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**Estimating the non-market benefit value of deep-sea ecosystem restoration: Evidence from a contingent valuation study of the Dohrn Canyon in the Bay of Naples.**


## Abstract

It is increasingly recognised that restoration actions in marine environments are required in order to deal with continued habitat degradation and to support conservation strategies. Restoration success is judged on the ecological outcomes but with limited resources the magnitude of the societal benefits achieved is an important consideration for policy makers. This study demonstrates how the potential non-market benefit value of a deep-sea restoration project might be assessed. The contingent valuation method is employed to elicit the Italian population's willingness to pay for the restoration of the Dohrn deep-sea canyon in the Bay of Naples. Sample selection models that control for the impact of protest zero bidders on benefit value estimation are compared to more traditional modelling approaches. The results indicate a positive willingness to pay for the restoration of the canyon ecosystem and the importance of accounting for protest zero bidders in contingent valuation studies, especially when the environmental good is unfamiliar to respondents. The paper argues that the inclusion of non-market benefit values is particularly important in assessing the potential for marine ecosystem restoration if a true reflection of the value to society of restoring such habitats are to be correctly captured.

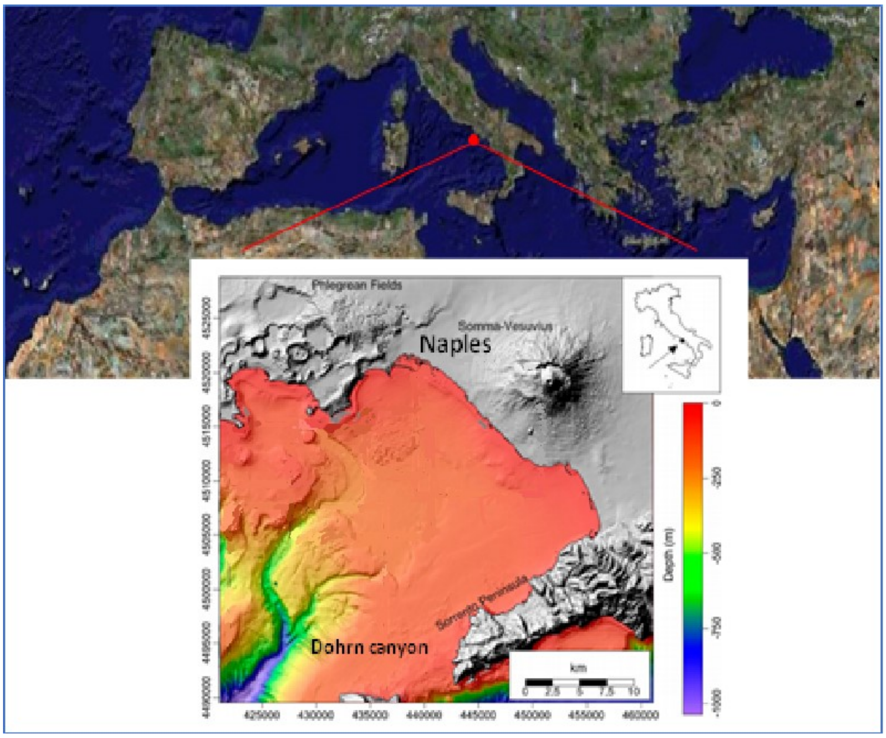
## 1. Introduction

Direct and indirect human pressures on marine ecosystems are expected to increase considerably in the coming decades, leading to a loss of marine biodiversity and the degradation of ecosystem functioning (Danovara et al., 2016). Since the functioning of marine ecosystems is upheld by high levels of biodiversity it is also expected that the continuing loss of biodiversity will lead to the unprecedented erosion of natural capital in marine ecosystems and of the services they supply (Worm et al., 2006; Thurber et al., 2014). In European seas, in particular, destructive fishing practices (e.g. bottom trawling), overfishing, unsustainable forms of aquaculture, the spread of invasive species, eutrophication, large-scale oil and gas operations, offshore renewable energy developments, coastal engineering, coastal development and climate change are among the major impacts responsible for marine habitat change (Claudet and Fraschetti, 2010; EC, 2019).

One of the primary aims of marine ecosystem restoration efforts is to counteract the impact of these pressures and to ensure the continued delivery of ecosystem services (Milton and Scrogin, 2006; Barbier et al. 2012). Given the considerable costs that are involved in marine ecosystem restoration (Bayraktarov et al., 2016), it is critical to understand the benefit values to society of restoration projects in order that restoration projects are chosen as efficiently as possible. Marine ecosystem restoration can create economic value if it increases the delivery of ecosystem services or increases the value of other economic activities that depend on the marine ecosystem's condition. If the total increased value of the benefits exceeds the costs of restoration, then it can be considered that the restoration had net economic benefits to society (Pendleton et al. 2010). As pointed out by Blignaut et al. (2014), prioritisation though cost-benefit analysis of restoration projects could also assist "decision makers to make informed decisions at a time when the demand for ecosystem restoration is required to grow exponentially". Consideration of the economic impact of restoration activity through ecosystem service accounting is also starting to become a priority internationally (UN, 2014) and aims to identify the temporal and spatial changes in ecosystems' contribution to society (Chen et al., 2019).

With consideration of these issues, this paper estimates the non-market benefit value to the Italian general public of the restoration of the deep-water Dohrn canyon ecosystem in the Bay of Naples. The Dohrn canyon crosses the Gulf of Naples (see Figure 1). It us up to 1000 meters deep in places and follows two main branches, the eastern one and the western one, merging in a single branch in a NE-SW direction. The area the canyon is situated in has long been recognized as one of the richest sources of marine biodiversity in the Mediterranean and is home to the world's first marine station founded by Anton Dohrn in 1872 (Carrada et al. 1980; Milia, 2000). The canyon's floor is characterized by a high abundance of charismatic species, such as cold-water corals and large size bivalves (giant deep-sea oysters and limids) which are rarely found in other parts of the Mediterranean Sea (Sgarrella and Moncharmont-Zei, 1993). The canyon's walls are also inhabited by a number of other mega- and macro-benthic taxa including cnidarians, sponges, polychaetes, molluscs, bryozoans, echinoderms and other crustaceans (Taviani et al. 2020). Indeed, Taviani et al. (2019) identifies and lists over 60 species to be found on the canyon walls and floor.

However, Taviani et al. (2019) also point out that over many decades this canyon has been subjected to severe anthropogenic threats, such as illegal dumping and damage to the flora and fauna in the canyon from fishery activity as well as coastal zone pressures due to its location close to one of the most densely populated regions in Italy. The same authors also note that during their survey work on the canyon floor they "documented the abundant presence of marine litter even of large size, as well as lost nets and longlines seen enveloping also epifaunal megabenthos [large organisms on the seafloor that are visible without the help of microscopes or other specific tools]". This has resulted in the change of the pristine environmental conditions of the canyon and the presence of litter along the canyon axis and walls. The EU Merces project is currently developing tools and methodologies for deep-sea ecosystem restoration with a pilot study aimed at restoring the damaged corals, sponges and other habitats on the canyon floor and removing the observed debris on the pilot site (Merces, 2020).




