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The Cost of Mediterranean Sea Warming and Acidification: A Choice Experiment Among Scuba Divers at Medes Islands, Spain

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Abstract A choice experiment is undertaken to elicit preferences of scuba divers in the Marine Protected Area of Medes Islands (Spain). This is the first non-market valuation study of a typical Mediterranean habitat, the Coralligenous, which is characterized by high biodiversity, geomorphologic complexity and iconic species like gorgonians. This habitat is not only very attractive for scuba diving, but is also threatened by climate change and ocean acidification, which is our motivation for undertaking this valuation study. Choice attributes include the number of divers on a diving trip, underwater landscape, presence of jellyfish species, expected state of gorgonians, and price of a dive. Results of multinomial and random parameter logit models indicate a decrease in the attractiveness of Coralligenous areas for scuba diving as a result of both environmental pressures. Estimates of welfare values show that the local extinction of gorgonians had the highest negative effect on utility equivalent to a cost of €60 per dive, followed by abundance of stinging jellyfish with a cost of €26 per dive. Choice probabilities for the selection of different dive experiences indicate the highest rejection rates for the combined sea warming and acidification scenarios.

In Honour of Anil Markandya.

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Abbreviations

CC	Climate change
CE	Choice experiment
CO_2	Carbon dioxide
CV	Contingent valuation
ECB	European Central Bank
GDP	Gross domestic product
IIA	Independence of irrelevant alternatives
IID	Identically and independently distributed
IP	Implicit price
LM	Lagrange Multiplier
LR	Likelihood-ratio test
MAP	Mediterranean Action Plan
MEA	Millennium Ecosystem Assessment
MNL	Multinomial logit
MPA	Marine Protected Area
OA	Ocean acidification
RAC	Regional Activity Center
RPL	Random parameter logit
SPA	Specially Protected Areas
UNEP	United Nations Environment Programme
WTA	Willingness to accept
WTP	Willingness to pay

1 Introduction

Sea warming and ocean acidification, both driven by anthropogenic carbon dioxide (CO_2) emissions, pose major threats to marine and coastal ecosystems, and therefore to the benefits they generate for humans. These include food provision, support of recreational opportunities and climate stability (MEA 2003; Coll et al. 2011). While potential harm is likely caused by both pressures on key ecological and economic species like molluscs and gorgonians (Gazeau et al. 2013; Cerrano et al. 2000; Bramanti et al. 2013), other organisms such as seagrasses and jellyfish may present some tolerance or even respond favourably (Attrill et al. 2007; Kroeker et al. 2013). Underwater marine life scenery may thus alter considerably, possibly involving a loss of habitat complexity, weaker trophic interactions, and changes in species dominance patterns (Hall-Spencer et al. 2008; Rossi 2013; Fabricius et al. 2014).

In the Mediterranean Sea, an endemic habitat known as the Coralligenous appears to be particularly vulnerable to both pressures (Gili et al. 2014). The singularity of this habitat is explained by its complex structure involving calcareous formations of biogenic origin (mainly encrusting algae), three-dimensional structures created by engineering species like gorgonians ("sea fans and whips"), and a diversity of geomorphology elements, including hard bottoms with boulders, vertical walls, caves, and tunnels. The Coralligenous is the second most important Mediterranean marine habitat in terms of species diversity, after

Posidonia oceanic meadows (“seagrass”). It hosts several taxonomic groups, namely sponges, gorgonians, molluscs, crustaceans and various fish species (Ballesteros 2006). As a result of these characteristics, coralligenous areas are considered as very attractive for the practice of recreational activities, such as scuba diving (Harmelin 1993; Boudouresque 2004b; Bramanti et al. 2011).

Recreational and aesthetic values associated with diving in the Coralligenous may be reduced as a result of exposure of this habitat to environmental pressures. In addition to destructive fishing practices, poaching, and occasionally harmful behaviours of diving itself, sea warming and ocean acidification are global pressures capable of causing severe changes in this habitat (UNEP-MAP-RAC/SPA 2008; Bramanti et al. 2013).

A summer heat wave occurring in 1999 and 2003 in the Mediterranean showed a low tolerance of certain Coralligenous species to an increase in sea water temperature (Garrabou et al. 2009). Mass mortalities of gorgonians, notably red coral (*Corallium rubrum*), red gorgonian (*Paramuricea clavata*) and white gorgonian (*Eunicella singularis*), have been documented (Cerrano et al. 2000; Garrabou et al. 2001; Bramanti et al. 2005). In addition, ocean acidification stands as a new peril for the Coralligenous habitats as it negatively affects biogenic calcification and may lead to the erosion of some of its keystone species, notably calcifying algae, bryozoans and stony corals (e.g., *Cladocora caespitosa, Myriapora truncata* or *C. rubrum*) (Coll et al. 2010; Lombardi et al. 2011; Bramanti et al. 2013).

Another type of environmental change that might affect the development of recreational and tourism activities in coastal and marine areas, is the more frequent appearance of certain types of jellyfish that present a high risk of stinging (e.g., *Pelagia Noctiluca*). There is an ongoing debate about the possible tolerance of jellyfish species to relatively warm, acidified waters (Condon et al. 2013; Attrill et al. 2007). Although scuba divers are generally better protected than swimmers, because of diving suits, they might nevertheless be injured by jellyfish stings, notably on unprotected body parts (face and hands). The potential attractiveness and repulsion effects on scuba divers of non-stinging and stinging jellyfish species are still little understood. Studies focusing on the potential negative effects and associated costs generated by jellyfish blooms can be found, but do not involve scuba diving. Instead, they focus on coastal residents and beach users (Kontogianni and Emmanouilides 2014; Diaz et al. 2014).

This study aims to value the impact of a combination of sea warming and ocean acidification on the quality of Mediterranean diving areas with Coralligenous. For this purpose, a choice experiment was undertaken for the Marine Protected Area (MPA) of Medes Island (Northwest Mediterranean). This is famous for its Coralligenous habitat with emblematic natural features. The method was motivated by its capacity to systematically address a range of important choice attributes, namely: (1) aspects influencing divers’ satisfaction that are independent of the particularities of a natural site (e.g., number of divers found on a diving trip); (2) unique geomorphological elements of the Medes Island Coralligenous area (notably the complex underwater landscape); (3) attributes simulating relevant environmental changes (e.g., the state of gorgonians and the presence of jellyfish species); and (4) the price (or total cost) of a dive.

Studies using choice experiments in the context of scuba diving have almost exclusively focused on coral reef areas. These included, inter alia, assessment of the economic value of coral reef attributes for the purpose of conservation (Sorice et al. 2005; Schuhmann et al. 2013), and estimates of the potential economic losses to scuba divers as a result of ecosystem degradation (Wielgus et al. 2003; Parsons and Thur 2008; Doshi et al. 2012).

The present study is innovative in various aspects. First, it combines the impact of sea warming and ocean acidification on Mediterranean marine and coastal ecosystems. Second, it makes use of various indicators which together capture some of the complexity of the Coralligenous habitat. Third, it deals with two unusual groups of species in the context of choice experiments, namely, gorgonians and jellyfish species.

The remainder of this paper is structured as follows. Section 2 introduces the study area. Section 3 describes the main steps followed in developing the choice experiment. Section 4 presents the results. Section 5 concludes.

2 The Study Area

The study was carried out in L'Estartit (Province of Girona). This locality (3230 inhabitants in 2012) (IDESCAT 2013) borders the Marine Protected Area (MPA) of Medes Islands to the west. This area is in the Northwest Mediterranean, and part of Catalonia, Spain. This MPA is an archipelago composed of seven islands and islets, comprising a total area of 23 ha (Fig. 1) (Mundet and Ribera 2001). It is part of a wider marine and terrestrial Natural Park of Medes Islands, el Montgrí, and el Baix Ter (9192.19 ha) (Generalitat de Catalunya 2010).

The local economy of L'Estartit is to a great extent based on tourism and recreation activities developed on Medes Islands and the Montgrí coast. Estimates from the last decade show that annual tourism revenues associated with the MPA exceeded 70 % of the local GDP (Muñoz 2006, reported in Vandenbroucke et al. 2012). In addition to the practice of snorkelling, and sea excursions on glass-bottomed boats, scuba diving is one of the main attractions. A total of 55,647 dives were registered in the MPA in 2012, with the highest concentration observed between May and September (information by the Natural Park of Medes Islands, el Montgrí and el Baix Ter) (Fig. 2). Together with other areas such as Calanques (France) and Portofino (Italy), Medes Islands is among the most attractive Mediterranean MPAs with coralligenous for the practice of scuba diving (Information provided by managers of Mediterranean MPAs).

