Preference classes in society for coastal marine protected areas

Ana Ruiz-Frau [Corresp., 1, 2] , James M Gibbons [3] , Hilmar Hinz [1] , Gareth Edwards-Jones [3] , Michel J Kaiser [4, 5]

[1] Department of Marine Ecology, Instituto Mediterráneo de Estudios Avanzados, Esporles, Spain

[2] School of Ocean Sciences, College of Natural Sciences, Bangor University, Bangor, United Kingdom

[3] School of Environment, Natural Resources and Geography, College of Natural Sciences, Bangor University, Bangor, United Kingdom

[4] Marine Stewardship Council, London, United Kingdom

[5] The Lyell Centre, School of Energy, Geosciences, Infrastructure and Society, Heriot-Watt University, Edinburgh, United Kingdom

Corresponding Author: Ana Ruiz-Frau
Email address: anaruiz@imedea.uib-csic.es

Marine protected areas (MPAs) are increasingly being used as conservation tools in the marine environment. Success of MPAs depends upon sound scientific design and societal support. Studies that have assessed societal preferences for temperate MPAs have generally done it without considering the existence of discrete groups of opinion within society and have largely considered offshore and deep-sea areas. This study quantifies societal preferences and economic support for coastal MPAs in Wales (UK) and assesses the presence of distinct groups of preference for MPA management, through a latent class choice experiment approach. Results show a general support for the protection of the marine environment in the form of MPAs and that society is willing to bear the costs derived from conservation. Despite a general opposition towards MPAs where human activities are completely excluded, there is some indication that three classes of preferences within society can be established regarding the management of potentially sea-floor damaging activities. This type of approach allows for the distinction between those respondents with positive preferences for particular types of management from those who experience disutility. We conclude that insights from these types of analyses can be used by policy-makers to identify those MPA designs and management combinations most likely to be supported by particular sectors of society.

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3   Kaiser [4,5]

4   [1] Department of Marine Ecology, Instituto Mediterraneo de Estudios Avanzados, Esporles,

5   Spain.

6   [2] School of Ocean Sciences, College of Natural Sciences, Bangor University, Bangor, UK

7   [3] School of Environment, Natural Resources and Geography, College of Natural Sciences, Bangor

8   University, Bangor, UK

9   [4] Marine Stewardship Council, London, UK

10   [5] The Lyell Centre, School of Energy, Geosciences, Infrastructure and Society, Heriot-Watt

11   University, Edinburgh, UK

13   Corresponding author: Ana Ruiz-Frau

14   Email address: anaruiz@imedea.uib-csic.es

16   ABSTRACT

17   Marine protected areas (MPAs) are increasingly being used as conservation tools in the marine

18   environment. Success of MPAs depends upon sound scientific design and societal support.

19   Studies that have assessed societal preferences for temperate MPAs have generally done it

20   without considering the existence of discrete groups of opinion within society and have largely

21   considered offshore and deep-sea areas. This study quantifies societal preferences and

22   economic support for coastal MPAs in Wales (UK) and assesses the presence of distinct groups

23   of preference for MPA management, through a latent class choice experiment approach.

24   Results show a general support for the protection of the marine environment in the form of

25   MPAs and that society is willing to bear the costs derived from conservation. Despite a general

26   opposition towards MPAs where human activities are completely excluded, there is some

27   indication that three classes of preferences within society can be established regarding the

28   management of potentially sea-floor damaging activities. This type of approach allows for the

29   distinction between those respondents with positive preferences for particular types of

30   management from those who experience disutility. We conclude that insights from these types

31   of analyses can be used by policy-makers to identify those MPA designs and management

32   combinations most likely to be supported by particular sectors of society.

33   1. Introduction

34   The marine environment provides society with a wide range of goods and services that are

35   essential for the maintenance of our economic and social wellbeing (MEA 2005; Liquete et al.

36   2013; Costanza et al. 2014). The recognition of the effects of anthropogenic activities on marine

37   ecosystems has led to increasing conservation initiatives globally. Marine protected areas

38   (MPAs) are among the most important tools available for achieving global marine conservation

39   targets, which are recognized both at international and European level (OSPAR 2003; CBD 2008;

40   MSFD 2008).

41   Although the role of MPAs in the recovery of fish stocks and fisheries management remains an

42   issue of debate (Kaiser 2005; Stefansson and Rosenberg 2006; Hilborn 2018), it is clear that the

43   establishment of MPAs has positive benefits for habitat restoration and biodiversity

44   conservation within the boundaries of the MPA (Halpern 2003; Blyth-Skyrme et al. 2006).

45   However, the creation and enforcement of MPAs is costly (Balmford et al. 2004) and despite

46   their potential benefits, their designation is often complex both legally and socially. This is

47   because the closure of portions of the sea to human activities has impacts on those sectors of

48   society directly affected by the closures, and not all of these impacts are perceived as positive.

49   However, if designed carefully MPAs can achieve a balance between marine conservation and

50   socio-economic objectives (Klein et al. 2008; Ruiz-Frau et al. 2015a, b). Consequently, the

51   design of MPAs is better addressed from an interdisciplinary perspective that is able to provide

52   insights into the range of potential consequences of implementation. If MPAs are to

53   successfully achieve their conservation objectives, then the biological principles of good reserve

54   design need to have a strong influence on the designation process (Roberts et al. 2003),

55   unfortunately however this is not always the case (Caveen et al. 2013, 2015). In addition,

56   conservation objectives cannot be met without support from members of local communities,

57   resource users and policy makers (Moore et al. 2004). Through the acknowledgement of the

58   role of the marine environment as supplier of ecosystem services and benefits fundamental for

59   the maintenance of human wellbeing (MEA 2005), there is increasing pressure to engage

60   stakeholders and in general members of society into marine and coastal planning (EU 2001;

61   Epstein et al. 2014; Christie et al. 2017). This paper focuses on expanding current knowledge

62   about how the general public perceives and values the conservation of the marine environment

63   and how distinct opinion groups can be established in society based on MPA management

64   preferences. To do this, a case study using discrete choice experiment methodology to assess

65   society's preferences for the establishment of MPAs around the coast of Wales (UK) is

66   undertaken.

