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Twenty Thousand Sterling Under the Sea: Estimating the value of protecting deep-sea biodiversity

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The deep-sea includes over 90% of the world oceans and is thought to be one of the most diverse ecosystems in the World. It supplies society with valuable ecosystem services, including the provision of food, the regeneration of nutrients and the sequestration of carbon. Technological advancements in the second half of the 20th century made large-scale exploitation of mineral-, hydrocarbon- and fish resources possible. These economic activities, combined with climate change impacts, constitute a considerable threat to deep-sea biodiversity. Many governments, including that of the UK, have therefore decided to implement additional protected areas in their waters of national jurisdiction. To support the decision process and to improve our understanding for the acceptance of marine conservation plans across the general public, a choice experiment survey asked Scottish households for their willingness-to-pay for additional marine protected areas in the Scottish deep-sea. This study is one of the first to use valuation methodologies to investigate public preferences for the protection of deep-sea ecosystems. The experiment focused on the elicitation of economic values for two aspects of biodiversity: (i) the existence value for deep-sea species and (ii) the option-use value of deep-sea organisms as a source for future medicinal products.

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1. Introduction

1.1 Deep-sea ecosystem services

The deep-sea is the largest ecosystem on the planet (Thiel, 2003). It includes all ocean areas, from the shelf edge at -200 m water depth, down to the deepest trenches at -11,000 m, and covers 65% of the Earth's surface (Thistle, 2003; Tyler, 2003). Despite this vast geographical extent, it was long thought that the deep-sea environment hosts little or no life (Tyler, 2003), mainly because of its extreme conditions, such as total darkness, low temperatures, high pressure, and low food availability (Thistle, 2003). However, today we know that a high diversity of life is found in the deep oceans, which might even rival the diversity of tropical rainforests (Grassle & Maciolek, 1992; Van Dover, 2000). It is also an area that sustains major ecosystem services (ES), which are crucial for life on Earth as we know it. The deep-sea provides society not only with provisioning services such as food and hydrocarbons, but also with important regulating services, such as temperature regulation, regulation of atmospheric greenhouse gasses, and absorption of waste and pollutants (Armstrong et al., 2010 & 2012). Most importantly, it supports ocean life by cycling nutrients and providing habitat for a vast array of species. Some authors have argued that only final ES should be taken into consideration for economic valuation, leaving supporting services out of the equation (Boyd & Banzhaf, 2007; Wallace, 2007), to avoid double counting of their value and because they are extremely difficult to value (Armstrong et al., 2012). However, in particular for the deep-sea environment, supporting services might constitute the biggest contribution to life on Earth and Armstrong et al. (2010 & 2012) highlighted the importance of considering them to identify the deep-sea's main values. Less tangible cultural ES such as the scientific, existence, and inspirational values of the deep-sea ecosystem are often overlooked, as well as the value of maintaining biodiversity for generations to come. Finally, we can consider the option-use value of deep-sea tourism and finding medicinal products. Such ES may sound like science-fiction, but future technological improvements might well allow these options to become reality. To date, the small amount of literature on deep-sea ES is mainly of a descriptive nature and next to nothing is known about the economic values of this environment.

1.2 Main threats to deep-sea biodiversity

Marine ecosystems and the ES they provide have declined dramatically over the last century (Barbier et al., 2011; Worm et al., 2006) and ecosystem degradation comes at a cost for society, as the provision of important ES is affected (Barbier et al., 2011; NRC, 2006). To be able to value these changes, it is crucial to understand the threats to the marine ecosystem and their effects on biodiversity. Scientists agree that despite its remoteness, the deep-sea is far from being unaffected by human activity and wide-spread changes are already noticeable today (Benn et al., 2010; Fosså et al., 2002; Ramirez-Llodra et al., 2011; Van den Hove et al., 2007). Climate change, which is resulting in increasing ocean surface temperatures and ocean acidification, is thought to be the biggest future challenge for the deep-sea ecosystem (Ramirez-Llodra et al., 2011). The most immediate threats however, are related to the fishing sector, oil and gas exploitation, cable laying, pipeline construction, underwater noise and water pollution from shipping routes, waste dumping, drill cuttings from mining activities, and pollution from terrestrial sources (Armstrong et al., 2010 & 2012; Benn et al., 2010; Ramirez-Llodra et al., 2011). Whereas the environmental impact of mining on the seabed is still unknown, deep-sea fishing has been identified as having a major impact (Benn et al., 2010). Fisheries have targeted ever deeper fish stocks since the 1950s, even though deep-sea species are particularly vulnerable to overexploitation, due to their slow growth and late maturity (Morato et al., 2006). Many deep-sea activities are likely to increase globally over the next decades (Glover & Smith, 2003; Ramirez-Llodra et al., 2011), such as mining activities for deep-sea resources, like rare earth metals (e.g. gold, copper, zinc, and cobalt), and hydrocarbons (e.g. oil, gas, and gas hydrates), which will pose new potential threats to the deep-sea ecosystem (Halfar & Fujita 2007; Kato, 2011; Ramirez-Llodra et al., 2011; Rona, 2003). Mineral and hydrocarbon resources are already technologically exploitable today, with extraction being mainly limited by cost-efficiency constraints. As soon as global demand and prices rise, the economically viable exploitation of these remote resources is expected to increase.

1.3 Current marine legislation

Recognising and quantifying the economic value of biodiversity is key to sustainable ocean management (TEEB, 2012). Ocean ecosystems are particularly vulnerable to degradation, due to the fact that they are often located across political borders, and because there is a general deficit of good governance in ocean areas (TEEB, 2012). Some international agreements to administer and control the exploitation of marine resources already exist [we refer the reader to Thiel (2003) for further detail on regulatory organisations of deep-sea areas]. The UN Convention on Biological Diversity (CBD; 1992) triggered biodiversity conservation goals globally, so that today Marine Protected Areas (MPAs) not only exist in shallower waters, but also in the deep-sea. Aspirations of some conservation groups go as far as demanding protection for at least 20-30% of each ocean habitat (Balmford et al., 2004). Currently, it is very uncertain if such goals will be met in the near future. The international community failed to meet its CBD target to protect 10% of the oceans by 2012 (UNEP, 2010 & 2012). In 2010 about 1.6% of the oceans were protected and most of the MPAs are located in the shallower areas (UNEP, 2012). The UN has declared 2011-2020 the Decade on Biodiversity (DEFRA, 2011) and many nations are currently extending their national MPAs to apply with the CBDs Strategic Plan for Biodiversity 2011-2020 (EP, 2012). This plan highlights natural capital as society's life insurance, stresses the economic importance of biodiversity (EP, 2012) and sets the scene for environmental values to enter cost-benefit analyses (CBAs). When "hard" economic facts (i.e. monetary values) are presented to decision makers rather than qualitative types of value, they can serve as incentives for protection (Morling, 2005; Tinch et al. 2011). The inclusion of the non-use values of protection can have a positive influence on the acceptance for conservation management decisions (Tinch et al., 2011). However, non-use values are difficult to obtain in general and mostly non-existent for the deep-sea.

1.4 Main challenges to valuing deep-sea ecosystem services

Science has a limited understanding of how biodiversity is affected by human impacts, and how changes in biodiversity bring about changes to ES. The major part of the deep-sea remains unknown and some scientists refer to it as one of the "least understood" environments on Earth

(Ramirez-Llodra et al., 2010; Tyler, 2003). The available information on deep-sea ES is mostly of a descriptive nature and the majority of experts would be reluctant to put numbers on the ES changes that we have to expect in the future. The biggest challenge of attaching economic values to deep sea ES and biodiversity, however, is not the lack of scientific certainty about the baseline and future trends, but rather the unfamiliarity of the general public with the deep-sea environment. This is relevant given the likelihood that researchers will need to use stated preference methods to estimate values for deep sea biodiversity. Ocean literacy across the population is thought to be limited in general (Steel et al., 2005) and awareness can be expected to be even lower for the deep-sea. The deep-sea environment remains remote to the majority of people (Ramirez-Llodra et al., 2011). Most members of the general public also poorly understand complex ecological concepts such as biodiversity (Christie et al., 2006; Ressurreição et al., 2011; Spash & Hanley, 1995; Turpie, 2003). However, people are able to learn and form their values given an appropriate approach to surveying (Christie et al., 2006), and by combining new information on biodiversity attributes with their attitudes and beliefs. Another factor that makes stated preference valuation difficult for the deep-sea is the lack of charismatic species, which has been shown to be an important factor determining WTP (Christie et al., 2006). However, interest in the deep-sea is rising (Tyler, 2003), thanks to public outreach incentives of international large scale projects, such as the Census of Marine Life, and documentaries like BBCs ‘Blue Planet’ (Beaumont et al., 2008).

