Spatial issues arising from a value transfer exercise for environmental quality of marine waters

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1. Introduction

As demands on the environment and associated ecosystem services increase, the need for a more integrated approach to managing the exploitation of these natural resources also increases. This is particularly true for coastal and marine natural resources. The EU aims to provide an integrated approach through the Marine Strategy Framework Directive (MSFD). The principal aim of the directive is to achieve and maintain good environmental status (GES) of marine waters by 2020 in order to protect the marine resources that underpin many marine and coastal economic and social activities (Long, 2011). These marine resources provide a variety of ecosystem goods and services that in turn generate benefits for society. Valuing these ecosystem services will provide policymakers with information on how society trades off the benefits the marine environment provides versus other goods.

From a policy making perspective, decisions that could affect the quality of these coastal and marine ecosystems are routinely made without taking into account the non-market benefits that would be foregone if the environmental quality of these ecosystems deteriorated. Decision making could be improved if both the level and accuracy of information on the non-market benefits of maintaining or achieving high environmental quality were improved[1]. At present, there are few decision making frameworks that facilitate integrated ecosystem service valuation and comprehensive planning in relation to all activities taking place in coastal areas and marine waters. According to Douvere (2008), the lack of such a framework can translate into spatial and temporal conflicts (user–user and user–environment conflicts) in the marine environment. In the EU, the Marine Strategy Framework Directive (MSFD) aims to provide a framework for resolving these conflicts.

[1] Some authors note that information from ecosystem valuations should also be used in conjunction with other studies (i.e. integrated modelling, nature protection, physical planning, stakeholder analysis, and multi-criteria evaluation) in deciding how to manage such ecosystems (Turner et al. 2000).

The MSFD requires member states (MSs) to achieve Good Environmental Status (GES) by 2020 in their marine waters by enacting a marine strategy. This marine strategy will be composed of a programme of measures that will improve different aspects of the state of the marine waters as measured by 11 descriptors. Bertram and Rehdanz (2012) note that the MSFD requires that these measures should be cost-effective and MSs will have to assess the social and economic impacts which may include cost-benefit analyses. MSs may delay or not achieve GES if the cost of the measures needed are disproportionate. Additionally, the MSFD calls for a social and economic analysis as part of the initial assessment and also calls for consideration of social and economic impacts when setting environmental targets. While costs are thought to be easier to estimate for measures, many of the benefits generated by the MSFD will be non-market goods and services (Bertram and Rehdanz, 2012).

It is expected that the non-use values arising from the introduction of the MSFD will form a considerable portion of its benefits (Bertram and Rehdanz, 2012) as non-use values attached to changes in the marine environment have been previous been found to constitute a significant proportion of the total economic value of the benefits produced by changes to marine and coastal environments (Luisetti et al., 2010, McVittie and Moran, 2010). Non-use values can only be estimated using stated preference techniques (Hanley et al., 2002) as there is no behaviour to observe that could be used as a proxy for their values, which is the basis for revealed preference methods. The two most commonly stated preference methods used are the contingent valuation method (CVM) and the choice experiment (CE). In this paper, only the CVM method is used and the interested reader is directed to Norton and Hynes (2014) for a demonstration of CE in valuing the benefits of the MSFD. CE deals with valuing each of the attributes used to measure a change whereas CVM takes a more holistic approach by focusing on the value of moving from the current policy situation to an alternative where the environment is improved under an environmental policy i.e. the MSFD.

CVM has been widely used in the valuation of environmental goods and services or for changes to the environment for many years (Darling 1973, Carson & Mitchell, 1989, Hanemann et al. 1991, Alberini et al. 2005, Bateman et al., 2006, Abdullah & Jeanty, 2011). The method was first used by Davis (1963), and has increased in popularity since a blue ribbon panel in the United States validated its use (Arrow et al. 1993). The CVM estimates values of a non-market good or service by presenting respondents with a hypothetical situation in the form of a questionnaire. The values are ‘contingent’ on the respondent’s willingness to pay or willingness to accept a change to the good or service being valued.

In a review of studies concerned with the valuation of coastal and marine environments in the Black Sea and Mediterranean, two of the regions designated by the MSFD, Remoundou et al. (2009) found that the CVM method was the most common valuation methodology used, being used in six of the thirteen studies reviewed. CVM has been also used by others to values changes in coastal and marine environments. For example, Carson et al. (2003) used CVM to estimate the non-use value or passive value of an oil spill in Alaska. The introduction of an escort ship programme was valued which would prevent or reduce the impact of another oil spill occurring in the same region. The payment instrument used was a onetime payment of federal tax. The survey was undertaken face to face and had a response rate of 75.2% that generated 1043 respondents. They estimated a mean WTP of $79.20 based on a modified Weibull distribution.

Machado and Mourato, (2002) also undertook a CVM study using a payment card to estimate the value of clean bathing along the Estoril coast in Portugal in 1997. Using a face to face interview approach on 11 beaches along the coast they gather 401 responses. The respondents were faced with a number of payment cards detailing their WTP to avoid illness associated with bathing in poor quality water. The mean WTP to avoid gastroenteritis was found to be 7,782 PTE (US$ 44.39) per person.

Nunes and van den Bergh, (2004) used a joint travel cost (TC) - CVM survey to estimate the value in preventing harmful algae blooms (HAB) for the Dutch coastline. The programme valued the treatment of ballast water for ships to prevent establishment of invasive algae species. The TC method was used to estimate the value of recreational users while the CV was targeted at valuing indirect and non-use values. Using the double-bounded dichotomous choice question the survey was face to face with 242 beach visitors. The participation rate for the survey was 69%. Using the TC method the authors estimated an annual gross recreation benefit per individual of €55. The CV results for the preventing HABs was estimated at €76 per respondent.

Hall et al. (2011) used CVM to value the changes to marine protected areas covering rocky intertidal zones (RITZ) in Southern California mainly by restricting access to the public. Only visitors to the sites were surveyed and using a double-bounded dichotomous choice question with tax as the payment instrument they estimated a value of $6.11 per visit for an improvement in RITZ environmental quality.

However, using primary valuation methods such as CVM and CE, as described above, can be costly and time-consuming and in the case of CE can be relatively complex to design and model. An alternative approach is value transfer (VT) also known as benefit transfer (Brouwer, 2000, Navrud and Ready, 2007). VT values a non-market good or service of a site (often called the policy site) using values estimated, generated through primary studies such as those mentioned above, for similar non-market services at another site (often called the study site) and applying these values to the policy site. This secondary valuation technique negates some of the problems with primary valuation as identified above; namely cost, time and complexity (Rosenberger and Loomis, 2003). However, the technique also has it disadvantages, the most significant is that the value transferred may not prove to be similar to the actual value (which is unrevealed to the VT practitioner) at the study site. This difference between the transferred value and the actual real value is known as the 'VT error'. Where this error has been calculated in some studies it has been found to be highly significant with values of up to 486% being reported (Rosenberger and Stanley, 2006).

As with CVM, the VT method has been widely applied in the environmental literature (Luken et al, 1992, Bateman et al., 1995, Brander et al. 2012) and also to value marine and coastal environments. Troy and Wilson (2006) provided a framework for using GIS (Geographic Information Systems) to help value ecosystem services and demonstrated three examples of applications. One of the applications which included coastal and marine ecosystems was for Maury Island, an island within Puget Sound in Washington State. For the Maury Island study, 43 applicable studies were used resulting in 71 data points that were used to estimate the value from 11 different ecosystem types for Maury Island. Six of the 11 ecosystems were coastal habitats. Four of the five highest yearly ecosystem services flow per hectare were for the coastal ecosystems (beach near dwelling US$117,254, beach US$88,204, coastal riparian/ estuary US$9396, nearshore aquatic habitat US$16,283, saltwater wetland US$1,413). The final estimates for the yearly non- market ecosystem services flow were US$22.6million^{2004} for Maury Island.