67   Discrete choice experiments (DCEs) are survey-based methodologies where respondents are

68   asked to choose their most preferred alternative among a set of hypothetical alternatives. Each

69   alternative is characterized by the same bundle of attributes, however the alternatives differ in

70   the levels displayed by the attributes. Through the analysis of responses, the marginal rate of

71   substitution between any pair of attributes that differentiate the alternatives can be

72   determined. If one of the attributes has a monetary price attached to it, it is then possible to

73   compute the respondent's willingness to pay (WTP) for the other attributes (Hanley et al. 1998;

74   Liu et al. 2010).

75   The body of literature using DCEs to determine the economic preferences and value that

76   society attaches to the conservation of the marine environment through MPAs is rapidly

77   growing (Torres and Hanley, 2017). A high proportion of studies however have focused on

78   tropical areas and on coral habitats, which are highly charismatic and might attract higher WTP

79   from the public (e.g. Mwebaze and MacLeod, 2013; Rogers, 2013; Rolfe and Windle, 2012; and

80   references in Torres and Hanley, 2016), however cultural aspects need to be taken into account

81   when considering studies from different locations, as charismatic species are not always the

82   main drivers in the WTP for biodiversity conservation (Ressurreição et al. 2012). Similarly,

83   studies on temperate areas are also increasing albeit at a lower pace (McVittie and Moran

84   2010; Wattage et al. 2011; Börger et al. 2014; Jobstvogt et al. 2014b, a; Kermagoret et al. 2016;

85   Börger and Hattam 2017). In general, these studies indicate that society values and is willing to

86   support the additional economic costs associated to conservation. As an example, Jobstvogt et

87   al. 2014 showed high WTP values (£70 to £77) for the protection of deep sea biodiversity while

88   McVittie and Moran 2010 found values of similar magnitude for halting the loss of marine

89   biodiversity in UK waters (£21 to £34). However, the focus of the DCE studies on temperate

90   MPAs has largely been on offshore and deep-sea areas (Wattage et al. 2011; Börger et al. 2014;

91   Jobstvogt et al. 2014a; Kermagoret et al. 2016; Börger and Hattam 2017), on the WTP for the

92   protection of charismatic species such as marine mammals through the use of MPAs (Boxall et

93   al. 2012; Batel et al. 2014) or on particular segments of society such as divers (Sorice et al.

94   2009; Jobstvogt et al. 2014b). Additionally, those studies that considered society as a whole did

95   not explore the existence of discrete opinion groups with distinct preferences for the

96   management of MPAs and how this might be linked to particular socio-demographic

97   characteristics and attitudinal aspects, as suggested by Börger and Hattam (2017) in a study on

98   offshore areas. We argue that this type of information can be highly relevant for policy-makers

99   during an MPA design process in order to enhance societal support.

100   The present study focuses on Wales in the United Kingdom (UK), a region with a long coastline

101   (approximately, 2700 Km) and strong historic connections to the sea, where Government

102   developed a Marine and Coastal Access Act 2009 in which it commits to "establishing an

103   ecologically coherent, representative and well-managed network of marine protected areas"

104   taking into account "environmental, social and economic criteria" (DEFRA 2009). In Wales,

105   comprehensive information is available for the distribution of biophysical and ecological

106   factors, however information on how much the public values the conservation of the marine

107   environment or on the support for MPAs in the area is scarce.

108   This case study offers an assessment of societal support for coastal MPAs located in temperate

109   areas and analyses the assumption that there is preference heterogeneity in society for the

110   type of protection of the marine environment and that discrete classes of preferences can be

111   established through a DCE. Additionally, the focus of the study is on coastal waters for which

112   people might be more familiar with and might have a greater sense of attachment in

113   comparison to offshore areas and therefore preferences might differ.

114

115   2. Methods

116 The economic value associated with changes in the size and uses allowed within the boundaries

117 of a temperate coastal MPA network were estimated using a discrete choice experiment (DCE).

118 DCE data were collected using questionnaires. Heterogeneity in societal preferences for MPAs

119 was estimated with a latent class choice experiment model (Train 2009).

120 Figure 1 about here

121 *2.1 Choice Experiments Econometrics*

122 The economic framework for DCE lies in Lancaster's theory of consumer choices (Lancaster

123 1966), which assumes that the utility of a good can be decomposed into the utilities of the

124 characteristics of that good and as a result consumers' decisions are determined by the utility

125 of the attributes rather than by the good itself. The econometric basis for DCE is provided by

126 the random utility theory framework, which describes consumers' choices as utility

127 maximization behaviors. Through the analysis of DCE data, marginal values for the attributes of

128 a good or individual's willingness to pay (WTP) can be calculated (Hensher et al. 2007).

129 However, DCE approaches remain controversial because of their hypothetical nature and the

130 contested reliability of their results (Hausman 2012), although it has been concluded that DCE

131 remains useful for non-market valuation, its results should be used with caution (Rakotonarivo

132 et al. 2016).

133 DCEs can be analyzed using different models. Due to its simplicity, the multinomial logit model

134 (MNL) is the most widely used. This model has important limitations; specifically, it assumes

135 independence of irrelevant alternatives (IIA) and it assumes homogeneous preferences for all

136 respondents (Hausman and McFadden 1984). However, within society preferences are

137   heterogeneous and the ability to account for this variation allows the estimation of unbiased

138   models that provide a better representation of reality. Random parameter logit models (RPL)

139   and latent class logit models (LC) relax the limitations of standard logit by allowing random

140   taste variation and unrestricted substitution patterns in their estimation. The RPL allows utility

141   parameters to vary randomly across individuals while in the LC formulation preference

142   heterogeneity is captured by simultaneously assigning individuals into latent segments or

143   "classes" while estimating a choice model. Within each latent class, preferences are assumed

144   homogeneous, but these can vary between classes (Boxall and Adamowicz 2002; Scarpa and

145   Thiene 2005; Colombo et al. 2009). RPL approaches might not reveal the existence of classes

146   since they are constrained by the assumed distribution across individuals, potentially hiding

147   discrete groups. Model fit criterion measures were calculated for all models to assess their

148   suitability to see which approach was most supported.