Scuba diving is regulated in the protected area to a maximum number of 450 dives per day, and through the payment of a tax per dive of €4.40 (reference year 2013). The tax revenue obtained with scuba diving and snorkelling represented approximately 50 % of the total budget of the management of the protected area in 2009 (Quintana and Hereu 2012). Thirteen main dive sites are available for divers in this MPA. Underwater dive experiences may vary, inter alia, in terms of maximum depth (approximate range of 20–50 m), underwater landscape elements (e.g., rocky boulders, caves, tunnels), and marine life communities (Muñoz 2007). The abundance of fish species, resulting from the reserve effect, is well appreciated by divers (Alban et al. 2008). In addition, other main features include unique Mediterranean habitats such as the Coralligenous and Posidonia oceanic meadows, and emblematic species, such as common eagle ray, "European barracuda", grouper, lobster, moray eel, nudibranch, octopus, red coral, red gorgonian, red scorpion fish, white gorgonian, and zebra seabream (Muñoz 2007; Quintana and Hereu 2012; Natural Park of Medes Islands, el Montgrí and el Baix Ter 2013).[1]

3 The Choice Experiment

A choice experiment (CE) is a stated preference technique that is often used for the economic valuation of goods and services. Through a survey-based study, a hypothetical market is

[1] The selection of these species was done in consultation with the diving centres of L'Estartit, and the Natural Park of Medes Islands, el Montgrí and el Baix Ter.

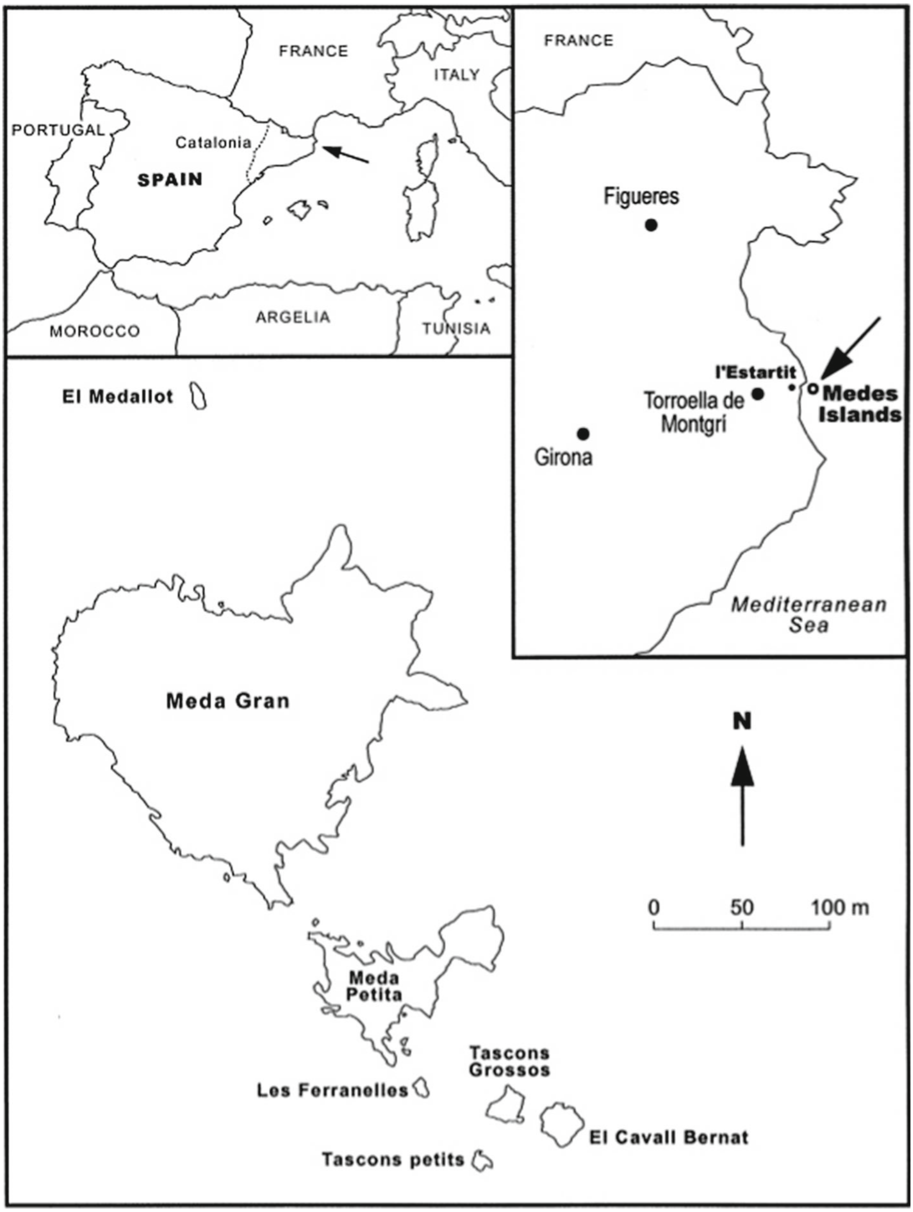

Fig. 1 The study area: The Marine Protected Area of Medes Islands. *Source*: Mundet and Ribera (2001)

created in order to estimate un-priced, in this case environment-related, benefits (Hensher et al. 2005). One advantage of using a CE is the possibility to forecast future choice responses by eliciting preferences of individuals regarding an environmental good under hypothetical policy-relevant conditions. The power of this method relies on not asking respondents directly for individuals' willingness to pay (WTP) or to accept compensation (WTA) for a certain environmental change; but instead offers a choice of a good or service characterized by a bundle of attributes, just like consumers are accustomed to do in normal products and service

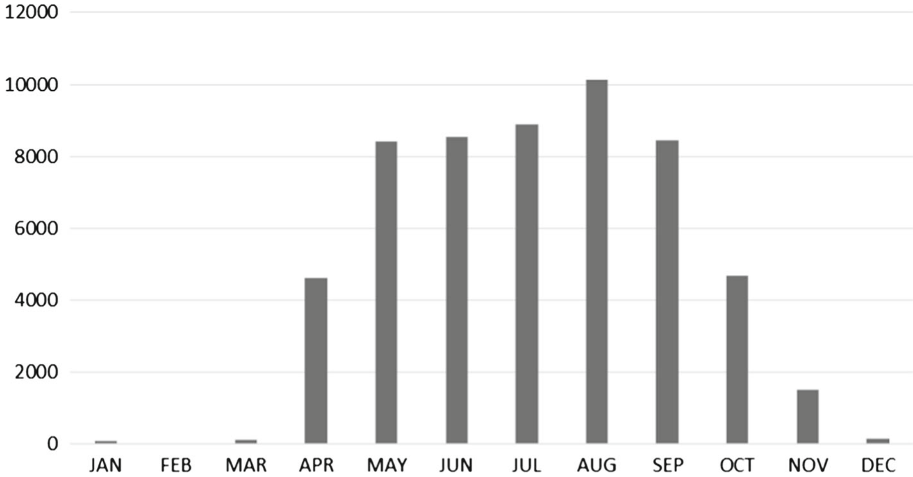

Fig. 2 Number of monthly dives at Medes Islands MPA in 2012. *Source*: Natural Park of Medes Islands, el Montgri and el Baix Ter

markets. Price or a proxy variable for price is one of the various attributes (Hanley et al. 1998).

Dive experiences can also be decomposed into a set of factors which influence the preferences of scuba divers (Mundet and Ribera 2001; Alban et al. 2008; Uyarra et al. 2009):

- components of marine and coastal ecosystems, comprising biotic (e.g., abundance and diversity of fauna and flora) and abiotic (e.g., structure of the soil, water clarity) elements;
- aspects depending on the service of dive operators and management of marine and coastal areas (e.g., guidance, prices and fees; level of crowding);
- and characteristics associated with diving locations, such as geographical proximity, and complementary tourist options.

Accordingly, by using a CE in this study it is be possible to elicit preferences of divers regarding underwater recreation experiences that depend on environmental changes associated with sea warming and acidification, levels of underwater complexity of the coralligenous, and other characteristics normally featuring in a diving experience.

The following sub-sections describe previous CE in the context of scuba diving, and the main steps followed in the development of the CE for this study.

3.1 Choice Experiment Studies Focusing on Scuba Diving

The use of CE for the assessment of the impacts of sea warming and ocean acidification in the context of recreational scuba diving is rare. Doshi et al. (2012) is one example presenting estimates of the cost of coral bleaching in Southern East Asia. This environmental problem is associated with a combination of several stresses, inter alia, changes in salinity, exposure to extreme low tides, and an increase in sea water temperature (Westmacott et al. 2000). Doshi et al.'s CE comprises two attributes characterizing the biodiversity of coral and other marine life, percentage of coral bleaching, and dive costs associated with the conservation of corals. Data obtained from 434 divers is used in a logit regression in order to derive WTP estimates. Costs associated with 100 % coral bleaching are US$73 per dive.