Liu (2007) undertook a value transfer for the state of New Jersey and used 94 peer-reviewed valuation studies, which provided 163 valuation points. After translating the values into US dollars per acre, GIS mapping of New Jersey was used to allocate the values. In this study, 13 ecosystem types were identified and this included four coastal ecosystem types. Two of the highest yearly ecosystem services flow per acre were for the coastal ecosystems, (beach US$42,147, saltwater wetland US$6,527, estuary US$715 and coastal shelf US$620. Liu estimated that the yearly ecosystem services flow was US$11.6 billion^{2004} for the state of New Jersey.

Brenner et al (2010) provided a valuation of the non-market ecosystem services in the Catalan coastal area of Spain using GIS with VT. Fifteen different ecosystem types were used of which 4 (coastal shelf, seagrass beds, beaches, saltwater marshes) were coastal ecosystem types and they made up 22.2% of the total study area. Ninety-four studies that generated a total of 188 valuation points was used in the valuation study. Three of the four highest yearly ecosystem services flow per hectare were for the coastal ecosystems (beaches – US$104,146^{2004}, seagrass beds – US$24,228^{2004}, saltwater marshes – US$15,147^{2004} and coastal shelf – US$3,210^{2004}). Brenner et al. found that coastal ecosystem types provided a far higher ecosystem services value flow to area ratio (18.1) compared to the marine and aquatic ecosystems (1.1) and terrestrial ecosystems (0.8). The yearly ecosystem services flow was estimated to be US$3.2 billion for the coastal area of Catalan.[2]

Hynes et al (2013) used an international value transfer with a cultural adjustment to value the marine and coastal ecosystems of Galway Bay, a coastal inlet on the western coast of Ireland. One hundred and sixty-nine estimates were used to estimate the values of eight ecosystem services for six ecosystem types within Galway Bay in 2007 Euros. The highest value was for €137 million for the sea ecosystem which was followed by beaches and dunes for €45 million. The highest valued ecosystem services were eutrophication mitigation with a value of €144 million, non-use value of €36 million and recreation values of €36 million. The cultural adjustment only lowered the VT error in two of the four cases tested.

Ghermandi and Nunes, (2013) undertook VT using a GIS based meta-analysis to generate a map of coastal recreation values around the globe. In the meta-analysis, 253 observations were used to generate the meta-analysis value transfer function that included for characteristics of the relevant population, the built coastal environment, natural elements of

[2] All values for the Troy and Wilson (2000), Liu (2007) and Brenner et al. (2010) studies are standardized for 2004 US Dollars.

the coastal environment and climate. In the study 93 of the 253 observations were from CVM studies and six ecosystem types were assessed (beach, estuary, coral reef, mangroves, marsh and other). While the authors showed values per hectare for recreational value for the world's coastlines, these were shown as high to low and no monetary amounts were noted in the paper.

VT's other major advantage is that it can also be applied on a scale that would be unfeasible for primary research in terms of valuing large numbers of services across multiple ecosystems. This is seen in most of the papers reviewed above. This has been enabled by the recent extension to the value transfer approach in using GIS (Geographical Information Systems). The use of GIS has been advocated by Lovett et al. (1997) and Bateman et al. (2002) as a way of improving VT and lowering transfer errors by including socio-economic characteristics allowing for substitute sites. In a later paper, Bateman et al. (2006) argued that the use of GIS coupled with the concept of distance decay may be a method of determining market size for public goods, especially for non-use values, coining the term "economic jurisdiction".

This paper examines how two spatial variables, the distance decay coefficient and the population density coefficient, are determined and modelled within VT function and how different choices can affect the market size and estimated consumer surplus (CS). The distance decay issue is examined through how it is modelled and the population density issue is examined through how the modifiable area unit problem (MAUP) manifests itself when undertaking a VT exercise.

In this paper, we add to the above literature by using the CVM methodology to estimate the value, to Irish residents, of the non-market ecosystem service benefits associated with the achievement of good (marine) environmental status (GES) in Irish waters as specified in the EU Marine Strategy Framework Directive (MSFD). Additionally, a VT exercise using the 'function transfer approach' is undertaken for the achievement of GES for five EU MSs. The paper explores the use of spatial variables in this function transfer and the issues arising from the use of these spatial variables in VT, namely specification of distance decay and the MAUP.

In what follows section 2 provides a description of the MSFD. Section 3 then describes the CVM methodology that is used to estimate the value of achieving GEV in Irish marine waters and the VT methodology and examines issues with including spatial variables in VT. Section 4 details the results and some discussion and conclusions are presented in Section 5.

2. The Marine Strategy Framework Directive

The Marine Strategy Framework Directive (MSFD) (2008/EC/56) requires that EU member states (MSs) achieve GES by 2020 in their coastal and marine waters by protecting, maintaining and preventing deterioration of the marine ecosystems and also by preventing polluting inputs being introduced into the marine environment. GES is measured using 11 descriptors and when all 11 descriptors are at good status then the marine region/ sub-region will have achieved GES. This target is to be achieved by developing and implementing measures that will manage of human activities to ensure a balance between sustainable use of the waters and conservation of marine biodiversity (Long, 2011).

The MSFD builds on previous EU legalisation in the environmental area such as the Water Framework Directive (WFD) (2000/60/EC). The MSFD complements the efforts of the WFD within coastal water bodies where the two Directives overlap by allowing for interaction of management plans but this does not apply to transitional waters which are solely covered by the WFD. This process may not be seamless though; Borja et al (2010) have identified some potential conflicts between the two directives due to issues of spatial application (e.g. Borja et al. (2010) question should transitional waters with a large marine influence be omitted from the MSFD), different terminology of the goals of the Directives (Good Ecological Status versus Good Environmental Status), different levels of GES status (WFD-5, MSFD-2) and different indicator measures of GES.

The MSFD established a number of marine regions / sub-regions on the basis of geographical and environmental criteria (Suárez de Vivero et al., 2009). There are four regions; North-East Atlantic Ocean, the Mediterranean Sea, the Baltic Sea, and the Black Sea. These regions are further divided into a number of sub-regions shown in Table 1 (adapted from Suárez de Vivero et al., 2009).

Marine Regions	Area (km^2)	Marine sub-regions	Area (km^2)
Atlantic NE Ocean	4,673,125	Greater North Sea	1,359,539
		Celtic Sea	518,672
		Bay of Biscay and Iberian Coast	821,374
		Atlantic Ocean	1,973,540
Baltic Sea	349,644	Baltic Sea	349,644
Black Sea	55,908	Black Sea	55,908
Mediterranean Sea	1,533,098	Western Mediterranean Sea	693,550
		Ionian Sea	359,906
		Aegean Levantine Sea	418,819
		Adriatic Sea	60,823

Table 1. EU MSFD Marine Regions and associated sub-regions (Adapted from Suárez de Vivero et al., 2009)

The MSFD requires MSs to undertake marine strategies for each region or sub-region that its marine waters cover. A marine strategy involves the following;

- the preparation of an initial assessment of current environmental status of the regions/sub-region and the impact of human activities on said region/sub-region
- the determination of what GES is for the region/sub-region and the establishment of environmental targets and associated indicators
- setting up of a monitoring programmes for the region/sub-region
- develop by 2015 a programme of measures to achieve or maintain GES by 2020 and implement such measures by 2016

The MSs are to cooperate with other MSs in designing and implementing marine strategies for each marine region (Long, 2011). However, a recent report (EC, 2014) by the EU Commission on the implementation of the MSFD has found many deficiencies in the manner MSs developed marine strategies and the lack of co-ordination between MSs leading to a lack of coherence in what GES is, even within the same regions/sub-regions and noting the lack of ambition in the programme of measures announced to-date. This could be considered a fulfilment of the concerns highlighted by some (Long, 2011, Van Leeuwen, 2012) of the willingness of MSs to implement the MSFD and improve the status of their marine waters.

