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Entropy balancing for causal effects in discrete choice analysis: The Blue Planet II effect

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Abstract

In this study the discrete choice experiment approach was employed in a survey of the Scottish general public to analyse how respondents make trade-offs between blue growth potential and marine ecosystem service delivery associated with the Mingulay cold water reef complex. Results indicate a higher willingness to pay for management options associated with the highest possible levels of marine litter control followed by the highest possible levels of fish health. Using entropy balancing, a multivariate reweighting method to produce balanced samples in observational studies, we also test the impact that having watched the BBC Blue Planet II documentary series may have had on individuals' willingness to support marine conservation activity. Whether or not respondents had seen the BBC Blue Planet II series was found to have a significant impact on people's preferences. Despite this, the willingness to pay (WTP) does not differ between the two groups suggesting that such documentaries may impact preferences but not the final action of WTP. It is argued that the entropy weighting approach can be a useful tool in discrete choice modelling when the researcher is concerned with estimating differences in preferences between a group of interest and a comparison group.

Keywords: entropy balancing; willingness to pay; discrete choice model; marine ecosystem services; nature documentaries

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"I personally can have enough of people leaning out of the television screen and saying 'you lazy, irresponsible, ignorant chap sitting there in your comfortable suburban home; why don't you care for this or subscribe to that or go out and do the other?' I actually think the best way of taking the message to the people is by showing them the pleasure, not necessarily by saying to them every time, 'You've got to do something about it,' but by saying, 'Look, isn't this lovely?' and the other bit follows"

- *Sir David Attenborough*

From a television interview with David Attenborough from early 1970s, reshown on the 2002 BBC documentary film 'Life on Air: David Attenborough's 50 Years in Television'

1. Introduction

Modelling the impact of a policy intervention or social factors on decision making is a common goal in choice experiments. For example, researchers may be interested in determining the influence of gender, or education level, or having previously been exposed to an environmental awareness campaign on attribute and option preferences in a choice model. In these cases where tastes may vary systematically with the observable variables or treatments, heterogeneity is often captured by using interactions between the observable characteristics of the decision-maker and the observable attributes of the alternatives in the chosen models. It has been argued though that capturing heterogeneity systematically in this manner may be insufficient in the presence of confounding influences or when tastes vary with unobservable variables or purely randomly, and may result in inconsistent parameter estimates (Chamberlain, 1980). Tests by Hess et al. (2013) also suggest that there is substantial scope for confounding in discrete choice analysis and that when it occurs it leads to serious bias in parameter estimates and elasticities. This paper proposes a strategy to control for these effects when the objective of the discrete choice analysis is to determine the impact of a particular 'treatment' for one portion of the population on choice and willingness to pay.

In particular, the 'treatment' analysed is having watched the BBC Blue Planet II (BPII) documentary series and the research question of interest is what impact this may have had on individuals' choices and willingness to support marine conservation activity as observed through the use of a choice experiment. In the discrete choice analysis, the preferences of the Scottish public for the deep-sea environmental management of the Mingulay cold water reef off the west coast of Scotland in the Sea of the Hebrides is assessed. These cold-water coral reefs are known to act like islands in what is "normally flat, featureless and muddy surroundings and harbour a distinct and rich ecosystem, providing niches and nursery grounds for a variety of species, including commercial fish species" (Freiwald et al. 2004). While the presentation of a data pre-processing method for estimating the impact of a particular treatment on the choices made in discrete choice analysis is the main contribution of this paper, testing if watching nature documentaries has a lasting effect on respondents' environmental preferences and willingness to pay (WTP) is in of itself an interesting line of research. If they can be shown to influence preferences then they could be used as an effective policy tool to encourage behavioural change to help tackle other environmental issues such as the looming climate and biodiversity crises.

Sir David Attenborough's second instalment of the Blue Planet series has been widely credited for being responsible for generating a surge of interest in marine conservation efforts, in reducing plastic pollution and in increasing recycling. When it first aired in October 2017, a significant increase in on-line searches for conservation charities both during and after each episode was observed (Hayns-Worthington, 2018)[1]. A recent study of consumer behaviours surrounding sustainable packaging in the UK and US also found an increase in internet searches for "plastic recycling" on the back of the series (Globalwebindex, 2019). Other high-profile television programs have also had an impact on public sentiment and environmental policy. Al Gore's 'Inconvenient Truth' film for example is known to have had a significant influence of environmental behaviour and policy (Jacobsen, 2011) while celebrity chef and campaigner Hugh Fearnley-Whittingstall's documentaries on commercial fishing practices were credited

[1] The eight episodes of the series ran from the 29th of October 2017 to the 1st of January 2018. Following its release the series was subsequently made available to download for UK based residents on the BBC iPlayer catch up service for a period of 7 months. It was also made available to purchase as a DVD box set from the BBC and was available to watch on Netflix from December 2018 to December 2019.

with having a major influence on the introduction of the discard ban under the EU Common Fisheries Policy (Borges, 2015).

While there has been much focus on the increased interest in conservation from the BPII series, we study whether it actually changes environmental preferences using a novel mechanism to explain differences between those who have and have not seen the series. In particular, we examine the impact of having seen the BPII series on preferences and willingness to pay (WTP) by including interaction terms between the BPII dummy and the observable attributes of the alternatives in the choice models employed. One might suspect however that those who have watched BPII may have different characteristics (perhaps from differing social classes, education levels, etc.) to those that have not, resulting in the non-random selection into the subgroups of those who have versus have not watched the BPII series. Also, there may be unobserved factors that simultaneously influence both watching the series and the choices made. In these cases, there may be important subgroup differences between the groups' covariates that, if not adequately accounted for through some form of adjustment to known sample moments (e.g. mean, variance, or skewness), could result in the interaction terms producing biased estimates and lead to inappropriate conclusions in relation to the effect of having seen the BPII series on an individual's preferences for marine environmental management options. That is, the preferences of those that have not watched the BPII series (the comparison group) may not represent the true counterfactual preferences of the group that did watch BPPI (the treated group), had the latter group not watched BPII.

In this study, we therefore propose entropy balancing (EB) as a pre-processing technique to achieve covariate balance between the two groups in the discrete choice analysis where the objective is to estimate the effect of a treatment (having seen at least one episode of the BPII series) on the choices made. EB is a multivariate reweighting method used to produce balanced samples in observational studies and was first developed in the field of political science where researchers are interested in estimating treatment effects in nonexperimental settings (Hainmueller, 2012). After applying EB, the BPII viewers and reweighted BPII non-viewers will have similar covariate distributions, mitigating self-selection bias from observed confounders. Conditional Logit and Random Parameter Logit models are estimated with and without weighting by the generated EB weights. To the best of the authors' knowledge this is the first study where the technique is applied in discrete choice analysis. We feel this approach has obvious appeal for other DCE studies interested in making cross-group comparisons.

Meyerhoff (2006) argues that in order to analyse the relationship between attitudes and a specific behaviour, it is crucial to distinguish at the outset between an attitude towards a target and an attitude towards a behaviour. The author argues that the important difference between these attitudes is that "they differ in their attitude object". For example, an individual donates money towards a marine conservation project. In this case, the project is the target of the behaviour of donating and the individual probably has a positive attitude towards this target. Simultaneously, it is assumed that the individual also has a positive attitude towards the behaviour of giving money to the conservation effort, but Meyerhoff (2006) suggests that these attitudes are not necessarily equally balanced. Individuals could have a positive attitude towards marine conservation in general, but may have a negative attitude towards contributing financially for such conservation. Therefore, an attitude towards a target may be an unreliable predictor of a specific behaviour. We examine this issue by testing the hypotheses that, firstly, having watched BPII influences the preferences of respondents for marine conservation management options, and that secondly respondents that watched BPII have higher WTP for marine conservation. A third hypothesis tested is that the WTP from the EB weighted models are significantly different from unweighted models.