Adapted from Passaro et al. (2016)

**Figure 1. Location of the Dohrn Canyon in the Central Mediterranean Sea.**

Jobstvogt et al. (2014b) identify 11 distinct ecosystem services with welfare implications arising from abundant biodiversity in submarine canyons as displayed in Table 1. Based on the many services delivered to society by such canyons it is expected that ecological restoration efforts to restore ecosystems in the Dohrn canyon system would likely have a positive impact on societal welfare. A challenge in estimating the non-market benefit values from restoration arises however, due to the deep-sea nature of the marine resource which will be relatively unfamiliar to the general public. Also, while it is acknowledged that such canyons provide many important ecosystem services these often come in the form of regulating or supporting services that are not directly observed by the general public (Hanley et al., 2015).

From an ecological perspective the link between ecosystem functioning of deep-sea resources and the services they support are not fully established (Armstrong, 2012). Modelling the likely effect of a change in the attributes of a given ecosystem and its subsequent effect on an economic resources such as for example fish stocks is particularly complex. There also exists uncertainty between restoration actions and their impact on restoring a functioning ecosystem. While restoration actions involving the transplanting of different stages of an organism life cycle, and the introduction of artificial substrata colonized by the target species have been shown to be highly successful in coastal marine habitats (Bowden-Kerby, 2001; Rinkevich, 2005; Edwards and Gomez, 2007; Basconi et al., 2020) the use of such techniques is still at an early stage of development in deep-sea habitats and the success rates of the limited attempts to date have been more variable (Bayraktarov et al., 2016; Da Ros et al., 2019).

The current study employs a stated preference approach to estimate the value to the Italian general public of the restoration of the Dohrn canyon. Stated preference approaches to non-market valuation involve asking individuals directly their willingness to pay for a hypothetical change in an environmental good. While acknowledging the uncertainty around the success of restoration actions in the deep-sea, within a stated preference exercise the hypothetical scenario presented to respondents must be unambiguous, clearly outlining in this case what the restoration action will achieve. As such the scenario analysed here reflect a situation where active restoration of deep-sea ecosystems has reached maturity and there is more certainty in the outcome of the restoration effort[1].

**Table 1. Typical ecosystem services from submarine canyons**

| Ecosystem services: | Explanation of the potential benefits derived |
|---|---|
| **Provisioning services:** | |
| Carbon sequestration and storage | The value of uptake, storage and burial of organic material within the canyon. |
| Food provision | The canyon's value of providing marine organisms for human consumption. |
| Genetic resources and chemical compounds | The option value of using canyon organisms in biotechnological, pharmaceutical, or industrial applications. |
| **Regulating services:** | |
| Waste absorption and detoxification | The value of burial, decomposition and transformation of waste within the canyon ecosystem. |
| **Cultural services:** | |
| Aesthetic and spiritual | The value of the canyon ecosystem for inspiring religion, arts, movies, documentaries, books and folklore. |
| Bequest and existence | The value of maintaining the canyon ecosystem for future generations and the intrinsic value of its marine species. |
| Scientific and educational | The cognitive value of the canyon ecosystem for science and education. |
| **Supporting services:** | |

[1] The current challenges of restoration actions in the deep-sea are succinctly summarised up by O'Leary et al. (2020); "The high costs of working in the deep-sea and with deep-sea species, the time required to evaluate success of restorative action, the large spatial extent of mining operations, poor information on ecosystem baselines and functioning, and the characteristics of deep-sea life that make them slower to recover than many terrestrial or coastal species all present obstacles to effective restoration". The issue of uncertainty in the outcome of the hypothetical scenario is returned to in the discussion section.

| | |
|---|---|
| Biologically mediated habitat | The value of canyon habitats formed by marine organisms. |
| Nutrient cycling | The value of storage and recycling of nutrients by canyon organisms. |
| Resilience and resistance | The value of the amount of disturbance that the canyon ecosystem can cope with and its ability to regenerate after disturbance. |
| Water circulation and exchange | The value of currents, such as up-and down-welling, dense shelf water cascading and mixing of water masses. |

Source: adapted from Jobstvogt et al. (2014a)

Stated preference approaches have been applied in a limited number of studies to value specific deep sea ecosystems. Glenn et al. (2010) found an average willingness to pay (WTP) lying in a 95% confidence interval of €0 to €10 for cold water coral protection in Ireland. Jobstvogt et al. (2014a) examined preferences for the creation of new marine protected areas (MPAs) in deep sea locations in Scottish waters via a discrete choice experiment. The authors generated a WTP estimate range of £70 to £77 per year for a scenario that involved a high degree of species protection and high potential for the development of medicinal products from deep sea organisms. Aanesen et al. (2015) ran a discrete choice experiment to value the protection of cold water coral in Norway. The authors in that study found a much higher valuation for protection of cold water reefs with a WTP value ranging between €235 and €287 per annum per household amongst the Norwegian population.

In addition, there have been a number of papers which have looked at how individuals form preferences for deep-sea resources. Sandorf et al. (2016) examined the role of information provision on the outcome of choice experiments to value deep-sea cold water coral in Norway. Elsewhere, Sandorf et al. (2017) further examined the role of knowledge of marine ecosystems attributes on attribute non-attendance in discrete choice stated preference studies using the same dataset as Aanesen et al. (2015). The authors found significant attribute non-attendance, i.e. some respondents did not consider all attributes in choosing alternatives. Finally, Aanesen and Armstrong (2019) found that for offshore resources respondents highly valued protection of deep-sea ecosystem services for the purpose of protecting fish species and were indifferent if this came at the expense of market activity such as fisheries and oil and gas.

While there has been previous work on the valuation of deep sea ecosystem service benefits, the current study, to the best of the authors' knowledge, is the first that examines the non-market values generated from the restoration of a deep sea canyon ecosystem. One other study of particular interest is Tonin (2018) where the Contingent Valuation Method (CVM) was also employed to estimate WTP for the restoration of a coral producing marine habitat off the coast of Venice. The scope of the study is similar in that the author estimated the WTP amongst the Italian population for restoration of a marine habitat off the coast of a major metropolitan area. In addition, while not a deep-sea habitat, the ecosystem in question was remote with little or no direct use value beyond fishery activity.