Within the MSFD, Bertram and Rehdanz (2012) identified the four main requirements for the valuation of ecosystem service benefits generated by the MSFD. These are:

- Initial assessment of a Member States' marine waters, including economic and social analysis (ESA) of the use of those waters, and of the cost of degradation of the marine environment (Art.8.1(c) MSFD).

- Establishment of environmental targets and associated descriptors describing GES, including due consideration of social and economic concerns (Art.10.1 in connection with Annex IV, No. 9 MSFD).

- Identification and analysis of measures needed to be taken to achieve or maintain GES, ensuring cost-effectiveness of measures and assessing the social and economic impacts including cost-benefit analysis (Art.13.3 MSFD).

- Justification of exceptions to implement measures to reach GES based on the disproportionate cost of measures, taking account of the risks to the marine environment (Art.14.4 MSFD).

Estimating the value of coastal and marine ecosystems service is even more difficult than estimating the value of their terrestrial counterparts as the majority of coastal ecosystem services are not traded in established markets where they command a price (fish consumption and established marine energy sources being obvious exceptions) (Beaumont et al. 2007, McVittie & Moran, 2010).

3. Methodology

A survey was undertaken with 812 respondents throughout the Republic of Ireland. The survey was conducted face-to-face and respondents were selected on a quota system based on gender, age and geography. The first section of the survey comprised of a number of questions related to use of the marine and attitudes to the marine environment. Additionally the survey undertook two valuation exercises. The first was a discrete choice experiment (DCE) that used the descriptors of GES to generate choice alternatives of GES for Irish marine waters.. The second valuation method, that followed the DCE, was undertaken using CVM

The survey was conducted between September 2012 and November 2012. To ensure a representative sample of the Irish public aged 18 years and above, a quota controlled sampling procedure was followed to ensure that the survey was nationally representative for the population. This was based on age, gender and region of residence. Table 2 demonstrates that the sample is representative of the population when compared to the 2011Irish National Census of Population statistics .

Table 2. Characteristics of this survey versus Census 2011[1]

	This survey (n=812)	Census 2011 – Republic of Ireland
Average Age (Years)	44.6	44.8
Gender (% Male)	49.8	49
Nationality (%Irish)	90	86
Education (% To primary level)	10	16
Education (% To secondary level)	56	53
Education (% To third level)	34	31
Marital Status (% Single)	29	27
Marital Status (% Married)	53	51
Marital Status (% Other)	18	12
Income[2] (€ per year)	33,300	36,138[2]

1. Note that that values refer to population aged 18+.
2. Income is only presented for those working who reported their personal income in the survey (n=185). This subsample is compared to available national data based on average earnings for third quarter, 2012 (CSO, 2012).

The respondents were given information (Outlined in Box 1) on the changes that implementing GES would involve. The respondents were told that

"The health of the marine environment is measured using a number of attributes.

(Choose the)... amount that you as an individual will have to pay annually for the next 10 years to help protect the Irish marine environment under this alternative. Payment is expected to be made through a ring fenced tax dedicated to protecting the marine environment either through your income tax or VAT. Please consider how much money is available in your budget considering all your other expenses before making your decision."

The question asked for the CVM was *" Based on all the information you have heard so far and again remembering your income and budget, what would be the most that you would be willing to contribute towards achieving good environmental status in the seas around Ireland?"* The respondents were then presented with the payment card shown in Figure 1.

Box 1. Description of Irish Marine Environment

a) Marine Biodiversity and Healthy Ecosystem

High levels of biodiversity are often a sign of a healthy well-functioning ecosystem. An area has high biodiversity if there are high numbers of different species (especially high level predators), high numbers of those species and the areas in which they live are protected from damage. Biodiversity and healthy ecosystems in Irish waters are known to be under threat from a variety of human activities (i.e. fishing, pollution, marine construction, etc). Currently, most of the seas and oceans around Ireland are rated as at good status with some areas of moderate and poor status; without protection, it is expected that biodiversity will decrease (less species) and there will be a reduction in the area and number of healthy ecosystems.

b) Sustainable and healthy fisheries

The sea provides a variety of fish species which are both nutritious and tasty. In Irish seas while some fisheries are currently have stable populations (e.g. it is sustainable to harvest them) and are safe to eat, other fisheries have been overfished and no longer produce the same yield as in previous years (e.g. it is unsustainable to harvest them). Providing sustainable fisheries may mean closing some fisheries in the short term to allow fish stock to replenish so that they are available both for us in the longer term and for future generations. Management may also be required to ensure fish are healthy and safe to eat.

c) Pollution levels in sea

A variety of polluting substances and litter are known to be entering the seas around Ireland. These pollutants can cause damage to marine environment (e.g. oil slicks), can affect humans by being absorbed through eating fish and can cause harmful algae blooms (e.g. red tides) which can close bathing areas and cause shellfish poisoning. Marine litter can look unsightly and cause damage to marine life. Preventive measures will be needed to reduce the levels of pollution and litter in Irish seas.

d) Non-native species

Marine non-native species are animals and plants that humans transport to Ireland either on purpose or accidently (attached to ships or in ballast water of ships).There are small numbers of marine non-native species in Irish marine waters currently. Non-native species are known to cause damage to oyster beds and disrupt ecosystems. Without preventative measures, these species could spread and new non-native species could travel to Irish waters.

e) Physical impacts on the sea

Physical altering the seabed and changing flows can cause damage to habitats on which various marine species depend and also may cause pollution by stirring up pollutants which were buried in the seabed. Different human activities in the sea and on the coast can change the sea bed and the flows of tides and currents. Underwater noise caused by sonar, ships propellers and construction within the marine environments can also cause disturbance to fish populations and induce stress in marine mammals that use sonar like whales and dolphins. It is expected that some of these activities will increase in the future which is expected to cause more changes to the sea bed and flows. Management of these activities will be needed to prevent significant damage to the marine environment.

Nothing/€0		€25		€100	
€1		€30		€120	
€3		€35		€150	
€5		€40		€200	
€8		€45		More than €200	
€10		€50			
€12		€55			
€15		€60			
€18		€70			
€20		€80			

Figure 1. Payment card for the CVM exercise

It is noted that the data generated through this method is interval data. Although it is highly possible that the amount chosen by the respondent correspond directly to the amount on the payment card (it was noted there were higher frequencies at euro note denominations), it is also possible that the amount chosen could also be the lower bound between that amount and the next higher amount on the payment card. Additionally, it is noted that there were a number of respondents that chose the €200 or more option meaning that these amounts are right censored. One may still use OLS regression in this case, using the midpoints of the intervals, however Hubbert and Cameron (1989) suggest that an interval regression model is a more appropriate for this type of data as using OLS leads to biased parameter estimates.