149   The utility (U) of a good consists of a known or systematic component (V) and a random

150   component (ε) which is not observable by the researcher. The systematic component of utility

151   can be further decomposed into the specific attributes of the good (βX), which in this case is a

152   policy for the establishment of MPAs. Thus, the utility that respondent n derives from a certain

153   MPA alternative i is given by:

154    $U_{in} = \beta_{in} + \varepsilon_{in}$ (1)

155   The probability that an individual n will choose MPA alternative i from a set of J alternatives is

156   equal to the probability that the utility derived from i is greater than the utility derived from

157   any other alternative:

158    $Prob_{in} = Prob(U_{in} > U_{jn}) \quad \forall j \in J$ (2)

159   Assuming the random term to be independent and identically distributed (IID) according to a

160   type I extreme value distribution, the probability that respondent chooses alternative *i* in

161   choice occasion *q* is a standard MNL (McFadden 1974):

162    $L_n(i,q \mid \beta_n) = \dfrac{\exp(\beta_n X_{inq})}{\sum_j^J \exp(\beta_n X_{jnq})}$ (3)

163   If z_{nt} is the respondent's chosen alternative in choice occasion q and $z_n = (z_{n1}, z_{n2}, ..., z_{nQ})$ is

164   the sequence of choices in Q choice occasions then the joint probability of the respondent's

165   choices is the product of the standard logits:

166    $Prob(z_n|\beta_n) = L(z_{n1}, 1|\beta_n) \cdots L(z_{nQ}, Q|\beta_n)$ (4)

167   The term β$_n$ is not directly observable, only its density $f(\beta \mid \theta)$ is assumed to be known, where

168   θ represents the parameters of the distribution. In RPL and LC models the unconditional

169   probability of the respondent's sequence of choices is the integral of equation (4) over all

170   possible values of β$_n$ determined by the population density of β$_n$:

171    $Prob(z_n|\theta) = \int Prob(z_n|\beta_n) f(\beta_n|\theta) d\beta_n$ (5)

172   The distribution of β will determine the type of model to be used. If β is continually distributed

173   it will result in a RPL (McFadden and Train 2000) while if the coefficients are discretely

174   distributed and class membership is homogeneous it results on a LCM, where β takes values for

175   each class.

176   The log-likelihoods for both specifications are determined by:

177    $L(\theta) = \sum_{n}^{N} \ln Prob(z_n)$ (6)

178   Since the choice probability in the RPL does not have a closed form the expression has to be

179   approximated using simulation (Train 2009). Repeated draws of β are taken from its density

180    $f(\beta\,|\,\theta)$. For each draw, the product of logits is calculated and the results are averaged across

181   draws. In this study Halton intelligent draws have been used for the simulation since they have

182   been found to provide greater accuracy than independent random draws in the estimation of

183   RPL models (Train 2009).

184    $L_{RPL}(\theta) = \sum_{n=1}^{N} \ln\left[\frac{1}{D} Prob\left(z_n|\beta^d\right)\right]$ (7)

185   where D is the number of draws and β^d is the dth draw. For a LCM with C latent classes, the log-

186   likelihood function is given by:

187    $L_{LCM}(\theta) = \sum_{n}^{N} \ln\left[\sum_{c=1}^{C} Prob(c)Prob(z_n|\beta_c)\right]$ (8)

188   where Prob(c) has a MNL form and is the probability of respondent n belonging to class c and β_c

189   represents a vector of class specific coefficients.

190   Welfare estimates can be derived from the models, they are calculated in the form of

191   willingness to pay (WTP) using the formula:

192    $WTP = \frac{\beta_a}{\beta_c}$ (9)

193   where β_a is the coefficient of the attribute of interest and β_c is the negative of the coefficient of

194   the monetary variable.

195   *2.2 Area of study*

196   The study focused around the coastal waters of Wales (UK) (Fig. 1), prior to the initiation of

197   formal Government consultation in late 2009. Here, we define Welsh coastal waters as those

198   within the 12nm territorial limit. In 2009, 32% of Welsh territorial waters were protected under

199   a range of European and UK designations (Marine Nature Reserve, Special Area of

200   Conservation, Special Protection Area and Site of Special Scientific Interest). However, existing

201   designations were limited in terms of the species, habitats or areas that were afforded

202   protection and also the level of protection these different designations offered. At the time of

203   writing, none of the designated areas were fully protected from human activities.

204   In the UK, the Marine and Coastal Access Act 2009 (DEFRA 2009) provided the legislative

205   powers necessary for the implementation of Marine Conservation Zones (MCZs). Back in 2009

206   in Wales, the MCZ designation was to be primarily used to establish Highly Protected Marine

207   Reserves (HPMRs), these are sites that are generally protected from extraction and deposition

208   of living and non-living resources, and all other damaging or disturbing activities. The aim to

209   establish HPMRs was to complement the existing network of protected areas, resulting in a

210   network of MPAs with varying levels of protection.

211   In 2014, the first MCZ in Welsh waters was established around the island of Skomer and the

212   Marloes Peninsula in Pembrokeshire (NRW 2015). Before 2014 the area had been Wales' only

213   Marine Nature Reserve (MNR) for 24 years. However, Skomer MCZ retained a similar level of

214   protection as when it was a MNR and the HPMR status was not enforced. At the time of writing

215   no area of the Welsh coast was highly protected.

216   *2.3 Study design*

217   The first step in any DCE is to define the good to be valued in terms of its attributes and levels.

218   This study focused on those aspects of MPA network design that were most likely to have an

219   impact on society. Initially, the attributes considered for the DCE were the location, total size of

220   the network, level of protection, proportion of areas with different levels of protection and the

221   price associated to the enforcement of protective measures. A focus group was carried out with

222   15 randomly sampled members of the general public to define the final list of attributes to be

223   included in the survey. During the meeting the list of attributes, possible associated levels and

224   alternative formats of the DCE survey were discussed. The focus-group exercise revealed that

225   the full set of attributes was too complex to enable respondents to make meaningful trade-offs

226   during the DCEs. The final set of attributes was reduced to include only size, level of protection

227   and cost.

228   The first attribute included in the DCE was the size of the network of MPAs. To define the levels

229   for this attribute, the situation in Wales in 2009 was taken as the baseline. In 2009, 32% of

230   territorial waters were protected under different EU designations with different levels of

231   protection. According to the statutory Governmental conservation advisory body (Natural

232   Resources Wales), it was unlikely that the area of the new network of MPAs would exceed that

233   of the existing protected areas. Thus, the highest level for the size attribute was set to 30% of

234   Welsh territorial waters (equivalent to 4,826 km^2), 20% and 10% were chosen as the alternate

235   levels.

236   The second attribute in the DCE was the type of protection for the MPA network. In this study

237   four levels of protection were selected as a representation of the most common management

238   alternatives in MPAs: (1) no take zones in which no activities were allowed, (2) areas in which

239   only scientific research and educational activities were allowed, (3) non-extractive recreational

240   activities allowed (e.g. scuba-diving, sailing, kayaking) and (4) recreational and commercial

241   fishing using non-damaging equipment to the sea floor allowed.

242   The third attribute included in the DCE was a monetary one, which is required to estimate

243   welfare changes of respondents. The range chosen for the monetary attribute and the payment

244   vehicle were determined during the focus group. The final set of selected attributes, their levels

245   and definition are reported in Table 1.