This paper primarily contributes to the above literature by estimating WTP for the restoration of a deep-sea marine resource. To achieve this the CVM approach is adopted. A further contribution of the paper is in the method employed to deal with a particular problem encountered in studies that ask respondents their WTP for an unfamiliar environmental good. In such studies a high number of protest zero bids (protest voters) are often observed. These are usually removed from the sample prior to model estimation. In this paper we instead use a two-stage bivariate probit sample selection model that first controls for the probability of the respondent being even willing to consider the bid value being offered (i.e. to offer a legitimate zero bid or accept the bid value, or instead offer a protest zero bid) while the second stage estimates the probability that the respondent is willing to pay the bid value offered.

The remainder of the study is structured as follows: Section 2 details the method employed, survey used, resulting data set and econometric approach toward estimating WTP. Section 3 reports the results of the econometric analysis. Finally, section 4 contains a discussion of the implications of the results for policy and future research as well as some conclusions.

## 2. Methods

To estimate the non-market benefit value to society of the restoration of the Dohrn canyon the CVM approach was adopted. CVM is a stated preference technique that uses a survey instrument to directly elicit information on individual's preferences and WTP for a hypothetical change in an environmental good or service. It is frequently used in contexts whereby a market for the good in question does not exist and there is lack of an established price by which to value the good. Contingent valuation overcomes this by creating a valuation task that attempts to replicate market conditions. The objective of the CVM approach in this instance is to derive an estimate of the average WTP of a representative individual of the Italian population for the restoration of the Dohrn canyon. This involves firstly collecting data on the individuals preferences through appropriate survey of a sample of the population. This data is then used to derive an estimate of the distribution of WTP for the population from which a measure of average WTP is derived. The remainder of this section describes the specific application of this process in the current study.

*2.1 Survey design and administration*

Collection of data to conduct a CVM analysis involves presenting individuals with a scenario involving a change in the quantity of the non-market good in question and the elicitation of the individual's willingness to pay for the associated change. The restoration scenario presented in the survey was developed in consultation with marine scientists from the Polytechnic University of Marche who are engaged in restoration efforts in the Dohrn canyon in collaboration with the Stazione Zoologica Anton Dohrn. The final survey instrument began by informing the participant about the purposes of the survey. The survey then asked a number of questions related to how the respondents use the marine environment as well as investigating their preferences for marine environmental conservation and restoration. The survey then proceeded to the valuation exercise.

To clearly inform the participants about the contingent scenario, participants were presented with information about the canyon and the ecosystems services derived from it. In particular they were told that "The Dohrn Canyon is the main canyon crossing the Gulf of Naples. It us up to 1000 meters  in depth in places and follows two main branches, the eastern one and the western one, merging in a single branch in a NE-SW direction. A large number of deep-sea species inhabit the canyon and in recent decades a number of unique species have been discovered there. The Dohrn Canyon is located close to the Gulf of Naples, which is amongst the most densely populated Italian regions. There are also approximately 30 ports and more than 300 maritime constructions located along the gulf's 195km of coastline. Over many decades the canyon has been subjected to pressures due to intensive fishing and coastal zone pressures. This has resulted in the change of the pristine environmental conditions of the canyon and the presence of litter along the canyon axis and walls."

Respondents were then informed that the specific restoration project proposed in the CVM question involved the deployment of Autonomous Reef Monitoring Structures (ARMS) in the main axis of the canyon at an approximate depth of 200m. ARMS provide a basis for new organisms to grow. Once the ARMS are colonized by organisms they can play a key role in driving the recovery of the degraded canyon ecosystem. The restoration project would involve taking the organisms from the ARMS units and distributing them on the canyon floor to facilitate the recolonization of the marine ecosystem. Figure 2 was shown to respondents to demonstrate the impact of using the ARMS. They were further informed that litter would be removed from the canyon floor area as part of the restoration efforts.

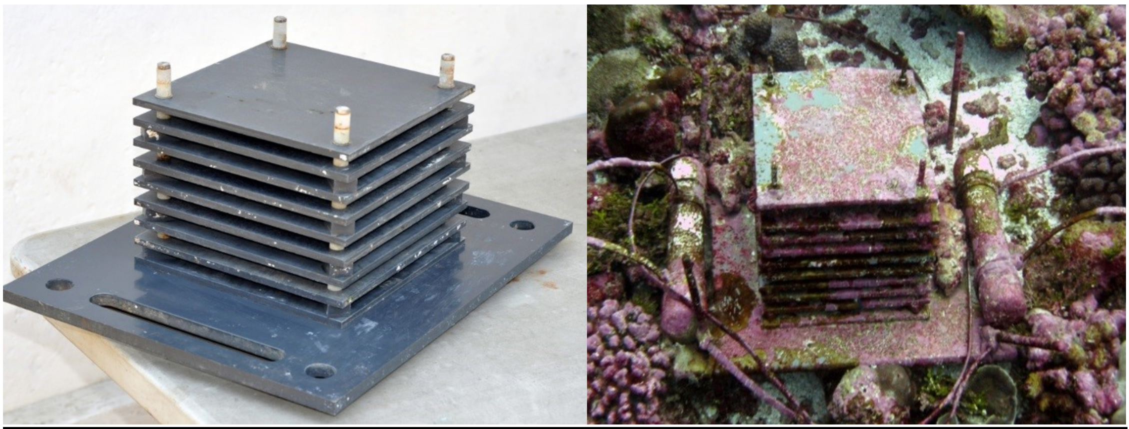


**Figure 2. Autonomous Reef Monitoring Structure Unit before and 2 years after deployment**

In the final scenario presented to respondents, it was proposed that the restoration would lead to improvement in the level of two key attributes of the canyon as displayed in Table 2; biodiversity and marine litter. Once again, these attributes and levels were chosen in consultation with the marine scientists currently working on restoration efforts in the canyon. While all the ecosystem services highlighted in Table 1 were considered it was felt by the marine scientists that the return of biodiversity to levels present prior to human induced damages was the central objective of a successful restoration effort and that the removal of debris was also important in achieving this goal. Therefore these two attributes were included in the scenario description[2]. Respondents were also informed, in the scenario table presented to them, that the restoration project would take place over an area of 20,000m$^2$ (3 soccer pitches). This was done to ensure that respondents were clear in terms of what exactly the magnitude of the restoration project would be. The scenario presented to all respondents was the same, i.e. everyone was presented with the same attributes and levels that would be achieved through restoration, as shown in Table 2.

[2] The 'good' level of litter used in the scenario description (only 0 to 1 item of litter per km$^2$) was based on deep-sea indicators of 'Good Environmental Status' (GES) as prescribed under the Marine Strategy Framework Directive (MSFD), that were developed by the EU ATLAS project. Scientists on that project derived deep-sea indicator levels for the MSFD descriptor of litter corresponding to the number of items of litter visible over a kilometre squared (Kazanidis, 2019).