Wielgus et al. (2003) present an economic valuation of coral reef degradation at Israeli Red Sea with a sample size of 181 divers. Attributes include water visibility, a biological index for fish and coral diversity and abundance, and a diver entrance fee. Using multinomial logit and nested logit models, estimates for marginal prices of additional units of the biological index and water visibility are US$2.60 and US$1.20 per dive, respectively. Furthermore, the study presents compensating surplus measures for scenarios involving an increase in the quality of the diving site.

Sorice et al. (2005) assesses the importance of various management measures for the conservation of coral resources to divers, focusing on the following attributes: number of people diving at a site, amount of MPA area open to diving, diver supervision, MPA fee, coral reef education, and the amount of fish and coral-related marine life expected to see underwater. Based on a sample of 462 divers, results from a conditional logit model show a stronger preference for a 50 % increase in the quantity of marine life over the status quo (Implicit price (IP) of US$34/dive). The less preferred change is associated with the restriction of 30 % in the number of divers at the site in comparison with the usual amount (IP= -US$23.2/dive).

Parsons and Thur (2008) estimate recreational economic losses resulting from hypothetical declines in the quality of coral reefs in Bonaire National Marine Park (Caribbean). This study used a sample of 211 divers and worked with the attributes: coral cover, species diversity in terms of numbers of fish and corals, visibility, and an annual dive tag price as payment vehicle. Main results following the implementation of fixed and random parameter logit models show annual losses per diver ranging from US$45 to US$192 for modest and extreme declines in quality, respectively.

Schuhmann et al. (2013) assesses the economic value of marine biodiversity to divers in Barbados as well as potential additional contributions for improvements in the quality of a variety of reef attributes. These included fish diversity, coral cover as percent of the benthos, number of divers at the site, and sea turtles encountered. The price of a 2-tank dive was used as a payment vehicle. Using a sample of 165 divers, the study applied conditional logit (CL), random parameter logit (RPL), and latent class (LC) models. Results show the WTP for quality improvements in dive characteristics relative to a reference level associated with a lower quality dive. Results from the ML model show a mean WTP of US$122.63 per 2-tank dive for improvements of 5–35 % in coral cover and US$101.21 per 2-tank dive for a decrease from 15 to 0 other divers at the site.

3.2 Identification of Attributes and Levels

Deciding which and how many attributes and levels need to be included in a CE is not a straightforward task. This involves, inter alia, a realistic representation of the good under valuation, clarity of the attributes' content in terms of meaning and measurement, and a market-based simulation that does not lead to a cognitive burden for the respondent (Hensher et al. 2005).

For the first step of identifying attributes and their levels, several stakeholders were involved: natural and social science experts, personnel from the Natural Park of Medes Islands, el Montgrí and el Baix Ter, diving centres and scuba divers. Furthermore, studies in the field of scuba diving served as a benchmark, notably Wielgus et al. (2003), Sorice et al. (2005), Parsons and Thur (2008), Uyarra et al. (2009) and Doshi et al. (2012). Finally, studies of the MPA were relevant for understanding the particularities of its diving sites. These include studies that characterize underwater marine life communities (Quintana and Hereu 2012), guides to diving itineraries (Llamas and Cáceres 2010; Natural Park of Medes

Islands, el Montgrí and el Baix Ter 2013), and analysis of the behaviour of scuba divers (Muñoz 2007).

On the basis of all this information, five attributes and associated sets of levels were defined with the purpose of creating different dive experiences in Medes Islands (Table 1):

(1) Number of divers found on a diving trip: The relevance of the level of crowding was suggested by several studies. These include CEs (Sorice et al. 2005; Schuhmann et al. 2013) and management reports focusing on recreation in the Medes Islands MPA (Alban et al. 2008; Parc Natural Montgri Illes Medes i Baix Ter and Submon 2012). Levels of this attribute in this study were defined in accordance with realistic crowding levels for Medes Islands, notably 5, 15, and 25 divers found on a diving trip.
(2) Underwater landscape: Geomorphological elements that can be found in Coralligenous areas of the Medes Islands were represented by this attribute. Three levels of geomorphology complexity were chosen with a descending level of complexity: hard bottoms with boulders, vertical walls, and caves/tunnels; hard bottoms with boulders, and vertical walls; and hard bottoms with boulders.
(3) Presence of jellyfish species: This attribute has three levels, namely none of these species encountered on a dive, abundance of non-stinging jellyfish, and abundance of stinging jellyfish.
(4) Expected state of gorgonians: These species are considered to be attractive features of Coralligenous habitats, and of Medes Islands in particular (Muñoz 2007; Quintana and Hereu 2012). This study focus on three species of gorgonians, namely red coral (*C. rubrum*), red gorgonian (*P. clavata*), and white gorgonian (*E. singularis*). Three levels were defined for this attribute: all gorgonians are of good quality; 50 % of the gorgonians have disappeared due to climate change, illustrating a mass mortality followed by a summer heat wave; and all gorgonians have disappeared due to climate change and ocean acidification, which represents a more extreme scenario reflecting local extinction due to the impact of both environmental pressures.[2]
(5) Price of the dive: This attribute refers to the price of a single dive of 50 minutes. This value includes the boat trip, air and tank to dive, the Medes Islands tax, and dive insurance costs. For the definition of the prices levels, these costs were checked for seven diving centres of L'Estartit. This resulted in an approximate average price of €50 for the high tourism season. For the CE, price levels were set at €30, €50, €70, €90, and €110.

Other typical features of dive experiences, such as weather conditions, visibility under water, and the presence of fish species, were not included in the CE, for two reasons. First, the number of attributes and levels has to be limited in order to control the complexity of choice tasks by participants. Second, some of these attributes have a less clear relationship with the environmental changes studied (notably sea warming and ocean acidification).

3.3 Choice Sets and Survey Implementation

Once the complete list of attributes and levels is defined, the next stage of a choice experiment involves selecting the combinations of dive attribute levels that will appear in a choice set. For this study, a two-step experimental design was used. First, through a full factorial design, 405 dive combinations were obtained from the previous list of attributes and their levels (four attributes with three levels and one attribute with five levels = $4^3 \times 5$). Second, by using a

[2] Scuba divers who participated in the choice experiment received an explanation of the potential effects of sea warming on gorgonian populations. Because of clarity and familiarity, the term "climate change" was used in the choice sets.

Table 1 List of attributes, and their levels, of a diving experience

Attributes	Levels
Number of divers found on a diving trip	5; 15; 25
Underwater landscape	Hard bottoms with boulders, vertical walls, and caves/tunnels
	Hard bottoms with boulders and vertical walls
	Hard bottoms with boulders
Presence of Jellyfish species	Not present
	Abundance of non-stinging jellyfish species
	Abundance of stinging jellyfish species
Expected state of gorgonians (red coral, red gorgonian, white gorgonian)	All gorgonians are of good quality
	50 % of the gorgonians have disappeared due to climate change
	All gorgonians have disappeared due to climate change and ocean acidification
Price of the dive (includes boat trip, air and tank to dive, Medes Island tax, and dive insurance)	€30; €50; €70; €90; €110

Table 2 An example of a choice set

Characteristics of the dive	Dive A	Dive B
Number of divers found on a diving trip	15	25
Underwater landscape	Hard bottoms with boulders and vertical walls	Hard bottoms with boulders
Presence of jellyfish species	Not present	Abundance of stinging jellyfish
Expected state of gorgonians (red coral, red gorgonian, white gorgonian)	All gorgonians are of good quality	All gorgonians have disappeared due to climate change and ocean acidification
Price of the dive (includes boat trip, air and tank to dive, Medes Island tax, and dive insurance)	€50	€30

Which diving experience do you prefer to undertake, A, B, or neither?

☐ Dive A ☐ Dive B ☐ Neither

main effects fractional factorial design this number was reduced to 24 dive alternatives, eliminating dominant alternatives and internally inconsistent combinations, while maintaining orthogonality. These were subsequently paired, resulting in a total of twelve choice sets. To avoid an overly complex choice task for participants, these choice sets were split and allocated over two survey versions (A and B), each containing six choice sets. Table 2 illustrates an example of a resulting choice set. It includes two dive alternatives and an opt-out option. Presentation of these choice options mimics real market situations where the consumer, in this case a scuba diver, is not forced to make a choice but can opt out (Champ et al. 2003).