246   Table 1, about here

247   The final questionnaire contained information on the relevance of the marine environment to

248   society from an economic, cultural and ecological perspective, general information on MPAs,

249   their associated possible outcomes and costs and design issues, and information on the current

250   situation and future plans for Wales. The DCE tasks were located after the general information

251   sections in the questionnaire. In addition to the DCE tasks, information was collected on

252   societal views and attitudes towards MPAs and the environment. Demographic data were

253   collected in order to assess the representativeness of the sample. Average questionnaire

254   completion time was 15 minutes. A copy of the questionnaire is available through the

255   Supplementary Information (SI 1).

256   *2.4 Experimental design and data collection*

257   SPSS Orthoplan was used to generate a (3^1 x 4^1 x 5^1) fractional factorial experimental design,

258   which created 25 choice options (SPSS, 2008). A blocking procedure was used to assign the

259   options to five bundles of five choice sets, thus five versions of the choice experiments were

260   produced. Each version contained a different combination of five DCE tasks and each choice

261   task consisted of three alternatives (A, B and Current situation in Wales, Table 2).

262   Data were collected between May-July 2008 using self-completion questionnaires.

263   Questionnaires were administered to consenting passengers on several train routes covering

264   the entire area of Wales. Bangor University research ethics procedures were followed and

265   informed verbal consent obtained from all participants. Since the completion time of the

266   questionnaire was high and required the full attention of the respondent it was felt that trains

267   would offer a receptive audience willing to participate in the study. In the UK, trains are widely

268   used by a cross section of society including business people, students, retired people and

269   families. Any potential bias that occurred as a consequence of sampling on trains could be

270   assessed through the socio-demographic data collected in the questionnaires (Table 3).

271   Although the chosen survey methodology allowed reaching a broad survey sample, it might

272   have under or over-sampled certain sectors of the population. The problem of sampling hard to

273   reach groups, however, is present in most surveys modes, such as Internet, mail or telephone

274   interviews.

275   Table 2, about here.

276   Two consecutive pilot phases were conducted on a total of seventy-three respondents prior to

277   the final administration of the survey. Minor corrections to the questionnaires were

278   implemented after the pilots. As the structure of the DCEs tasks did not change during the pilot

279   phases, all pilot questionnaires were included in the final DCE analysis.

280   A total of 448 people were approached to take part in the study of which 78 declined to

281   participate. Of the 368 questionnaires handed out, 14 did not fully complete the DCE section,

282   leaving a total sample of 354 respondents. Each version of the DCE tasks was allocated

283   approximately 71 times.

284   Table 3, about here.

285

286

287   *2.5 Model specification*

288   Since the interest of the present study was to test for the existence of discrete classes of

289   preference for MPA management within society, we apply LC and RPL models and compare

290   their support. MNL was estimated as a representation of the average preference of the sample

291   since it assumes that preferences are constant across respondents. Models in the study were

292   estimated using mlogit and gmnl R packages (Sarrias and Daziano 2017; Croissant 2018). CE

293   models were designed under the assumption that the observable utility function would follow a

294   strictly additive form. Models were specified so that the probability of selecting a particular

295   MPA configuration scenario was a function of the attributes of that scenario and a constant,

296   which was specified to equal 1 when either alternative A or B was selected, and 0 when the

297   current situation scenario was selected. Attributes size and cost were treated as continuous

298   variables while effects-coding (Hensher et al. 2007) was used for the allowed uses attribute. A

299   protected network covering 30% of territorial waters (i.e. Size 30) and the permission of

300   recreational uses within the protected areas were used as a baseline in the models for

301   comparative purposes as this combination is what most closely reflects the current situation.

302   Socio-demographic and attitudinal variables were included in the models. An "Environmental

303   consciousness" factor was calculated according to the responses given for a set of questions

304   presented in Table 4. Factor values ranged from 1 to 4, 1 indicating higher degree of

305   environmental consciousness.

306   Table 4, about here.

307   3. RESULTS

308   *Sample characteristics*

309   A total of 354 respondents completed the questionnaire. To assess the representativeness of

310   the sample, socio-demographic characteristics were compared against Welsh population

311   means. Gender distribution, median age range, household size and average annual income per

312   capita, reflected the distribution in the population (Table 3). However, the proportion of people

313   holding higher education degrees was more than double in the sample than in the population.

314   Conversely, the number of children per household in the sample was lower than in the

315   population.

316   *3.1 Public attitudes towards marine conservation*

317   Results from the attitudinal study revealed that public knowledge regarding MPAs was low. On

318   a scale of 1 to 4 (1 = "*Never heard of MPAs*" and 4 = "*I consider I've got a good knowledge of*

319   *MPAs*") 79% of respondents chose either options 1 or 2.

320   Despite the lack of knowledge on marine protected areas, the questionnaire showed that the

321   general public had a positive and supportive attitude towards marine reserves. Over 66% of

322   respondents thought that current levels of protection of the sea were insufficient and the vast

323   majority (90% of the sample) liked knowing that certain areas of the sea were fully protected,

324   and agreed with the principle of protection of the Welsh marine environment even if they

325   might never make use of it. Most respondents (75%) agreed that MPAs can provide a good

326   balance between conservation and human activities and a high proportion (86%) thought that

327   there are conservation benefits related to protected areas.

328   Half of the study participants (50%) believed that the benefits associated with the

329   establishment of protected areas would most likely be greater than its costs. However, in

330   general, it was considered that those affected by the establishment of MPAs should receive

331   compensation for any financial losses (76%) and that paying higher prices for marine-related

332   products or services was a suitable option in order to facilitate the preservation of areas of the

333   sea around Wales (63%). Public opinion was equally divided regarding the proposition that no-

334   one should be restricted from using the sea. Half of respondents (50%) considered that there

335   was no need to restrict uses that do not cause damage to the seafloor, this percentage however

336   dropped to 38% when the specific use under consideration was fishing.

337   *3.2 Determinants of marine protection contribution and latent class preferences*

338   The majority of respondents were able to make a choice between the three alternatives offered

339   in the DCE and only 2% of the sample did not complete the total number of choice tasks. About

340   76% of respondents were completely, mostly or somewhat certain of the choices they made.

341   One of the two MPA alternatives was chosen 69% of the times and there is evidence that

342   respondents compared the alternatives, as in 84% of the cases respondents varied their choice

343   across the five choice tasks. Only 3% of the sample consistently chose either alternative A or B.