2. Effect of Nature Documentaries on Environmental Perceptions and Behaviours

The relationship between media and the environment has been studied from a wide range of perspectives within the field of mass communication for many decades (Holbert et al., 2003). Nature documentaries are now an increasingly used modality to communicate environmental issues in order to create awareness, change behaviours or perhaps motivate increased viewers' demand for environmental policy action. According to Östman (2013), media can play an important role in engaging the public on environmental issues and asserts that fostering societal awareness of their impact on the environment is a precondition to successful environmental policy. Early empirical studies of media treatment effects on environmental behaviour typically focused on public affairs (Atwater et al., 1985; McLeod et al., 1987; Brother et al., 1991), while others focused on broad range of media communication content and consequences (Daley and O'Neill, 1991; Meister, 2001).

In examining the relationships between television viewing and environmental concern, Shanahan et al. (1997) showed that exposure to conservation messages on television is associated with a general apprehension about the state of the environment. The authors found however, that it was not consistently related to viewer's perception of threats from specific sources and frequent viewers were less willing to change their behaviour for the good of the environment. Hynes et al. (2014) also reflect on the divergence between what the public perceive to be major marine environmental threats compared to that of scientists. Holbert et al. (2003) examined the differences between the direct effects of factual versus fictional-based television programming on environmental attitudes and behaviour, with factual-based television programming such as nature documentaries and current affairs being found to have a statistically significant positive influence on individual's desire to recycle, purchase eco-friendly products and to be more energy efficient in daily routines.

In Australia, Hofman and Hughes (2018) determined that nature documentaries with specific environmental conservation messages can influence viewers' attitudes and bring about immediate changes in behaviour. However, the authors note that post-viewing materials and strategies were needed to ensure that these behavioural changes continued in the long-term. Elsewhere, Barbas et al. (2009) also found that nature documentaries about insects had a positive effect on student's environmental sensitivity. The study also concluded that less conventional documentary styles such as non-verbal films were more effective in the development of environmental knowledge amongst the students, but the traditional nature documentaries, such as BPII, were effective in fostering positive environmental attitudes and beliefs. An interesting question arising from the positive effects of nature documentary on behavioural intentions observed in the literature is whether these intentions translate into policy support and financial commitments.

In attempting to answer that question other research has questioned the role of nature documentaries on pro-environmental behaviour and financial support to conservation efforts (Meyerhoff, 2006; Arendt and Matthes, 2016). In an experiment where the treatment group watched a nature documentary, and the control group watched an unrelated science documentary, Arendt and Matthes (2016) found that viewing the nature documentary did not result in a significant increase in 'connectedness to nature'. It was found however to increase actual donations to animal and environmental conservation societies, but only for those who were already observed to have had a strong pro-environmental attitude. In a similar finding to Hofman and Hughes (2018) in relation to the lasting impact of viewing nature documentaries on behaviour, Jacobsen (2011) found that while the purchase of voluntary carbon offsets significantly increased in regions where Al Gore's 'Inconvenient Truth' documentary was released compared with regions where the film was not released the effect did not last. The authors found that carbon offset purchases went back to prior levels within two months. Janpol and Dilts (2016) also examined the effect of watching a nature documentary on the natural environment on post-viewing financial support. They found significant effects on environmental perceptions and on the choice of charitable donations amongst the participants in their experiment[2].

Following another Attenborough BBC documentary, Planet Earth II, Fernández-Bellon and Kane (2019) analysed Twitter and Wikipedia big data activities and showed that nature documentaries can generate awareness of unfamiliar animal species and that the viewers will engage with the information provided at levels comparable to those achieved by other environmental conservation initiatives such as world species awareness days. The analysis however, suggested a lack of proactive engagement stemming from Planet Earth II through charitable donations. According to the authors this latter effect was not unexpected given that environmental awareness generated by the documentary is only one of many moderating factors influencing the decision to donate and the effect may happen at a considerable lag. This makes it difficult to establish a cause-and-effect relationship.

[2] It should be noted however that in this instance the donations were not the respondents' own money but was donated on their behalf by the researchers conducting the experiment.

Conservation of natural resources and their financial requirements are often researched in the field of economic valuation. However, the role the viewing of nature documentaries has on the publics' environmental preferences and willingness to pay has generally been ignored in the valuation literature. We aim to fill this gap by estimating choice models that test for the impact of having seen the BPII series on both marine management preferences and willingness to pay to support the delivery of deep-sea ecosystem services. The paper is also the first to examine the use of EB in discrete choice analysis to increase the reliability of comparisons between groups. We apply this method to study possible differences in preferences for those who have and have not seen the BPII series, where we reweight those who have not seen the BPII series to be similar to those who have seen the series in terms of their observable respondent characteristics.

3. Survey Design and Choice Experiment

An online survey was carried out in January and February 2019 over a four week period. The aim of the survey was to obtain information relating to the Scottish publics' preferences for cold-water coral conservation and their associated ecosystem service benefits. The survey attempted to also ascertain the ecosystem service benefit values that might be received by the Scottish public through the management of the Mingulay Reef complex found off the west coast of Scotland at a depth of 100-200m, 8.7 miles east of the Island of Mingulay in the Sea of the Hebrides (Henry et al. 2013), under two different management scenarios. With this in mind, a choice experiment was included in the survey instrument in order to generate data for the estimation of the public good benefit value of such conservation. Extensive discussions with marine scientists on the EU ATLAS project who have in-depth knowledge of this particular reef led to the choosing of the relevant attributes and levels that should be used in the choice experiment. Focus group discussions were also used to refine the language, descriptions and other questions asked in the survey instrument. While the scientists provided the detail for the appropriate attributes and levels to be used the focus groups ensured that the descriptions were clearly understandable by the general public that would be responding to the survey. The UK based market research company YouGov was employed to collect the data using their established online panel of the general public. Pilot testing of the survey instruments was conducted prior to the main survey.

In the final survey instrument, respondents were given some background information on the cold-water coral reefs and the Mingulay Reef complex. They were then asked a series of questions related to their attitudes towards Scotland's deep seas and marine wildlife and how it was being managed as well as questions that retrieved respondent's direct experience with Scottish waters either through recreation or by being involved in an industry associated with the sea. Within the survey a series of 8 choice cards were presented to each respondent that examined their preferences for a set of ecosystem service attributes associated with the management of Mingulay Reef Complex. As is common in these types of surveys, the questionnaire concluded with a number of socio-demographic questions related to age, gender, marital status, occupation, working status, income, number of persons in household and education. The surveys resulted in 1,025 complete observations.

To generate the choice cards used in the survey, a Bayesian efficient design was employed that attempts to minimize the Bayesian Db-error criterion (Hess et al., 2008; Scarpa and Rose, 2008). A sequential experimental design where the choice cards were updated from the pilot to the main survey was employed where the prior coefficients used in the design are updated. Initially, prior coefficients for the pilot study were based on the results of similar surveys in the literature. New prior coefficients estimates were generated based on the estimation of choice models from the pilot study (n = 63). Such a sequential approach to choice card design has been shown to deliver significant efficiency gains (Scarpa et al., 2007). The design for the main survey was generated using the NGENE software and the value of the D-Error for the main design was 0.55 (mean value).

For the choice experiment, respondents were first informed that: "*The Scottish Government are responsible for delivering new plans on how best to manage Scotland's deep seas and wildlife. As part of this scientists are assessing the "health" or the environmental quality of the deep sea, including the Mingulay Reef Complex, with regard to a number of characteristics*" Respondents were then presented with a description of the 5 characteristics used in the choice cards; the health of commercial fish stocks, the amount of marine litter, the size of area that is protected, the possible expansion of the ocean economy in the area of the reef associated with the creation of new marine related jobs and the price of each restoration option.