The CE was developed with the support of a survey instrument in the form of a questionnaire in order to collect data from scuba divers.[3] The questionnaire was structured as follows. First, it included questions aimed at knowing the interviewee's general dive experience, comprising total years of experience, number of dives made until the present moment, and the benefits obtained with this activity (e.g., connection with nature, aesthetic enjoyment). Second, questions were raised regarding the stay in L'Estartit (e.g., approximate cost of stay, number of dives intended to be made during the stay). Third, the questionnaire focused on assessing the past dive experience in Medes Islands, including questions such as the number of dives made, and a personal evaluation of the dive quality. Fourth, a brief explanation was prepared about the purpose of the CE. Finally, the survey included several socio-economic questions (e.g., gender, age, nationality, and level of net monthly income of the household). The survey was refined several times after consulting natural and social science experts, personnel from the Natural Park of Medes Islands, el Montgrí and el Baix Ter, diving centres, and pre-testing it with scuba divers.

3.4 Utility Specifications

CEs are based on the so-called "characteristics theory of value" (Lancaster 1966), as well as on random utility theory (McFadden 1974). Utility (U_{ij}) represents the satisfaction of an individual (i) regarding the consumption of a certain good, also known as alternative (j). In this study, alternatives are expressed as types of dives. In its general specification presented in Eq. (1), overall utility of an alternative is represented as a function of an observed and deterministic component which includes a K-vector of observed attributes composing alternative j (χ_{ij}), and a random, unobserved component (ε_{ij}). The latter term is identically and independently distributed (IID) as extreme value. The parameter β is homogeneous across individuals and is considered as a weight measure explaining the contribution of each random variable to the overall utility of an alternative (Mariel et al. 2013).

$$U_{ij} = \beta' \chi_{ij} + \varepsilon_{ij} \tag{1}$$

One important difference between multinomial logit (MNL) and random parameter logit models (RPL) is that the coefficient vector in RPL is allowed to vary among individuals instead of being fixed as in the MNL specification. This allows capturing heterogeneity of preferences as a function of individuals' characteristics (Train 1998; Mariel et al. 2013). In the RPL specification represented in Eq. (2), the coefficient vector is defined as ($\beta + \eta_{ij}$), where β represents the mean attribute utility weights in the population, while η stands for the individual deviation from the mean (Train 1998; Mariel et al. 2013).

$$U_{ij} = \left(\beta + \eta_{ij}\right)' \chi_{ij} + \varepsilon_{ij} \tag{2}$$

In CEs it is assumed that individuals compare alternatives and choose the option that gives them most satisfaction or maximizes their utility given an (unknown) budget constraint (Louviere et al. 2010). This is represented in Eq. (3) as a higher probability of an individual (i) choosing an alternative (j) over other options (q) of a certain choice set (C). Utilities of different alternatives include a deterministic (V) and random, unobserved component (ε).

$$Prob\,(j|C) = Prob\left\{V_{ij} + \varepsilon_{ij} > V_{iq} + \varepsilon_{iq}, \forall q \in C\right\} \tag{3}$$

The inclusion of a monetary attribute, which is defined as the payment-vehicle, is essential in a CE. By knowing if and how much divers are willing to pay for certain experiences, it is

[3] A full version of the questionnaire can be obtained from the autors upon request.

possible to derive implicit prices (IP) for marginal changes in attribute levels. This is given as a negative ratio between the parameters of a specific attribute (β_A) and price (β_p).

$$IP = -\left(\beta_A/\beta_p\right) \tag{4}$$

In addition, it is possible to estimate welfare gains or losses obtained when moving from a status quo option to a different alternative. This is derived as the negative ratio of the difference of the utilities for the two alternatives (V_1, V_0) and the price coefficient (β_p).

$$WTP = -(V_1 - V_0)/\beta_p \tag{5}$$

4 Results

Face-to-face questionnaires were conducted between 24 of August and 14 of September 2013 in L'Estartit. Divers were randomly approached in a wide area of L'Estartit, including ports, beach areas, hotels and campings facilities, diving centres, and in several main streets of the municipality.

From a total of 587 scuba divers asked to participate in the study, 432 completed the survey (a response rate of 73.6 %). From these, 42 surveys were identified as invalid, resulting in 390 valid surveys (an effectiveness rate of 90.2 %). Invalid surveys relate to respondents satisfying one or more of the following conditions: did not complete the CE, revealed a low level of understanding regarding the survey[4], were younger than eighteen years, refused to state their income level, or worked in the diving sector of the locality (thus were considered to be not representative of the general population of divers).

Another possible reason for considering a survey as invalid is the case of protest responses. This may occur, inter alia, when participants are not in accordance with the payment vehicle, reject the idea of paying for an environmental good, or have difficulties in stating their WTP or WTA for environmental quality changes in open-ended bid questions (Barrio and Loureiro 2011). The latter situation is more associated with contingent valuation (CV) studies. In CE, protest answers can be associated with respondents who always select the status quo option over the alternatives (Barrio and Loureiro 2011). In this study such a status quo option did, however, not exist. Another indication of protest answers may be that participants select the "opt-out" in all choice sets. Only six participants answering survey version A and one taking part in survey version B satisfy this condition. If these surveys would be removed from the analysis, then in order to maintain a balance, five other (valid) surveys would have to be randomly removed from version B. In view of this, we decided not to remove them. This is also justified by the fact that it is not certain at all that participants who always selected the opt-out intended this as a protest answer. Participants might be indifferent regarding the options presented.

The following sub-sections present the results of the study, notably the descriptive statistics, econometric model analysis, welfare measures, and choice probabilities for different scenarios.

4.1 Descriptive Statistics

Table 3 shows that the respondents were mainly males (80 %) with an average age of 44 years old. There was a high participation of French divers and individuals with a high education.

[4] For each survey, interviewers had to classify the level of understanding of the respondents as "very good", "good", "regular" or "bad". Surveys classified as "bad" were excluded from the analysis.

Table 3 Socio-economic characteristics

	Mean (SD)
Gender[a]	0.8 (0.4)
Age	44.2 (12.1)
Monthly household net income level[b]	7.9 (3.2)
	%
Nationality	
Spanish	21.8
French	43.1
Other European nationality	33.1
Non-European nationality	2.1
Educational level	
None	0.3
Primary	2.8
High school	28.5
College/University and higher	62.7
Other[c]	5.7
Employment status	
Unemployed	2.3
Student	3.1
Full-time employed	66.7
Retired	9.8
Other[d]	18.1

[a] 0 = female; 1 = male.
[b] 1 = < €500; 2 = €500–€1000; 3 = €1000–€1500; 4 = €1500–€2000; 5 = €2000–€2500; 6 = €2500–€3000; 7 = €3000–€3500; 8 = €3500–€4000; 9 = €4000–€4500; 10 = €4500–€5000; 11 = €5000–€5500; 12 = €5500–€6000; 13 => €6000.
[c] Includes vocational education.
[d] Includes categories such as unpaid work, part-time employed, and irregular employment and without contract

Respondents worked mainly in full time jobs, and indicated a mean monthly household net income close to €3500.

Regarding the scuba divers profile presented in Table 4, respondents had an average of 12.6 years of experience, 472 lifetime dives, and approximately 50 dives in Medes Islands. Most of the respondents considered the dive experience in Medes as "good" or "very good". In the questionnaire, scuba divers were asked to select three species, from a group of twelve emblematic species of Medes Islands, they preferred to see under water. The three most favourite species were, in descending order, common eagle ray, octopus, and "European barracuda". According to the results shown in Table 4 gorgonians were not considered as the most attractive when compared with other species. Red coral was the most appreciated of gorgonian species.

The respondents indicated several types of benefits associated with scuba diving. The connection with nature and aesthetic enjoyment were the most appreciated categories, while the development of social contacts between scuba divers was the least valued.

4.2 Econometric Model Analysis

The analysis of the CE data involved the estimation of several econometric models.[5] All models included categorical coded variables with effects coding, thus producing parameter estimates which can be interpreted as marginal utilities in comparison with reference levels

[5] Model estimates were obtained with LIMDEP 10.0 and NLOGIT 5.0.

