information Criterion because it imposes a stronger penalty on the inclusion of more parameters in the model.

preferences by means of the choice tasks presented to them despite the low level of prior knowledge of the topic reported earlier. Beyond that, the level of choice certainty summed up for all six choice tasks (CERTAIN) did not significantly affect choice probabilities in the mixed logit models 1 to 3.

The level of education of the respondent (approximated by the dummy variable UNI) did not show any significant effect on choices in models 1 to 3. There were no effects of respondents' age (AGE) and household income (INCOME) on choices. Similarly, there was no influence of respondents' previous experience of sea angling (ANGLING) or scuba diving (SCUBA), professional experience in any marine sector (MARSEC) or their distance from the Dogger Bank (DIST_DB). Alternative distance variables to the North Sea and the nearest coast, as well as the natural logarithm of the three different distance variables were tested, however, none of them had an impact on choices when interacted with ASC_CHANGE. In an alternative model, dummy variables indicating respondents that live within 1, 2, 4, 6, 10, 25 and 50 miles from a coastline were interacted with ASC_CHANGE, but again there were no significant effects of these variables on choices.

In model 2, a set of dummy variables drawn from attitudinal questions, some of which were also used to identify protest respondents,[9] were added. All significantly influence choices. Coefficients of statements adverse to the Dogger Bank management plan (NOTNEC) and its financing (BURDEN, ENOUGH) were negative and remain so after including further variables in model 3. This means that respondents agreeing to the statements "I think a Dogger Bank management plan is not necessary" (NOTNEC), "Taxes and fees are already too high, so there should not be an additional financial burden" (BURDEN) and "I already pay enough for other things" (ENOUGH) had a lower probability of choosing one of the management options. The effect of a fourth statement critical of the financing of the management plan reading "The government should cut public spending on other things instead of expecting a contribution from me" (CUT) was significantly positive in models 2 and 3. In contrast, respondents agreeing to the statements "I enjoy contributing to a good cause no matter what it is" (ENJOY) or "I think it is better to ask experts whether or not to carry out this Dogger Bank management plan" (EXPERTS) were more likely to prefer a costly management option over the no-change (zero cost) option.

Model 3 included further attitudinal variables, which are related to specific attributes and were therefore interacted with these attributes rather than with ASC_CHANGE. Results in Table 6 show that respondents agreeing with the statement "Without a management plan the diversity of species on the Dogger Bank will continue to decrease" (SPECDIV) had a stronger preference for species diversity. The coefficients of the main effects of SPEC10 and SPEC30 (Table 6) were not significant in model 3. While respondents who agreed with the statement (SPECDIV) preferred higher species diversity more strongly, choices of respondents who did not agree with this statement were not influenced by this attribute (i.e. indifferent to changes in species diversity). In a model not reported here, choices of respondents who did not agree to SPECDIV were completely indifferent to changes in species diversity. This supports the finding that agreement to this attitudinal statement is a valid predictor of preferences for the respective benefits. Respondents agreeing to "Porpoises, seals and seabirds need protecting through the management plan" (PROTECT) valued this particular feature of the plan significantly more than respondents not holding this view.[10] Preferences for a reduction of the spread of invasive species (INVASIVE) were not influenced by the inclusion of these interactions.

In all of the reported models, the model fit to the data was very good. Louviere et al. (2000) state that adjusted McFadden's ρ^2 between 0.2 and 0.4 indicate extremely good model fit for this type of logit model. Overall, model fit improved from model 1 through to model 3 as indicated by an increasing adjusted ρ^2 and a decreasing BIC. The inclusion of attitudinal variables in models 2 and 3 further increased the predictive power of the model and thus better explained stated choices.

4. Discussion, Policy Implications and Concluding Remarks

The main focus of this study was to test the applicability of DCE for the valuation of benefits arising from the management of an offshore MPA. While there are a very limited number of stated preference studies relating to offshore sites, this is one of the few studies to explicitly link the valuation scenarios to current marine management discussions. This particular approach includes a set of largely quantifiable attribute specifications that can be directly linked to real-world management measures. Establishing these links and conveying them in a credible and readily understandable way in the valuation scenarios proved challenging with respect to an offshore marine site. Yet results from valuation studies of this kind can be most informative to marine management if the link between proposed management measures, ensuing environmental change, and the assessment of the resulting benefits is as clear and direct as possible (McVittie and Moran, 2010).

4.1. Level of Concern of the General Public

The importance of the coastal and marine environment to an island nation such as the UK is reflected in the finding that a large majority of respondents have visited and/or travelled across the North Sea. As anticipated this study found low levels of self-rated knowledge about the

[9] While only those respondents agreeing to these statements and choosing the no change option in every choice task had been identified as protesters, these variables are used to test the influence of those attitudes towards the proposed management measures and its provision mechanism on choices.