344   Approximately 13% of respondents who selected the current situation constantly across the

345   tasks were identified as protesters based on their selection of the *"I support the conservation of*

346   *the marine environment but object to having to pay for that"* statement. Respondents identified

347   as protesters were excluded from the models as protest responses are inconsistent with the

348   random utility theory framework. Respondents who did not complete all the relevant

349   information sections for the model were also excluded. Models were performed with the

350   remaining 255 respondents. As each respondent undertook five choice tasks, models were run

351   using a total of 1275 observations.

352   *3.2.1. Latent Class segmentation*

353   Model fit criterion measures, the Akaike (AIC) and the Bayesian Information Criteria (BIC) were

354   estimated for the RPL and LC models with 2 to 5 classes to ascertain their suitability (Scarpa and

355   Thiene 2005). Model fit criterion measures indicated that LC models with 2 to 5 classes

356   presented a better fit than the RPL model. For LC models with increasing number of classes the

357   log likelihood was improved. AIC decreased with increasing number of classes and BIC was at its

358   minimum for the 2-class model (Table 5). No unequivocal decision could be made on the

359   number of classes. Since the greatest improvement in both log-likelihood and AIC was observed

360   when moving from the 2-class to the 3-class model and to facilitate the interpretation of the

361   results by keeping the number of classes to the minimum, the 3-class model was chosen.

362

363   Table 5, about here

364

365   *3.2.2. The Multinomial logit model (MNL)*

366   Results from the MNL model (Table 6), representing the average preference of the sample,

367   reflect a significant decrease in utility in the reduction of the area of the MPAs from 30 to 10%

368   of Welsh territorial waters, indicated by the negative sign of the WTP (-£23). In terms of the

369   uses allowed within the boundaries of the MPA, the coefficients for HPMR and MPAs where

370   only research activities would be allowed were significant and negative, indicating an

371   opposition for MPAs with these characteristics (-£54 for HPMRs and -£14 for MPAs restricted to

372   research). The positive sign of the constant shows a preference for MPAs where recreation is

373   allowed. The coefficient for fishing activities within the boundaries of the MPAs was not

374   significant, denoting an indifference towards the permission of these activities.

375   Table 6, about here
376
377
378   *3.2.3. The Latent class model (LCM)*

379   Results for the 3-class LCM are given in Table 6, where the upper part displays the utility

380   coefficients for MPAs attributes and the lower part reports class membership coefficients.

381   Membership coefficients for Class 1 were normalized to zero in order to identify the remaining

382   coefficients and all other coefficients were interpreted relative to this normalized class.

383   The relative size of each class was estimated and each respondent assigned a probability for

384   belonging to each of the three classes. Class membership was determined by the highest

385   probability score. Approximately, 28% of respondents were identified as members of Class 1,

386   34% as members of Class 2 and 38% as members of Class 3.

387   Coefficients for the different classes suggest that preferences among classes differed

388   substantially. Costs coefficients were significant for all classes. Members of Class 1 opposed to a

389   reduction in size of the MPA network down to 10% of territorial waters (WTP = -£43) or to 20%

390   (-£35). Class 1 members did not favor HPMRs (-£94) or MPAs were only research related

391   activities were allowed (-£45). The positive sign of the constant indicates a preference for MPAs

392   where recreational activities were permitted. Similarly, they were willing to pay (£23) in order

393   to allow fishing activities within the boundaries of the MPA network. Members of Class 2 were

394   willing to pay (£13) for smaller MPAs which would cover 20% of territorial waters and were

395   indifferent towards a reduction down to 10% of territorial waters. They opposed HPMRs (-£25)

396   and MPAs where only research would be allowed (-£15). Recreational activities and fishing

397   (£12) were supported. Members of Class 3 were indifferent towards a reduction in the MPA

398   network down to 20% but opposed a further reduction to 10% in the network area (-£91). They

399   were not in favor of HPMRs (-£149) but were indifferent towards MPAs where only research

400   would be allowed. They were in favor of MPAs where recreational activities would be allowed

401   but not of MPAs where fishing could take place (-£113). The level of education, income per

402   capita and the level of environmental consciousness showed significant effects on class

403   membership (Table 6). Profiles for the different classes were calculated on the basis of class

404   membership coefficients (Table 7). Members of Class 3 (i.e. against fishing) were characterized

405   by a higher degree of environmental consciousness (i.e. lower Environmental Factor value, EFV

406   = 1.5), had the highest income per capita (£18,945) and the greatest proportion of members

407   with higher education degrees (80%). Class 3 also showed the greatest proportion of members

408   living within 10 miles of the coast (56%) and undertaking some type of water related activities

409   (67%) in comparison to Classes 1 and 2. The proportion of Class 3 members who considered

410   they had good MPA knowledge was also higher (36%). Members of Class 1 (i.e. bigger MPAs

411   where fishing would be allowed) showed the lowest degree of environmental consciousness

412   (i.e. highest EFV, 2.2), lowest proportion of members with high self-assessed MPA knowledge

413   (15%) and income per capita (£16,740); the proportion of members with higher education

414   degrees (65%) was in between Classes 2 and 3. Class 2 was characterized by the lowest

415   proportion of people living within 10 miles of the coast (38%), of people undertaking water

416   activities (47%), lowest proportion of people with higher education degrees (55%) and lowest

417   income per capita (£16,447). They presented midrange values for MPA knowledge (21%) and

418   environmental consciousness (1.9).

419   Table 7, about here.

420   4. DISCUSSION

421   The main focus of this study was to test the existence of preference heterogeneity classes in

422   society for different types and levels of coastal protection in the form of MPAs in a temperate

423   area. The study provides evidence that the general public supports the establishment of an

424   enhanced network of MPAs in Welsh waters, however it also shows that societal preferences

425   for coastal MPAs are not homogeneous and that different and defined opinion groups exist.

426   This is in agreement with findings from a similar study carried out in the Northeast United

427   States in which three groups with different preferences for MPAs were identified (Wallmo and

428   Edwards, 2008), however not such evidence exists for European waters. Studies with a focus on

429   Europe have either not assessed preference heterogeneity (Wattage et al. 2011) or have done

430   it on an individual basis through the use of Conditional and Random Parametres Logit models

431   (McVittie and Moran 2010; Börger et al. 2014; Jobstvogt et al. 2014a). Studies that have

432   assessed societal heterogeneity on a class level have done it for marine offshore areas

433   (Kermagoret et al. 2016; Börger and Hattam 2017) but no studies have so far focused on the

434   coastal zone. In the following discussion we discuss the validity of the elicited values and the

435   utility of the results for the design of marine management plans.