Table 4 Profile of scuba divers

	Mean (SD)
Diving experience	
Years of scuba diving experience	12.6 (11.3)
Number of lifetime dives	472 (876)
Number of dives made in Medes Islands	49.4 (265.7)
Level of satisfaction with the dive experience in Medes Islands[a]	3.5 (0.6)
Preferred species to see under water in Medes Islands[b]	0.3 (0.6)
Benefits obtained from scuba diving[c]	
Connection with nature	3.6 (0.5)
Development of social contacts between scuba divers	3.1 (0.8)
Contribution for physical and mental well-being	3.4 (0.7)
Aesthetic enjoyment	3.6 (0.6)
Improvement of knowledge about nature	3.4 (0.7)

[a] 0 = very bad; 1 = bad; 2 = acceptable; 3 = good; 4 = very good
[b] 0 = no gorgonian species were selected; 1 = one gorgonian species selected; 2 = two gorgonian species selected; 3 = three gorgonian species selected.
[c] 0 = strongly disagree; 1 = disagree; 2 = neutral; 3 = agree; and 4 = strongly agree

for all attributes (with the exception of price). These reference levels were defined as the first levels of attributes as listed in the second column of Table 1. The specification of the models included a dummy variable for taking a dive (identified as variable DIVE), which captures the utility associated with the option of diving, in contrast with the opt-out option. In the CE, the decision of taking a dive was chosen by respondents in 1729 of 2340 choice simulations, corresponding to an opt-out of 26.1 %. Table 5 summarizes the main results for three different models.

First a multinomial logit model (MNL) was tested (first column of Table 5). The validity of this specification requires complying with the assumption of independent irrelevant alternatives (IIA). Using a Hausman-McFadden test, the IIA assumption was rejected.[6]

In addition, a random parameter logit specification (RPL) was estimated in order to overcome the problem of non-satisfaction of the IIA assumption. RPL allows testing preference heterogeneity among individuals regarding specific combinations of attributes and levels by working with random instead of fixed parameters.

For the determination of the random coefficients two approaches were followed. First, a specification test based on the Lagrange Multiplier (LM) test in accordance with McFadden and Train (2000) was applied. This test compares two models, notably a base MNL model similar to the one presented in Table 5 with another MNL specification which also integrates artificial variables (results for both models are presented in Table 8 in the appendix). The application of the likelihood-ratio test for these models allowed rejecting the null hypothesis, which implies that the artificial variables do not have zero coefficients, thus confirming potential randomness for some coefficients.[7] According to McFadden and Train (2000), the absolute value of the t-statistic may suggest some heterogeneity for certain parameters when it is higher than one. This was the case for the variables "Hard bottoms with boulders and

[6] $\chi^2 = 237.13$ was obtained for an MNL model which excludes one of the three alternatives.

[7] Based on a likelihood-ratio test of 53.008 with $\chi^2_{(8)d.f.} = 15.507$.

Table 5 Econometric model estimates

	MNL	RPL (a)	RPL (b) with socio-economic characteristics
Number of divers found on a diving trip[a]			
15 divers	0.025	0.014 (0.283)	0.024
25 divers	−0.380***	−0.386***(0.0005)	−0.389***
Underwater landscape[b]			
Hard bottoms with boulders and vertical walls	−0.396***	−0.417*** (0.002)	−0.402***
Hard bottoms with boulders	−0.594***	−0.626*** (0.442***)	−0.698*** (0.386***)
Presence of jellyfish species[c]			
Abundance of non-stinging jellyfish	0.111**	0.105* (0.011)	0.109*
Abundance of stinging jellyfish	−0.399***	−0.414*** (0.094)	−0.410***
Expected state of gorgonians[d]			
Less 50 % of gorgonians due to CC	−0.271***	−0.289*** (0.129)	−0.269***
All gorgonians have disappeared due to CC and OA	−0.910***	−0.951*** (0.0006)	−0.943***
Price	−0.025***	−0.027***	−0.031***
DIVE	2.607***	2.738***	2.678***
Interaction with socio-economic variables			
Hard bottoms with boulders × number of dives (≤50)	–	–	0.320***
Price × gender	–	–	0.006***
Price × income	–	–	0.002
Summary statistics			
Number of observations	2340	2340	2340
Log likelihood	−1992.294	−1988.371	−1978.327
Log likelihood (DIVE variable only)	−2510.623	−2510.623	−2510.623
McFadden Pseudo r-squared	0.207	0.227	0.230
Inf.Cr.AIC	4004.6	4012.7	3984.7

***, **, *Statistical significance at 1, 5, 10 % level, respectively; parameter estimates for the RPL models were derived according the Halton method with 1000 draws, and followed a normal distribution for the case of the random parameters; standard deviations for the random parameters are presented in parenthesis; CC is an abbreviation for climate change and OA for ocean acidification
[a] 5 divers; [b] hard bottoms with boulders, vertical walls, caves and tunnels; [c] non presence of jellyfish species; [d] all gorgonians are of good quality

vertical walls", "Hard bottoms with boulders", "Less 50 % of gorgonians due to CC", and "All gorgonians have disappeared due to CC and OA". Second, several RPL models were tested where all parameters were treated as random with the exception of those associated with price and the variable DIVE. The decision of maintaining the price coefficient fixed was followed in order to facilitate the estimation of welfare measures, since the distribution of WTP will be the scaled distribution of the attribute's coefficient (Train 2009). Standard deviations presented in parenthesis provide an indication of heterogeneity for the random parameters. The results indicate heterogeneity of preferences for underwater landscapes composed by hard bottoms with boulders (see RPL (a)).

To identify the sources of this heterogeneity for the basic level of underwater landscape complexity, we have tested the terms of interaction between its attribute level and various socio-economic variables collected in the study. Highly significant results were only found for the interaction between respondents who had made fifty or fewer dives and those who had a higher preference for this type landscape in comparison with more experienced divers. This relationship is presented in Table 5 as RPL (b).

A possible explanation is that less experienced divers find diving routes involving vertical walls, caves and tunnels more risky and thus requiring more experience. For the same model specification, we further tested the interaction of fixed parameters, notably price, with the socio-economic variables gender (a dummy variable with taking a value 1 for male and 0 for female) and income level (a dummy variable taking a value 1 for divers with a monthly household net income level higher or equal than €5000 and 0 otherwise). The results show a positive and significant interaction of price with the variable gender, indicating that male divers are more willing to pay higher prices for a dive. For the interaction with the variable income, no significant effect was found. The utility function for this model is specified in Eq. (6), where β_{10} represents the coefficient of the random parameter (i denotes individual, j alternative).

$$
\begin{aligned}
U_{ij} = {} & \beta_{o*} DIVE + \beta_{1*} 15\, divers_{ij} + \beta_{2*} 25\, divers_{ij} \\
& + \beta_{3*} Hard\ bottoms\ with\ boulders\ and\ vertical\ walls_{ij} \\
& + \beta_{4*} Hard\ bottoms\ with\ boulders_{ij} + \beta_{5*} Abundance\ of \\
& non\text{-}stinging\ jellyfish_{ij} + \beta_{6*} Abundance\ of\ stinging\ jellyfish_{ij} \\
& + \beta_{7*} Reduction\ of\ 50\,\%\ of\ gorgonians\ due\ to\ CC_{ij} \\
& + \beta_{8*} All\ gorgonians\ have\ disappeared\ due\ to\ CC\ and\ OA_{ij} \\
& + \beta_{9*} Price_{ij} + \beta_{10*} Hard\ bottoms\ with\ boulders_{ij} \times Number\ of\ dives\ (\leq 50)_i \\
& + \beta_{11*} Price_{ij} \times Gender_i + \beta_{12*} Price_{ij} \times Income_i + \varepsilon_{ij}
\end{aligned} \tag{6}
$$

For the RPL models presented in Table 5, parameter estimates were derived according to the Halton method with 1000 draws, following a normal distribution for the case of the random parameters. The selection of this type of distribution allows respondents to have both positive and negative preferences (Carlsson et al. 2003). A triangular distribution was also tested but led to insignificant differences with the normal distribution.

Likelihood-ratio tests performed for the three models confirm their overall significance.[8] This confirms the rejection of the null hypothesis that the specified models are no better than the baseline comparison models (with the variable DIVE only) (Hensher et al. 2005). Comparing all models, the constant increase in the log likelihood and in the pseudo R^2 from the first to the third model, denotes that the RPL (b) has the best fit. All coefficient estimates are significant at 99 % with the exception of those for the attribute level "abundance of non-stinging jellyfish" (significance of 95 % for the MNL, and 90 % for both RPL models) and for the attribute level "15 divers" and the interaction between the variables price and income, which were non-significant.

[8] For the MNL model the ratio is 1036.66 with $\chi^2_{(9)d.f.} = 16.919$, for the first RPL, 1044.51 with $\chi^2_{(17)d.f.} = 27.587$, and for the second RPL, 1064.59 with $\chi^2_{(13)d.f.} = 22.362$.