[10] In another model not reported here, interactions of statements SPECDIV and PROTECT with ASC_CHANGE yielded significantly positive coefficients indicating a higher WTP of supporters of these statements for all attributes. However, the coefficients of the main effects (SPEC10, SPEC25, PROT25 sand PROT50) were still significantly positive. Consequently, these statements need to be included in interaction with their respective attributes to detect different effects on choices.

Table 6
Mixed logit models with interactions.

	Model 1		Model 2		Model 3	
	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
Mean of random coefficients						
ASC_CHANGE	−0.060	(0.716)	0.318	(0.685)	0.882	(0.659)
SPEC10	0.258**	(0.112)	0.249**	(0.112)	−0.127	(0.161)
SPEC25	0.495***	(0.087)	0.495***	(0.086)	0.069	(0.150)
PROT25	1.541***	(0.098)	1.540***	(0.098)	0.972***	(0.153)
PROT50	1.967***	(0.115)	1.973***	(0.114)	1.167***	(0.164)
INVASIVE	−1.675***	(0.109)	−1.681***	(0.110)	−1.694***	(0.111)
Standard deviation of random coefficients						
ASC_CHANGE	2.377***	(0.118)	2.115***	(0.111)	1.987***	(0.108)
SPEC10	0.564**	(0.222)	0.621***	(0.198)	0.568***	(0.216)
SPEC25	0.863***	(0.124)	0.848***	(0.125)	0.875***	(0.124)
PROT25	0.044	(0.359)	0.122	(0.405)	0.215	(0.334)
PROT50	1.325***	(0.099)	1.300***	(0.100)	1.352***	(0.102)
INVASIVE	2.023***	(0.122)	2.039***	(0.121)	2.082***	(0.122)
Non-random coefficients						
COST	−0.065***	(0.003)	−0.065***	(0.003)	−0.066***	(0.003)
AGE[a]	0.007	(0.007)	0.008	(0.006)	0.006	(0.006)
MALE[a]	−0.530**	(0.212)	−0.573***	(0.198)	−0.476**	(0.190)
UNI[a]	−0.119	(0.213)	−0.271	(0.199)	−0.283	(0.191)
INCOME[a]	0.000	(0.000)	0.000	(0.000)	0.000	(0.000)
HHSIZE[a]	0.000	(0.082)	0.002	(0.077)	0.014	(0.074)
ENVORG[a]	1.289***	(0.238)	0.930***	(0.223)	0.866***	(0.212)
ANGLING[a]	0.130	(0.263)	0.059	(0.243)	−0.061	(0.233)
SCUBA[a]	−0.005	(0.280)	0.082	(0.258)	0.127	(0.248)
FERRY[a]	0.446**	(0.213)	0.287	(0.198)	0.211	(0.189)
FLIGHT[a]	0.455**	(0.210)	0.382**	(0.195)	0.353*	(0.187)
MARSEC[a]	−0.580	(0.530)	−0.470	(0.500)	−0.440	(0.474)
DIST_DB[a]	0.001	(0.001)	0.001	(0.001)	0.000	(0.001)
CERTAIN[a]	0.021	(0.020)	0.004	(0.019)	−0.005	(0.018)
NOTNEC[a]			−0.741**	(0.340)	−0.534*	(0.322)
BURDEN[a]			−0.886***	(0.227)	−0.821***	(0.218)
ENOUGH[a]			−0.755***	(0.225)	−0.749***	(0.216)
CUT[a]			0.504**	(0.204)	0.400**	(0.196)
ENJOY[a]			1.392***	(0.205)	1.188***	(0.198)
EXPERTS[a]			0.693***	(0.195)	0.467**	(0.190)
SPECDIV*SPEC10					0.545***	(0.171)
SPECDIV*SPEC25					0.602***	(0.169)
PROTECT*PROT25					0.714***	(0.154)
PROTECT*PROT50					1.102***	(0.170)
Log-likelihood	−4548		−4481		−4446	
Observations	17,118		17,118		17,118	
Halton draws	1000		1000		1000	
Adjusted ρ^2	0.267		277		0.282	
BIC	9274		9100		9085	

***, ** and * indicate 1%-, 5%- and 10%-level of confidence, respectively. The top sections of the columns report mean estimates of attribute coefficients modelled as random. Adjusted ρ^2 is computed as $\rho^2 = 1 - (LL_m - k)/LL_0$, where LL_m and LL_0 are the log-likelihoods of the full model, and the intercept-only model respectively, and k the number of parameters. Bayesian Information Criterion (BIC) is calculated as $BIC = -2LL_m + k \cdot \ln(N)$ with N denoting the number of respondents. The use of BIC is preferred to Akaike Information Criterion because it imposes a stronger penalty on the inclusion of more parameters in the model.