1.5 Previous studies valuing deep-sea biodiversity and ecosystem services

The socio-economic valuation of marine ecosystems services lags far behind that of terrestrial ecosystems. A global valuation of ecosystem services estimated an annual flow value for the marine environment (including coastal waters) of $20.9 trillion, or 63% of the value provided by all ecosystem services globally (Costanza et al., 1997), although there are well-known problems with the interpretation of this figure.

A survey in Ireland estimated non-use values that the general public had for the protection of cold water coral (CWC; deep-sea species) habitats off the Irish coast (Glenn et al., 2010; Wattage et al., 2011). The respondents of this survey were willing to pay (WTP) for CWC protection, between

€0-10 per person. Follow-up questions identified different non-use values for corals: 84% of participants would like to see corals protected for their existence value, whereas 90% stated they wished to leave them protected for future generations (Glenn et al., 2010; Wattage et al., 2011). Marine biodiversity valuation studies often focus on single or high profile species, such as CWC, and Ressurreição and colleagues (2011) argue that other ecosystem components and low profile species respectively, should be taken into account. A second case study, which included parts of the deep-sea in addition to shallower waters, focused on valuing species loss around the Azores archipelago (Ressurreição et al., 2011). A contingent valuation survey was undertaken which discussed the protection of a wide range of species, compared to the single species approach in the Irish CWC study. Choice scenarios were presented as one-off payments for avoiding reductions in species richness and resulted in WTP estimates of €405 to €605, per visitor or resident, for preventing 10-25% losses in marine species richness in the region.

There is thus a dearth of empirical studies which try to quantify the non-market benefits of protecting deep sea areas. Our case study presents empirical data from a national stated preferences survey, undertaken in Scotland in 2012. We now describe the methods used in and the design of this survey (section 2). Section 3 presents results, and Section 4 provides a discussion and conclusion.

2. Methodology

2.1 Discrete choice experiments

The discrete choice experiment (DCE) method, as described by Hensher et al. (2005) and Louviere et al. (2000), is an increasingly popular approach to elicit monetary values for non-marketed goods. The DCE method belongs, like contingent valuation, to the family of stated preferences methods (Carson & Louviere, 2011). The DCE method has the advantage that the hypothetically marketed good is divided into its components or attributes. This improves its usefulness in a management context. Participants are asked to make a choice between alternatives with different attribute-levels. The method allows us to infer which attributes are most important for people's choices, estimate WTP for changes in attributes (i.e. marginal values), and predict WTP for future scenarios with different bundles of attributes (i.e. total value) (Hanley & Barbier, 2009).

Our un-labeled DCE offered three options per choice task, with two hypothetical management options and one business as usual option. If feasible, it is good practice to include a status quo or opt-out option, in case the participant is not willing or able-to-pay for either of the hypothetical options (Ryan & Skåtun, 2004). Our DCE questionnaire reminded participants (i) to account for budget constraints, and (ii) to think about their other household expenses in making their choices. The focus area of this survey was the deep-sea area of the UK's North and Northwest Exclusive Economic Zone (12 - 200nm off the coast), which for this survey was referred to as the Scottish deep-sea. The hypothetical market consisted of options to establish different protected areas within this area, at a cost to households and to the sectors impacted by restrictions.

2.1.1 Designing the hypothetical DCE scenarios

The hypothetical scenarios were built around government plans to extend existing Marine Protected Areas (MPAs) around the UK as part of the UK's biodiversity conservation strategy. Details on how new MPAs will be implemented in future, or to what extent, did not exist by the time of survey design. For the design of the choice experiment scenarios we therefore used a conservative MPA area estimate, which remained below the maximum values that conservation organisations were proposing (20-30% of each habitat; Balmford et al., 2004). Survey participants were told that deep-sea areas of 7,500 km^2 (1.5% of Scottish waters; status quo in January 2012) are currently protected. The DCE enhanced protection scenarios proposed a fourfold increase of the existing protected deep-sea area to 6% of Scottish waters. Participants were asked for their WTP for this increase. The population sample was split into two groups, which were told different stories of how protection would be achieved. Group A was told that the additional MPAs would exclude the fishing sector, and group B was told, that not only the fisheries sector, but also the oil and gas sector would be affected by the implementation of new MPAs. The two sectors had been identified as the most important marine sectors in deep-sea areas, and those sectors with the largest potential future impacts on deep sea ecosystems. People were told that additional protection would impose costs on Scottish tax payers to cover the costs of environmental assessments, administration, and patrolling of the protected areas. Payments would be collected via an additional income tax per household. Participants were also told that the additional tax payments would take effect from the end of 2012, as protection plans would be implemented by the end of the same year. Both, the payment vehicle as well as the cost for protection were of a hypothetical nature and solely developed for the DCE scenarios. It is very likely that future protection plans would indeed be paid for with tax revenues, so that a national tax increase was the most realistic payment vehicle to use.

2.1.2 Developing the choice attributes

A list of deep-sea ecosystem services by Armstrong *et al* (2010) and Hove *et al* (2007) served as source of potential attributes for the DCE design. The following criteria were used to pre-select ES from that list to enter into the potential attribute list:

(I) ES expected to be affected by anthropogenic impacts, excluding climate change

(II) Magnitude of the ES impact potentially manageable by marine protected areas

(III) ES of a biotic nature (excluding abiotic goods and services, such as minerals or water circulation; i.e. all ES greyed out in table 1)

(IV) Exclusion of supporting services, such as nutrient cycling, on account of concerns on double-counting ecosystem service values

(V) Adaptable to DCE framework (i.e. different levels are exchangeable across choice task options)

The potential attributes list was then further refined with five focus groups and face-to-face interviews with UK residents. A total of 37 people were included in this pre-pilot survey process and strongly influenced the in-/exclusion of attributes and the framing of scenarios and attributes respectively. Two ES were then chosen for the final experimental design. These were (I) potential for new medicines from deep-sea organisms (a measure of option value) and (II) number of protected species (a measure of existence value). We decided against the inclusion of a habitats attribute (e.g. cold water coral reef, seamount, and continental slope), as focus group participants were not familiar with these deep-sea habitats and the cognitive burden of developing preferences, based on brief introductory text, and within the short time available, was seen as too high. Restriction on the fishery and hydrocarbon sectors entered the DCE via the scenarios as fixed attributes through the use of split samples, after the inclusion of restrictions into the DCE as an interchangeable attribute had been tested unsuccessfully. Focus group participants found it difficult to make judgements on the type of restrictions that should be imposed for protected areas when they had the choice between fisheries sector and oil & gas sector. The reason for this lack of confidence was thought to be a lack of information and the cognitive burden of processing new information on restrictions and their potential economic impact, if in the latter case an introduction on impacts related to marine activities was provided. Using a split sample with fixed restrictions per group of respondent was therefore preferred for the final design. This means that one half of respondents received a choice experiment where new deep sea protected areas were created through restrictions on the fishery sector alone; and the other half received a choice experiment where these restrictions extended to the oil and gas industry as well as the fisheries sector (it was not realistic to consider *only* restricting oil and gas, since fisheries have the most important impact on deep sea biodiversity around the Scottish coast).