In general, respondents showed a higher preference for the lowest level of crowding (5 divers) in comparison with the highest level (25 divers), but appear to be somehow indifferent when the level of crowding was fixed at 15 divers. Negatives signs of parameter estimates for the two levels of underwater landscape that were compared with the reference level (hard bottoms with boulders, vertical walls, and caves/tunnels) indicate a stronger preference for a more complex underwater landscape, where tunnels and caves appear to be elements highly appreciated. Regarding the presence of jellyfish species, there is a slight indication that respondents positively valued the presence of non-stinging jellyfish. On the contrary, a negative valuation was found for the abundance of stinging jellyfish. Furthermore, scuba divers' satisfaction decreases when gorgonians register a decline of 50 and 100 % in their populations. The total disappearance of these species as a result of climate change and ocean acidification was the attribute level change less valued. Finally, the negative sign in the mean of the price parameter indicates an expected decrease in utility when prices of dives increase, and the positive sign for the DIVE variable means that in general respondents preferred to select a dive alternative instead of choosing the "neither option", i.e. not diving.

4.3 Welfare Estimates

From the parameter estimates presented in Table 5 it is possible to derive welfare changes in monetary terms. These values are associated with changes in the level of an attribute compared with its reference level, provided that the remaining parameters are held constant. Welfare estimates designated as IP, or a measure of WTP, reflect utility increases when the value is positive. This can be interpreted as WTP for a change in a certain attribute level. However, a negative value indicates a decrease in utility. This suggests that individuals require compensation through lower prices (Train and Weeks 2005) in order to have the same level of utility as in the reference dive. We calculated the negative ratios of the parameters associated with each attribute level and price as presented in Eq. 4 (Sect. 3.4). As a result of using categorical coded variables with effects coding this ratio was multiplied by two (Olynk et al. 2010). RPL (b) was used for this purpose as this specification had the best fit.

Table 6 shows that the disappearance of all gorgonians due to climate change and ocean acidification had the highest negative effect on utility (≈−€60/dive). The welfare value of a 50 % decrease in gorgonian populations, due to only climate change, is about −€17/dive. Changing from a dive without jellyfish species to one characterized by an abundance of stinging jellyfish was associated with a welfare loss of ≈−€26/dive. On the contrary, non-stinging jellyfish presence was positively valued (≈€7/dive). For the remaining attributes, diving in areas with less underwater landscape elements is associated with a decrease in utility. Moving from areas with the highest to the lowest level of landscape complexity was valued as ≈−€45/dive. In addition, when the crowding level changes from 5 to 25 divers, there is a decrease in utility valued as almost ≈−€25/dive. Finally, the welfare estimates for the change from 5 to 15 divers are not significant.

In addition to the valuation of the changes in the levels of a single attribute, the impact of a combined change in two attribute values is assessed to illustrate a scenario with sea warming and ocean acidification. This includes the abundance of stinging jellyfish and the disappearance of the gorgonians as the changes compared to the reference level (5 divers; hard bottoms with boulders, vertical walls, caves and tunnels; non presence of jellyfish species; and all gorgonians are of good quality). The results show an approximate welfare loss of −€91/dive and a total economic loss, adjusted for the total dives made in a year in Medes Islands (based on 55,647 dives made in 2012), of −€5.1 million/year (Table 7). This may be

Table 6 Welfare estimates for changes in attribute levels (in 2013€)

	Single dive (€)
Number of divers found on a diving trip[a]	
15 divers	n.s.s.
25 divers	−24.87*** (−34.43, −15.31)
Underwater landscape[b]	
Hard bottoms with boulders and vertical walls	−25.68*** (−35.50, −16.86)
Hard bottoms with boulders	−44.57*** (−55.53, −33.61)
Presence of jellyfish species[c]	
Non-stinging jellyfish	6.95* (−0.16, 14.07)
Stinging jellyfish	−26.17*** (−35.44, −16.90)
Expected state of gorgonians[d]	
Less 50 % of gorgonians	−17.15*** (−24.62, −9.68)
All gorgonians have disappeared	−60.22*** (−71.90, −48.56)

***, **, * Statistical significance at 1, 5, 10 % level, respectively; 95 % confidence intervals estimated with the Delta method are presented in parenthesis; n.s.s. means not statistically significant
[a] 5 divers; [b] hard bottoms with boulders, vertical walls, caves and tunnels; [c] non presence of jellyfish species; [d] all gorgonians are of good quality

Table 7 Estimates of welfare losses for the sea warming and acidification scenario (in 2013€)

	Single dive	Total dives/year
Stinging jellyfish become abundant and all gorgonians disappear	−91.45***	−5.1 million***
	(−106.71, −76.18)	(−5, 938, 091; −4, 239, 188)

*** Statistical significance at 1 %; 95 % confidence intervals estimated with the Delta method are presented in parenthesis

regarded as an upper bound as not all dives were made in the same conditions as the reference scenario.

4.4 Simulation of Choice Probabilities

In a choice analysis it is possible to examine how changes in the levels of attributes affect the probability of one particular alternative being chosen. This allows simulating (potential) choice situations which are not explicit in the experiment. Figure 3 presents the rejection rates for different types of dives, in other words, the probabilities of respondents not choosing to dive. We defined possible dives associated with four cases, each one representing environmental changes caused by sea warming and/or acidification. These cases included: (1) abundance of stinging jellyfish due to either sea warming or ocean acidification; (2) 50 % decrease of gorgonians as a result of sea warming; (3) total disappearance of gorgonians because of a combination of both pressures; and (4) abundance of stinging jellyfish and total disappearance of gorgonians as a consequence of both pressures. Rejection rates were estimated for different dive price levels (€30, €50, €70, €90, and €110). For the simulations, RPL (b) was used.

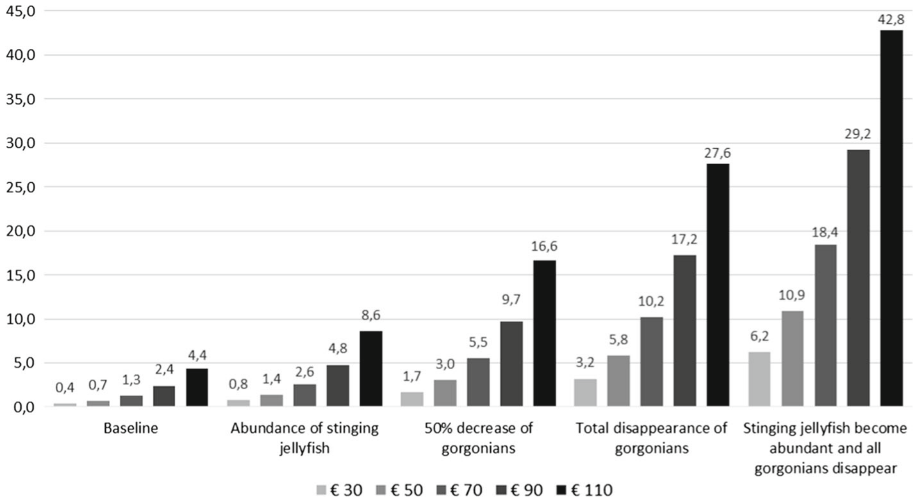

Fig. 3 Rejection rates (%) for dives associated with the reference level and various combinations of sea warming and acidification

Results indicate an overall increase in the rejection rates for higher prices under all scenarios. This outcome was to some extent expected as it is in line with a downward sloping demand curve for a normal (desirable) good: when the price of a good increases its demand falls. The probability of not choosing to dive is considerably lower for all price levels in the reference level. Even when the price reaches its maximum value (€110) the rejection rate is only 4.4 %. On the contrary, for the scenarios combining two environmental pressures the rejection rates are the highest.

5 Conclusions

This study has reported the results of a choice experiment among scuba divers at the touristic destination of L'Estartit, near the Marine Protected Area of Medes Islands (Spain). We aimed to asses the behaviour of scuba divers under conditions of sea warming and ocean acidification.

Respondents considered the total disappearance of gorgonians caused by both pressures as the most disliked change. This resulted in a welfare loss of approximately −€60 for a single dive compared with diving under conditions of all gorgonians having a good quality. A 50 % decrease of gorgonian populations as a result of climate change was associated with a lower decrease in utility (−€17/dive). Our results can be compared somewhat with those of Doshi et al. (2012), even though there are important differences, namely with regard to the valuation context, the experimental design, the geographical focus, and type of environmental impact. Doshi et al. (2012) estimate that the costs of 100 % coral bleaching is US$73 per dive. Corresponding value in EUR currency for 2013 is approximately €55, which is close to the welfare value presented for the local extinction of gorgonians (−€60).[9] In other words, the order of magnitudes of our and their estimates are consistent.

[9] Doshi et al. (2012) presents currency values in 2010 USD. According the European Central Bank (2015), the exchange rate between USD and EUR was approximately the two years, namely 1.3257 in 2010 and 1.3281 in 2013.