When presenting the change scenario in a CVM question it is also important that the language used is understandable to the general public. To this end technical language was avoided in the description of the attribute levels and the terminology used was tested in focus group discussions prior to administering the pilot study. This is also why the area attribute was presented in terms of soccer pitches as well as meters squared as the former is often more intuitive for many people (and perhaps especially so for football loving Italians). Testing of the earlier drafts of the survey instrument with Italian citizens in the focus groups also ensured that the necessary background information was included and that the final scenario and the final questions asked were easily understood by the general public.

**Table 2. Attributes used to describe restoration Scenario in CVM question**

| Management Plan Attribute | Attribute level achieved |
|---|---|
| **Biodiversity** (abundance of animals such as fish, starfish, corals, worms, lobsters, sponges & anemones). | **High** – back to pristine habitat levels for the canyon |
| **Density of marine litter on canyon floor** | **Good** (only 0 to 1 item of litter per $km^2$) |
| **Size of protected area in canyon** | 20,000$m^2$ (3 soccer pitches) |

The final survey was carried out over a two week period in March 2019. To administer the survey a market research company, Istituto Piepoli, was employed to utilise their access to an online panel of the Italian general public. As it was intended that the sample be representative of the adult population, only respondents aged 18 plus were surveyed. In addition, to ensure the survey was representative of the entire adult population respondents were sampled from all regions in Italy, with numbers sampled from each region proportional to the population share of the respective region. Finally, prior to the administration of the full survey an initial pilot test was carried out by the market research company to ensure the effectiveness of the survey instrument. The price range used in the CVM question in the main survey instrument was based on the responses to the pilot study which utilized an open-ended elicitation format for the same question. The distribution of responses to the open ended question in the pilot provided the basis for deciding on the final range of bid values.

When presented with the CVM question the participants were told:

"We would now like to ask you what, if anything, you might be willing to pay to support a restoration project in the canyon. We would like to mention that some people say they are willing to pay more in surveys for these types of improvements in ecosystems than that they actually would pay if the situation were real. This is because when people actually have to part with their money, they take into account that there are other things they may want to spend their money on".

Participants were subsequently instructed to carefully consider their budget; to imagine themselves actually paying the amounts specified each year, for the next 10 years; to keep in mind the impacts on them and their family of restoring deep sea ecosystems and finally that the payment would take the form of an increase to annual personal income tax rates or VAT and would be 'ring-fenced' into a secure marine restoration fund.

Following this, participants were asked if they were willing to pay to see the canyon restored to the attribute levels shown in Table 2. As recommended by Arrow et al., (1993) (NOAA expert panel on contingent valuation), the WTP elicitation question took the form of a closed-end, single bound dichotomous choice. This involves asking the individual if they would be willing to pay a presented bid amount $A$ (a yes/no response) for the associated change in the non-market good $q_j^0 \rightarrow q_j^1$. In contrast to the open-ended format which elicits the WTP of individuals directly, the discrete choice format instead provides an interval within which the WTP of the individual will lie. The advantage of this approach is that it is less complex for individuals to respond to accurately and mimics market conditions where individuals are typically faced with a take it or leave it purchase (Carson, 2012). Having been presented with the background information the single bound dichotomous choice question was then presented as follows:

"Bearing in mind the importance or unimportance of the protection and health of deep sea ecosystems in Italian waters to you personally; would you be prepared to pay €X per year [one of a possible six values (€4, 8, 10, 15, 20, 30) was asked of each respondent] for the next 10 years to ensure that a restoration and monitoring plan are implemented in the Dohrn Canyon that achieves the following ecosystem attribute levels [shown in Table 2]."

The survey concluded by asking a number of follow up questions surrounding the participant's responses and further questions about the socio-economic status of the participants.

*2.2 Modelling Framework*

WTP was estimated using three different models. The first two models are the standard linear utility probit models, as first employed for contingent valuation studies by Haneman (1984), including and excluding protest responses. The third is the Heckman style two stage sample selection model (Heckman, 1979[3]). All three models account for the fact that the dependent variable takes the form of a dichotomous choice (0/1) meaning that the researcher must employ a model that estimates WTP since all the respondent reveals is whether he or she is willing to pay a given amount, not his or her maximum. While the standard probit is the primary model for WTP estimation, when using it the analysist must make a decision on whether or not to include or exclude any protest zero bids in the estimation process.

Protest responses occur when the individual objects to payment for the non-market good at any bid value but may not necessarily derive zero utility from the provision of the good. Such responses are likely to occur due to a number of reasons including adverse reaction to the interview in general (in particular the payment vehicle used) or a conviction that the government should pay for the good using existing resources (Strazzera et al., 2003). In protest situations information regarding WTP is viewed as missing. The protest bids are determined by examining the responses to follow on questions asked of those that indicate they are not willing to pay the presented bid value. However, the inclusion or exclusion of the protest zero bids could result in sample selection bias in the estimation of WTP, particularly if the number of protest responses is large.

The advantage of the Heckman style model is that it directly controls for any sample selection issue by the simultaneous estimation of two processes; an outcome equation and a selection criteria equation. In this case the selection criteria is a binary choice indicating whether the respondent is first even willing to consider the bid value being offered (i.e. to offer a legitimate zero bid or accept the bid value, or instead offer a protest zero bid) while the second stage equation also has a binary outcome dependent variable indicating if the respondent is willing to pay the bid value offered. Heckman style bivariate probit models have been employed previously in a limited number of contingent valuation studies (Garcia et al. 2009; Petrolia et

[3] The original Heckman two stage sample selection model involved situations where the selection criteria equation was a binary choice while the second stage equation of interest had a continuous dependent variable but Van de Ven and Van Praag (1981) adapted the original model so that the equation of interest can also be a binary outcome variable, as is the case here.

al. 2010; Hynes et al. 2019; McGurk et al, 2020). Model estimations were carried out using the *probit* and *heckprob* command routines in the statistical software package Stata (version 15).

While several approaches are available to estimate WTP from a single bound dichotomous choice CVM design, they all treat WTP as the compensating surplus $C_i$ from a change in the non-market good $q_j$ (Carson and Hanneman, 2005). $C_i$ is the quantity that satisfies the following equality.

$$v_i(p^0, q_j^1, Q_{-j}^0, y_i - C_i) = v_i(p^0, q_j^0, Q_{-j}^0, y_i) \quad (1)$$

In (1) $v(.)$ represents the individual's indirect utility function with $p^0$ representing the prices of all market goods, $q_j^0$ the quantity of non-market good $j$ (in this case the Dohrn canyon) at the original level and $q_j^1$ the quantity of non-market $j$ post-change. $Q_{-j}^0$ represents the quantity of all non-market goods not including $q_j$ and $y$ represents an individual's income. If the individual derives a positive marginal utility from $q_j$, $C_i$ can be thought of as the income an individual is willing to forgo to attain the new level of the non-market good.