[a] Interacted with ASC_CHANGE.

case study site and its management, an observation also made for the case of the deep-sea by Jobstvogt et al. (2014). Nevertheless, following the provision of limited information on the implications of management of the main commercial activities on the Dogger Bank, support for their regulation was found. This provides evidence of the level of concern of the general public regarding the consequences of these offshore activities and supports the approach taken in the subsequent choice experiment. Nevertheless, these findings should be interpreted with caution due to the potential influence of the provided information on responses.

4.2. Social Benefits of the Proposed Management Plans

Results further show that the UK public hold significant values for environmental benefits generated by conservation measures in an offshore location. The elicited values obtained through this study correspond to real-world management options that are currently under discussion for an offshore MPA in the UK. Regarding the specific choice attribute values, protection of charismatic species (porpoises, seals and seabirds) on 25% of the UK section of the Dogger Bank is proportionately greater than for protection on 50% of the area. This non-linear increase is important given the disagreement over such protection between the fishing industry and the ENGOs who advocate for these respective protection levels. Similarly, WTP for increasing species diversity by 25% resulting from the exclusion of bottom trawling from 50% of the UK section of the Dogger Bank is higher than for an increase of only 10%, if bottom trawling was excluded on just 25% of the area, although again there is no linear relationship. Comparing these two attributes, values for the protection of charismatic species exceed those for general species diversity. This supports findings elsewhere that suggest that respondents are capable of distinguishing between different (quantitative) levels of species protection but that they react more strongly to charismatic species compared to general diversity (Martín-López et al., 2007; Jacobsen et al., 2008). However, this might depend on the cultural background of respondents (Ressurreição et al., 2012). A confounding issue in this survey could result from the link suggested between the regulation of two

commercial sectors on the Dogger Bank and the resulting environmental changes. While the choice tasks focus specifically on the different levels of environmental changes, it is conceivable that some respondents' choices were motivated by the underlying restrictions to fishing and wind farm development. This ambiguity often occurs when basing valuation scenarios on real-world management decisions where environmental improvements may come at the expense of economic or social factors.

4.3. Validity of the Elicited Values

Despite respondents' low levels of prior knowledge of the study site and its characteristics there are several indicators supporting the validity of the elicited values. Self-reported choice certainty, as assessed after each choice task, was found to be high. This can be considered an indication that the information provided was sufficient for respondents to link the scenarios to their existing attitudes, and consequently to state choices based on individual preferences. Choice certainty, however, does not affect choices indicating no systematic difference between the preference structures of respondents who feel certain about their choices and those who are less certain.

The validity of the elicited values is further supported because preferences for the proposed benefits are predicted by certain respondent characteristics in a plausible manner. The higher likelihood of respondents who have seen the North Sea (from a flight or ferry) to prefer one of the management options indicates that familiarity with the good or some feeling of connection (but not direct use) increases the benefits to be expected from the proposed measures. Similarly, members of environmental organisations value the proposed measures more than non-members. This effect is frequently found in studies valuing biodiversity (e.g. Jobstvogt et al., 2014; Yao et al., 2014). Indicators of direct use of the marine environment, such as recreational angling and scuba diving or professional experience in a marine sector do not systematically affect choices. This is in contrast to the results of Jobstvogt et al. (2014) with respect to deep-sea ecosystem services.[11] The findings of the present study therefore indicate that values for the proposed benefits are mostly non-use in nature. This interpretation is further supported by the lack of any distance effects. Attitudes towards the management plan and recognition of existing financial burdens for households influence choices and WTP mostly as expected.

In addition to preference heterogeneity explained by these attitudinal variables, there is evidence of further random heterogeneity in preferences for the proposed benefits. This heterogeneity is particularly strong for changes in species diversity and the spread of invasive species, the two attributes which are likely to be more difficult to understand. Consistent with this, the results indicate rather uniform preferences for the protection of some charismatic species on 25% of the UK sector of the Dogger Bank — a benefit potentially more easily understood by respondents.