The number of protected species was used as a proxy for biodiversity since species richness (i.e. the total number of species) is a simple concept to assess and understand. Species richness has been successfully used by other stated preferences surveys (Ressurreição et al. 2011). From an ecological perspective, species richness is thought to be a good index when impacts and the ecosystem response have to be assessed (Olsgard, 1993). We used total species estimates, rather than non-quantitative attribute-levels for the species protection attribute (e.g. high / medium / low species numbers). Scientists are uncertain about the number of species in the deep-sea and information on species-area relationships varies very much between studies. We therefore decided to base our estimate on the most extensive study of deep-sea bed fauna that has been conducted to date (Grassle & Maciolek, 1992) and used the maximum species estimate of this study as our maximum species number: 1600 deep-sea species under protection. Grassle & Maciolek (1992) found 1597 species on a

180 kilometre long sampling transect across the North-western Atlantic continental slope. They also assumed that for every added transect kilometre only one more species would be found. The main objective of using a quantitative estimate was to present the potential relative possible change in regional species numbers between a high (i.e. large area) and a low protection scenario (i.e. small area) with a realistic baseline. Seafloor surveys showed that species numbers can be as much as 59% reduced in trawled areas compared to non-trawled areas (Koslow et al., 2001). We were therefore interested in a change of species numbers between 0% and 60% (a maximum of 1600 species compared to the hypothetical baseline of 1000 species).

Aspirations to find biomedically-active compounds in the future are high within the science community (Arico & Salpin, 2005; Leary et al., 2009). Such medicinal products were chosen as a DCE attribute, to include an engaging and non-altruistic example for deep-sea ecosystem services, compared to the other often complex or less tangible deep-sea ES. Examples for biomedical discoveries in shallower, tropical waters are relatively plentiful compared to a handful of successful deep-sea case studies, due to the high costs of exploring the deep-sea ecosystem (Maxwell, 2005). To date, scientists have mostly discovered toxins from snails or sponges that are now used in cancer treatment or as pain killers. Future developments of currently unknown medications from deep-sea microorganisms are a major research aspiration (Arico & Salpin, 2005; Leary et al., 2009). Scientists are concerned that some of the potential useful compounds might never be found due to destructive marine activities that may wipe out species before they are discovered (Arico & Salpin, 2005; Maxwell, 2005). The medicinal products attribute combined uncertainty with a future use value (i.e. option value). Direct comparison with the preferences for species existence was possible as part of the DCE framework.

2.1.3 Choice tasks

For the design of the main survey a D-efficient design with two blocks and a total of 12 choice cards was chosen. A pilot survey with 42 participants was conducted to obtain informed priors for the design produced in Ngene (Econometric software; version 1.1.0). Participants were offered six choice cards each and were asked to choose from three different options per card, including a business as usual (BAU) option. An example choice card is provided in figure 1.

The BAU option was described as a no-cost option with no additional protected areas. A total of 1000 species under protection was set as the baseline for the BAU option, as opposed to 1000, 1300, or 1600 species in the hypothetical protection scenarios (in the model dummy variables for these attribute levels are called SP1300 & SP1600). The baseline for medicinal products was described as currently unknown and with a possible change to high potential in one of the future scenarios (dummy variable: MED). The change from unknown to high potential was explained to participants through a lack of current scientific knowledge and the necessity of additional research effort and time to find biomedical substances in the future. Whereas, species protection was described as an outcome that would be immediately available (i.e. after implementation of protected areas), medicinal products were described as a future possibility, with an uncertain outcome in respect to its scope. It was pointed out to participants, that both species diversity and scope for medical products were expected to deteriorate outside the protected areas in the future. The cost attribute (variable: COST) was a continuous variable with six levels: £5, £10, £20, £30, £40, and £60. Participants were reminded to choose the business as usual option if they felt that all other options were too expensive. They were also asked, after completing the six choice tasks, why they had decided to choose the business as usual. This information was used to identify protesters among the respondents, which were then excluded from the statistical analysis.

2.2 Survey and questionnaire

All participants for the main survey were randomly selected from the Scottish phone directory and contacted via mail. In total 1,984 households around Scotland were contacted (0.05% of the Scottish population[5]). Addresses were known, but no information on gender, age, income or occupational status was available prior to the survey. A first reminder letter was sent two weeks after the first contact attempt and a third mail out, containing an additional copy of the questionnaire, followed five weeks after the initial mail out (sampling procedure based on Dillman, 1978). In

[5] According to the Scottish Population Census 2010 (NS, 2011), a total of 4.184 million people of age 18 and older lived in Scotland in 2010.

principle, every adult household member was allowed to fill out the questionnaire. Of all 1984 mailed out questionnaires, 545 (27%) were returned at least partially completed, which is a high response rate for a postal survey. Only 3% of the addressees could not be contacted (i.e. addressee moved, deceased, or returned for unknown reason), and 4% chose not to participate. After three contact attempts, there was no information available for the remaining 65% of the originally contacted households.

The questionnaire contained 38 questions spread over ten A4 pages. Focus group trials suggested that participants needed 20-30 minutes to complete it. Participants were provided with a map of the Scottish deep-sea and a one-page introduction on what was meant by the term “deep-sea”. The introduction was followed by a self-evaluation (five-point scale from ‘I knew everything’ to ‘I knew nothing’) of participant’s knowledge, depending on how much of the information, provided in the introduction, they thought they already knew before participating. Further on, choice attributes and scenarios were explained, followed by six choice tasks. Every choice task was accompanied by a question on how confident (five-point scale from ‘very confident’ to ‘not very confident’) the respondent felt to choose one of the three options. The statements on confidence provided valuable information on how people felt about completing the choice tasks and their perceived ability to make choices. A copy of the questionnaire is available online as supplementary material.

2.3 Statistical analysis

The statistical analysis was conducted in STATA (version 12.1). The two survey samples, group A (fisheries industry would be restricted in protected areas) and group B (oil & gas industry and fisheries restricted in protected areas), were both analysed separately and as a merged dataset, which is referred to as MERGED below. For this merged data an additional dummy variable was introduced (REST), to account for the different scenario descriptions in respect to the marine sector restrictions. Two different models were used to estimate attribute coefficients, the mixed logit model (ML; random parameter model), and the conditional logit model (CL). The ML used normally- distributed random parameters with a fixed cost coefficient. All variables used in the models were dummy variables, apart from the COST, AGE, FISH and CONF, which were treated as continuous variables (table 2). Implicit prices for the main attributes and the consumer surplus for the “best” protection scenario were estimated. The “best” scenario was defined as the highest species protection level and high potential for new medicinal products.

A number of responses, in total 148 (27%), were excluded from the estimation process in Stata. The exclusion criteria were: (a) incomplete choice cards; (b) irrational choices (i.e. one scenario offered a better future scenario for lower cost and responses were categorised as irrational if they did not select either the business as usual or the lower cost option); (c) protest responses (including answers such as ‘others should pay’, ‘options are unrealistic and won’t work’, ‘disagree with additional restrictions on the fisheries or oil and gas sector’); (d) missing data within the individual specific characteristics used as interactions.

3. Results

3.1 Sample characteristics

The socio-demographic analysis revealed a skew towards the retired male population. The mean age group was 56-65 years and retired people made up 50% of the responses compared to the Scottish average of 14% (NS, 2010). The age groups below 45 years were underrepresented, as well as women with only 35% participation rate. The vast majority of respondents (97%) were British citizens, with 85% claiming to be Scottish. Overall 12% stated to have worked for either the oil & gas (10%) or the fisheries sector (2%). Affiliation to either of the two marine sectors entered the model as dummy variable SECTOR. The mean income was within the £20,001 – £30,000 per household income group. Mean household size was 1.9 members and the three highest ranking educational levels were: (I.) further education (25%), (II.) standard grade (23%), and (III.) undergraduate degree (20%). Within the sample 49% were working, 20% were or had been members of an environmental organisation, 11% stated to have some dive experience, and 63% said that they eat fish at least once per week. The latter four individual specific variables entered the DCE model estimation as interactions (WORK, NGO, DIVER, and FISH; variables explained in table 2), as they were considered to have a potential effect on choice behaviour.