The interval regression model (Hubbert and Cameron, 1989) is a generalisation of the Tobit model (Amemiya 1973) and is estimated using the maximum likelihood method. The likelihood contribution for the value of the *j*th individual is

$$\Pr\,(y_{1j} \leq Y_j \leq y_{2j}) \qquad (3)$$

where the value of the *j*th individual is in the interval [y_{1j}, y_{2j}]. The *intreg* command in STATA 12 was used to estimate the model and this command also allows for censored data. The likelihood contribution from left censored data is given as

$$\Pr\,(Y_j \leq y_j) \qquad (4)$$

and the likelihood contribution from the right censored data is given as

$$\Pr\,(Y_j \geq y_j) \qquad (5)$$

where y_j is the observed censoring value and Y_j is the random variable representing the dependent variable. The log likelihood was calculated as follows:

$$lnL = -\frac{1}{2}\sum_{j\in C}\left\{\left(\frac{y_j - x\beta}{\sigma}\right)^2 + log2\pi\sigma^2\right\}$$

$$+ \sum_{j\in L} log\Phi\left(\frac{y_{Lj} - x\beta}{\sigma}\right)$$

$$+ \sum_{j\in R} log\left\{1 - \Phi\left(\frac{y_{Rj} - x\beta}{\sigma}\right)\right\}$$

$$+ \sum_{j\in \chi} log\left\{\Phi\left(\frac{y_{2j} - x\beta}{\sigma}\right) - \Phi\left(\frac{y_{1j} - x\beta}{\sigma}\right)\right\} \qquad (6)$$

where Φ( ) is the standard cumulative normal. For further detail the interested reader should consult Hubbert and Cameron (1989). This model has previously been used to estimate WTP for reducing air and noise pollution connected with the introduction of hydrogen buses in London (O’Garra & Mourato, 2007) and for estimating airline passengers WTP to offset carbon emissions from their flights (Brouwer et al., 2008).

The second methodology used in this paper is value transfer (VT). An alternative to the primary non-market valuation methods such as revealed (e.g. travel cost and hedonic valuation methods) and stated (e.g. CVM and CE) preference approaches is value transfer (VT). Each primary economic valuation methodology has its own strengths and limitations, thereby restricting its use to a select range of goods and services associated with a coastal zone. Primary valuation research, while being a 'first best' strategy, is also very expensive and time consuming. Thus, secondary analysis of the valuation literature is a 'second best' strategy that can yield very important information in many scientific and management contexts (Rosenberger and Loomis, 2000, Brouwer, 2000, Ledoux and Turner, 2002). When analyzed carefully, information from past studies published in the literature can form a meaningful basis for coastal zone management policy. Indeed, a number of benefit transfer exercises have already been reported for coastal zones (Troy and Wilson, 2006, Liu, 2007, Brenner et al. 2010, Hynes et al. 2013).

From a marine management perspective, such transfer values have a number of potential uses. These include use in the cost-benefit analysis (CBA) of investment projects and policies aimed at managing coastal and near-shore resources (e.g. preservation of coastal wetlands or sand dunes, restrictions on the recreational harvesting of shellfish, and estuary pollution prevention measures), or projects that affect the coastal or marine zones (e.g. construction, drilling, port extensions); environmental accounting; calculating the marginal external costs as a basis for optimal economic management of the coasts and design of optimal regulatory instruments (e.g. a tax on aggregate extraction from the foreshore or charges on effluent discharges into an estuary). VT could also assist in environmental liability cases, to calculate compensation payments to injured parties for pollution damages to coastal and marine ecosystems.

There are a number of methods of transferring values between sites (Colombo & Hanley, 2008). The simplest and most commonly used is to use the unadjusted willingness to pay (WTP) estimates from one or more study sites and apply their average value to the policy site. This method is referred to as ‘unit value transfer’. An extension to the unit value transfer method is where the WTP values are adjusted for one or more factors (e.g. adjustments for differences in income between study and policy sites and for differences in price levels over time or between sites) before the values are transferred between the sites. The next step in complexity of benefit transfer is to use a value ‘function transfer’ method (Loomis, 1992). This is the approach adopted in this paper. This involves using the parameters from the original demand function from the study site (WTP^S) and using environmental and population characteristics from the policy site to generate the WTP for the policy site (WTP^P). In effect it is assumed that;

$$predicted\, WTP\, (\beta^S, X^P) \;=\; WTP^P \qquad (1)$$

Meta-analysis is a more complex form of value function transfer that uses a value function estimated from multiple study results together with information on parameter values for the policy site, to estimate policy site values (Wilson and Liu, 2008, Brander et al., 2012). The use of spatial micro-simulation techniques for VT is another form of value function transfer that has been recently suggested by Hynes et al. (2007) and Hynes et al. (2008).

More recently, Glenk et al. (2014) used VT in conjunction with a CE valuing WTP for good ecological status in river basins in Spain. They noted that non accounting for attribute non-attendance in CE can have significant effects on the values estimated which in turn will affect the value estimated using VT. The importance of having the correct model before transferring values should not be underestimated.

Transfer errors and the applicability of transferring certain values are of the greatest concern in the transfer valuation literature as these issues are the most important for providing confidence in the final valuation of the policy site (Colombo and Hanley, 2008). The subject of VT is a maturing area, and with more studies and more understanding of the valuation of ecosystems, more confidence will be attained in the methodology. However, the issue of transfer errors is the most significant disadvantage in this method (Rosenberger and Stanley, 2006). However, it has been acknowledged that the general view within the literature is that function transfers generally outperform unit transfers (Johnston and Rosenberger (2010) although this is not always found to be true. Brouwer (2000) found that the unit-VT method had a lower range of transfer errors in half of the VT studies he reviewed. Transfer errors are typically presented as the percentage difference between the value estimated for the policy site and the 'actual' value at the policy site. Following Bateman et al. (2000), the transfer error is calculated as:

$$Transfer\ Error = \left(\frac{Transferred\ Estimate - Policy\ Site\ Esimate}{Policy\ Site\ Esimate}\right) \times 100 \qquad (2)$$

While the reason for undertaking a VT exercise is that the 'Policy Site Estimate' is unknown, a number of studies have estimated the policy site value using primary valuation techniques and then undertaken VT and tested the difference between the two. Brouwer (2000) reviewed a number of VT exercises which reported transfer errors and found transfer errors varied between 1% to 475% but noted that most were in the range of 20%-50%. The large variability in transfer errors was also noted by Rosenberger and Stanley (2006) who found transfer errors between 8 and 577%.

One suggested method of reducing transfer errors is through the use of geographic information systems (GIS). Eade & Moran (1996) were one of the early adopters of GIS for VT noted that it had great scope to take account of the spatial variation of a respondents characteristics in VT. Lovett et al. (1997) used GIS to improve a travel cost demand function for forest recreation by incorporating spatial variation in socio-economic characteristics and allowing for substitute sites. They noted that using GIS in improving VT is dependent on the amount of data available and the spatial scale at which data is available. Bateman et al. (2002) also noted that using GIS with VT can allow easier communication of results to policymakers and the general public.

Another important issue in using GIS with VT is defining the extent of the market at the policy site. Bateman et al. (2006) state that aggregating benefit transfer values (to estimate the total ecosystem value of the policy site) depend on both the benefits per person and the population of beneficiaries (the extent of the market). Loomis (2000) and Bateman et al. (2006) argue that the extent of the market may be more important in determining aggregate values than any changes related to the precision of the estimates of per-person values. Hynes et al. (2006) also highlight the importance the choice of relevant population and the extent of the market in the aggregation process.

The concept of distance decay has been used to determine the extent of the market for non-market goods (Bateman, 2000). Often this is based on the concept that users will pay and Bateman noted that where both users and non-users are surveyed (as in this study) distance decay will arise due to a lowering in the number of users (that should have a higher value for a resource relative to non-users) relative to non-users. Bateman (2000) also noted that some in the literature had found a distance decay element for 'pure' non use values but stated that there was no theoretical basis for this. However, if one considers the composition of the different elements of non-use value, there are valid reasons for non-use values incorporating distance decay. The first is the altruistic element where respondents value a site for the reason of knowing that someone else might use it. Often people may have a higher value if the site is near to their family and friends that are in turn are near to the person. This could be considered an application of Tobler's First law of geography – "All things are related, but near things are more related than far things." (Tolber, 1970). This causes some element of distance decay for this type of non-use value. The same concept can be applied to the inheritance element of distance decay in passing down an environment in good condition to the next generation, often the generation with whom the respondent shares the same genes. The final element of non-use value is option use where the person may opt to use it in the future and geography dictates that location may be a factor in this.