436   *Validity of the DCE values*

437   Arguably, the high level of low MPA self-rated knowledge amongst respondents could have

438   hindered the validity of the values elicited from the DCE, since generally DCE encompasses

439   attributes that respondents are familiar with. However, there is evidence that unfamiliarity with

440   particular environmental aspects should not preclude the application of DCE (Barkmann et al.

441   2008) since respondents have been shown capable of learning about unfamiliar aspects during

442   a DCE experiment and to make choices based on their own moral values (Christie et al. 2006;

443   Kenter et al. 2011). Here, this is supported by the high levels of self-assessed choice certainty

444   and further sustained by the reasonable manner in which certain respondents' characteristics

445   predicted particular choices. As an example, the higher likelihood of a respondent with higher

446   levels of environmental consciousness to prefer MPAs where fishing activities likely to damage

447   the seafloor were banned, shows that a greater concern for the environment is translated into

448   more restrictive management measures. High levels of unfamiliarity with the marine

449   environment have been found in other DCE studies (Börger et al. 2014; Jobstvogt et al. 2014a).

450   However, the focus of these studies was on deep-sea and off-shore areas which, since they are

451   spatially removed from the majority of society, might feel more remote and unfamiliar than

452   coastal areas. Despite this unfamiliarity, valuation studies are important in highlighting the

453   potential economic values held by the average citizen, which are generally absent from

454   economic assessments (Hanley et al. 2014).

455   The DCE analysis points towards a division of society in classes according to their preferences

456   for MPAs design and management. However, the exploration of socio-demographic data

457   revealed the study sample not to be representative of the Welsh population. Therefore, while

458   the outcome of this study is suitable to be used as a guiding and exploratory tool to achieve

459   MPA designs with higher society acceptance, it should not be used as part of full cost benefit

460   analysis or benefit transfer exercises, as the elicited DCE values are not based on a

461   representative sample.

462   *Implications for Coastal Management*

463   Outcomes from studies like the one presented here can be used to shape the development and

464   design of MPA networks on coastal waters and maximize the acceptance and compliance of the

465   associated management restrictions. Results suggest the existence of three distinct classes with

466   different sets of preferences regarding the implementation of MPAs. All classes were in favour

467   of MPAs and were not supportive of the idea of MPAs as HPMRs where no activities could be

468   carried out within their boundaries. Instead, all three classes supported those MPAs where non-

469   damaging recreational activities were allowed. These results align with the concerns expressed

470   by the Welsh public during the public consultation carried out in 2012 on the proposal of highly

471   protected sites around the Welsh coast. Strong opinions were held both for and against the

472   proposed high level of protection. Many were in favour of having such sites but coastal

473   communities and business were concerned about unacceptable socio-economic impacts with

474   little evidence of the benefits (Welsh Government 2013). In addition, it was generally

475   considered unnecessary to have an indiscriminate approach with a high level of protection

476   regardless of whether activities would have an impact on ecological features. In 2014, the

477   Welsh Government established the first MCZ where the HPMR status was finally not adopted.

478   The main differences between classes arise regarding the size of the network and the

479   permission of fishing activities within their boundaries. We find that two currents of opinion

480   exists, those who are in favour of particular activities within the MPAs (fishing: Class 1 & Class

481   2) and those who oppose (fishing: Class 3). In terms of the area covered by the MPA network,

482   there was general support for a network that would cover 30% of territorial waters, Class 2 also

483   showed support for 20% of territorial waters while Class 1 was opposed to that idea. In

484   summary, Class 1 favored bigger MPAs where all the activities considered in this study would be

485   allowed and supported fishing to a greater extend than Class 2, Class 2 was in support of both

486   bigger and medium sized MPAs where recreation and fishing would be allowed and Class 3

487   favored bigger MPAs where recreation but no fishing would be allowed.

488   In accordance with other DCE studies (McVittie and Moran 2010; Wattage et al. 2011; Börger et

489   al. 2014; Jobstvogt et al. 2014b, a; Kermagoret et al. 2016; Börger and Hattam 2017) our results

490   indicate that the general public is willing to bear the additional economic cost associated with

491   the implementation of MPAs. However, the comparison of our study, which has solely focused

492   on coastal MPAs, with others which have included inshore and offshore MPA areas, shows

493   differences between society's preferences for management strategies adopted in exclusively

494   coastal MPAs and those that include inshore and offshore areas. As an example, McVittie and

495   Moran (2010) showed a WTP ranging from -£17 to £17 for highly restrictive measures in a

496   network of MPAs that include both inshore and offshore areas while results from our study

497   indicate a much stronger opposition to HPMRs located in coastal waters (-£25 to -£149). This

498   highlights the importance of eliciting separate value estimates for coastal and offshore areas, as

499   it would be incorrect to extrapolate values estimated for offshore areas to coastal zones on

500   benefit transfer exercises. It also serves as an indication that people are capable of making

501   distinctions between the associated society's burden in terms of restrictions between coastal

502   and offshore areas, since the intensity of use of coastal areas by different sectors of society is

503   much greater than for offshore areas, as the latter are generally inaccessible for the majority of

504   people.

505   Arguably, the design of the DCE in terms of the restriction levels associated with the network of

506   MPAs could have better reflected reality by incorporating zonation within the MPA network.

507   However, the focus groups carried out as part of this study revealed that the cognitive burden

508   imposed by an additional MPA zonation attribute was too great and the design too complex for

509   respondents to make meaningful trade-offs during the DCE. Results indicate that the great

510   majority of the public was not supportive of the idea of MPAs as HPMRs. However, it is possible

511   that the level of support for HPMRs would have increased if the DCE had offered respondents

512   the option of MPAs encompassing areas with a range of different protection and restriction

513   levels. This is supported by the fact that the majority of respondents in the study (90%)

514   indicated that they "like knowing that certain areas of the sea are fully protected" thus,

515   showing their support for areas where no activities are allowed and biodiversity is fully

516   protected. The combination of the LC DCE and the questionnaire results provides useful

517   information for coastal resource managers as it allows to infer that HPMRs combined with

518   adjacent areas with differing levels of user-access, particularly areas where non-damaging

519   recreational activities would be allowed, would appear to be the type of MPA design that would

520   receive the greatest public support, while also ensuring effective conservation. This conclusion

521   is in line with results from a survey carried out among users of MPAs in southern Europe that

522   showed a strong preference for having MPAs with different use zonation, including areas

523   designated for restricted fishing, non-damaging recreational activities and the full protection of

524   species and ecosystems (Mangi and Austen, 2008). This approach enables decision-makers to

525   evaluate the preferences of those classes with a higher number of members from two

526   complementary angles. On the one hand, the combination of attribute levels that shows the

527   greatest societal support can be identified and pursued, if the MPA design is in line with

528   conservation objectives. In our study, there is indication that MPAs where fishing activities

529   likely to produce disturbance to the seafloor would be banned but recreation would still be

530   allowed, would receive the greatest level of support. On the other hand, it allows for the

531   identification of large groups that might not be willing to engage in imposed restrictions, which

532   would make management and enforcement more difficult (Ban et al. 2013). In our study, we

533   have been able to identify that all classes object to the concept of highly restrictive MPAs.