3.2 Attitudes towards marine conservation

The survey follow-up questions revealed that the majority (73%) of respondents found it worth paying for protection of deep-sea areas, because society would benefit from it in the long-term. 81% of respondents agreed that marine protection around Scotland would be beneficial for the marine environment and only 6% were opposed to this notion. People were more divided when it came to the impact that the additional protection would have on the marine economy in the future. Here, 22% saw a negative impact on the marine economy, whereas 48% did not believe that this would be the case. The extraction of marine resources was seen by 18% as more important than deep-sea protection.

The main reason for 178 respondents to choose a business as usual (BAU) option at least once was the costs of protection (61%). Beyond that, additional restrictions (33%) were an important factor, as was the sentiment that others should pay for protection (17%). A general lack of interest (9%) was the least selected reason for choosing the BAU. Many respondents stated that they were concerned about the effect that additional MPAs would have on remote communities and the fishing sector in particular (e.g. "the marine industries support many remote communities"; "I would not like to see our trawler men facing further restrictions"). Existing EU fisheries restrictions were seen as a problem (e.g. "there is already too much interference and regulation"; "local fishing industry should be protected"; "unfair advantage to foreign fleets"), but also the need for international agreements to manage the deep-sea areas (e.g. "Scotland cannot do it alone"; "international solutions needed"). Overall the opinions on human impacts were very wide spread, but people showed higher solidarity with the fishing sector than the oil and gas sector (e.g. "Oil and gas companies wreck the environment for profit"; "I think it is a shame to lump together the gas/oil and the fishing industry. Scottish fishermen have a long history.").

The self-evaluation of deep-sea knowledge revealed that 63% of the respondents felt that they knew only half or less of the information discussed in the survey introduction. 17% of respondents stated to know most or all of the topics that were discussed (a remainder of 20% skipped this first question). Irrespective of the little knowledge people stated to have, 53% felt confident or very confident to answer the six choice tasks of the DCE. Only 19% did not feel confident or not very confident to choose from the three options. A relatively small percentage (6%) of respondents found the survey not credible, whereas 70% stated that they found it interesting.

3.3 Choice preferences

For the choice analysis in STATA 148 responses (27%) were excluded from the analysis, with the maximum remainder of 397 fully completed surveys. All main attributes showed *a priori* expected coefficient signs with MED, SP1300, and SP1600 being positive and the cost attribute being negative. The main attributes were significantly different (at the 1% level) from the baseline across all datasets and estimated models. The average respondent had similar preferences for 'new medicinal products' as for the highest level of 'number of protected species'. We found a significant positive relationship between the confidence level and choices where respondents had not selected the BAU option, this was the case across both samples and all statistical models. It did not matter for choice making if people had been working in one of the affected marine sectors (SECTOR). SECTOR was not significant in any of the samples or models. Overall WTP was positive and significant for all attributes, across all samples and models.

3.3.1 The merged dataset

When looking at the merged dataset (MERGED; table 3 & 4), we found that the consumer surplus for the "best" option (i.e. highest species protection and high potential for new medicinal products) was on average £70 for the CL and £77 for the ML model respectively. Respondent's WTP was similar for the potential for medicinal products (MED) and the highest level of species protection (SP1600), with £35-38 (MED) and £35-39 (SP1600). Respondents held, as expected, a significantly higher value for the highest species protection (SP1600) as opposed to intermediate species protection (SP1300) expressed as a £12 higher WTP in both models. Interactions between the ASC and individual specific characteristics were significant in both models for gender (GEND), fish consumption (FISH), being a member of environmental organisation (NGO), and confidence level (CONF). Being a member of an environmental organisation turned out to have a significant effect on respondents to choose one of the future protection options. Male participants were more likely to choose one of the protection options, as were people who ate relatively more fish, and people who felt more confident in their choices. Being a diver was a very strong explanatory variable for choosing an option different from the BAU with an additional average WTP of £34 to swap from the BAU to a protection option, at least in the CL model. The ASC was very high for both models but only significant for the ML model. It showed the widest standard deviation for the ML model, which indicated high preference heterogeneity for the unobserved part of the model. People who worked (WORK), or who were older (AGE) were not making significantly different choices. We did not find any significant differences in choice making depending on which sample group respondents belonged to (i.e. group A or B). The coefficient for REST was insignificant when looking at the MERGED data. However, samples were analysed separately to find differences that had not been picked up by analysing the MERGED data.

3.3.2 Differences between samples

The two samples A and B showed some important differences for the significant individual specific interactions (table 5) We found that, for group A respondents, fish consumption (FISH), being a diver (DIVER), and being male (GEND) had a significant negative effect on choosing BAU, whereas for group B these variables were not significant. Instead, being a member of an environmental organisation (NGO) and their confidence on completing the choice tasks (CONF) were the only significant explanatory variables apart from the main attributes. For group B the ASC was significant, which indicates a high unobserved utility within this model. As in the MERGED dataset, the age of the respondent and if they were working, were insignificant variables for choice making. The consumer surplus for the "best" option was not significantly higher for group A with £72 compared to group B with £67. The analysis of the separate datasets with the ML model did not lead to any additional insight on choice behaviour beyond the CL model. Both models provided similar WTP values for species protection and medicinal products.

4. Discussion

A lack of evidence on monetary values of deep-sea ES and biodiversity was one of the main research gaps highlighted by a recent review on deep-sea ES by Armstrong et al. (2012). Our Scottish case study can help to increase the understanding on deep-sea existence values, option-use values, and the valuation of unfamiliar and remote goods and services in general. In the following discussion we highlight our experience on how to value species existence and option-use of deep-sea organisms, but also discuss the wider challenges of valuing ES that people are unfamiliar with.

4.1 WTP for deep-sea protection

High WTP for deep-sea protection, ranging from £70 to £77 for the "best" option, points out that survey participants cared for protection of vulnerable ocean areas, despite the remoteness of and their own lack of familiarity with these areas. At the same time it was important to respondents *how* protection was achieved. It is uncommon in marine planning to include non-users into the decision process, even though non-users can hold high values for the ocean, as we demonstrated with our survey. We argue that good ocean governance starts with a more democratic approach and should encourage the inclusion of the general public into the decision making process for conservation. One of the key questions is, is it reasonable to promote the citizen as a steward of the marine environment, even though she possesses much less knowledge on the topic than marine users, conservation groups, or policy makers? The Scottish case study generally supports this idea. The majority of the citizens who participated in our survey were not affiliated with the marine economy and stated to have very little knowledge on deep-sea issues, which however did not translate into a general lack of interest. On the contrary, the high WTP for increasing the UK deep-sea protected areas mirrors the high value that people associate with medicinal products and species' existence, even though the latter ES was of no direct benefit to them.

Aldred (1994) explains existence value as a moral resource, which increases the valuer's utility in the absence of any direct benefit, and for which the valuer is willing to give up scarce resources, in this case part of her income. It is possible that the questions on the existence value of deep-sea species have caused decision conflicts for some participants, as they had to make trade-offs between their deeper held moral values for species protection, their personal economic loss (i.e. additional tax) and the economic loss of others (i.e. restrictions on the marine sector). The latter was a complex trade-off, because it involved not just the direct economic loss for fishermen, but also uncertain consequences for rural communities dependent on the fishing sector, and the cultural and historical importance of fishing to Scottish coastal areas. The trade-off with the personal economic loss through taxes seems to have been relatively easy for participants, as indicated by a high confidence during the DCE. However, the second trade-off, appeared to be much more challenging, as can be gathered from participants' comments. This had to do with the little knowledge that most people had on the marine economy and restrictions in general, but also the complex values that participants expressed for the fishing industry. In this respect some researchers have pointed out that one of the valuation challenges, when moral principles are involved, is that own values and values of others can become intertwined and increase complexity for the choice maker (Brennan, 1995; Chan et al., 2012). That means that it might be necessary to pose the question on deep-sea protection in a wider context, taking other societal issues into account. A social survey by Potts et al. (2011) for example found that ocean conservation had a very low priority for the UK general public. Ocean health was ranked last of 11 societal issues, such as (I) the cost of living, (II) the economy, and (III) affordable energy. Only 32% of the UK participants stated that ocean health was important or very important to them.