The other spatial issue that has not been previous discussed in detail in the VT literature is the modifiable areal[3] unit problem (MAUP). This arises in this study due to the inclusion of population density as an explanatory variable. While it is not commonly included within CS or demand functions for public goods, it has been noted that those in urban areas have tended to have higher WTP compare to rural counterparts (Lovett et al. 1997). However, it is commonly used in meta-analysis VT and found to be positively related to WTP (Brander et al. 2006, Brander et al., 2007, Ghermandi & Nunes, 2013).

The MAUP problem as identified by Openshaw and Taylor (1979) arises from the use of modifiable areal units in quantitative analysis. These areal units can take a variety of shapes or sizes. This causes complications with statistical analysis related to both scale and the method used to create the areal units. The scale issue is the complication in this paper.

The EU has a number of spatial levels at which demographic and socioeconomic is reported at and is available. These are termed Nomenclature of Units for Territorial Statistics (NUTS). Different types of data are reported at various levels. The highest level, with the coarsest level of spatial detail, is the NUTS1 regions which often has the greatest level of socioeconomic data. These are either large areas of MSs or the entire MS itself for smaller EU members. The levels then go down to NUTS2, NUTS3, LAU1 and LAU2. . As the spatial detail of the NUTS area increases the amount of data available for that area decreases. Therefore there is a trade-off in what level is acceptable in terms of spatial detail and

[3] The word “areal” is the adjective version of the noun "area".

socioeconomic or demographic detail. Goodchild et al. (1993) identified this as a particular problem for using population density as a socioeconomic variable.

Population density is calculating by dividing the population within an area by that area. It is assumed that the population is distributed evenly throughout this area. However, the population density effect is likely to work at a smaller spatial level e.g. LAU1 or LAU2. In this study, population density for each respondent is calculated based on the LAU2. However, most of the variables used for the VT exercise were measured at the NUTS3 level. This leads to the MAUP as identified by Goodchild et al. (1993).

Imagine picking random people from a NUTS3 region and calculating the population density in their area. If the area is NUTS3, they all people from the same NUTS3 will have the same population density. However, imagine again picking random people from a NUTS3 region but this time their population density variable is based on the LAU2 region they are in. Then the odds of picking a person from a higher density area is higher due to its larger population. Therefore, the mean population density for a NUTS3 region based on LAU2 region as weighted by population will be higher. This spatial mismatch between data zones is the MAUP as the population density was calculated for Irish LAU2 in the survey data but the spatial unit for the VT exercise is the NUTS3 level.

While the CV valuation exercise was restricted to Ireland, it was decided that VT would be used to estimate values for achieving GES across a number of Atlantic EU MS. However, while the Atlantic marine region covers all of Irish waters, the question used was not specific to that region. Therefore the values estimated for other Atlantic states is considered to cover all their European marine waters, no matter what region they are in. This means that this VT exercise covers part of the Mediterranean marine region for the MSs of France and Spain.

It was decided that the NUTS3 level would be used as the spatial unit for the VT exercise due to the inclusion of the geographic variables of distance and population density to allow for intra-heterogeneity within MSs and this was the finest scale for which data was readily available. Most of the data was available from Eurostat or its agglomeration of Census 2011 results from all MSs, CensusHub2, or from individual MSs central statistics agencies. All data used was based on the year 2011 as this was the census year for which most of the data was available and income data was purchasing power parity (PPP) adjusted. Additionally, the income data was only available at the NUTS2 level, and the attitudinal variables from the KNOWSEAS Project (Potts et al., 2011) were only available at the MS level. Table 3 details the source of each variable used in the VT exercise.

Variable	**Geo. Level**	**Source**
PPP Adjusted Income (€1,000's)	NUTS2	Eurostat (2011)
Married	NUTS3	CSO, INE (ES), INE (PT), INSEE, ONS (2011)
Children in the household	NUTS3	CSO, INE (ES), INE (PT), INSEE, ONS (2011)
Has third level education	NUTS2	Eurostat (2011)
Male	NUTS3	Eurostat (2011)
Age (years)	NUTS3	Eurostat (2011)
Distance from the coast	NUTS3	QGIS - Own calcs.
Rated ocean health as important or very important	Member State	Knowseas (2010-2011)
Log of population density (ED level)	NUTS3	Eurostat (2011)
Agreed or strongly agreed with Marine Protected Areas	Member State	Knowseas (2010-2011)
How competent is the government to manage and protect the marine waters	Member State	Knowseas (2010-2011)

Table 3. Sources of data for the VT exercise

4. Results

The interval regression used 558 of the 812 survey observations of which 184 choose zero WTP. The other 254 respondents gave zero values for their WTP and were classed as protest responses due to their answers to the follow-up questions. People were classed as having protest responses if they choose one of the following options, "I object to paying taxes; The Government/ County Council/EU or other body should pay; I don’t believe the improvements will actually take place; Those who pollute the seas and ocean should pay; I didn’t know which option was best, so I stayed with the “No Change” option; Don’t know".

Table 4 presents the results of the interval regression models with WTP to achieve GES per annum over ten years as the dependent variable. Two different models were estimated. Both models are similar except for the variable measuring distance from the coast. This variable was included to measure the distance decay as discussed above. In model 1 the distance is modelled linearly. In model 2 the distance decay is measured using a log function that assumes that the WTP values decay exponentially. Figure 2 shows how the values decline over distance between the models, *ceteris paribus*.

The coefficient results from an interval regression model can be interpreted in the same manner as OLS model (Mahieu et al., 2012). Most the variables perform as expected and the coefficients are very similar in both models (apart from the distance decay variable). WTP for GES increases with income and having a third level education. Having children in the household increases the WTP by a significant amount in both models (Model 1 - €5.90, Model 2 - €6.01), this is thought represent part of the bequest element of non-use value, in that those in households with children may consider the state of the environment that their children will enjoy.

Males also tend to have a higher WTP but the most surprising result is that respondents who are married have such a high negative WTP that is also highly statistically significant. It may be due to the nature of the Irish economy when this survey was undertaken. It is expected that many married people own their own homes and may under financial pressure and the married coefficient could be the channel through which this is expressed in the two models. Age was modelled as a quadratic function and both elements are insignificant.

Examining the two spatial variables, distance decay and population distance, it can be seen that in both models they are highly statistically significant. The distance decay variable in both models is negative as expected. The linear model suggests that WTP decreases by €0.26 per km. Figure 2 shows the difference in reduction of WTP by distance from the coast in both models. The log of population density was used due to the power distribution of population densities. It is shown to have a positive marginal WTP that suggests that people living in more urban areas have a higher WTP than those living in more rural areas. Since both models take account of income (incomes tend to be higher in urban areas) and distance (Irish cities tend to be located close to the coast), the population density result is not wholly linked to both of these .

Examining the attitudinal variables, the highest marginal WTP (model 1 - €12.38, model 2 - €12.74) was found for the dummy attitudinal variable for those who rated ocean health as very important or important on a five point Likert scale. This was statistically significant in both models but this was not the case for the other attitudinal variables that were both statistically insignificant for model 2. However, both variables performed as expected with those who agreed or strongly agreed with marine protected areas having a positive marginal WTP. The constant in both models was statistically significant.