The health of commercial fish stocks was measured by the number of adult fish compared to young fish in the population (scientists refer to this as the abundance ratio). The more adult fish, the healthier the population. Respondents were told this and informed that the reef is an important nursery area for young fish where they can mature into breeding adults and eventually move out of the reef complex into the surrounding seas where they can be commercially caught. The levels of the attribute were presented as high, medium or low in each option of the choice cards. The level of marine litter was described as good, moderate or poor and was based on the observed number of items of litter per square mile. Marine scientists within the EU ATLAS project developing indicators of Good Environmental Status (GES) of EU deep-sea waters as required under the Marine Strategy Framework Directive (MSFD) advised on what the corresponding number of items of litter should be for each level of the marine litter attribute. The size of protected area attribute was presented in the form of a percentage of the Sea of Hebrides and as the corresponding multiple of the current management area; either 1% of the Sea of the Hebrides (current management), 6% of the Sea of the Hebrides (six times the size of current management), 10% of the Sea of the Hebrides (10 times the size of current management) or 15% of the Sea of the Hebrides (15 times the size of "current management).

- **Table 1 here**

The fourth attribute chosen was the possible expansion of the ocean economy in the area of the reef through the creation of new marine related jobs. Additional jobs have tended to be the most popular economic factor to be used in environmental valuation surveys, framed in the concept of the non-use value of employment (Aanesen et al., 2018; Morrison et al. 1999; Othman et al. 2004). Respondents were informed that in the Mingulay Reef Complex there is potential to develop new industries such as fisheries, new forms of aquaculture, tourism and marine renewable energy and that it was possible that these developments could provide employment for local communities. This attribute was included to examine possible perceived trade-offs between developing the area commercially and protecting the cold-water coral reef and associated marine wildlife. Finally, the cost of each option (the price) was presented in the form of an annual increase in personal income tax. The reef management attributes and levels used to describe the choice alternatives are also shown in Table 1.While the description in the choice cards for each attribute was kept simple for the sake of clarity, additional information explaining each of the attributes was provided to respondents in the questionnaire.

Following the presentation of the attributes, the respondent was then informed that "*different levels of each of these can be delivered as part of the management plan: i.e. more or less jobs, more or less marine litter, healthier fish stocks and a larger protected area. We would like you to think about different "bundles" of these aspects of management and as a tax payer how much you would be willing to pay for these different management aspects*". Furthermore, they were told "*Any changes from the status quo would need to be funded by the Scottish taxpayer. This would take the form of an increase to annual personal income tax rates over a 10 year period and 'ring-fenced' into a secure marine fund*". Respondents were also asked to imagine themselves actually paying the amounts specified and to think about their own budget and ability to pay when considering each option.

An example choice card was then presented and described (Figure 1). Following that 8 choice cards presented three management alternatives and respondents were asked to choose their most preferred option on each card. The third option on each card was always the status quo alternative and the attribute levels for this option did not vary across the 8 cards. In this case, the status quo describes the situation (the attribute levels that would be achieved) in the future if there was no further change from current management and is associated with no additional financial cost to respondents. The first and second options on each choice card represented management alternatives leading to improvements in the delivery of the ecosystem service benefits, represented by the attributes, and were associated with a positive cost.

Following the choice experiment, a series of questions were asked to determine if the respondents ignored any of the attributes informing their choices and to acquire an explanation if respondents picked the status quo option on all choice occasions. Further questions were asked related to the socio-demographic profile of respondents, their marine related past-times, and, of particular interest to the analysis here, whether they had watched one or more episodes of David Attenborough's television series Blue Planet II.[3]

4. Methodology

The use of choice experiments in the valuation of ecosystem service benefits can provide valuable information and social insights to assess environmental policy options and can act as a bridge between environmental sciences, society, policy makers and planners (Perni and Martínez-Paz, 2017; Birol and Cox, 2007). The basis for the analysis of the response data to a choice experiment is the commonly applied McFadden's (1974) random utility model (RUM)[4]. The RUM model can be specified in different ways depending on the distribution of the error term (Hynes et al., 2008). If the error terms are independently and identically drawn from an extreme value distribution, the RUM model is specified as the Conditional Logit (CL) (McFadden, 1974). Alternatively, the random parameter logit (RPL) overcomes the two major limitations of the CL model, i.e. the independence of irrelevant alternatives (IIA) property and the limited ability of the CL model to explicitly account for preference heterogeneity (Train, 2003). The RPL allows the coefficients of observed variables to vary randomly over people rather than being fixed for all individuals; thereby accounting for preference heterogeneity. The utility of individual *i* from the alternative *n* in time *t* is specified in the RPL model as:

$$U_{int} = (\beta + k_i)x_{int} + \varepsilon_{int} \qquad (1)$$

where within the deterministic component of the model (V_{int}), the vector of coefficients β associated with the attributes denoted by x_{int}, vary across individuals *(n)*, thus accommodating heterogeneous preferences in the sampled population. The error term ε_{int} captures the factors that affect utility but are not observed by the modeller. The error components of different alternatives within the RPL is also

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3 We did not record the number of episodes watched so cannot explore effects with respect to the level of exposure. This is a potential avenue for future research.

4 Although not applied here the latent class model is another popular alternative for analyzing stated preference choice data (Grilli and Curtis, 2020). For a more in-depth presentation of the RUM framework and the alternative choice models that can be applied the interested reader is directed to Train (2003) and Hensher et al. (2010).

allowed to be correlated. The unknown parameters of the RPL model are distributed across the population according to a specified distribution function (Hensher and Greene, 2003). In this paper, the RPL has a fixed cost parameter but assumes normally distributed parameters for the other management attributes, with mean β and standard deviation σ. The conditional choice probability for respondent *i* choosing alternative *n* is given by:

$$P_{int} = \Pr(y_i^t \mid \cdot) = \int_\beta \prod_{t=1}^{Ti} \frac{e^{V_{int}}}{\sum_{m=1}^{M} e^{V_{imt}}} f(\beta|\theta)d\beta, \qquad (2)$$

Finally, the model is estimated by simulated maximum likelihood. The log-likelihood (LL) function for the model is given by $LL(\theta) = \sum_{i=1}^{N} \ln P_{int}$ where *N* is the size of the sample population. This expression cannot be solved analytically and simulation-based estimation of the model is used to evaluate P_{int} with a large number of draws from β (in this study we use 300 Halton draws).

The simulated log likelihood of the RPL model is given by:

$$LL(\theta) = \sum_{i=1}^{N} \ln\left[\frac{1}{R}\sum_{r=1}^{R} P_i(\beta^{in/\theta})\right] \qquad (3)$$

where *R* is the number of draws, $\beta^{in/\theta}$is a vector of βs obtained in the *r*-th draw from the distribution $f(\beta|\theta)$ for individual *i*. In the RPL model, the parameters of β distribution (θ) are estimated, rather than a vector of β point values as is done in the basic CL model. Following McFadden and Train (2000), uncorrelated utility coefficients are assumed in the estimated RPL model.