The survey by Potts et al. (2011) can help to explain the societal context for the very specific question on deep-sea protection that we asked. It was apparent during our DCE survey that most participants found the topic interesting, but had mostly not thought about the issue of marine protection before being contacted. However, moral concerns for unsustainable deep-sea exploitation that ignores species protection were high. High WTP for protecting deep-sea areas in our study echoes the high WTP for species protection demonstrated by Ressurreição et al. (2011) for the Azores archipelago (Portugal), and Portuguese respondents had shown equally low priority for ocean health as the UK (Potts et al., 2011). Potts and colleagues also demonstrated a positive relationship between support for MPAs and the amount of fish consumed on an international level. We found that this relationship appears to exist on a national level as well, as the variable for fish consumption was positively correlated with deep-sea protection in our sample. The significant positive relationship that we found between protection and being a member of an environmental organisation or being a diver was less surprising. We argue that divers had higher WTP for deep-sea protection, because they had seen underwater landscapes (even though not those of the deep-sea) and could better relate to the marine environment, than people who had never looked below the ocean surface. Whereas donors of environmental organisations were expected to seek protection for its own sake (Chan et al., 2012), i.e. without any future direct personal benefit.

4.2 Unfamiliarity and uncertainty in DCE

The classic DCE includes a bundle of attributes that people are familiar with. For our deep-sea DCE it is certain that most respondents learnt for the first time about the deep-sea attributes that they were confronted with. Unfamiliarity with deep-sea ES per se is not a reason to abandon the DCE approach (Barkmann et al., 2008). Participants are able to learn during an experiment (Christie et al., 2006) and to tell us about their newly developed preferences based on deeper held moral values (Kenter et al., 2011). Here we follow the arguments of Meinard & Grill (2011), who state that there is no study which shows that people are incapable of expressing their values for something for which they did not have a pre-existing preference and how much they are willing to pay for it. Some researchers go even further when they say that most people do not have clearly defined, pre-existing welfare preferences for environmental goods and services at the point of participation in a valuation survey (Chan et al., 2012).

Either way, here it appears that people easily formed preferences, in this case for new medicinal products, which have obvious benefits. This was despite the fact that the attribute contained some uncertainty about when these medicines would be found and if researchers would be able to identify medicines from deep-sea compounds at all. This framed uncertainty was a reflection of the scientific dispute on the potential of deep-sea organisms for industrial or medicinal use. Due to the high costs for deep-sea exploration, part of the science community remains dubious about the success rate of this enterprise (Leary et al., 2009). We were interested to see the degree of support across the population to set aside areas to search for potentially interesting substances and found that it was equally important for choices as species protection.

The considerable WTP expressed by participants overall, after being confronted with information on the deep-sea, suggests that lack of knowledge rather than the lack of interest explains the near absence of wider societal values associated with deep-sea protection found by Potts et al.

(2011). Thus, the lack of ocean literacy undermines the value of marine biodiversity and it is therefore crucial to increase public understanding for ocean ES if their value is to be recognised and accurately accounted for.

4.3 Policy application

It is virtually certain that the provision of ecosystem services would change drastically if we allow marine activities to continue in the same way over the next decades. Nonetheless, there remains much uncertainty about the scope and direction of changes that have to be expected for the ocean as a whole (Ramirez-Llodra et al., 2011). Direct links between deep-sea species and direct benefits to society have not been successfully shown to date, except for the fishing sector, and might not be shown in the near future. That means that a fully monetary approach to estimate the total economic value of the oceans, using only final ES and ignoring supporting services, would devalue the deep ocean rather than support its conservation. Protection for the sake of species and habitat diversity should remain a priority regardless, since several deep-sea habitats (e.g. cold-water coral reefs and seamounts) have been identified as biological hotspots (Ramirez-Llodra et al., 2010) and should be protected under the precautionary principle. When it comes to trade-offs with the marine industry, the high non-market values that we have identified can help decision makers to justify marine conservation on a more democratic basis than it is often the case today. Given the strong values for potential medicinal products even whilst taking uncertainty into account, we recommend using this ES more often in justification for protecting certain areas, such as hydrothermal vents among others, which host low biodiversity, but have high biotechnological utility (Leary et al., 2009). The possibility of medicines from deep-sea organisms has a huge potential for public outreach programmes, as there is a future-use value associated with the ES, and survey participants found this topic particularly interesting. To increase appreciation for deep-sea ES in general, more educational programmes are necessary to highlight the potential links between the ocean and societal benefits. We expect that the more certainty arises around actually being able to benefit from ES such as medicinal substances, the higher WTP in future studies such as ours will be.

4.4 Conclusions and further research

Our survey showed that Scottish participants supported the idea of deep-sea protection and that despite a limited knowledge, the results show that given basic information, citizens can be useful participants in marine policy formation. We successfully demonstrated that policy makers are better off to consider the existence value that people associate with species protection in combination with the direct benefits of marine protection, and that overlooking non-users will necessarily lead to undervaluation of marine ecosystems. For the successful transfer of our results it would be beneficial to look into the cultural differences between countries and how the availability of information (low vs. high amount of information prior to the DCE) affects people’s preferences (Hynes et al., 2013). Comparing expert’s preferences with that of the general public might be a good indicator in this respect.

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Table 1: Deep-sea ecosystem goods and services

Supporting services	Biodiversity
	Chemosynthetic primary production
	Habitat
	Nutrient cycling
	Resilience and resistance
	Water circulation and exchange
Provisioning services	Carbon sequestration and storage
	Chemical compounds
	Construction and shipping space
	Finfish, shellfish, and marine mammals
	Minerals, and hydrocarbons
	Waste disposal sites
Regulating services	Biological control
	Gas and climate regulation
	Waste absorption and detoxification
Cultural services	Aesthetic, spiritual, and inspirational
	Educational and scientific
	Existence and bequest

Goods and services that are not dependent of deep-sea biota, are greyed out. Source: Armstrong et al. (2012) with alterations.

Table 2: Attribute variables and levels used in DCE

MED	Potential for the discovery of new medicinal products from deep-sea organisms. a) High potential and b) unknown potential (baseline).
SP1300 & SP1600	Number of deep-sea species under protection. a) 1600 species (SP1600), b) 1300 species (SP1300), and c) 1000 species (baseline).
COST	Additional annual income tax per household. Levels: £5, £10, £20, £30, £40, and £60.
ASC	Alternative specific constant (1 = BAU).
GEND	Gender (1 = male)
WORK	Working (1 = yes) as opposed to not working, students, or pensioners
AGE	Age (range 18 to 75+ years)
FISH	Fish consumption (0 = ”never eat fish”, 3 = “eat fish at least once per week”)
DIVER	Diver (1 = yes)
NGO	Member of environmental organisation (yes = 1)
SECTOR	Worked in one of the affected marine sectors (1 = yes); either fisheries or oil & gas sector
CONF	Confidence on completing the choice task (0 = not very confident to 4 = very confident)
REST	Economic restriction in the introduction (1 = fisheries and oil & gas sector)

The main attribute variables and the levels that were used for the DCE are listed in the upper block of the table, and interactions with individual specific parameters in the lower block. All interactions were created with the ASC [1 = business as usual (BAU)].

Table 3: Attribute coefficients and WTP estimates for the conditional logit model for the MERGED dataset.