Another environmental change potentially associated with sea warming and ocean acidification is the higher abundance of jellyfish species. Results show a reduction in scuba divers' satisfaction for abundance of stinging jellyfish, resulting in a welfare estimate of −€26/dive. On the contrary, a modest, but still positive effect was associated with the abundance of non-stinging jellyfish, with a WTP close to €7/dive. The combination of the disappearance of all gorgonians and the abundance of stinging jellyfish represent the worst consequences of sea warming and acidification scenarios. Together they are associated with a welfare change of −€91/dive in comparison with the reference scenario, i.e. with no (effects of) climate change and ocean acidification. When aggregated to the number of dives made in a year in Medes Islands, the total value reached −€5.1 million.

An analysis of the rejection rates for diving under the reference level and different sea warming and ocean acidification scenarios was conducted. Various simulations of probabilities involving variations in the price of the dive showed an increase in the rejection rates with higher prices, which is in line with regular demand curves for normal goods. The lowest rejection rates were found for the reference level (0.4–4.4 %) and the highest rates for the combined sea warming and acidification scenarios (6.2–42.8 %).

Scuba divers expressed a positive preference for less crowded diving sites, therefore, changing a dive experience with 5 divers to one with 25 divers was negatively valued (≈−€25/dive). This result is consistent with findings of Schuhmann et al. (2013), which also suggests that divers prefer to dive in areas that are not crowded.

Furthermore, underwater landscapes composed by hard bottoms with boulders, vertical walls, and caves/tunnels were preferred in comparison with more basic configurations such as those only integrating hard bottoms with boulders. The latter type of underwater landscape was, however, more appealing to less experience divers, which are not so skilled for dives in vertical walls, caves and tunnels as more experienced divers. The change from the highest to the lowest level of underwater landscape complexity gave rise to a large negative effect on utility (≈−€45/dive).

This study concludes that the environmental changes associated with sea warming and ocean acidification may reduce the attractiveness of Mediterranean Coralligenous areas for scuba diving. Economic costs may not only relate to recreational welfare losses for scuba divers, but also to a decline in tourism revenues with possible effects at the local economy level. In this context, one should realize that more than 70 % of the local annual GDP of the study area in the last decade was associated with tourism activities developed at Medes Islands. Furthermore, a high percentage of the annual budget of the Marine Protected Area for the year 2009 (approximately 50 %) came from the revenues obtained from scuba diving and snorkelling.

The valuation of economic impacts will benefit from advances on the knowledge of the potential effects of both pressures in the natural systems, as well as their synergies with other stressors. The magnitude of the estimated costs could be substantially higher if direct effects involving other Coralligenous species (e.g., calcifying algae, bryozoans, and stony corals), as wells as the repercussions in the entire ecosystem, are considered.

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Appendix. Specification test

Table 8 presents a specification test as explained in Section 4.2

Table 8 Specification test for the determination of random coefficients

	MNL	MNL with artificial variables
Number of divers found on a diving trip[a]		
15 divers	0.025	0.129
25 divers	−0.380	−0.850
Underwater landscape[b]		
Hard bottoms with boulders and vertical walls	−0.396	−0.414
Hard bottoms with boulders	−0.594	−2.169
Presence of jellyfish species[c]		
Abundance of non-stinging jellyfish	0.111	0.787
Abundance of stinging jellyfish	−0.399	−0.688
Expected state of gorgonians[d]		
Less 50 % of gorgonians due to CC	−0.271	−1.145
All gorgonians have disappeared due to CC and OA	−0.910	−1.779
Price	−0.025	−0.031
DIVE	2.607	3.771
Artificial variables		
15 divers	–	−0.121
25 divers	–	0.533
Hard bottoms with boulders and vertical walls	–	0.475*
Hard bottoms with boulders	–	−0.841*
Abundance of non-stinging jellyfish	–	−1.001
Abundance of stinging jellyfish	–	0.843
Less 50 % of gorgonians due to CC	–	−1.926*
All gorgonians have disappeared due to CC and OA	–	0.321*
Summary statistics		
Number of observations	2340	2340
Log likelihood	−1992.294	−1965.790
Log likelihood (DIVE variable only)	−2510.623	−2510.623
McFadden Pseudo r-squared	0.207	0.217
Inf.Cr.AIC	4004.6	3967.6

* Artificial variables with $|T| > 1$; CC is an abbreviation for climate change and OA for ocean acidification
[a] 5 divers; [b] hard bottoms with boulders, vertical walls, caves and tunnels; [c] non presence of jellyfish species; [d] all gorgonians are of good quality

References

Alban F, Person J, Roncin N, Boncoeur J (2008) Analysis of socio-economic survey results. EMPAFISH Project, p 139

Attrill MJ, Wright J, Edwards M (2007) Climate-related increases in jellyfish frequency suggest a more gelatinous future for the North Sea. Limnol Oceanogr 52(1):480–485

Barrio M, Loureiro M (2011) The impact of protest responses in choice experiments: an application to a Biosphere Reserve Management Program. For Syst 22(1):94–105

Ballesteros E (2006) Mediterranean coralligenous assemblages: a synthesis of present knowledge. Oceanogr Mar Biol Ann Rev 44:123–195

Boudouresque CF (2004b) The erosion of Mediterranean biodiversity. In: Rodríguez-Prieto C, Pardini G (eds) The Mediterranean Sea: an overview of its present state and plans for future protection. Lectures from the 4th International Summer School on the Environment. Universitat de Girona, Girona, pp 53–112

Bramanti L, Magagnini G, De Maio L, Santangelo G (2005) Recruitment, early survival and growth of the Mediterranean red coral *Corallium rubrum* (L. 1758), a 4-year study. J Exp Mar Biol Ecol 314:69–78

Bramanti L, Vielmini I, Rossi S, Stolfa S, Santangelo G (2011) Involvement of recreational scuba divers in emblematic species monitoring: the case of Mediterranean red coral (*Corallium rubrum*). J Nat Conserv 19(5):312–318. doi:10.1016/j.jnc.2011.05.004

Bramanti L, Movilla J, Guron M, Calvo E, Gori A, Dominguez-Carrió C, Grinyó J, Lopez-Sanz A, Martinez-Quintana A, Pelejero C, Ziveri P, Rossi S (2013) Detrimental effects of ocean acidification on the economically important Mediterranean red coral (*Corallium rubrum*). Glob Change Biol 19:1897–1908. doi:10.1111/gcb.12171

Carlsson F, Frykblom P, Liljenstolpe C (2003) Valuing wetland attributes: an application of choice experiments. Ecol Econ 47(1):95–103

Cerrano C, Bavestrello G, Bianchi CN, Cattaneo-vietti R, Bava S, Morganti C, Morri C, Picco P, Sara G, Schiaparelli S, Siccardi A, Sponga F (2000) A catastrophic mass-mortality episode of gorgonians and other organisms in the Ligurian Sea (North-western Mediterranean), summer 1999. Ecol Lett 3:284–293. doi:10.1046/j.1461-0248.2000.00152.x

Champ P, Boyle K, Brown T (2003) A primer on nonmarket valuation. The economics of non-market goods and resources. Springer, Berlin

Coll M, Piroddi C, Steenbeek J, Kaschner K, Ben Rais Lasram F et al (2010) The biodiversity of the Mediterranean sea: estimates, patterns, and threats. PLoS One 5(8):e11842. doi:10.1371/journal.pone.0011842

Condon RH, Duarte CM, Pitt KA, Robinson KL, Lucas CH, Sutherland KR, Mianzan HW, Bogeberg M, Purcell JE, Decker MB, Uye S-I, Madin LP, Brodeur RD, Haddock SHD, Malej A, Parry GD, Eriksen E, Quinones J, Acha M, Harvey M, Arthur JM, Graham WM (2013) Recurrent jellyfish blooms are a consequence of global oscillations. Proc Natl Acad Sci 110(3):1000–1005. doi:10.1073/pnas.1210920110

Diaz P, Koundouri P, Rulleau B, Remoundou K (unpublished) Valuing climate change mitigation in coastal environments exposed to extreme natural hazards: a choice experiment simulated for different time horizons. DEOS working papers 1203, Athens University of Economics and Business. http://ideas.repec.org/p/aue/wpaper/1203.html. Cited 1 April 2014

Doshi A, Pascoe S, Thébaud O, Thomas CR, Setiasih N, Hong JTC, True J, Schuttenberg HZ, Heron SF (2012) Loss of economic value from coral bleaching in S.E. Asia. In: Yellowlees D, Hughes TP (eds) Proceedings of the 12th international coral reef symposium, 9–13 July 2012, Cairns, QLD, Australia, pp 1–5