The marginal utility estimates for changes in the level of each attribute from the choice models can be easily converted to the marginal willingness to pay for the particular change in each attribute. These marginal values are derived by dividing a β parameter for a non-cost attribute *x* in alternative *n* (x_n) by the β parameter for the cost attribute:

$$Marginal\ WTP_{x_n} = \frac{\beta_{x_n}}{-\beta_{cost}} \qquad (4)$$

In estimating the marginal effects using the RPL the expected measure requires integration over taste distribution in the population which is computed by simulation from draws of the estimated distributions for the random parameters (Scarpa and Thiene, 2005; Hynes et al., 2008). In addition, the value (the compensating surplus) of a management option that leads to specified changes in the cold water coral reef ecosystem service provision, as described by the attribute levels, may be calculated using the standard utility difference expression (Hanemann, 1984). Two management scenarios where the average WTP to move from the state of the world given in the baseline (the status quo scenario) to the state of the world that results with alternative levels of each attribute in the choice experiment is therefore estimated.

The study was particularly interested in examining what influence, if any, having seen BBII might have on attribute preferences and WTP. It has previously been pointed out that differences in sociological, psychological and biological constructs, such as attitudes, values, perceptions, normative beliefs, affects, lifestyles, etc. can have a profound influence on taste heterogeneity (Vij and Krueger, 2017; Ben-Akiva et al., 2002) and it may be the case that there are underlying factors driving individuals to watch BBII that would also influence choices made and make it impossible for the analyst to disentangle the true effect of having seen BBII on marine environmental preferences.

Ideally, one would have two identical groups, one of which was exposed to BPII and another that was not. The difference in outcomes could then be attributed to their exposure to BPII. One could achieve this by randomising individuals to watch/not watch BPII. As is usual in observational studies this was not possible in this case. Therefore, in order to examine the impact of having seen the BPII series on preferences and WTP, EB is used to reweight those who have not seen the nature series to be similar to those individuals in the sample that have seen any of the series, in terms of the mean, variance, and skewness of a range of observed covariates. The approach assures that the two sets of respondents are exactly the same on these three moments across the chosen variables. Thus, any observed differences in outcomes are not attributable to these covariates. Choosing covariates that might be considered important explanatory variables in explaining the respondent's environmental attitudes, perceptions, etc. should provide more assurance to the analyst that any observed impacts of having viewed BPII are meaningful.

The EB reweighting procedure employed in this paper is formally presented by Hainmueller (2012). In this analysis the population average treatment effect on the treated group is used. Assuming there is no unobserved confounding, the outcomes of the observed control group can be reweighted to represent the expected counterfactual outcome of the treated group. While there are a number of data pre-processing methods that could be used to reduce the imbalance in the covariate distributions (e.g. nearest neighbour matching, coarsened exact matching, propensity score matching) EB is used in this application as it has the advantage that it directly incorporates the information about the known sample moments (*m*) for those who have not seen BPII and adjusts the weights such that the user obtains exact covariate balance for all moments included in the reweighting scheme (Hainmueller and Xu, 2013). The EB weights w_i are chosen by minimizing the entropy distance metric:

$$\min_{w_i} H(w) = \sum_{\{i|D=0\}} w_i \log(w_i/q_i) \quad (5)$$

subject to balance and normalizing constraints

$$\sum_{\{i|D=0\}} w_i c_{ri}(x_i) = m_r \text{ with } r \in 1, \ldots, R$$

and

$$\sum_{\{i|D=0\}} w_i = 1$$

and

$$w_i \geq 0 \text{ for all I such that } D = 0$$

where $q_i = 1/k_0$ is a base weight, k_0 is the sample of control units, and $c_{ri}(x_i) = m_r$ describes a set of *R* balance constraints imposed on the covariate moments of the reweighted control group and *D* is the binary treatment indicator coded 1 or 0 if individual *i* has seen the BPII series or has not (the control condition), respectively. In this application the moment constraints include the mean, the variance, and the skewness. EB is less prone to giving extreme weights to individuals than approaches such as Inverse Probability Weighting and is generally more efficient than propensity score matching.

Once the covariate distributions are adjusted and the EB weights are fitted, the estimated individual level weights are incorporated into the log likelihood function of the choice models in order to examine the impact of having seen the BPII series on a person's environmental preferences and WTP for marine ecosystem conservation. Thus, the simulated log likelihood of the RPL model described in (3) is now given by:

$LL(\theta) = \sum_{i=1}^{N} w_i \ln\left[\frac{1}{R} \sum_{r=1}^{R} Pn(\beta^{in/\theta})\right]$ where w_i is the balancing weight used for individual *i*.

5. Results

Table 2 provides summary statistics for the sample of the 1,025 Scottish respondents to the survey. The average age in the sample (adults aged 18 plus) is 49 while 44% were male and 52% had a third level qualification (including technical, professional or higher qualification). Six per cent of the sample were active students, 28% were retired and 4% indicated that they were currently unemployed. Six per cent of respondents were from the Highlands and Islands region. Only 2% had visited the island of Mingulay while 12% indicated that they had visited the nearest populated island Barra. Just under 25% of the sample had however visited the Outer Hebrides at some point previously. Of particular interest to this study is the fact that there was almost a 50/50 split in terms of those who had and had not watched BPII with 55% indicating that they had seen at least one episode of the series.

- **Table 2 here**

Before proceeding to choice modelling results we first review the EB procedure used to pre-process the choice data. All observations in the sample are used in the choice models, but these observations are given different weights. Each respondent who has seen BPII is given a weight of 1 because we are interested in the effect of having been exposed to the television series on deep-sea management choice. Respondents who have not seen BPII are assigned varying weights greater than zero that meet the EB conditions. The procedure effectively assigns more weight to respondents who have not seen BPII, who have more comparable case conditions and characteristics to respondents who have seen BPII, and less weight to respondents who have not seen BPII whose features are more different. The entropy weights were generated using the "ebalance" package in the statistical software package STATA (Hainmueller & Xu, 2013).

Respondents who have not seen BPII were weighted to meet the targets of balance on the three moments (mean, variance, and skew) of the 9 independent variables shown in table 3. The EB algorithms were restricted to a maximum number of 20 iterations and a maximum tolerated deviation is set at .015 for the reweighted moments of the covariates. As pointed out by MacDonald and Donnelly (2019) this maximum number of iterations and predefined tolerance level encourages convergence and the optimization of covariate balance. Table 3 displays descriptive statistics for the 9 covariates before and after matching the sub samples based on EB. The balance table includes the means, variances, and skewness of covariates for both treatment, and control pre and post weighting. As can be seen from the table the moments of these variables across the 2 subsamples are already reasonably similar prior to reweighting which should also aid the convergence and optimization process. In fact, the balancing algorithms only required 13 iterations to fully converge.

Also evident in Table 3, before reweighting, the treated and control groups differ slightly in terms of their covariate distributions, suggesting perhaps some degree of self-selection. However, a simple logit model where 'watches BPII or not' is the dependent variable and the nine independent variables are the regressors would suggest that only age and being aware of information given on Scottish marine environment at start of survey have a significant influence on the decision to watch BPII or not. The pseudo R^2 of this model is also low at 0.026 (see logit model results in table A1 of the appendix). This is further indication that the initial level of imbalance between treatment and control groups is low. A 'leave-covariates-out' (LCO) approach (Cerulli, 2019) was also employed to assess the sensitivity of the results to unobserved confounders. The entropy balancing procedure was rerun a further eight times, excluding one of the nine independent variables each time. The results of this analysis show little variation in the resulting effect estimates. The effect estimate in each case range from 0.01586 to 0.01984 and hence the main choice model estimates are likely to be relatively insensitive to unobserved confounders, since a potential omitted confounder would have to exert a greater influence than all of the observed confounders to overturn the findings. This provides some reassurance that the assumption of no unobserved confounders is not too restrictive in this case.