Variable	Coefficient	WTP (£)
ASC (business as usual option)	2.059 (0.904)**	-
MED (high potential for medicinal products from deep-sea organisms)	1.056 (0.065)***	35.43
SP1300 (intermediate level of species protection)	0.670 (0.066)***	22.48
SP1600 (high level of species protection)	1.038 (0.091)***	34.83
COST (additional income tax per household)	-0.030 (0.002)***	-
GEND (male)	-0.732 (0.271)***	-24.56
WORK (working)	-0.343 (0.363)	-
AGE (years)	-0.008 (0.015)	-
FISH (high fish consumption)	-0.374 (0.158)**	-12.54
DIVER (some dive experience)	-1.026 (0.556)*	-34.42
NGO (member of environmental organisation)	-0.718 (0.406)*	-24.08
SECTOR (affiliation with fisheries or oil and gas sector)	0.090 (0.564)	-
CONF (very confident about choice)	-0.351 (0.131)***	-11.77
REST (restrictions for fisheries and oil and gas sector)	-0.355 (0.281)	-

Significance levels are shown as ***, **, * for 1%, 5%, and 10% level respectively. The dataset contained 7146 observations over 397 individuals (max LL = -1938; pseudo R^2 = 0.26). Interactions of individual specific characteristics with the BAU are presented in the second part of this table. A negative interaction coefficient indicates that respondents preferred not to stay with the BAU.

Table 4: Attribute coefficients and WTP estimates for the mixed logit model for the MERGED dataset.

Random parameters	**Mean of coefficient**	**WTP (£)**
ASC (business as usual option)	2.907 (2.022)	-
MED (high potential for medicinal products from deep-sea organisms)	1.459 (0.108)***	37.85
SP1300 (intermediate level of species protection)	1.012 (0.104)***	26.28
SP1600 (high level of species protection)	1.501 (0.136)***	38.70
	SD of mean coefficient	
ASC	-4.248 (0.471)***	-
MED	0.865 (0.118)***	-
SP1300	0.000 (0.107)	-
SP1600	1.126 (0.472)***	-
Non-random parameters	**Fixed coefficient**	
COST (additional income tax per household)	-0.038 (0.002)***	-
GEND (male)	-1.701 (0.671)**	-44.18
WORK (currently working)	-0.376 (0.806)	-
AGE (years)	-0.023 (0.030)	-
FISH (high fish consumption)	-0.813 (0.371)**	-21.12
DIVER (some dive experience)	-1.402 (1.129)	-
NGO (member of environmental organisation)	-1.585 (0.855)*	-41.17
SECTOR (affiliation with fisheries or oil and gas sector)	-0.423 (1.133)	-
CONF (very confident about choice)	-0.874 (0.188)***	-22.71
REST (restrictions for fisheries and oil and gas sector)	-0.575 (0.627)	-

The standard deviation (SD) is given for the four random parameters (ASC, MED, SP1300, and SP1600). The dataset contained 7146 observations over 397 individuals (max LL = -1643; pseudo R^2 = 0.17; 1000 Halton draws). Interactions of individual specific characteristics with the BAU are presented in the second part of this table. A negative interaction coefficient indicates that respondents preferred not to stay with the BAU.

Table 5: Conditional logit model estimates for DCE attribute coefficients and WTP of the two sampled groups

	Group A		Group B	
Variable	**Coefficient**	**WTP (£)**	**Coefficient**	**WTP (£)**
ASC	1.468 (1.150)	-	2.665 (1.547)*	-
MED	1.100 (0.083)***	35.95	1.010 (0.100)***	34.81
SP1300	0.723 (0.094)***	23.64	0.614 (0.092)***	21.17
SP1600	1.113 (0.133)***	36.38	0.959 (0.124)***	33.04
COST	-0.031 (0.003)***	-	-0.029 (0.003)***	-
GEND	-0.880 (0.363)**	-28.77	-0.573 (0.416)	-
WORK	0.037 (0.442)	-	-0.931 (0.590)	-
AGE	0.002 (0.018)	-	-0.025 (0.026)	-
FISH	-0.389 (0.203)*	-12.71	-0.324 (0.233)	-
DIVER	-1.356 (0.793)*	-44.31	-0.764 (0.959)	-
NGO	-0.450 (0.537)	-	-1.225 (0.598)**	-42.21
SECTOR	0.228 (0.650)	-	-0.318 (1.098)	-
CONF	-0.351 (0.197)*	-11.47	-0.345 (0.171)**	-11.88

Group A with fisheries restrictions (observations = 3744; individuals = 208; max LL = 1038; pseudo R^2 = 0.24) and group B with oil & gas sector and fisheries restrictions (observations = 3402; individuals = 189; max LL = -893; pseudo R^2 = 0.28). Significance levels are shown as ***, **, * for 1%, 5%, and 10% level respectively. A negative interaction coefficient indicates that respondents preferred not to stay with the BAU.

SCENARIO 5	Option A	Option B	Option C (“Business as usual”)
New medicinal products (potential for the discovery of new medicinal products from deep-sea organisms)	**Unknown** (potential for new medicinal products unknown)	**High potential for new medicines** (protect animals with potential for new medicinal products)	**Unknown** (potential for new medicinal products unknown)
Number of protected species (includes animals such as fish, starfish, corals, worms, lobsters, sponges & anemones)	**1600 species** (600 more than “business as usual”)	**1300 species** (300 more than “business as usual”)	**1000 species** (base level)
Additional costs (per household per year)	**£ 5**	**£ 40**	**£ 0**
Your choice for scenario 5 *(please tick A, B or C)*	☐	☐	☐

Figure 1: Choice card example

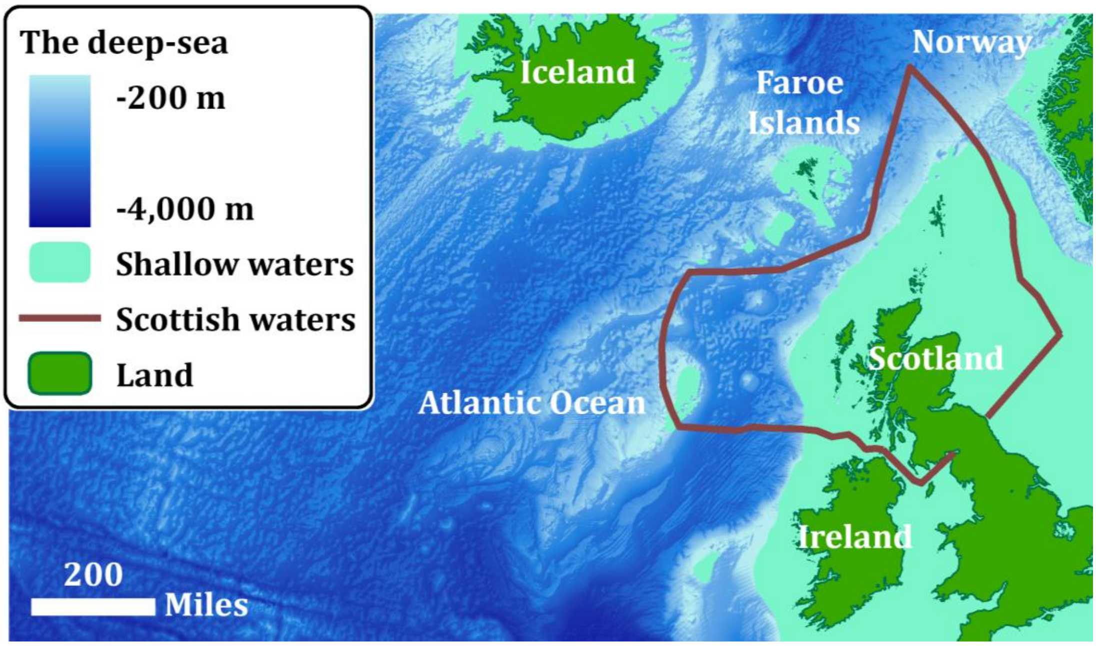
Apendix: Choice experiment questionnaire

CHOICE EXPERIMENT

We would like to learn more about your personal views on the government plans to protect deep-sea areas around Scotland. This choice experiment provides you with key information about the deep-sea. **You might not have thought about this topic yet, but your participation is very important to us. Evidence from studies such as this one can help the government and society decide how best to manage our oceans.**

Please start by reading the following background information on the deep-sea.