534   Consequently, it would not be advisable for managers to pursue the design of MPAs as

535   exclusively no-take zones, where no type of activity would be allowed. Additionally, through LC

536   analysis it is possible to establish a relation between preferences for particular bundles of

537   attributes and respondents characteristics. Here, we find that those respondents in favor of

538   more restrictive MPAs, where fishing was not allowed, have an overall higher environmental

539   consciousness and posses greater MPA related knowledge. These indications provide coastal

540   resource managers with tools to work towards an increased support for MPAs where fishing

541   might not be allowed through environmental and awareness education campaigns. The

542   integration of environmental education as part of MPA management (Zorrilla-Pujana and Rossi

543   2014) is a necessary element in achieving sustainable management, as access to balanced

544   environmental information provides resource users with a wider picture of environmental and

545   societal benefits related to conservation, becoming more willing to accept trade-offs (Ruiz-Frau

546   et al. 2018).

547   Moreover, these types of approaches provide an opportunity for coastal managers to propose

548   different management measures since society shows an array of divergent interests. Following

549   preference indications, different types of protected areas can be implemented on different

550   coastal areas accompanied by the assessment of societal post-implementation support and

551   compliance to help in the identification of those MPA design combinations potentially most

552   likely to succeed.

553   5. CONCLUSIONS

554   The attitudes and preferences of resource users of MPAs are a key issue for the management of

555   protected areas (Jones, 2008). It has been widely acknowledged that for the management of

556   MPAs to be successful and to ensure compliance it is necessary that users have positive

557   attitudes towards MPAs and their associated regulations (White et al., 2000; Himes, 2007).

558   Previous studies have investigated the design of MPAs considering influential stakeholder

559   groups preferences such as fishermen (Richardson et al., 2006). Studies which have assessed

560   societal preferences for temperate MPAs have mostly done it for deep-sea and off-shore areas.

561   However, little information has been gathered on societal preferences for MPAs in coastal

562   areas adopting a segmented preference approach. This study shows a general support for the

563   protection of the marine environment in the form of MPAs, however it also shows that there

564   are distinct groups with different preferences for the management of MPAs. We conclude that

565   including this preference heterogeneity in the design of MPA networks in the form of zonation

566   and inclusion of areas which allow recreation but not fishing should be preferred in conjunction

567   with targeted environmental and awareness education campaigns.

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734

Figure 1

Overview map of the study area

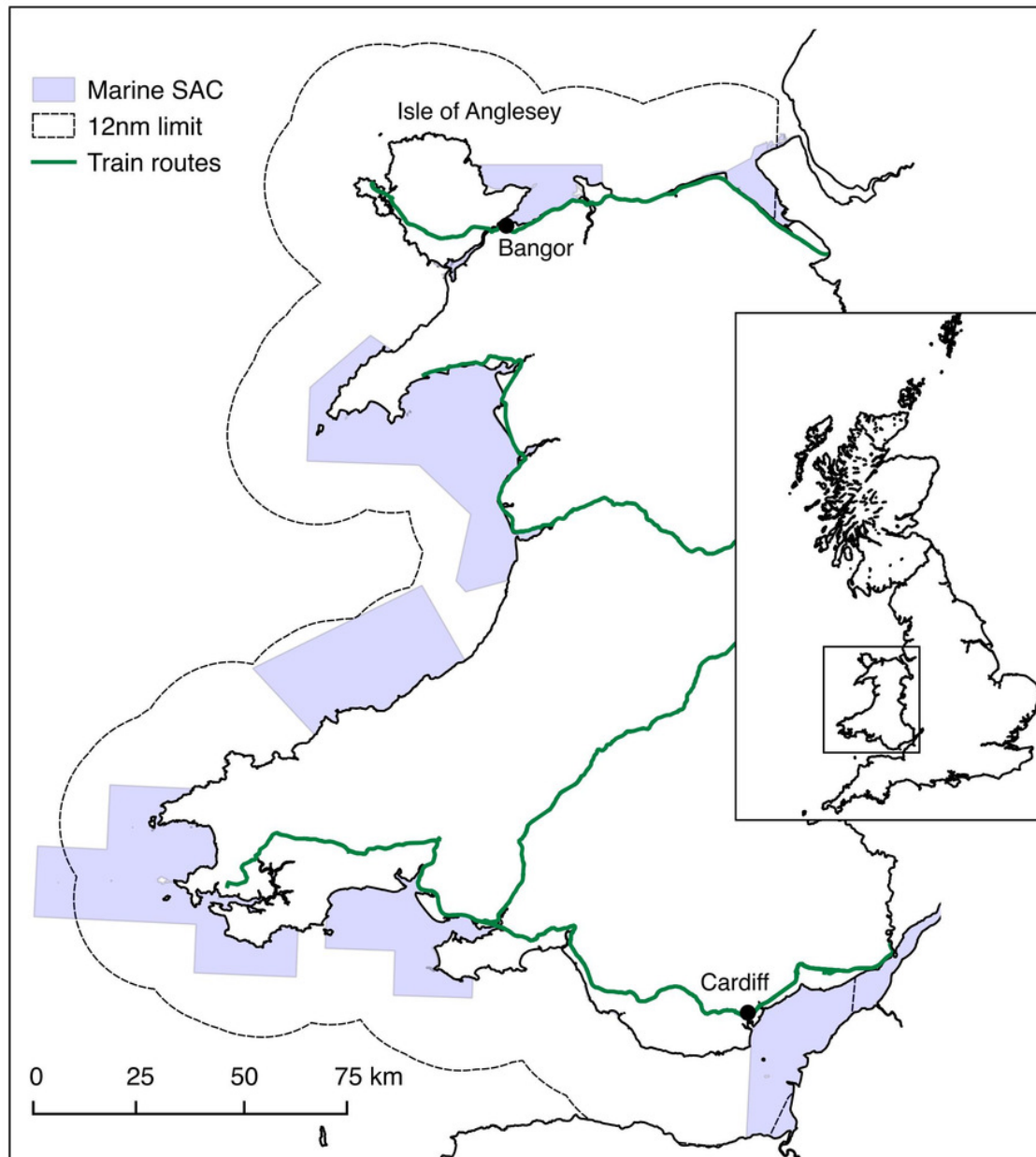
Dashed lines indicate the 12 nm territorial waters limit, marine Special Conservation Areas (SACs) are shown in blue, green lines indicate the train routes where questionnaires were undertaken