WTP to achieve GES	*Model 1- Linear Distance Decay*		*Model 2- Exponential Distance Decay*	
Variables	*Coefficient*	*Std. Error*	*Coefficient*	*Std. Error*
Log of Income (€1,000's)	28.21	(4.42) ***	26.67	(4.41)***
Married	-9.96	(3.94) **	-9.71	(3.97)**
Children in the house hold	5.90	(3.49) *	6.01	(3.51)*
Has third level education	9.73	(3.41)***	10.72	(3.41)***
Male	6.61	(2.93) **	6.40	(2.95)**
Age (years)	-0.51	(0.01)	-0.45	(0.59)
Age^2 (years)	0.01	(0.14)	0.01	(0.01)
Distance from the coast (km)	-0.26	(0.07) ***		
Log of distance from the coast (log (km))			-3.72	(1.40)***
Log of population density (LAU2 level)	1.53	(0.76)**	1.68	(0.79)***
Rated ocean health as important or very important	12.38	(3.56)***	12.74	(3.58)**
Agreed or strongly agreed with Marine Protected Areas	5.27	(3.06)*	4.06	(3.05)
Constant	-74.21	(17.17)***	-67.78	(17.90)***
Log Likelihood	-2128.17		-2131.61	
AIC	4282.34		4289.22	
BIC	4338.56		4345.43	
n	558		558	

Table 4. Interval regression models for WTP for GES in Irish marine waters

A VT exercise was undertaken using the dataset based on a spatial unit of NUTS3 regions (See section 3, Table 3) where available. Table 4 below shows the descriptive statistics for each of the NUTS3 variables used in the VT.

VT Exercise **NUTS3 Variables (n=332)**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Income (€1,000's)	25.43	6.82	16.26	46.07
% Married	0.49	0.05	0.31	0.63
% people living with children in the house hold	0.32	0.07	0.20	0.49
% with third level education	0.25	0.07	0.10	0.51
% Male	0.49	0.01	0.47	0.53
Mean Age (>17years)	48.02	2.59	39.60	55.30
Distance from the NUTS3 centroid to the coast (km)	84.01	94.36	0.20	421.50
Population density (NUTS3 level)	767.78	1837.64	7.13	21347.01
% that rated ocean health as important or very important	0.47	0.13	0.32	0.80
% that agreed or strongly agreed with marine protected areas (MPAs)	0.75	0.07	0.61	0.86

Table 5. Descriptive statistics for NUTS3 regions used in the VT exercise.

Where a minus values were estimated, the WTP was set at zero. Table 6 shows the results from the VT exercise showing the population weighted mean value for the five Atlantic MSs and the aggregated values for each MS. Both Ireland and Portugal have the highest individual WTP's in both models and this is followed by the UK in model 1. However, model 2 shows that French individuals have a higher WTP compared to the average UK resident. Model 2 produces higher figures for four MSs, Ireland being the exception. The biggest difference between models is for France. This is thought to relate to the fact that most NUTS3 regions fall into area A in figure 2 but that French NUTS3 regions (especially around Paris region) fall into area B. The reason is thought to related to the high incomes and high population density around Paris which enable these NUTS regions to fall into area B in Figure 2 offsetting the lower value NUTS3 regions closer to the coast. A similar but less extreme story can be used to explain the differences between models for Spain.

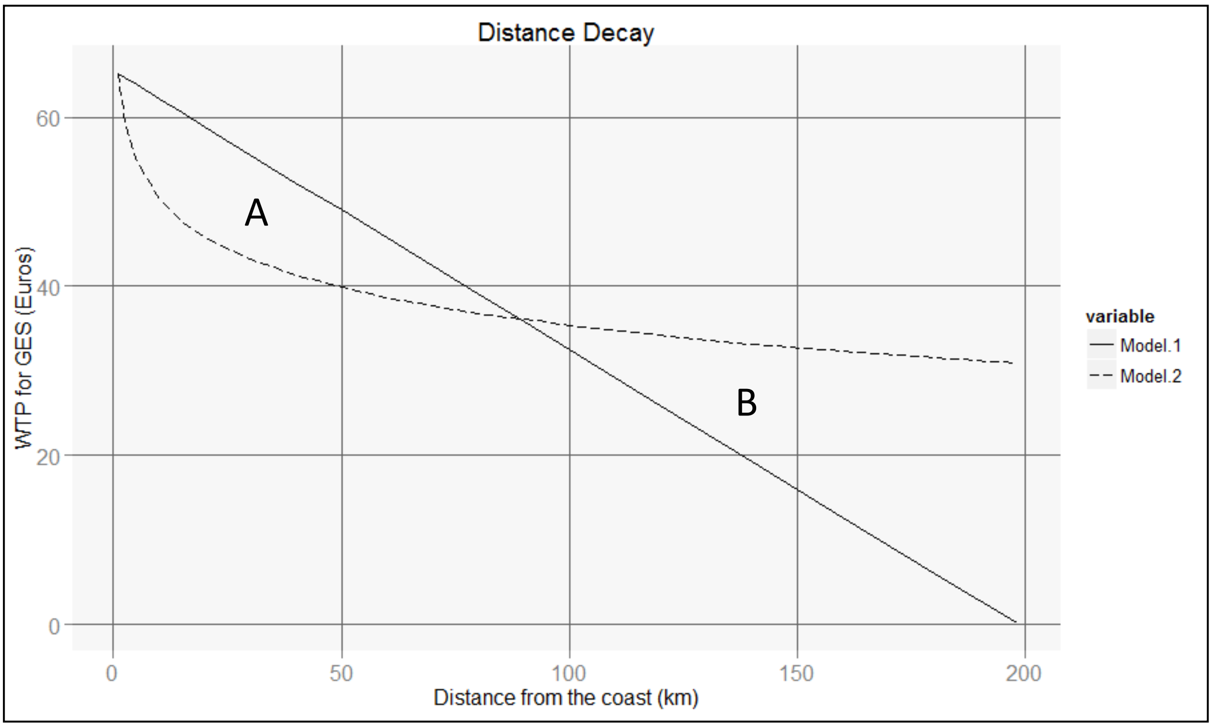

Figure 2. Distance Decay for Model 1 and Model 2

Member State	Mean (Pop. Wt.)	Mean (Pop. Wt.)	Total (millions)	Total (millions)
	Model 1	Model 2	Model 1	Model 2
Ireland	€25.82	€24.89	€89	€85
UK	€19.76	€20.19	€983	€1,004
France	€11.80	€23.02	€581	€1,133
Spain	€11.97	€16.07	€460	€618
Portugal	€25.28	€24.51	€219	€213
			€2,331	€3,052

Table 6. Results from VT exercise for each MS

The main reasons for Ireland and Portugal having such high WTP values is due to the high rating that both MS respondents gave ocean health and high income in the Irish case and the high population density in the coastal area of Portugal coupled with closeness of the all NUTS3 regions to the coast.

Overall model 2 produced higher estimates for achieving GES than model 2. Model 1's estimated aggregate annual WTP for achieving GES in Atlantic MSs is €2.3 billion compared to over €3 billion for model 2. However, there is nothing to say which functional form of distance decay is more accurate.

In terms of which model performs better, model 1 (the linear distance decay) was found to have a smaller AIC and BIC and a larger log-likelihood. However, model fit should not solely determine which model is best for VT. Bateman (2009) noted the phenomenon whereby unit VTs often outperform function VTs as measured by transfer errors could be due to researchers typically transferring statistical best fit functions, a problem that could be mitigated through the use of functions that were derived solely from theoretical principles.