Following Hanneman (1984) an estimate of $C_i$ is derived by applying the random utility maximisation framework (RUM) (McFadden, 1973). Under the RUM framework it is assumed that the individual knows his or her own preferences and maximises utility accordingly. Preferences however are affected by factors that are unobservable to the researcher. Such factors can include attributes of the goods available for consumption or characteristics of the individual that affect their choice behaviour (McFadden, 1973). The RUM framework therefore assumes that utility consists of a deterministic component $v_i$ and a random component $\varepsilon_i$ which captures factors that are unobservable to the researcher as follows:

$$u_i(.) = v_i(q_j, y_i, z_i) + \varepsilon_i \quad (2)$$

where $y_i$ represents income and $z_i$ represents observable characteristics of the individual and $q_j$ represents the state of the non-market good $q_j$ (in this instance the health of Dohrn Canyon.). Employing Haneman (1984)'s linear utility formulation, the deterministic proportion of the indirect utility function can be written as:

$$v_i(q_j, y_i, z_i) = \alpha_j z_i + b y_i \quad (3)$$

From (3) equation (1) can thus be reformulated as:

| | |
|---|---|
| $\alpha_1 z_i + b(y_i - C_i) + \varepsilon_1 = \alpha_0 z_i + by_i + \varepsilon_0,$ | (4) |
| $C_i = \dfrac{\alpha z_i + \eta_i}{b}$ | |

From (4), $\alpha = \alpha_1 - \alpha_0$, and $\eta_i = \varepsilon_1 - \varepsilon_0$. The probability of a respondent answering yes to a given bid $A$ is $\Pr(\text{Yes}) = \Pr(C_i \geq A) = 1 - \Pr(\eta_i \leq \alpha z_i - Ab)$. Assuming that $\eta_i$ is a standard normal variable this reverts to a standard probit model as seen in (5).

| | |
|---|---|
| $\Pr(\text{Yes}) = \Phi(\alpha z_i - Ab)$ | (5) |

where Φ () represents the cumulative density function of the standard normal distribution.

The third model employed to estimate the probability of a respondent answering yes to a given bid is an adaptation of Van de Ven and Van Praag (1981)'s sample selection model for binary outcome variables and closely follows the applications of Petrolia et al. (2010), Calia and Strazzera, (1999), Strazzera et al. (2003) and Grammatikopoulou and Olsen (2013). The two stage sample selection bivariate probit model can be expressed as follows.

Firstly let $Y_1$ equal a binary variable that indicates whether the respondent will consider participation in the market for the hypothetical good on offer; i.e. is not a protester as defined earlier. $Y_2$ is a further binary variable that indicates whether the individual answers yes to pay for the non-market good at the given bid price *A,* with $Y_2$ only observable if $Y_1 = 1$. The approach adopted models both responses simultaneously with two equations. The first equation controls for the probability of observing $Y_1$ and is referred to as the *selection equation.* For the selection equation it is assumed that the latent variable, $Y_1^*$, the respondent's propensity to participate or not protest, is a linear function of a vector of observable characteristics $x_i$ and an error term $u_i$ as follows:

| | |
|---|---|
| $Y_1^* = \delta_i' x_i + u_i$<br>$Y_1 = 1 \; if \;\; Y_1^* > 0$<br>$Y_1 = 0 \; if \;\; Y_1^* \leq 0$ | (6) |

The second equation is the outcome equation, and is equivalent to (5) with the latent variable $Y_2^*$ representing $C_i$, now conditional on $Y_1 = 1$. The full model, following Calia and Strazzera, (1999) can be specified as follows:

$$\begin{gathered} Y_1 = 1 \ if \ \delta_i' x_i + u_i > 0 \\ Y_2 = 1 \ if \ C_i \geq A \\ Y_2 = 0 \ if \ C_i < A \\ Y_1 = 0 \ if \ \delta_i' x_i + u_i \leq 0 \end{gathered} \tag{7}$$

The resulting likelihood function can be written as:

$$L = \prod_{Y_1=0} Pr(Y_1^* \leq 0) \prod_{Y_1=1} \left[ \prod_{Y_2=1} Pr\,(Y_1^* > 0, C_i \geq A) \prod_{Y_2=0} Pr\,((Y_1^* > 0, C_i < A) \right] \tag{8}$$

To estimate the model it is first assumed that $u_i$ is a standard normal variable with the Pr $(Y_1 = 1|x) = \Phi\,(\delta_i' x_i)$. As before $\Pr(C_i \geq A) = 1 - \Pr\,(\eta_i \leq \alpha z_i - Ab)$, which reverts to $\Pr(C_i \geq A) = \Phi\,(\alpha z_i - Ab)$ as $\eta_i$ is assumed to also follow a standard normal distribution. To estimate the joint probability of $Y_1^*$ and $Y_2^*$, it is assumed that $(u_i, \eta_i)$ has a bivariate normal distribution with mean zero and covariance matrix as follows:

$$\Sigma = \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix} \tag{9}$$

with $\rho$ representing $corr\,(u_i, \eta_i)$. We can reformulate (8) as follows:

$$L = \prod_{Y_1=0} [1 - \Phi_1(\delta_i' x_i)] \prod_{Y_1=1} \left[ \prod_{Y_2=1} \Phi_2\,(\delta_i' x_i, \alpha z_i - Ab; \rho) \prod_{Y_2=0} \Phi_2\,(\delta_i' x_i, -\alpha z_i + Ab; \rho) \right] \tag{10}$$

where the univariate standard normal CDF is represented by $\Phi_1$, and the bivariate standard normal CDF with $\Phi_2()$. The model is estimated using the maximum likelihood approach.

Selection bias in the model can be determined by examining the correlation between the error terms as measured by $\rho$. If the section and output choices are independent of each other the two decisions could be estimated separately without any loss of efficiency. In this case, $\rho$ will be equal to zero. However a significant correlation indicates that both decisions are not independent and that the two decisions should be modelled simultaneously to avoid selection bias. In the context of the current study a significant correlation coefficient would indicate that not controlling for protest voters is likely to bias the subsequent estimation of willingness to pay. A positive (negative) sign indicates that the researcher is likely to overestimate (underestimate) the willingness to pay in a model that excludes (includes) protest voters. Finally the mean WTP of is calculated following Haab and McConnell (2002) as follows:

$$E(WTP|\alpha, z_i, b) = \frac{\alpha z_i}{b}. \tag{11}$$

The covariates chosen for inclusion is the same for each WTP model, where WTP is assumed to be a function of *Bid value, Age, Female, Income, Student, Employed, Obtained third-level education, Single, Inland Provinces, Campania, Awareness of Marine Protected Areas, Frequent Water User and Member of Environmental Organisation.* Covariates included in the sample selection portion of the sample selection probit model include the socio-economic variables *Age, Female, Income, Student, Obtained third-level education* and the locational variables *Central Italy, Islands, North-eastern Italy, North-western Italy*.