- **Table 3 here**

The EB procedure produces an almost perfect balance between the groups across all observed covariates. The means of the covariates in the reweighted control group (those who did not watch BPII) perfectly match the means in the treatment group (those who did watch BPII). The only slight imbalance occurs for the variance and skew of the income and age variables, although their means are well-balanced so we do not anticipate this will introduce significant bias. The individual level EB weights generated in the pre-processing step are stored for use in the subsequent discrete choice analysis where they enter the log-likelihood function of the chosen models as outlined in the methodology section.

For the analysis, we restricted the sample to those respondents who did not serially choose the status quo option as a protest response; this left a usable sample size of 994 respondents. The models include dummies for the choice attributes and BPII interaction terms with the attribute level dummies as well as the interaction of the status quo option with age, gender and being from the highland and islands region. The results from the alternative CL models with and without the EB weighting are presented in Table 4[5].

Results for the unweighted and reweighted sample are quite similar, although it should be noted that the reweighted results relate to a hypothetical population containing the treated units with and without having watched BPII. While there are slight differences in the magnitude of coefficient estimates across the weighted versus unweighted versions of the model there are no statistical differences observed. This was not a surprising result given how closely the sub samples were even without using the EB procedure.

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[5] Separate CL models for the subsamples who watched BPII, who did not watch it (unweighted), who did not watch it with EB weights, and a model for entire sample excluding BPII interaction terms is also provided for comparison in the appendix (table A2).

All of the choice attribute level coefficients are significant at the 1% level. For all attributes, the level against which estimates are compared in all models is the lowest level in each case (attributes and all associated levels were summarized in table 1). As shown in table 4, the magnitude and signs of the attribute coefficients in the CL models are broadly in line with expectations. In particular, respondents show a stronger preference for higher levels of healthy fish stock, lower levels of marine litter, more ocean economy job opportunities and a larger area protected. In the latter case though, the medium level (10% of the Sea of Hebrides around the reef complex protected) has a marginally lower coefficient than the 6% protection level. The 15% protection area is still the most preferred however. As expected the coefficient on cost is negative and significant, suggesting that ceteris paribus, respondents prefer to pay lower amounts of additional taxation. The alternative specific constant for the status quo alternative is negative and significant indicating that respondents are more likely all else being equal to choose a management option that is different from the status quo option.

The attribute level dummies were also interacted with a binary variable that indicates whether a person watched even one episode of the BPII series and these interaction terms were included in all models. Examining the results of the weighted CL model, which thanks to the EB pre-possessing procedure is closer to an experimental data setting, one can see that those who have seen BPII display statistically higher preferences for management options that achieve the highest level of fish stock health, higher levels of area protected and lower levels of marine litter compared to those who have not seen any of the series. The BPII watchers do not appear to have any statistically different preferences when it comes to the creation of additional ocean economy jobs however. Interestingly though, they do display higher sensitivity to the price of a management option than those who have not seen the series as is evident from the significant and negative sign on the cost interaction term. The results also highlight that a respondent who is male or older is not statistically more or less likely to choose the status quo option but being from the Highlands and Islands is a negative and significant predictor of choosing the status quo option.

- **Table 4 here**

Table 5 presents the results from the RPL model for the weighted choice data[6]. A Hausman test showed that the CL model does not hold to the restrictive substitution patterns implied by the IIA assumption. This suggests the need for an alternative specification such as the RPL model that relaxes this assumption and also accounts for the panel nature of the data and allows for unobserved heterogeneity in tastes and preferences. The parameters for the cost attribute, the alternative specific constant for the status quo alternative and all interaction terms are specified as fixed. The fixed cost attribute facilitates the calculation of welfare effects and reduces the possibility of retrieving extreme welfare estimates.

As is evident from Table 5 both the means and the standard deviations are significant for all random parameters. The mean coefficients for the attribute level dummies are all of the expected sign and also show the same pattern as in the CL case. As with the CL model the highest level of the marine litter attribute has the largest coefficient value indicating a strong preference for management options that achieve this outcome. There is however a wide distribution in the preferences for the management attributes as seen in the magnitude and significance of the standard deviation coefficients. The largest difference between mean and standard deviation coefficient is observed for the highest level of the area protected and may reflect the fact that some respondents believe that too large an area under protection may be detrimental to other users of the marine space.

- **Table 5 here**

In the case of the non-random BPII interaction terms, a similar pattern to the CL results is also observed with significant preference differences for those who have seen BPII; the one change from the CL results being that a management option with the medium level for size of area protected is now the only area level to be statistically more likely to be chosen by those who have seen BPII. The highest level of the marine litter attribute in the interaction terms once again has the largest coefficient value indicating a strong preference for management options that achieve this outcome for those individuals who have seen the BPII series. This may reflect the

[6] As in the CL case no statistical differences were found in the coefficient estimates across the weighted versus unweighted versions of the RPL model so to focus the analysis only the weighted results are shown here. The unweighted RPL model results are available from the authors upon request.

fact that the final episode of the series focused on how plastic is having a devastating effect on the ocean and sea creatures and was credited with being a catalyst for changes in attitudes toward how society uses plastic.

In Tables 6 and 7, the marginal WTP per person per year estimates calculated based on both the EB weighted CL model and EB weighted RPL model are presented for both those who had and had not seen BPII along with their 95% confidence intervals. The marginal values were estimated using the Krinsky and Robb (1986) procedure. As was the case for CL and RPL models it follows through that there were no statistical differences in the marginal WTP values derived from the weighted versus unweighted versions of the models so once more the focus is on the EB weighted results. The estimates produced by the CL and RPL models across both subgroups are similar. The highest estimated marginal WTP figure is for a high level (Good) for marine litter in both the CL and RPL models (£54.68 and £46.85 for those who have not and who had seen BPII respectively, in the case of the RPL model results) followed by the highest possible level for health of fish stocks (£41.23 and £35.66 for those who have not and who had seen BPII respectively, in the case of the RPL model results). The lowest level of the ocean economy jobs created attribute (+20 jobs) is associated with the lowest marginal WTP in both models. The results of a Poe test (Poe et al. 2005) however fails to reject the null hypothesis that the difference in the two empirical distributions of the individual level marginal WTP values, across those who have and have not seen BPII, are equal to zero and thus indicates no statistical difference in the marginal WTP estimates across the groups.

- **Table 6 and table 7 here**

The results in Table 8 present the estimates of the compensating surplus (CS) associated with two possible management scenarios, based on the results of the EB weighted RPL model. The first is a cold-water coral reef conservation management option and is associated with the highest levels of the attributes health of fish stocks, marine litter and area to be protected but the status quo level for blue growth opportunities, i.e. no new ocean economy jobs are created. We also estimate the compensating surplus associated with a management plan that is more focused on blue growth with 40+ ocean economy jobs created in the area, but the plan only achieves the medium levels of all the other attributes. As was the case for the marginal WTP per person per year estimates, and as can be seen from the results presented in table 8, no statistical differences in the estimated welfare impact of alternative management options are observed between those who have seen and have not seen BPII. This can be seen in the overlapping confidence intervals and once again confirmed with a Poe test.

- **Table 8 here**

The welfare impact for scenario 1 (management to the highest possible level of all attributes) is significantly larger than for the medium level management of scenario 2 based on the results of the CL model (£70.70 versus £51.89). The difference is not as great in absolute terms (or statistically) when the RPL results are used to estimate the scenario welfare effects. Although not reported here, the estimated compensating surplus measures are higher from the CL model compared to the RPL model (not unexpected given the observed magnitude of the coefficient estimates in Tables 3 and 4). However, the estimates are not significantly different between the models.