To examine which model is more accurate a VT transfer error test was undertaken based on Ireland and its eight NUTS3 regions. The interval regression models were used to estimate the value of all the respondents (n=812) in the survey and these values were used to estimate the individual WTP for each region (Median n =84, Max n = 231 (Dublin NUTS3 region), Min n = 64, (Midland NUTS3 region). The results of this transfer error test are shown in Table 7.

The estimated value for the average Irish individual's WTP to ensure GES was €29.90 in model 1 and €30.00 in model 2 a difference of just 0.3%. It varied from a high of €38.55 for the Dublin NUTS3 region (model 1) to a low of €21.04 (model 1) for the Mid-West NUTS3 region. The models predicted the same values for all NUTS3 regions at the 95% confidence level except for the Midlands NUTS3. A t-test shows significant difference at the 95% level (p= 0.0041).

NUTS3	n	Model 1 - Mean	Model 1 - S.E.	Model 2 - Mean	Model 2 - S.E.	Difference
Ireland	812	€29.91	0.59	€30.00	0.58	0.33%
Dublin	231	€38.55	0.97	€38.05	0.96	-1.30%
Mid-East	72	€25.92	2.23	€24.96	2.24	-3.80%
Midlands	64	€21.88	1.68	€28.74	1.64	23.90%
South-East	112	€27.89	1.60	€27.34	1.55	-2.00%
South-West	96	€30.45	1.57	€28.37	1.54	-7.30%
Mid-West	69	€21.04	1.71	€22.33	1.65	5.80%
West	80	€28.41	1.96	€28.85	1.86	1.50%
Border	88	€26.62	1.72	€26.10	1.72	-2.00%

Table 7. Regression models predictions for each NUTS3 region in Ireland

Both VT exercises underestimated the value for Ireland (model 1 by -14%, model 2 by -17%) but both did identify the Dublin NUTS region as that with the highest mean WTP. Both models also identified the Midland Region as having the lowest valued mean WTP compared to the regression predictions which predicted the Mid-West. While model 1 had a lower mean transfer error of -18% compared to -22% in model 2, using the absolute values of the errors which is most likely a better measure, model 2 performed better and also had lower variances between all regions. This is despite model 1 lower transfer errors in four of six NUTS3 regions which differed. The transfer error values are comparable or maybe even better to those found in the literature (Brouwer, 2000, Rosenberger & Stanley, 2006).

MS/NUTS3	Interval Regression (Model 1)	Value Transfer (Model 1)	% VT Error (Model 1)	Interval Regression (Model 2)	Value Transfer (Model 2)	% VT Error (Model 2)
Ireland	€29.91	€25.82	-14%	€30.00	€24.89	-17%
Dublin	€38.55	€35.99	-7%	€38.05	€33.98	-11%
Mid-East	€25.92	€26.27	1%	€24.96	€24.40	-2%
South-East (IE)	€27.89	€25.26	-9%	€27.34	€23.61	-14%
South-West (IE)	€30.45	€25.17	-17%	€28.37	€23.53	-17%
Mid-West	€21.04	€31.42	49%	€22.33	€23.73	6%
West	€28.41	€15.08	-47%	€28.85	€15.22	-47%
Midland	€21.88	€3.89	-82%	€28.74	€12.96	-55%
Border	€26.62	€17.76	-33%	€26.10	€16.64	-36%
Mean Error (Variance)			-18% (14.6%)			-22% (4.7%)
Mean of Absolute Errors (Variance)			31% (7.6%)			24% (3.9%)

Table 8. Transfer errors for Ireland and Irish NUTS 3 Regions

Another factor that may impact the results is the MAUP in relation to population density. This may be an insolvable issue (McMaster & Sheppard, 2004) but in an effort to lessen this distortion, population weighted LAU2 population densities are used for each NUTS3 region.

The VT exercise was undertaken with NUTS3 as the spatial unit. Population density was calculated at the NUTS3 level then log transformed. In the regression models 1 and 2, the log transformed population density was calculated based on NUTS3 regions. This MAUP may be a source of error in the VT. Table 7 shows that the population density measure used in the regression is larger than in the initial VT exercise. This seemed to be a bigger issue for rural areas compared to the large urban agglomeration of Dublin NUTS3 region. In order to eliminate this source of error, a dataset was identified (LAU2 population density data from the Irish Central Statistics Office (CSO, 2015)) and the population weighted LAU 2 log transformed population density was calculated for each of the 8 Irish NUTS3 regions. These values, seen in column three of Table 7, are very close matches to the survey data. This method of population weighting the LAU 2 population densities was then also applied to the other EU Atlantic MSs based on the Census 2011 results and the LAU2 areas in each NUTS3. The new VT results which attempt to account for the MAUP are model 1-M for the liner distance decay model and model 2-M accounting for the exponential decay model.

NUTS 3	This Survey (n=812)	NUTS3 (Ireland) (n=8)	LAU 2 (Ireland) (n=3409)
Dublin	8.38	7.23	8.35
Mid-West	6.41	3.87	6.59
Mid-East	6.13	4.48	6.38
Border	6.34	3.76	6.01
South-East (IE)	7.02	3.98	6.47
South-West (IE)	7.05	4.00	6.92
West	5.66	3.48	6.20
Midland	6.23	3.78	5.92

Table 9. Population weighted natural log of population density for Irish NUTS3 regions based on this survey, NUTS3 data and LAU2 data.

The results from table 9 show the effect of using the population weighted log transformed LAU2 population densities in place of the NUTS3 log transformed population densities. It reduces the mean VT error for Ireland from -18% to -3% in model 1-M and from -17% to -5% in model 2-M. Looking across the NUTS3 regions, there is no difference in the models based on the mean errors but model 2-M still outperforms Model 1-M on mean of absolute errors and on lower variances.

Undertaking the VT exercise across the five MSs whilst adjusting for the MAUP increases the overall value of GES across the five North-East Atlantic MSs to €2,628 million using model 1-M and to €3,482 million using model 2-M, an increase of 12.7% and 14.1% respectively over models 1 and 2. The MAUP adjustment caused an increase of between 7.3% (Portugal, Model 1-M) and 20.7% (Spain, Model 2-M). Portugal had the lowest level of adjustment which is thought to relate to the high number of NUTS3 regions relative to its population (352,072 persons per NUTS3 region) which is less than 45% that of Spain (793,490 persons per NUTS3 region). However, there may be other factors, such as the heterogeneity of population density, affecting the adjustment rate as this relationship does not hold for all MSs.

MS/NUTS3	Interval Regression (Model 1)	Value Transfer (Model 1M)	% VT Error (Model 1M)	Interval Regression (Model 2)	Value Transfer (Model 2M)	% VT Error (Model 2M)
Ireland	€29.90	€ 29.02	-3%	€30.00	€28.40	-5%
Dublin	€38.55	€37.70	-2%	€38.05	€35.86	-6%
Mid-East	€25.92	€29.18	13%	€24.96	€27.59	11%
South-East (IE)	€27.89	€29.07	4%	€27.34	€27.79	2%
South-West (IE)	€30.45	€29.65	-3%	€28.37	€28.44	0.2%
Mid-West	€21.04	€35.58	69%	€22.33	€33.95	52%
West	€28.41	€19.26	-32%	€28.85	€19.80	-31%
Midland	€21.88	€7.17	-67%	€28.74	€16.55	-42%
Border	€26.62	€21.21	-20%	€26.10	€20.42	-22%
Mean Error			-5%			-5%
(Variance)			(15%)			(8.4%)
Mean of Absolute Errors			26%			21%
(Variance)			(7.6%)			(3.7%)

Table 10. Transfer errors for Ireland and Irish NUTS 3 Regions with MAUP adjustment