The failure to detect any decreasing or increasing distance effect in the choice data is interesting against the backdrop of ongoing discussions relating to distance decay of values elicited in stated preference surveys. Previous studies have found evidence for distance decay for use and non-use values in terrestrial (Bateman et al., 2006) and coastal settings (Luisetti et al., 2011). Schaafsma et al. (2012) have further shown that distance decay with respect to a terrestrial environmental good also depends on the availability of substitutes, which might differ between different geographical directions from the good to be valued. The present study, however, does not find evidence for any of those spatial patterns in values for Dogger Bank ecosystem services. Nor are there differences between respondents living near the coast (and potentially having substitutes for the proposed benefits available) and further inland. In an island nation such as the UK it is conceivable that respondents living at another part of the coast value the benefits from conservation of the Dogger Bank differently because (some of) these benefits are provided by the marine environment on their doorstep. Yet such differences could not be found. These findings reflect those reported by Rolfe and Windle (2012) and Choi (2013). They indicate that considerations about distance effects found for terrestrial and coastal environmental goods do not translate to an offshore site, such as the Dogger Bank. Non-use values, which constitute the major motivation for the benefits assessed in this study, might not exhibit linear distance effects but instead could show other spatial patterns (Johnston et al., 2011). It is possible that respondents living close to each other exhibit local clusters of relatively high or low WTP. Further research in this area is needed to clarify these preference patterns for marine environmental goods and services.

Finally two further caveats require mention. The first concerns values for species protection. There is still debate about how to include the conservation status of species (Jacobsen et al., 2008). This survey avoided explicit mentioning of conservation status of the harbour porpoise because it is not one of the features that led to the designation of the UK part of the Dogger Bank as a cSAC. Nevertheless conservation value may be an important component of non-use value. Secondly, standard survey practice requires the description of the payment mode to be as plausible as possible. The present survey did not further specify the household tax. Reasons for this are mentioned earlier, however, it cannot be said with certainty that this did not diminish the perceived realism of the valuation scenarios. The results should therefore be interpreted against this background.

Despite the mentioned limitations, an online survey allowed respondents from across the UK to be sampled. The resulting sample reflects the general structure of the UK population in terms of certain demographic characteristics. This is crucial when valuation estimates are to be used in an environmental CBA to support decision-making. It has also been shown that WTP estimates from postal and online surveys are comparable (Olsen, 2009; Rolfe and Windle, 2011). However, online surveys offer limited control on how respondents complete the questionnaire and take in the information. Christie and Rayment (2012) have shown that in workshop settings complex valuation topics can successfully be conveyed to respondents, it is not clear whether this is also true for online surveys. Most variables in the regression models affect choices in a plausible way, but it remains unclear to what extent respondents really grasp the concepts of species diversity and invasive species. Proper testing of questionnaires such as the use of "think-aloud" interviews proved to be crucial in this respect. It should also be stressed that the use of pictograms to increase understanding of choice attributes is not undisputed. While such pictograms ease the cognitive burden for respondents, they may cause emotional reactions in the respondent that might bias choices but are unobservable to the analyst.

4.4. Implications for Marine Management and Policy

In terms of marine management, the Dogger Bank provides a case study of a transnationally governed offshore MPA. Although there are likely to be additional cross-border benefits of consistent management of the MPAs by respective Member States, these were not assessed in the present survey but should be incorporated into future studies. Nevertheless results of studies such as this one can inform bio-economic models used to identify optimal locations for offshore wind farms or MPAs. For example, the model developed by Punt et al. (2009) determines the optimal location of a wind farm in the Dutch EEZ given local physical conditions and impact on ecosystem services but does not take into account the changes in values resulting from the ecological changes. Börger et al. (2014) have argued that valuation is indispensable for the incorporation of ecosystem services into such marine

[11] As one referee pointed out one choice attribute in Jobstvogt et al. (2014) relates to future use, which might explain the effect of angling on such values. Moreover, the fact that this study was conducted as a postal survey might have led to a high number of active users of the marine environment in the sample, which might be another explanation of that effect.

planning efforts as required by recent legislation, such as the EU Marine Strategy Framework Directive (Bertram et al., 2014) or in a less explicit manner by the US National Ocean Policy (NOC, 2013).

4.5. Concluding Remarks

The survey clearly identifies the conservation benefits from an offshore MPA for the general public. Through the use of a DCE, the present study has significance beyond this particular case. It demonstrates the applicability of stated preference methods to inform detailed policy-making for offshore sites. Despite limited prior knowledge about the study site, survey respondents are able to develop and express preferences on specific attributes based on the information provided in the survey. Studies of this kind can be employed to assess the attainment of potential benefits from marine management by the general public, a group beyond the immediate stakeholders and direct marine user communities. In negotiations about marine management plans, valuations can inform negotiations by providing the wider societal perspective and, thus, help to establish priorities among conflicting management goals.

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