## 3. Results

In total 1,060 responses were returned from the online survey. Descriptive statistics for the sample are presented in Table 3. Where available, the mean of each variable in the population are also provided from Italian Census of Population statistics. Overall Table 3 indicates that the sample is broadly representative of the general population of Italy based on the demographic characteristics. Examining the main socio-economic variables in the sample, the average age is 41, personal income is €25,629, and 63% of the sample are in employment. Examining the distribution of the sample throughout Italy, it can be seen that the sample is also spatially representative when compared to the national averages in the final column of Table 3. North West Italy is most represented at 26%, followed by Southern Italy 24%, North East

Italy 19%, Central Italy 19% and the Islands at 12%. Campania is the region which the Dohrn Canyon is situated closest to and 10% of the sample are residents of that region.

A number of variables related to respondent's use of the sea and preferences for environmental protection are also reported in Table 3. *Frequent Visitor to Seaside* and *Frequent water user* are dummy variables that indicate whether the individual visits the seaside or participates in water activities at least once every three months and are represented by 64% and 48% of the sample, respectively. As seen in Sandorf et al. (2017) knowledge of the resource can affect the value attributed to the marine resource. To account for this we report two variables that indicate the respondent's awareness of the marine ecosystems; *awareness of marine protected areas* and *awareness of the Dohrn Canyon*. In total, 78% of respondents had heard of MPAs. However, only 16% had heard of the Dohrn Canyon. Finally, 11% of the sample are, or have a family member who is, a member of an environmental organisation.

**Table 3. Summary statistics for the sample compared to national averages**

| | Sample | Census of Population* |
|---|---|---|
| Variable | Mean (Std. Dev) | Mean |
| <u>*Socio-demographic information*</u> | | |
| Age (working population) | 40.55 (11.86) | 42.8 |
| Female | 0.51 (0.50) | 0.50 |
| Income (median) | €25,629 (€16,245) | €25,426 |
| Full-time Employee | 0.46 (0.50) | 0.51 |
| Student | 0.09 (0.29) | 0.05 |
| Obtained third-level education | 0.36 (0.48) | 0.36 |
| Single | 0.32 (0.47) | 0.33 |
| <u>*Region*</u> | | |
| Central Italy | 0.19 (0.39) | 0.19 |
| Islands | 0.12 (0.32) | 0.11 |
| North-eastern Italy | 0.19 (0.39) | 0.20 |
| North-western Italy | 0.26 (0.44) | 0.27 |
| Southern Italy | 0.24 (0.43) | 0.23 |
| Inland Provinces | 0.24 (0.44) | 0.27 |
| Campania | 0.10 (.30) | 0.10 |
| <u>*Use and awareness of coastal resources*</u> | | |
| Frequent Visitor to Seaside | 0.64 (0.48) | - |
| Frequent Water User | 0.48 (0.5) | - |
| Awareness of Marine Protected Areas | 0.78 (0.41) | - |
| Awareness of Dohrn Canyon | 0.16 (0.37) | - |
| Member of Environmental Organisation | 0.11 (0.31) | - |

*Population equivalent statistics are derived from the Italian census of population reports from the Italian national statistics agency's (Istat) online databases (ISTAT, 2020).

In total, 58% of the sample agreed to pay for the restoration scenario presented to them at the given bid value, i.e. they responded yes to the CVM question. As the bid value increases the positive response rate follows a declining pattern. However, as displayed in Table 4, the 'yes' response increases marginally between the lowest two bid values possible (€4 and €8) and also between the values of €15 and €20, although these differences are not statistically significant. Issues also arose regarding the prevalence of protest responses amongst those who responded that they were not willing to pay. In the current study we followed the standard approach of asking those respondents who indicated zero-willingness to pay for the non-market good follow-on questions to ascertain whether they were valid zero bidders or protesters.

**Table 4. Percentage of respondents who indicated that they would be willing to pay the bid value offered in the CVM question**

| Bid Value | €4 | €8 | €10 | €15 | €20 | €30 |
|---|---|---|---|---|---|---|
| % Responding Yes | 59% | 63% | 65% | 53% | 56% | 49% |

Each respondent was presented with only one bid value in the CVM question

The follow-on questions used and responses are presented in Table 5. Here it is assumed that those responders who indicated a zero WTP for the reason that "The Government /Council /Other Authority should pay out of its current budget" or "I object to paying taxes" represent protest voters. Such responders represented 47% of no responders and 19.8% of total responders. This percentage is above the average number of protest voters within stated choice valuation studies of 17.69% identified by Meyerhoff and Liebe, (2010) via a meta-analysis, but below the authors observed maximum of 59.28%. Similar protest issues were encountered in Tonin (2018) who found had an equivalent rate of protest responders in the study of WTP for cold water coral restoration off Italy's Adriatic coast. In that study the authors measured willingness to pay by employing separate models that included and excluded protest votes and presenting the resulting range of estimates. In this study however we control for the effect of protest votes through the use of the sample selection model.

**Table 5. Numbers and reason why certain respondent in sample chose €0 WTP**

| Category of Negative Responders | Number of Responders | % Negative Responders | % Overall Sample | Responder Type |
|---|---|---|---|---|
| The Government/Council/other body should pay out of its current budget | 182 | 42% | 18% | Protest |
| I object to paying taxes | 20 | 5% | 2% | Protest |
| I cannot afford to pay | 164 | 38% | 16% | True Negative |
| The ecological restorations are not important to me | 4 | 1% | 0.4% | True Negative |
| I don't believe the restorations will actually take place | 35 | 8% | 3% | True Negative |
| I don't use the marine environment | 10 | 2% | 1% | True Negative |
| Other | 17 | 4% | 2% | True Negative |
| Total Number of Negative Responses | 432 | | | |

The results of the two standard probit models including and excluding protests are presented in Table 6. As expected, the bid variable is negative and significant across both models indicating that as the price of restoration rises willingness to pay decreases. The bid coefficient is significant at the 99% level in the model including protest votes compared to being significant at the 95% for the model excluding protest votes. The variable indicating the individual's use of the marine environment, *frequent water-user,* shows a positive and significant effect across both models. This indicates that those who frequently use the seaside are more likely to place a higher value on the restoration of the canyon ecosystem. Likewise being a member of an environmental organisation and being aware of MPAs has a positive and significant impact on WTP across both models.