European Central Bank (ECB) (2015). Euro foreign exchange reference rates. https://www.ecb.europa.eu/stats/exchange/eurofxref/html/index.en.html. Cited 16 May 2015

Fabricius KE, De'ath G, Noonan S, Uthicke S (2014) Ecological effects of ocean acidification and habitat complexity on reef-associated macroinvertebrate communities. Proc R Soc B 281(1775):20132479

Garrabou J, Perez T, Sartoretto S, Harmelin JG (2001) Mass mortality event in red coral *Corallium rubrum* populations in the Provence region (France, NW Mediterranean). Mar Ecol Prog Ser 217:263–272

Garrabou J, Coma R, Bensoussan N, Bally M, Chevaldonné P, Cigliano M, Diaz D, Harmelin JG, Gambi MC, Kersting DK, Ledoux JB, Lejeusne C, Linares C, Marschal C, Pérez T, Ribes M, Romano JC, Serrano E, Teixido N, Torrents O, Zabala M, Zuberer F, Cerrano C (2009) Mass mortality in Northwestern Mediterranean rocky benthic communities: effects of the 2003 heat wave. Glob Change Biol 15:1090–1103

Gazeau F, Parker L, Comeau S, Gattuso J-P, O'Connor W, Martin S, Pörtner H-O, Ross P (2013) Impacts of ocean acidification on marine shelled molluscs. Mar Biol 160:2207–2245

Generalitat de Catalunya (2010) El Govern dóna llum verda al Parc Natural del Montgrí, les Illes Medes i el Baix Ter. In Acords de Govern, 5 de Gener de 2010. Generalitat de Catalunya. Departament de la Presidència. Direcció General de Comunicació del Govern. http://www.gencat.cat/acordsdegovern/20100105/20100105_AG.pdf. Cited 1 April 2014

Gili JM, Sardà R, Madurell T, Rossi S (2014) Zoobenthos. In: Goffredo S & Dubinsky Z (eds) The Mediterranean Sea: its history and present challenges. Fauna. Springer, Germany, pp 213–236, ISBN 978-94-007-6703-4, Chapter 12

Hall-Spencer JM, Rodolfo-Metalpa R, Martin S, Ransome E, Dine M, Turner SM, Rowley SJ, Tedesco D, Buia MC (2008) Volcanic carbon dioxide vents show ecosystem effects of ocean acidification. Nature 454:96–99

Hanley N, Wright RE, Adamowicz V (1998) Using choice experiments to value the enviroment—design issues, current experience and future prospects. Environ Resour Econ 11(3):413–428

Harmelin JG (1993) Invitation sous l'écume. Cahiers Parc National Port-Cros 10:1–83

Hensher DA, Rose JM, Greene WH (2005) Applied choice analysis: a primer. Cambridge University Press, Cambridge

IDESCAT (2013) Nomencat. Nomenclàtor estadístic d'entitats de població de Catalunya 2012. Estadística Instrumental. Generalitat de Catalunya. http://www.idescat.cat/cat/idescat/publicacions/cataleg/pdfdocs/nomencat2012.pdf. Cited 1 April 2014

Kontogianni AD, Emmanouilides CJ (2014) The cost of a gelatinous future and loss of critical habitats in the Mediterranean. ICES J Mar Sci 71(4):853–866. doi:10.1093/icesjms/fst194. (May/June 2014)

Kroeker KJ, Kordas RL, Crim RN, Hendriks IE, Ramajo L, Singh GG, Duarte CM, Gattuso JP (2013) Impacts of ocean acidification on marine organisms: quantifying sensitivities and interactions with warming. Global Change Biology. doi:10.1111/gcb.12179

Lancaster K (1966) A new approach to consumer theory. J Polit Econ 74:132–157

Llamas A, Cáceres P (2010) Guía submarina de les Illes Medes i la Costa del Montgrí. Editorial Anthias, p 184

Lombardi C, Rodolfo-Metalpa R, Cocito S, Gambi MC, Taylor PD (2011) Structural and geochemical alterations in the Mg calcite bryozoan *Myriapora truncata* under elevated seawater pCO2 simulating ocean acidification. PSZN I: Mar Ecol 32:211–222

Louviere JJ, Flynn TN, Carson RT (2010) Discrete choice experiments are not conjoint analysis. J Choice Model 3(3):57–72

Mariel P, Ayala A, Hoyos D, Abdullah S (2013) Selecting random parameters in discrete choice experiment for environmental valuation: a simulation experiment. J Choice Model 7:44–57

McFadden D (1974) Conditional logit analysis of qualitative choice behavior. In: Zarembka P (ed) Frontiers econometrics. Academic Press, New York, pp 105–142

McFadden D, Train K (2000) Mixed MNL models for discrete response. J Appl Econom 15:447–470

Millennium Ecosystem Assessment (MEA) (2003) Ecosystem and human well-being: a framework for assessment. Island press, Washington

Mundet Ll, Ribera Ll (2001) Characteristics of divers at a Spanish resort. Tour Manag 22(5):501–510

Muñoz N (2006) Proceedings of the MedPAN Workshop: Mediterranean marine protected areas and sustainable management of tourism, March 2006

Muñoz N (2007) Spatial use and divers' behaviour in the Medes Islands. MedPAN report, p 137

Natural Park of Medes Islands, el Montgrí and el Baix Ter (2013) Marine area at the Montgrí, Medes Islands and Baix Ter Natural Park. http://www20.gencat.cat/docs/parcsnaturals/Home/Montgri-Medes/Visitans/Normes%20i%20consells/Normes/Parc_WEB_ENG.pdf. Cited 1 April 2014

Olynk N, Tonsor GT, Wolf C (2010) Consumer willingness to pay for livestock credence attribute claim verification. J Agricl Resour Econ 35:261–280

Parc Natural Montgri Illes Medes i Baix Ter, Submon (2012) Gestió del busseig a les Illes Medes: Capacitat de càrrega i limit de canvi acceptable

Parsons GR, Thur SM (2008) Valuing changes in the quality of coral reef ecosystems: a stated preference study of SCUBA diving in the Bonaire National Marine Park. Environ Resour Econ 40(4):593–608

Quintana XD, Hereu B (eds) (2012) El fons marí de les illes Medes I el Montgrí: Quatre dècades de recerca per a la conservació. Col·lecció Recerca i Territori 4. Càtedra d'Ecosistemes Litorals Mediterranis, Torroella de Montgri

Rossi S (2013) The destruction of the 'animal forests' in the oceans: towards an oversimplification of the benthic ecosystems. Ocean Coast Manag 84:77–85. doi:10.1016/j.ocecoaman.2013.07.004

Schuhmann PW, Casey JF, Horrocks JA, Oxenford HA (2013) Recreational scuba divers'willingness to pay for marine biodiversity in Barbados. J Environ Manag 121:29–36

Sorice M, Oh C, Ditton R (2005) Using a stated preference discrete choice experiment to analyze scuba diver preferences for coral reef conservation. National Fish and Wildlife Foundation Grant

Train K (1998) Recreation demand models with taste differences over people. Land Econ 74:230–239

Train K, Weeks M (2005) Discrete choice models in preference space and willingness-to-pay space. In: Scarpa R, Alberini A (eds) Applications of simulation methods in Environmental and Resource Economics. Springer, Dordrecht, pp 1–16

Train K (2009) Discrete choice methods with simulation, 2nd edn. Cambridge University Press, Cambridge

UNEP-MAP-RAC/SPA (2008) Action plan for the conservation of the coralligenous and other calcareous bio-concretions in the Mediterranean Sea. Ed. RAC/SPA, Tunis, p 21

Uyarra MC, Watkinson AR, Côte IM (2009) Managing dive tourism for the sustainable use of coral reefs: validating diver perceptions of attractive site features. Environ Manag 43:1–16

Vandenbroucke D, Bogaert S, Volckaert A, Taylor T, Arnold S, Mannaart M, Perez C, Bogaert S (eds) (2012) Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive. Project No 11601. Final report. Contract No 070307/2010/577902/ETU/F1. http://ec.europa.eu/environment/enveco/water/pdf/report.pdf. Cited 1 April 2014

Westmacott S, Cesar HSJ, Pet-Soede L, Lindén O (2000) Coral bleaching in the Indian Ocean: socio-economic assessment of effects. In: Cesas HSJ (ed) Collected essays on the economics of coral reefs. CORDIO, Kalmar University, Kalmar, pp 94–106

Wielgus J, Chadwick-Furman NE, Zeitouni N, Shechter M (2003) Effects of coral reef attribute damage on recreational welfare. Mar Resour Econ 18:225–237