<u>THE DEEP-SEA</u> includes all parts of the oceans **deeper than 200 m** and can be as deep as 11,000 m, in the Mariana Trench in the Pacific Ocean. The deep-sea covers **more than 65% of the earth's surface**, making it the largest living space on this planet. Despite difficult living conditions such as high pressures, total darkness, low temperatures and very little food, the **diversity of life in the deep-sea is huge** and rivals that of the tropical rainforests. **Up to 2 million species** are estimated to live in the oceans alone [for comparison only 1.7 million species (land & sea) have been identified by scientist thus far]. Our knowledge of ocean life lags far behind that of life on land.



Most of the deep-sea bed is covered by **sand or mud** which hosts **high species numbers** scattered over a vast area. Other features particular to the Scottish deep-sea include **submarine volcanoes**, which rise more than one thousand meters from the seabed. Their rocky surfaces support the growth of **deep-sea reefs**, which are built up of **corals and sponges**. These living spaces also occur in many other parts of the deep-sea and host **very high species numbers**. The reef forming corals and sponges **grow very slowly** and some reefs are **several thousand years old**. As well as being a living space for many species, the deep ocean is very important for the **storage of CO_2** and global **temperature regulation**.

Please answer the following question

Q.1 - How much of what we told you about the deep-sea did you know already?

(1 =I knew nothing; 2 =I knew very little; 3 =I knew half of it; 4 =I knew most of it; 5 =I knew everything)

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

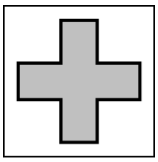
We would like to know your views

During the following experiment, we will ask you whether or not you would wish to protect additional parts of the deep-sea by choosing **different future scenarios**. All choices can be made on the basis of the information that we provide and your personal opinion. You will find the actual experiment on the next pages but **please read the following instructions first.** The experiment consists of six independent scenarios that offer three different options each.

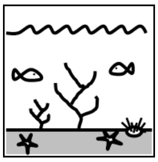
OPTION C – "BUSINESS AS USUAL": This is a **no-cost option**, because no changes to the current management will be made. Only small protected no- fishing areas will remain in the deep Scottish waters. In exchange a decline in species numbers and living spaces for animals in the region is to be expected in the future.

OPTIONS A OR B: In response to the increasing pressure on the deep ocean, the UK is now planning to implement additional marine protected areas in the deep-sea. Scotland has the majority of UK's deep-sea areas, but only a small percentage of it is protected. Options A and B describe future scenarios after creating additional protected areas in Scottish waters (please refer to the map on page 1 to get an idea of the size of Scottish waters). Both options would involve restrictions for the deep-sea fisheries sector. This economic activity would not be allowed within the protected areas. **The size of deep-sea areas under protection would increase from about 1.5% ("Business as usual") to 6% of the Scottish waters.**

All options other than option C ("Business as usual") would impose an additional financial cost on you and your family. The options that are offered to you within each future scenario vary. **We now show you a list of the three characteristics that are included in each of the options.**



1. NEW MEDICINAL PRODUCTS: Some deep-sea organisms have a high potential for use as new medicines. They offer a wide variety of potentially interesting substances that could be used in cancer medication and pain killers for example. The management of the protected areas could include sites where such organisms are thought to live in high numbers and allow researchers to search for new substances. A few medicinal products from marine organisms are already on the market, but our current level of knowledge is very limited in comparison to what could be possible in the future. By protecting certain deep-sea areas we reduce the risk of losing the potential for such discoveries.



2. NUMBER OF PROTECTED SPECIES: The creation of additional protected areas might result in a higher number of species that are under protection. Animals such as deep-sea fish, starfish, corals, worms, lobsters, sponges, and anemones would benefit most from the protection. In the "Business as usual" option a maximum number of 1000 species is protected. By increasing the size of the protected areas to 6% of the Scottish waters (options A and B), a **protection of at least 1000 species but up to 1600 species is possible**.

£

3. ADDITIONAL COSTS: No management plan is without costs. The costs for additional environmental assessments, administration and patrolling of the protected areas will have to be covered by the tax payer. This would result in **increased annual income tax payments** for your household from 2012 on. Remember to think about the expenses that your household is paying already. Carefully consider the fact that money spent on deep sea protection cannot be spent on achieving other social objectives (e.g. more recycling or better schools).

The protection of deep-sea areas around Scotland could have different objectives and we would like to hear what is most important to you. The main focus of this experiment is to find out about your personal opinion and how you value different options. Please try to ask yourself if you would really pay X amount of money for your favourite option. **In the case that the option is too expensive please choose option C ("Business as usual" option without additional costs).**

The characteristics within the six different future scenarios vary considerably, so please choose ONE OPTION FROM EACH SCENARIO and think about each scenario independently.

Please choose option C, if you are not willing to pay for either option A or B.

SCENARIO 1	Option A	Option B	Option C ("Business as usual")
New medicinal products (potential for the discovery of new medicinal products from deep-sea organisms)	**Unknown** (potential for new medicinal products unknown)	**High potential for new medicines** (protect animals with potential for new medicinal products)	**Unknown** (potential for new medicinal products unknown)
Number of protected species (includes animals such as fish, starfish, corals, worms, lobsters, sponges & anemones)	**1300 species** (300 more than "business as usual")	**1600 species** (600 more than "business as usual")	**1000 species** (base level)
Additional costs (per household per year) £	**£ 5**	**£ 60**	**£ 0**
Your choice for scenario 1 *(please tick A, B or C)*	☐	☐	☐

Q.2 - How confident do you feel about your last choice *(1 = very confident to 5 = not very confident)*

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

The characteristics within the six different future scenarios vary considerably, so please choose <u>ONE OPTION FROM EACH SCENARIO</u> and think about each scenario independently.

<u>Please choose option C, if you are not willing to pay for either option A or B.</u>

SCENARIO 2	**Option A**	**Option B**	**Option C** ("Business as usual")
New medicinal products (potential for the discovery of new medicinal products from deep-sea organisms)	**Unknown** (potential for new medicinal products unknown)	**High potential for new medicines** (protect animals with potential for new medicinal products)	**Unknown** (potential for new medicinal products unknown)
Number of protected species (includes animals such as fish, starfish, corals, worms, lobsters, sponges & anemones)	**1600 species** (600 more than "business as usual")	**1300 species** (300 more than "business as usual")	**1000 species** (base level)
Additional costs (per household per year)	**£ 30**	**£ 20**	**£ 0**
Your choice for scenario 2 *(please tick A, B or C)*	☐	☐	☐

Q.3 - How confident do you feel about your last choice *(1 = very confident to 5 = not very confident)*

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

SCENARIO 3	**Option A**	**Option B**	**Option C** ("Business as usual")
New medicinal products (potential for the discovery of new medicinal products from deep-sea organisms)	**High potential for new medicines** (protect animals with potential for new medicinal products)	**Unknown** (potential for new medicinal products unknown)	**Unknown** (potential for new medicinal products unknown)
Number of protected species (includes animals such as fish, starfish, corals, worms, lobsters, sponges & anemones)	**1000 species** (base level)	**1300 species** (300 more than "business as usual")	**1000 species** (base level)
Additional costs (per household per year)	**£ 40**	**£ 10**	**£ 0**
Your choice for scenario 3 *(please tick A, B or C)*	☐	☐	☐

Q.4 - How confident do you feel about your last choice *(1 = very confident to 5 = not very confident)*

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

The characteristics within the six different future scenarios vary considerably, so please choose <u>ONE OPTION FROM EACH SCENARIO</u> and think about each scenario independently.