Being from Campania, the region where the Dohrn canyon is situated, has a positive and significant effect across both models. Being from an inland province has a significant but negative effect, indicating that those in coastal regions are more likely to support marine restoration. Examining the influence of the socio-economic explanatory variables the income coefficient is found to be significant and positive across both models. Similarly, being employed also has a positive and significant effect across both models. The remaining socio-demographic variables were found to be insignificant across both models.

**Table 6. Probit CVM model results**

| | Probit (protest views included) | Probit (protest views excluded) |
|---|---|---|
| Bid value | -0.016*** (0.005) | -0.014** (0.006) |

| | | |
|---|---|---|
| Age | -0.0001216 (0.004) | 0.003 (0.005) |
| Female | 0.104 (0.086) | 0.048 (0.102) |
| Income | 0.009*** (0.003) | 0.009*** (0.003) |
| Student | 0.242 (0.181) | 0.115 (0.201) |
| Employed | 0.211** (0.1) | 0.294** (0.117) |
| Obtained third-level education | 0.073 (0.091) | 0.077 (0.111) |
| Single | -0.028 (0.102) | -0.022 (0.12) |
| Inland Provinces | -0.177* (0.096) | -0.199* (0.113) |
| Campania | 0.362** (0.148) | 0.521*** (0.192) |
| Awareness of Marine Protected Areas | 0.333*** (0.101) | 0.253** (0.122) |
| Frequent Water User | 0.33*** (0.088) | 0.432*** (0.109) |
| Member of Environmental Organisation | 0.473*** (0.142) | 0.419** (0.174) |
| Constant | -0.491 (0.253) | -0.24 (0.299) |
| Log Likelihood | -637.7 | -438 |
| AIC | 1303.4 | 904.1 |
| BIC | 1372.3 | 969.9 |

*** indicates significant at the 1% level. ** indicates significant at the 5% level and * indicates significant at the 10% level.

The results of the two stage sample selection probit model are reported in Table 7. The estimated coefficients for the WTP portion of the model are largely consistent with the previous two models in terms of sign and significance. The coefficients of the selection portion of the model, indicate the effect of those variables on the likelihood of the respondent choosing to participate (i.e. not protest). Having a higher income and being a student have a positive and significant effect on the likelihood of participation. Interestingly, as indicated by the significant and negative coefficients, those respondents that originated from the islands and central regions of Italy are more likely to protest than those from southern Italy (which represents the base case in this instance).

**Table 7. Sample Selection CVM Model**

| WTP stage of model | Coefficient (Standard Error) |
|---|---|
| Bid value | -0.011** (0.004) |
| Age | -0.0002431 (0.004252) |
| Female | 0.108 (0.086) |
| Income | 0.01*** (0.003) |
| Student | 0.249 (0.176) |

| | |
|---|---|
| Employed | 0.214** (0.089) |
| Obtained third-level education | 0.068 (0.093) |
| Single | -0.041 (0.087) |
| Inland Provinces | -0.171* (0.093) |
| Campania | 0.422** (0.148) |
| Awareness of Marine Protected Areas | 0.182** (0.097) |
| Frequent Water User | 0.309*** (0.088) |
| Member of Environmental Organisation | 0.267** (0.136) |
| Constant | -0.43* (0.245) |
| **Selection stage of model** | |
| Age | -0.004 (0.004) |
| Female | 0.144 (0.092) |
| Income | 0.006** (0.003) |
| Student | 0.359* (0.207) |
| Obtained third-level education | 0.074 (0.099) |
| Central Italy | -0.225* (0.125) |
| Islands | -0.299** (0.142) |
| North-eastern Italy | 0.018 (0.128) |
| North-western Italy | -0.164 (0.123) |
| Constant | 0.833*** (0.23) |
| Log likelihood | -932.5 |
| $\rho$ | 0.928583 |
| Prob > chi2 = 0.0436 | |

*** indicates significant at the 1% level. ** indicates significant at the 5% level and * indicates significant at the 10% level.

The correlation coefficient $\rho$ in the model indicates whether the selection and WTP portions of the models are independent. As shown in Table 7, $\rho$ is positive with a magnitude of 0.929. To formally test for the significance of $\rho$, we complete a likelihood-ratio test (the Heckman test) by comparing the likelihood of the full sample selection model versus the sum of the log likelihoods for the WTP elicitation and selection parts of the model. We reject the null hypothesis that $\rho$ is not significantly different from zero at the 95% confidence level. This suggests that that joint estimation via the two stage bivariate Probit is more efficient than separate estimation either with or without the protest respondents and will be effective in removing sample selection bias. Comparing the AIC and BIC statistics of the sample selection model relative to the standard estimated standard Probit models also indicates that the sample selection model is the best fitting model.

The average WTP estimates from each model are reported in Table 8. The Probit model that excludes protest votes has a higher mean WTP relative to the other two models. This result is expected as the exclusion of the protest zeros automatically raises the probability of acceptance of the offered bid value in the model. Concurrently, treating all protest votes as true-zero-bidders and including them in model estimation is likely to cause a downward bias in WTP. In this case, as expected, the estimate of mean WTP from the model which includes all zero bid values is the lowest from the three models. The estimated average WTP from the sample selection model lies between the estimates of the two Probit models. This is not unexpected given the significant and positive correlation coefficient from the two stage sample selection model indicates that those more likely to participate are also relatively more likely to support the restoration at the presented bid value.

**Table 8. Estimated mean willingness to pay per person per year from alternative models**

| Model | Mean WTP Per Person | Std. Err. | [95% Confidence Interval] |
|---|---|---|---|
| Probit (protest views included) | € 27.63*** | 4.99 | [17.84, 37.43] |
| Probit (protest views excluded) | € 58.03*** | 18.76 | [21.25, 94.81] |
| Sample Selection Model | € 34.69 *** | 9.56 | [15.94, 53.43] |

*** indicates significant at the 1% level. ** indicates significant at the 5% level and * indicates significant at the 10% level.

## 4. Discussion and Conclusions

The objective of this paper was to estimate the benefit value to society from the restoration of the Dohrn Canyon in the Bay of Naples. Using a contingent valuation approach an average willingness to pay per person of €34.69 was estimated based on the preferred two stage bivariate sample selection model. While identification of the relevant population to aggregate the average non-market values up to is often difficult (Bateman et al., 2006) if we conservatively assume in this case that the region of Campania implements the additional taxation policy[4] to fund the restoration effort then the aggregate value to the 3,674,052 adult residents of the region is estimated to be approximately €127 million per annum. Cost estimates for implementing the restoration action in the Dohrn canyon are not available but in a review of the cost estimates from the literature Da Ros et al. (2019) suggest that the rearing and transplant of nubbins of deep corals would cost greater than US $1.5 million per hectare in year one and that the equivalent cost for transplanting fragments from donor colonies would be US $3 million, while the recruitment of larvae in shallow depths and translocation to deeper areas could cost US $3.3 million per hectare. Given these estimates it is unlikely the actual costs of

[4] In Italy, residents are subject to national, regional and municipal income tax. Regional income tax depends on the region of residence and ranges from 1.23% to 3.33%.

the restoration scenario presented here would surpass the estimated aggregated on-market benefit value generated.