Marine SAC
12nm limit
Train routes

Isle of Anglesey

Bangor

Cardiff

0   25   50   75 km

Attributes and levels used in the choice experiment

1   Table 1. Attributes and levels used in the choice experiment

Attribute	Definition	Levels
Network size	Percentage of territorial waters to be protected	10%, 20%, 30%
Uses permitted	Uses permitted within the boundaries of the network	- All activities prohibited - Only scientific research and educational activities - Non-extractive activities (i.e. sailing, diving, kayaking, wildlife watching) allowed - Recreational and commercial fishing using non-damaging equipment to the sea floor allowed (previous level included)
Cost	Household annual contribution to a neutral charity. The charity works with the government to negotiate, monitor and manage the MPAs	Payment levels: £5, £10, £25, £50, £100

Choice card example

	Option A	Option B	Current Situation
Size of the network of MPAs	20% of coastal waters (equivalent to 4½ times the area of Anglesey)	30% of coastal waters (equivalent to 6¾ times the area of Anglesey)	30% of coast as SAC (equivalent to 6¾ times the area of Anglesey)
Level of Protection	Only scientific research and educational activities allowed	Non-extractive activities (i.e. sailing, diving, kayaking, wildlife watching) allowed	Minimum level of protection Most activities including commercial fishing allowed
Cost to you **each year**	£25	£5	No additional cost to you
Which of the three options do you most prefer?	I prefer Option A ☐	I prefer Option B ☐	I prefer the Current Situation ☐

2   Table 2. Choice card example

Comparison of respondents' socio-demographic characteristics vs. 2011 census data for Wales (ONS 2012)

1   Table 3. Comparison of respondents' socio-demographic characteristics vs. 2011 census data for Wales
2   (ONS 2012)

	Sample average	Census average
Gender (% male)	49	52
Median age range	45-59	45-59
University degree & above (%)	63	24
Household size	2.6	2.4
Number of children	0.5	1.7
Annual income x capita (£)	15,248	14,129

Environmental statements included in the survey measured on a five-point Likert scale, ranging from "Completely true" to "Not at all true".

1 Table 4. Environmental statements included in the survey measured on a five-point Likert scale,
2 ranging from "Completely true" to "Not at all true".

Environmental statements
MPAs provide a good way to get the right balance between conservation and activities such as fishing or shipping
There are conservation benefits related to MPAs
There is no need for MPAs in Wales because the seas around the Welsh coasts are in good health
People who are affected by the creation of MPAs, like fishermen, should receive compensation for any financial losses derived from the establishment of MPAs
I'm willing to pay higher prices for sea-related products or services to preserve areas of the sea around Wales
Costs of MPAs will most likely be greater than the benefits obtained from them
MPAs should be large enough to protect every type of organism living in the sea regardless of costs
The sea is a common resource and no one should be restricted from using it
There is no need to restrict uses that don't damage the seafloor in MPAs
Fishing equipment that sits on the seafloor and does not cause damage should be allowed in MPAs
Current levels of protection of the sea are enough
I like knowing that certain areas of the sea are being fully protected

Model fit criterion measures for Latent Class models with 2, 3, 4 and 5 classes.

1   Table 5. Model fit criterion measures for Latent Class models with 2, 3, 4 and 5 classes

	RPL	LC - N classes			
		2	3	4	5
Log likelihood	-1275	-997	-958	-932	-919
AIC	2577	2031	1977	1950	1947
BIC	2646	2130	2137	2171	2230

Parameter estimates for three-class latent class model. Size 30 and recreational uses have been used as a baseline in the models.

1   Table 6. Parameter estimates for three-class latent class model. Size 30 and recreational uses have been
2   used as a baseline in the models

| | MNL | | | Latent Class | | | | | | | | |
| | | | | Class 1 | | | Class 2 | | | Class 3 | | |
	Coef.	(s.e.)	WTP	Coef.	(s.e.)	WTP	Coef.	(s.e.)	WTP	Coef.	(s.e.)	WTP
Utility function parameters												
Const	1.70	(0.12)***		1.36	(0.37)***		3.51	(0.66)***		4.61	(0.68)***	
Size 10	-0.46	(0.09)***	-23	-1.24	(0.30)***	-43	0.91	(0.57)		-0.39	(0.15)**	-91
Size 20	-0.14	(0.09)		-1.00	(0.28)***	-35	1.44	(0.54)**	13	-0.03	(0.14)	
HPMR[a]	-1.08	(0.12)***	-54	-2.71	(0.49)***	-94	-2.80	(0.64)***	-25	-0.64	(0.19)***	-149
Res	-0.43	(0.11)***	-14	-1.31	(0.38)***	-45	-1.65	(0.61)**	-15	-0.00	(0.18)	
Fish	0.17	(0.10)		0.66	(0.27)**	23	1.35	(0.64)*	12	-0.48	(0.17)**	-113
Cost	-0.02	(0.00)***		-0.03	(0.00)***		-0.11	(0.03)***		-0.01	(0.0)*	
Class membership function												
HE[b]							0.19	(0.07)**		-0.17	(0.08)*	
Acts[c]							0.24	(0.19)		-0.19	(0.20)	
EnvF[d]							-1.27	(0.21)***		-4.14	(0.30)***	
Inc x capita[e]							0.00	(0.00)		0.00	(0.00)***	
LC prob				0.28			0.34			0.38		
Loglike	-1382			-958								
AIC	2779			1977								
BIC	2815			2137								
N Resp	255			255								
N Obs	1275			1275								

4   ***0.1% significance level, **1% significance level, *5% significance level
5   [a]HPMR: Highly Protected Marine Reserve, [b]Higher Education, [c]Water related activities (marine), [d]Environmental factor, [e]Income
6   per capita

Table 7 **(on next page)**

Respondents' profiles for each latent class.

1   Table 7. Respondents' profiles for each latent class

	Class 1	Class 2	Class 3
Within 10 miles %	49	38	56
Water Activities %	48	47	67
High MPA knowledge %	15	21	36
Environmental Factor	2.2	1.9	1.5
Higher Education %	65	55	80
Income x capita (£)	16,740	16,447	18,945
Household size	2.8	2.7	2.6
Gender % males	46	42	53