6. Discussion and Conclusions

This paper presented the results of a discrete choice experiment that was employed to estimate the willingness to pay of the Scottish public to conserve the Mingulay cold water reef complex and analysed how respondents make trade-offs between blue growth potential and ecosystem service delivery. The impact that having watched the BBC Blue Planet II documentary series may have had on individuals' preferences and willingness to support marine conservation activity was also examined. To test this impact we first had to control for the possibility of confounding covariates using EB, a multivariate reweighting method to produce balanced samples in observational studies. It may be the case that those who have watched BPII have different characteristics (education levels, environmental awareness, etc) from those that have not, resulting in the non-random selection into the subgroups of those who have versus have not watched the BPII series. The EB procedure allows the researcher to control for the differences in characteristics across subgroups through the subsequent use of the generated individual EB weights in the choice models.

The EB reweighting approach has desirable appeal in discrete choice modelling when the researcher is concerned with estimating differences in preferences between a group of interest (treatment group) and a counterfactual comparison group (control). In a randomized experiment, respondents are randomly assigned to treatment or control groups. Conceptually, this means that the only difference between the groups is whether or not they receive the treatment. Therefore, any difference in outcomes must be due to the treatment and not to any other pre-existing differences in the respondents. With observational data however, such as that generated from a choice experiment, the treated and control groups may have very different distributions of the confounding covariates that can lead to biased model estimates. The goal in pre-processing the response choice data using the EB approach is to adjust the covariate distribution of the control group data by reweighting the observations such that it becomes more similar to the covariate distribution in the treatment group (Abadie and Imbens, 2011; Hainmueller, 2012).

In this study, no significant differences in the magnitude of coefficient estimates were found across the weighted versus unweighted versions of the choice models. This was not a surprising result given how closely the sub-samples matched on the covariates even without using the EB procedure. Nevertheless, the study demonstrates how entropy weighting can be used as a robust estimator to examine the effect of a campaign or programme on preferences in a discrete choice setting. In the weighted RPL model all attributes were significant and of the expected sign but based on the magnitude and significance of the standard deviations there was evidence of substantial unobserved preference heterogeneity in preferences across all attributes. The results also demonstrated a difference in the observed preferences for management option outcomes between those who had and had not seen the BPII series, particularly in relation to marine litter and the health of fish stocks.

The fact that those who have seen BPII were found to display higher sensitivity to the price of a management option as indicated by the significant and negative interaction term Cost*BPII in all model specifications suggest that those who have seen the series are not willing to pay as much for deep-sea management as those who have not seen the television series (the larger coefficient of the price coefficient in the denominator in equation (4) in effect cancels out the higher attribute coefficient values in the numerator). So, while the weighted models suggest an influence of watching BBPII on an individual's preferences for better management of marine litter, for moderate increases in the size of the protected area and for the highest level for healthy fish stocks they are not found to be willing to pay a premium for these outcomes compared to the average person who did not watch BPII.

This result; no statistical differences between the two group in terms of marginal WTP estimates and welfare impacts of alternative management options may seem counter-intuitive at first but there are a number of possible reasons for this result. Firstly, it may be that those who have watched the series already pay into some form of conservation fund (or were persuaded to on the back of having seen the series) and thus are taking that into account in their choices. Secondly, it may be the case that those who watch nature documentaries are more likely to seriously consider what such deep-sea management may involve and thus may be more 'thoughtful' in their responses in terms of what they can truly afford to pay in support. Finally, and in line with the findings of Meyerhoff (2006), it may be the case that well-designed documentaries with targeted conservation messages have the potential to influence the viewer's attitudes but post-viewing strategies may be needed to further action in the form of WTP. Also, given the 13 month time gap between the first complete airing of the series and the administration of the survey it may be the case that the initial spike in observed enthusiasm for donating to ocean conservation had decreased; a phenomenon noted elsewhere in the literature (Jacobsen, 2011; Hofman and Hughes, 2018).

While the use of the EB procedure allows us, to some extent, to gets closer to saying what the effect of BPII watching has on the demand for potential marine conservation outcomes it is important to keep in mind that the underlying choice data is still observational rather than experimental. There could still be other unobserved factors that may have a confounding effect on the analysis that are not being controlled for in the balancing of the chosen covariates although the results of the LCO analysis would suggest that this is not a major concern in this case. Balancing on covariates that are likely to have a key influence on both the treatment and decision making over choices is important for confidence in results. Also, while the EB approach could be extremely useful where the only goal of the modelling exercise is to analyse the effect of some treatment on choices made if the initial level of imbalance in the covariates is high, then the reweighted model results may not be appropriate to draw general conclusions about preferences in the population. Having said this Hainmueller (2012) points out that one of the key advantages of EB is that it retains valuable information in the pre-processed data by allowing the unit weights to vary smoothly across units; "it reweights units appropriately to achieve balance, but at the same time keeps the weights as close as possible to the base weights to prevent loss of information and thereby retains efficiency for the subsequent analysis".

The EB approach offers researchers a useful and flexible method for estimating the impact of a particular treatment on the choices made in discrete choice analysis. While the effect of the EB approach here was limited due to the close balance already observed in the covariates in both sub-samples prior to the rebalancing it could have much greater influence in situations where the sub-samples of interest display greater differences. Furthermore, the procedure could have other uses in discrete choice analysis and environmental valuation more generally. It is a procedure that could be used to reweight an entire survey of valuation observations to known characteristics of some target population. This could be particularly useful for on-line samples which are often not representative for certain age-groups or social classes. It could also be useful in a benefit transfer situation where a national level sample, for example, could be reweighted to be representative of a subsample of interest (perhaps a region with different population characteristics) on known moments of the characteristics of that subsample. This would be similar to how Hynes et al. (2010) used a spatial microsimulation modelling framework in the transfer of a value function from an existing study to a policy study of interest. In this setting the EB approach would be a far less complex procedure to undertake and implement.

The paper started with a quote from a young Sir David Attenborough in which the broadcaster was espousing the view that demonstrating the value of nature to the public is more beneficial than lecturing them on what they should be doing to prevent damages. Although it would take another decade for the first mention of the idea of ecosystem services (Ehrlich and Ehrlich, 1981), forty years on 'ecosystem services' now constitute a key conceptual framework for discussing ecological, economic and social interactions in many areas of policy and has done what Attenborough hoped;

shifting the conversation from the negative impacts of humans on the environment to the positive benefits society receives from a healthy environment. As Kronenberg (2014) points out, the concept of ecosystem services refocuses the conversation by suggesting that destroying the environment runs counter to societies' interests. The results presented in this paper show that Sir David Attenborough's BPII series has not only highlighted the importance of the ecosystem services provided by the marine environment but may also have had an impact on how the public form their preferences for the services that marine ecosystems such as cold water corals deliver, and their choices on how they should be managed in the future.