Comparing the results of the present study with Tonin (2018) where the authors gave a range of per person per year estimates for restoration of the coastal cold water coral ecosystem ranging from €16.75 to €64.02 (with a preferred average estimate of €27.03), it is argued that the two results have particular implications for both policy and further research. Firstly, the estimated WTP for restoration of the Coralligenous habitats in the Northern Adriatic are broadly similar to the derived estimates for WTP for the restoration the Dohrn Canyon. This result is interesting as it suggests that Italians place a similar value on the restoration of two distinct types of marine ecosystems in different locations. Furthermore it indicates that, amongst the Italian population, this stable preference for marine ecosystem restoration exists despite both of the ecosystems under investigation being relatively unknown to the general population. Previously, Armstrong et al. (2012) argued that a prior lack of knowledge of an environmental good does not preclude the existence of a value as individuals can hold latent values for resources that are information dependent. Jobstvogt et al. (2014) and Aanesen et al. (2015) argue the same point in their respective marine ecosystem service valuation studies.

The similarity of the WTP estimates from both studies also has potential implications for benefit transfer between similar projects in Italy and may facilitate more straightforward comparison of benefits values between alternative marine restoration projects at a policy level. There is however a need for caution in interpreting this result as it arises from the comparison of a single pair of studies. It is also possible that the similarities across projects may indicate a degree of insensitivity to scope, a common issue in CVM studies (Carson, 2012). Therefore, further research is required to verify the stability of preferences for marine restoration amongst the Italian population.

The second result concerns the implication of the effects of alternative treatment of protest voters. Excluding protest voters from the sample is a common within the CVM literature. Dropping protest voters however, is only justified when such voters are missing at random and their exclusion does not bias the results. In both this study and Tonin (2018) dropping protest voters completely leads to what appears to be a significant overestimation of mean WTP, at €64.02 in the case of Tonin (2018) and €58.03 in the current study. These results, as well as the significance of the correlation coefficient $\rho$ in the sample selection model point to the need to control for the preferences of protest voters in CVM studies that estimate WTP for marine restoration projects.  A similar conclusion was reached in a CVM study by McGurk et al. (22020) when they examined landowners' willingness to accept compensation for participation in an agri-environmental scheme.

Another approach commonly adopted to limit the effect of protest voters, is to tailor the payment vehicle used so as to minimise the number of protests returned (Meyerhoff and Liebe, 2010). Meyerhoff and Liebe (2010) did a meta-analysis of past CVM studies to examine the effect of design components on the rate of protesting. The authors found that the payment vehicle can have a significant effect on the rate of protest voters returned. In the current study we use an increase in tax as the payment vehicle while Tonin (2018) uses a form of donation with both studies resulting in a similar rate of protest votes. Examining the reasons given for protests in both studies is also informative. In both studies the majority of the protest responders stated they protested due to a belief that the government should pay for restoration using its existing resources (90% in the current study and 82% in Tonin (2018)). This would indicate that the payment vehicle was not the motivating factor determining protest votes. Thus, it is likely that protesting will be an issue in future contingent valuation studies for remote marine resources regardless of the question elicitation format. These and other methodological and practical challenges that are present when attempting to value relatively unknown marine ecosystem services have previously been highlighted by Hanley et al. (2015) and Aanesen et al. (2015).

The models used to derive WTP estimates are also informative as to the distribution of WTP across the population. The significant and positive effect of *Frequent Water User, Awareness of Marine Protected Areas*, and *Member of Environmental Organisation* would indicate that as expected, use and awareness of the marine environment are a predictor of a positive preference for the restoration of marine restoration. The significance of the *Campania* and *Inland Provinces* regional dummy variables is likely indicative of the distance decay effect, whereby preferences for a spatially defined resource are likely to decay with increasing distance from that resource (Bateman et al., 2006; Norton and Hynes, 2018). Lastly, there is evidence that there is heterogeneity across the population with regard to preferences for marine ecosystem restoration. As noted by Hynes et al. (2010) it is important to account for these variations in preferences if considering aggregation of preferences to calculate total societal willingness to pay at different regional scales.

The CVM restoration scenario was presented to respondents assuming that the attribute levels would be achieved with 100% certainty. This was necessary as it's important that the respondent to a CVM question knows with certainty what they are being asked to pay for in terms of the environmental improvement. However uncertainty of outcome is ever present in marine restoration actions and even more so in the deep-sea (Da Ros et al., 2019). Even if the technological difficulties of attempting ecological restoration in the deep-sea can be overcome policy would still be needed to ensure that the original pressures on the ecosystem were prevented from having the same destructive impact again. In the case of the Dohrn Canyon Taviani et al. (2020) call for the preservation of these unique deep-sea habitats by adopting protection measures that prevent damage from bottom contact fishing, dumping and other source impacts. The authors believe this could be achieved by granting the Dohrn Canyon the status of a Site of Community Importance under the European Commission Habitats Directive and by establishing a deep-sea MPA in this area of the Mediterranean.

Given the uncertainty that is present in efforts to restore marine ecosystems an interesting area for further research would be to explore the effect of alternative levels of risk for restoration action failure on the valuation of benefits through stated preference studies. The results of such a study would indicate if respondents are willing to pay for the now necessary *attempts* at restoration even if the outcome is uncertain. The restoration effort here was also presented as a bundle of attributes that were valued together. It would be interesting to explore respondents' marginal willingness to pay for the biodiversity and debris clean up attributes separately, along with other canyon ecosystem service benefits. This could be done within the framework of a choice experiment and represents another avenue for future research.

This study examined the non-market benefit value of ecological restoration in a deep-sea canyon ecosystem. Such information is critical when decision makers are faced with multiple restoration/conservation needs and can help to ensures that the most efficient restoration projects are chosen. Marine restoration is also increasingly being seen as a vehicle to offset the impacts of off-shore developments. It is important therefore to develop a clear picture of the benefit values that are to be derived from such restoration projects in order that the value of the ecosystem services that may be reduced through developments are adequately compensated for in the offsetting process. As pointed out by Bayraktarov et al. (2016) optimal conservation outcomes in the future will require both protection and restoration but which projects are actual chosen will depend on their relative costs, the rate at which habitat is being lost, the time required between restoring a habitat and recovery of its ecosystem services, and the magnitude of the societal benefits achieved by restoring the ecosystems. As demonstrated in this study the inclusion of non-market ecosystem service benefit values is particularly important in terms of assessing the potential for marine ecosystem restoration if a true reflection of the benefit values to society are to be captured.

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