<u>Please choose option C, if you are not willing to pay for either option A or B.</u>

SCENARIO 4	**Option A**	**Option B**	**Option C** ("Business as usual")
New medicinal products (potential for the discovery of new medicinal products from deep-sea organisms)	**High potential for new medicines** (protect animals with potential for new medicinal products)	**High potential for new medicines** (protect animals with potential for new medicinal products)	**Unknown** (potential for new medicinal products unknown)
Number of protected species (includes animals such as fish, starfish, corals, worms, lobsters, sponges & anemones)	**1600 species** (600 more than "business as usual")	**1000 species** (base level)	**1000 species** (base level)
Additional costs (per household per year) £	**£ 60**	**£ 5**	**£ 0**
Your choice for scenario 4 *(please tick A, B or C)*	☐	☐	☐

Q.5 - How confident do you feel about your last choice *(1 = very confident to 5 = not very confident)*

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

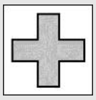
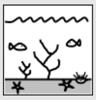
SCENARIO 5	**Option A**	**Option B**	**Option C** ("Business as usual")
New medicinal products (potential for the discovery of new medicinal products from deep-sea organisms)	**High potential for new medicines** (protect animals with potential for new medicinal products)	**Unknown** (potential for new medicinal products unknown)	**Unknown** (potential for new medicinal products unknown)
Number of protected species (includes animals such as fish, starfish, corals, worms, lobsters, sponges & anemones)	**1000 species** (base level)	**1300 species** (300 more than "business as usual")	**1000 species** (base level)
Additional costs (per household per year) £	**£ 10**	**£ 40**	**£ 0**
Your choice for scenario 5 *(please tick A, B or C)*	☐	☐	☐

Q.6 - How confident do you feel about your last choice *(1 = very confident to 5 = not very confident)*

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

The characteristics within the six different future scenarios vary considerably, so please choose <u>ONE OPTION FROM EACH SCENARIO</u> and think about each scenario independently.

<u>Please choose option C, if you are not willing to pay for either option A or B.</u>

SCENARIO 6	Option A	Option B	Option C ("Business as usual")
New medicinal products (potential for the discovery of new medicinal products from deep-sea organisms) 	**High potential for new medicines** (protect animals with potential for new medicinal products)	**Unknown** (potential for new medicinal products unknown)	**Unknown** (potential for new medicinal products unknown)
Number of protected species (includes animals such as fish, starfish, corals, worms, lobsters, sponges & anemones) 	**1600 species** (600 more than "business as usual")	**1300 species** (300 more than "business as usual")	**1000 species** (base level)
Additional costs (per household per year) £	**£ 20**	**£ 30**	**£ 0**
Your choice for scenario 6 *(please tick A, B or C)*	☐	☐	☐

Q.7 - How confident do you feel about your last choice *(1 = very confident to 5 = not very confident)*

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Q.8 - <u>If you selected the option C ("Business as usual")</u> for one or more of the choice sets, could you please try to explain why you made that choice?

(Please tick as many answers as you like)

- ☐ The other options are too costly.
- ☐ Deep-sea protection is not as important to me.
- ☐ Others should pay for the protection.
- ☐ The options are unrealistic and would not work.
- ☐ I disagree with additional restrictions on the fisheries and/or oil & gas sector.
- ☐ Other reason(s): ______________________________

Q.9- **<u>If you selected options A or B</u> for one or more of the choice sets, could you try to explain how you made your choices? What was important for your choice?**

	New medicinal products	**Number of protected species**	**Additional costs**
Very Important	☐	☐	☐
Less important	☐	☐	☐

Q.10 - Do you personally agree with the following statements?
(Please tick one box for each statement)

"Protected areas in the sea around Scotland would be beneficial for the marine environment."

(1 = Strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree).

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

"Protected areas around Scotland would have negative impacts on the marine economy."

(1 = Strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree).

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

"The marine industries should <u>not</u> be restricted, because the extraction of marine resources such as fish and oil is more important than protecting parts of the sea."

(1 = Strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree).

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

"It is worth paying for the protection of the deep-sea environment,
because society will benefit from it in the long-term."

(1 = Strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree).

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

"The costs for marine protection should be covered by the government & tax payers."

(1 = Strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree).

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

"The marine industries (fisheries/oil & gas companies) should cover the expenses for the management of new protected areas."

(1 = Strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree).

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

"Marine animals should be protected even when they provide no direct benefits to society."

(1 = Strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree).

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Q.11 - If you would like to comment on the statements in Q.10, please do so here.

____

____

____

____

Q.12 – We would now like you to think about one more possible plan for protecting deep-sea areas. Information about people's views on this plan can be used to help guide future management of the oceans. This plan would have the following characteristics:

- The size of deep-sea protected areas would increase from currently 1.5% to 6% of Scottish waters.
- The new protected areas will be created inside of the Scottish waters (rough locations are indicated by two white crosses in the map).
- High potential for new medicines (protect deep-sea organisms with potential for new medicinal products).
- 1600 deep-sea species under protection.

The best estimate that we can make is that this plan would cost a household like yours **60 POUNDS PER YEAR** in extra taxes. Would you be willing to pay this increase in taxes for this particular plan? Please remember what you already have to spend money on.

☐ Yes I would be willing to spend £60 in extra taxes on this plan

☐ No I would not be willing to spend £60 in extra taxes on this plan

About yourself

Finally it would be of great help for us to get some basic information about you. This helps us to better understand your answers? Remember that the whole survey will be anonymous. We take the confidentiality of your answers very seriously.

Q.13 - Are you…

☐ Male

☐ Female

Q.14- Your nationality?

☐ Scottish

☐ If other please specify: ____________________

Q.15 - Where do you live? (Please state only the city or village.)

____

Q.16 - How old are you?

- ☐ <18
- ☐ 18-25
- ☐ 26-35
- ☐ 36-45
- ☐ 46-55
- ☐ 56-65
- ☐ 66-75
- ☐ 76+

Q.17 - Have you ever worked in…?

- ☐ Oil & gas industry
- ☐ Fisheries sector
- ☐ Neither

Q.18 – Have you ever been a member of an environmental group (RSPB, WWF or else)?

- ☐ Yes
- ☐ No

Q.19 - Have you ever been diving?

- ☐ Yes
- ☐ No

Q.20 - How often do you eat fish?

- ☐ Never/ less than once a year
- ☐ Less than once a month
- ☐ Less than once a week
- ☐ At least once per week

Q.21 - What is the highest degree or grade of school that you have <u>completed</u>?

- ☐ Standard grade/ GCSE
- ☐ Undergraduate degree
- ☐ Higher grade/ A levels
- ☐ Postgraduate degree
- ☐ Further education (HND/HNC/BTEC or equivalent)

Q.22 - Your current type of occupation/ employment?

- ☐ Not working
- ☐ Professional (employed/ self-employed)
- ☐ Student
- ☐ Part-time working
- ☐ Retired

Q.23 - Please estimate your household's yearly income after tax & benefits.

(This helps us to better understand your answers from the choice experiment.)

- ☐ Up to £10,000
- ☐ £40,001 – £60,000
- ☐ £10,001 – £20,000
- ☐ £60,001 – £80,000
- ☐ £20,001 – £30,000
- ☐ £80,001 - £100,000
- ☐ £30,001 – £40,000
- ☐ More than £100,000

Q.24 - How many people live in your household?

Number of adults: ☐ Number of children: ☐

Q.25 - Finally, please let us know your opinion on this survey. "For me this survey was…"
(Please select as many answers as you like.)

- ☐ not credible
- ☐ comprehensible
- ☐ too complicated/too long
- ☐ interesting

Please feel free to put any further comments on this survey in the box. We are very interested to hear about your opinion and feelings on this survey and will use this information to improve our future research.

Please use the <u>prepaid envelope</u> to send the completed survey back to our freepost address. If you like to participate in the prize draw, please do not forget to fill out the contact details on your cover letter.

Thank you very much for your help!

If you have lost the envelope please return your questionnaire to our freepost address below:

UNIVERSITY OF ABERDEEN
FREEPOST – AB567
ACES – Auris building
Niels Jobstvogt
23 St Machar Drive
ABERDEEN
AB24 3UU

<u>The postage will be paid by the university.</u>

Choice experiment (version 1.1)

Last update 5 June 2012

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