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Figure 1 Sample choice card

SCENARIO 1	Option A	Option B	Option C (current management)
Health of commercial fish stocks	**Low:** 40% of commercial stocks s at healthy stock levels	**Moderate:** 50% of commercial stocks at healthy stock levels	**Low:** 40% of commercial stocks s at healthy stock levels
Density of Marine litter	**Poor** (5 to 8 items of litter per mile^2)	**Moderate** (2 to 4 items of litter per mile^2)	**Poor** (5 to 8 items of litter per mile^2)
Size of protected area	**10% of the Sea of the Hebrides**	**1% of the Sea of the Hebrides**	**1% of the Sea of the Hebrides**
Marine economy jobs created from sea based commercial activities in the area	**No employment change**	**+ 40 jobs**	**No employment change**
Additional costs (per person per year) £	**£ 5**	**£ 20**	**£ 0**
Your choice for scenario 1 *(please tick A, B or C)*			

Table 1 Attributes and Levels Description

Attribute Definition	Scotland – Levels
Health: % of commercial stocks at healthy stock levels.	High (>80%) Moderate (40 – 80%) Low (<40%)
Litter: Density of marine litter measured as number of items of litter per square mile	Good (0 to 1) Moderate (2 to 4) Poor (5 to 8)
Area: size of protected area.	15% of the Sea of the Hebrides (15 times the size of current management) 10% of the Sea of the Hebrides (10 times the size of current management) 6% of the Sea of the Hebrides (6 times the size of current management) 1% of the Sea of the Hebrides (current management)
Jobs: number of marine economy jobs created from sea based commercial activities in the area	+ 40 + 20 No employment change
Additional costs: Unit currency per person per year	£0 (for status quo option only), £5, £10, £20, £30, £40, £60

Table 2. Summary Statistics

Variable*	Mean or Proportion	Std. Dev.
Age	49.59	16.88
Male	0.440	0.497
Number of persons in household	6.323	1.218
Third level education	0.518	0.500
Full time employed	0.380	0.486
Part time employed	0.133	0.339
Currently a student	0.064	0.246
Retired	0.281	0.450
Unemployed	0.044	0.205
Resident of Highlands and Islands	0.063	0.244
Have visited island of Mingulay	0.023	0.151
Have visited island of Barra	0.119	0.324
Have visited elsewhere in the Outer Hebrides	0.238	0.426
Respondent or member of household employed in sea related industry	0.089	0.285
Marine sports enthusiast	0.384	0.487
Have seen Blue Planet II Series	0.549	0.497

* Bar Age and Number of persons in household all other variables are expressed as proportions

Table 3. Entropy Balancing Outcomes

	Before: Without Weighting						**After: With Weighting**		
	Treatment: Have seen Blue Planet II			*Control before EB : Have not seen Blue Planet II*			*Control after EB: Have not seen Blue Planet II*		
	Mean	Variance	Skewness	Mean	Variance	Skewness	Mean	Variance	Skewness
Third level education	0.540	0.248	-0.160	0.491	0.250	0.035	0.540	0.248	-0.160
Part time employed	0.128	0.112	2.228	0.139	0.119	2.093	0.128	0.112	2.228
Unemployed	0.041	0.039	4.639	0.048	0.045	4.249	0.041	0.039	4.639
Male	0.448	0.247	0.211	0.431	0.245	0.280	0.448	0.247	0.211
Income level/1000	22.5	198.2	2.329	20.6	156.6	2.166	22.5	206.8	2.456
Resident of Highlands and Islands	0.068	0.063	3.448	0.058	0.055	3.765	0.067	0.063	3.448
Age	51.0	285.0	-0.151	47.9	279.1	-0.026	51.0	270.7	-0.208
Marine sports enthusiast	0.385	0.237	0.471	0.383	0.236	0.481	0.385	0.237	0.471
Aware of information given on Scottish marine environment at start of survey	0.425	0.244	0.306	0.582	0.243	-0.334	0.425	0.244	0.304

Table 4. Conditional Logit Models

	Attribute level	**Unweighted CL**	**Weighted CL**
Health of fish stocks	High: > 80% of commercial stocks have healthy stock levels	0.611***(.054)	0.606***(.049)
	Moderate: 40 to 80% of commercial stocks have healthy stock levels	0.359***(.056)	0.334***(.051)
Marine litter	Good (0 to 1 item of litter per mile2)	0.723***(.062)	0.736***(.057)
	Moderate (2 to 4 items of litter per mile2)	0.353***(.057)	0.398***(.053)
Size of area protected	15% of the Sea of the Hebrides (15 times the size of "current management)	0.348***(.072)	0.389***(.066)
	10% of the Sea of the Hebrides (10 times the size of current management)	0.332***(.064)	0.364***(.059)
	6% of the Sea of the Hebrides (six times the size of current management)	0.366***(.063)	0.373***(.057)
Blue Growth (ocean economy jobs created in area)	+40 Jobs	0.472***(.051)	0.449***(.047)
	+20 jobs	0.227***(.055)	0.277***(.050)
Cost		-0.015***(.002)	-0.014***(.002)
Alternative Specific Constant for Status Quo Option (ASC3)		-0.576***(.122)	-0.474***(.119)
Blue Planet (BPII) Interactions			
Health of fish stocks*BPII	High: > 80% of commercial stocks have healthy stock levels	0.157*(.069)	0.157*(.067)
	Moderate: 40 to 80% of commercial stocks have healthy stock levels	0.084 (.073)	0.106 (.070)
Marine litter*BPII	Good (0 to 1 item of litter per mile2)	0.232**(.081)	0.215**(.078)
	Moderate (2 to 4 items of litter per mile2)	0.217**(.075)	0.169*(.071)
Size of area protected*BPII	15% of the Sea of the Hebrides (15 times the size of "current management)	0.245**(.094)	0.200*(.090)
	10% of the Sea of the Hebrides (10 times the size of current management)	0.225**(.082)	0.189*(.078)
	6% of the Sea of the Hebrides (six times the size of current management)	0.145 (.081)	0.133 (.077)
Blue Growth (ocean economy jobs created in area)*BPII	+40 Jobs	0.076 (.067)	0.096 (.064)
	+20 jobs	0.127 (.071)	0.073 (.068)
Cost*BPII		-0.007***(.002)	-0.009***(.002)
Other Interactions with ASC3			
Age*ASC3		0.0051*(.002)	0.003 (.002)
Male*ASC3		0.141*(.069)	0.078 (.067)
Highlands and Islands resident*ASC3		-0.851***(.186)	-0.867*** (.176)
Log Likelihood		-7701	-8408
Likelihood Ratio Chi^2 (24)		2515	2796
Observations		7952	7952

Standard errors in parentheses, ***indicates significant at 1%, ** 5% and * 10%

Table 5. Random Parameters Logit estimated using entropy balancing weights

	Attribute level	Mean of coefficient	Standard deviation of coefficient
Health of fish stocks	High: > 80% of commercial stocks have healthy stock levels	0.872***(0.091)	1.135***(0.069)
	Moderate: 40 to 80% of commercial stocks have healthy stock levels	0.411***(0.076)	0.587***(0.092)
Marine litter	Good (0 to 1 item of litter per mile2)	1.157***(0.104)	1.544***(0.078)
	Moderate (2 to 4 items of litter per mile2)	0.616***(0.078)	0.719***(0.075)
Size of area protected	15% of the Sea of the Hebrides (15 times the size of "current management)	0.459***(0.106)	1.186***(0.107)
	10% of the Sea of the Hebrides (10 times the size of current management)	0.514***(0.084)	0.428***(0.107)
	6% of the Sea of the Hebrides (six times the size of current management)	0.525***(0.081)	0.459***(0.106)
Blue Growth (ocean economy jobs created in area)	+40 Jobs	0.678***(0.082)	1.086***(0.069)
	+20 jobs	0.460***(0.089)	1.125***(0.083)
Non-random parameters in utility functions			
Cost		-0.021***(0.002)	
Alternative Specific Constant for Status Quo Option (ASC3)		-0.329** (0.153)	
Blue Planet (BPII) Interactions			
Health of fish stocks*BPII	High: > 80% of commercial stocks have healthy stock levels	0.234* (0.126)	
	Moderate: 40 to 80% of commercial stocks have healthy stock levels	0.162 (0.104)	
Marine litter*BPII	Good (0 to 1 item of litter per mile2)	0.297** (0.141)	
	Moderate (2 to 4 items of litter per mile2)	0.234** (0.105)	
Size of area protected*BPII	15% of the Sea of the Hebrides (15 times the size of "current management)	0.121 (0.146)	
	10% of the Sea of the Hebrides (10 times the size of current management)	0.256** (0.112)	
	6% of the Sea of the Hebrides (six times the size of current management)	0.168 (0.109)	
Blue Growth (ocean economy jobs created in area)*BPII	+40 Jobs	0.133 (0.110)	
	+20 jobs	0.082 (0.120)	
Cost*BPII		-0.010*** (0.003)	
Other Interactions with ASC3			
Age*ASC3		0.003(0.003)	
Male*ASC3		0.052(0.089)	
Highlands and Islands resident*ASC3		-0.855***(0.213)	
Log likelihood	-7041		
Likelihood Ration chi^2 (?)	3853		
Observations	7952		

Figures in parenthesis indicate the values of the standard errors. ***indicates significant at 1%, ** 5% and * 10%.