Member State	Mean (Pop. Wt.)	Mean (Pop. Wt.)	Total (millions)	Total (millions)
	Model 1-M	Model 2-M	Model 1-M	Model 2-M
Ireland	€29.02	€28.40	€99	€97
UK	€22.05	€22.72	€1,097	€1,130
France	€13.31	€25.04	€655	€1,277
Spain	€14.08	€19.39	€541	€746
Portugal	€27.15	€26.81	€235	€232
			€2,628	€3,482

Table 11. Results from VT exercise for each MS with MAUP adjustment

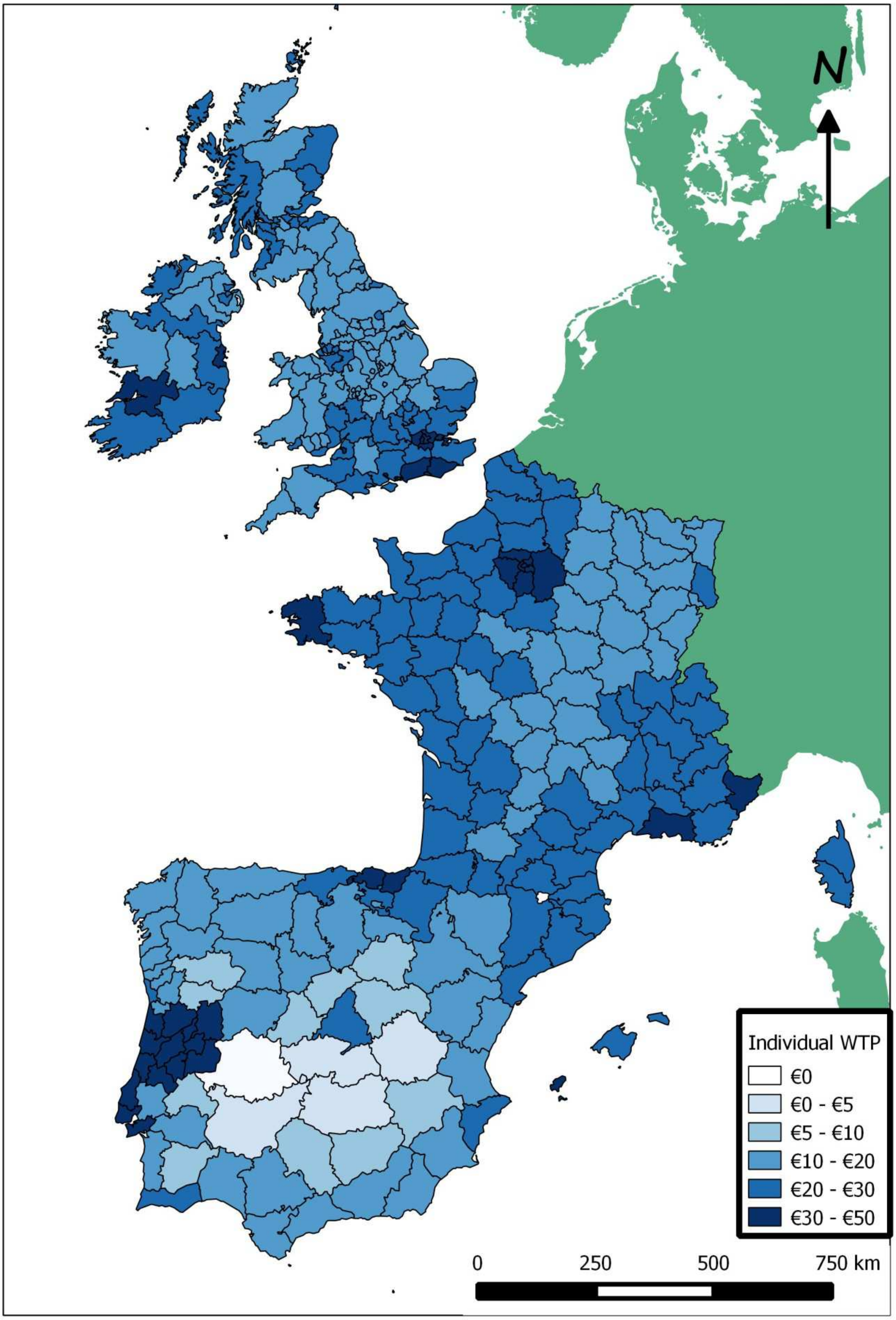

Figure 3. Map of estimated individual's WTP to achieve GES in their nations marine waters using model 2-M.

5. Discussion and conclusion

This paper presents the results of a valuation exercise that was undertaken in Ireland on the non-use values associated with implementation of the MSFD. This work provides estimates of the non-market benefits generated by the MSFD that are needed to undertake CBA as required under article 13 of the MSFD and to provide evidence of disproportionate costs of measures as required under article 14 of the MSFD. This valuation exercise using VT showed that there are significant benefits based on non-use value attached to achieving GES in these MSs waters. The MAUP adjusted models 1-M and 2-M estimate the value of achieving GES is between €2.6 billion and €3.5 billion per annum for marine areas within these MSs.

Primary valuation studies are important and are likely to increase similar to what happened after the introduction of the WFD (Kontogianni et al., 2005, Hanley et al., 2006, Spash et al., 2009, Moran & Dann, 2008, Martin-Ortega, J. and Berbel, J., 2010, Doherty et al, 2014). Similar to the WFD, as the number of studies increases so does the greater potential to use VT (Bateman et al, 2011, Norton et al. 2012) as a cost-effective tool and that was also explored in this paper. The use of VT does not come without a cost as there is a chance of producing misleading welfare estimates. The use of GIS has been advocated as a means of reducing these errors but as this paper shows much is still made of how much variability the VT function captures, the specification of the model and the spatial level at which data is obtained and the level at which it is applied.

There is no clear choice of the functional form of distance decay to use based on the comparison in Table 8. Based on the model fit (See table 4), it would have seemed that model 1 (linear distance decay) would be the better choice, but model 2 (exponential distance decay) performed better and seems more robust based on absolute mean error and the variances of errors (albeit these are based on a small number of observations (n=8)).

Additionally, model 2 performed better for the Midlands NUTS3 region which is important as this model is being applied to MSs where NUTS3 regions exhibit larger distances to the coast. Also it may be worth considering both models predictive power. Pseudo R^2 values indicate that the models predict circa 20% of the variability in the data, which is low, and it may be that both models are mis-estimating the distance decay coefficient. It may be that both functional forms of the distance decay are inappropriate.

However, the use of GIS should not be dismissed. Tompkins and Southward (1999) noted that one of the benefits of GIS is its ease in presenting large volumes of data in a spatial manner to policymakers and other stakeholders and allowing for linkages between research, policy and practice. An example of this is shown in figure 3. A map of estimated individual's WTP to achieve GES in their nation’s marine waters using model 2-M is shown in figure 3. This map clearly shows the distance decay effect, especially for France and Spain, indicating that large swathes of both nations have lower values for the marine environment.

Another issue which arose is obtaining socio-demographic data. While, much of the data was standardised and available either at Eurostat or CensusHub2, some MSs still have not made all their data available on these platforms. Future initiatives by such projects like MARNET which collates and makes available a variety of demographic and socio-economic data related to the marine and coastal areas may be alternative source of data to those undertaking similar functional VT exercises in marine related areas.The five North-East Atlantic MSs have 188 million people (37% of EU population), a GDP of 5,778 billion (42% of EU GDP) and a EEZ covering over 5.8 million km^2 (74% of EU EEZ). How these member states implement the MFSD will affect a large proportion of the EU's people and economy and most significantly its marine area.

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