Table 6. Marginal WTP based on EB weighted Conditional Logit model results (£ Sterling)

	Attribute level	Those who have not seen Blue Planet	Those who have seen Blue Planet
Health of fish stocks	High: > 80% of commercial stocks have healthy stock levels	44.35*** (5.11)	55.85*** (7.72)
	Moderate: 40 to 80% of commercial stocks have healthy stock levels	24.40*** (4.34)	32.16*** (5.39)
Marine litter	Good (0 to 1 item of litter per mile2)	53.85*** (5.21)	69.58*** (9.43)
	Moderate (2 to 4 items of litter per mile2)	29.08*** (4.26)	41.42*** (6.24)
Size of area protected	15% of the Sea of the Hebrides (15 times the size of "current management)	28.47*** (4.29)	43.09*** (7.31)
	10% of the Sea of the Hebrides (10 times the size of current management)	26.60*** (4.42)	40.41*** (6.61)
	6% of the Sea of the Hebrides (six times the size of current management)	27.31*** (4.85)	37.04*** (6.19)
Blue Growth (ocean economy jobs created in area)	+40 Jobs	32.86*** (4.61)	39.86*** (5.99)
	+20 jobs	20.28*** (4.11)	25.65*** (4.74)

Figures in parenthesis indicate the values of the standard errors. ***indicates significant at 1%.

Table 7. Marginal WTP based on EB weighted Random Parameter Logit model results (£ Sterling)

	Attribute level	Those who have not seen Blue Planet	Those who have seen Blue Planet
Health of fish stocks	High: > 80% of commercial stocks have healthy stock levels	41.23*** (5.14)	35.66*** (3.05)
	Moderate: 40 to 80% of commercial stocks have healthy stock levels	19.45*** (4.01)	18.47*** (2.64)
Marine litter	Good (0 to 1 item of litter per mile2)	54.68*** (5.67)	46.85*** (3.53)
	Moderate (2 to 4 items of litter per mile2)	29.12*** (3.98)	27.40*** (2.52)
Size of area protected	15% of the Sea of the Hebrides (15 times the size of "current management)	21.70*** (4.80)	18.71*** (3.31)
	10% of the Sea of the Hebrides (10 times the size of current management)	24.31*** (4.06)	24.85*** (2.76)
	6% of the Sea of the Hebrides (six times the size of current management)	24.84*** (3.99)	22.35*** (2.69)
Blue Growth (ocean economy jobs created in area)	+40 Jobs	32.07*** (5.02)	26.17*** (3.00)
	+20 jobs	21.75*** (4.62)	17.46*** (2.94)

Figures in parenthesis indicate the values of the standard errors. ***indicates significant at 1%.

Table 8. Attribute levels and compensating surplus value estimates for two policy scenarios (£ Sterling per person per year) based on EB weight RPL results

Management Plan	Attribute levels	Welfare Impact of average person (95%CI)	Welfare Impact who have not seen Blue Planet (95%CI)	Welfare Impact who have seen Blue Planet (95%CI)
Marine Conservation Management Option	Health of fish stocks: High Marine litter: Good 15% of the Sea of the Hebrides No new ocean economy jobs created in area	107.11***(96.32, 117.90)	117.61*** (97.39, 137.84)	101.22*** (89.72, 112.72)
Blue Growth Management Option	Health of fish stocks: Moderate Marine litter: Moderate 10% of the Sea of the Hebrides +40 ocean economy jobs created in area	71.50*** (62.03, 80.96)	72.88*** (56.98, 88.77)	70.72*** (60.36 81.08)

Figures in parenthesis indicate 95% confidence intervals. ***indicates significant at 1%, ** indicates significant at 5%.

Appendix 1

Table A1. Logit model of whether or not a person has watched any of the Blue Planet II series

	Coefficient	Standard Error
Third level education	0.128	-0.131
Part time employed	-0.0241	-0.194
Unemployed	0.0679	-0.319
Male	-0.0331	-0.134
Income level/1000	0.00923	-0.0052
Resident of Highlands and Islands	-0.0249	-0.266
Age	0.00989**	-0.00394
Marine sports enthusiast	-0.023	-0.132
Aware of information given on Scottish marine environment at start of survey	-0.603***	-0.13
Constant	-0.227	-0.274
LogLikelihood	-687	
LR chi2(9)	37*	
Pseudo R2	0.0263	

***indicates significant at 1%, ** indicates significant at 5%.

Table A2. Separate conditional logit models for portion of sample who watched BPII, who did not watch it, who did not watch it with EB weights, and model for entire sample excluding BPII interaction terms.

		BPII watchers	BPII non-watchers (un-weighted)	BPII non-watchers (weighted)	Full sample
Health of fish stocks	High: > 80% of commercial stocks have healthy stock levels	0.733***	0.641***	0.655***	0.695***
		(0.051)	(0.052)	(0.057)	(0.038)
	Moderate: 40 to 80% of commercial stocks have healthy stock levels	0.414***	0.361***	0.396***	0.404***
		(0.052)	(0.053)	(0.058)	(0.039)
Marine litter	Good (0 to 1 item of litter per mile2)	0.921***	0.774***	0.771***	0.848***
		(0.059)	(0.06)	(0.065)	(0.044)
	Moderate (2 to 4 items of litter per mile2)	0.534***	0.434***	0.401***	0.472***
		(0.054)	(0.056)	(0.061)	(0.041)
Size of area protected	15% of the Sea of the Hebrides (15 times the size of "current management)	0.519***	0.478***	0.511***	0.512***
		(0.048)	(0.049)	(0.054)	(0.036)
	10% of the Sea of the Hebrides (10 times the size of current management)	0.325***	0.303***	0.263***	0.296***
		(0.051)	(0.051)	(0.057)	(0.038)
	6% of the Sea of the Hebrides (six times the size of current management)	0.554***	0.430***	0.402***	0.480***
		(0.068)	(0.069)	(0.076)	(0.051)
Blue Growth (ocean economy jobs created in area)	+40 Jobs	0.518***	0.404***	0.383***	0.455***
		(0.059)	(0.061)	(0.067)	(0.045)
	+20 jobs	0.471***	0.410***	0.416***	0.444***
		(0.059)	(0.06)	(0.066)	(0.044)
Cost		-0.022***	-0.014***	-0.016***	-0.019***
		(0.002)	(0.002)	(0.002)	(0.001)
Alternative Specific Constant for Status Quo Option (ASC3)		-0.863***	-0.119	-0.295	-0.534***
		(0.177)	(0.162	(0.17)	(0.121)
Age*ASC3		0.00645*	0.00053	0.00405	0.00432*
		(0.003)	(0.003)	(0.003)	-0.003)
Male*ASC3		0.306**	-0.125	-0.0219	0.137*
		(0.098)	(0.092)	(0.098)	(0.069)
Highlands and Islands resident*ASC3		-0.963***	-0.778***	-0.736**	-0.848***
		(0.274)	(0.231)	(0.256)	(0.186)
Observations		13296	10560	10560	23856

Standard errors in parentheses, ***indicates significant at 1%, ** 5% and * 10%.

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