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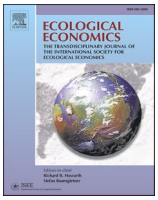

ANALYSIS

Could a mix of short- and long-term policies be the solution to tackle marine litter? Insights from a choice experiment in England and Ireland

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ABSTRACT

Marine litter is a problem impacting the coasts and seas of the whole world. Whilst an increasing number of studies investigate the effects of marine litter on public welfare, most of the research to date considers it as a component of coastal environmental quality. This study specifically examines the preferences and willingness to pay of English and Irish respondents towards the removal and prevention of marine litter, and the trade-off between different short-term (e.g., beach clean-up) and long-term (e.g., ban on single use plastic) policy actions. An online survey, including a choice experiment and behavioural questions, was used to quantify the welfare impacts of marine litter on the provision of recreation and cultural ecosystem services. We found that respondents are generally inclined to the implementation of a policy mix, with propensity for immediate action. Our results confirm the loss of societal benefits due to the presence of marine litter on beaches. The estimated marginal willingness to pay can be used to inform the design and assess costs and benefits of new local, national or supra-national mixed policies directed at reducing litter in the coastal and marine environment.

1. Introduction

Litter discharged into coastal and marine environment is recognized as one of the major contemporary global pollution problems (Galgani et al., 2015; Sutherland et al., 2010). The amount of marine litter accumulating in oceans and coastal areas has reached alarming levels worldwide (Jambeck et al., 2015; UNEP, 2016; Eriksen et al., 2014). Marine litter is defined as "any solid material which has been deliberately discarded, or unintentionally lost on beaches and on shores or at sea, including materials transported into the marine environment from land by rivers, draining or sewage systems or winds" (OSPAR, 2017). It is generally due to a variety of human activities and their resulting production, consumption and waste disposal practices; although marine litter originates from different sources and is mainly land-based (UNEP, 2016; Galgani et al., 2015; Jambeck et al., 2015). Plastic accounts for around 80% of the amount of marine litter found in coastal habitats (OSPAR, 2017).

Litter has well documented negative impacts on the coastal and marine ecosystems (Gregory, 2009; Law, 2017), and potential adverse impacts on human health are increasingly acknowledged (Almroth and Eggert, 2019; Vethaak and Leslie, 2016). Marine litter also considerably affects a number of economic sectors such as fisheries, aquaculture, shipping, and tourism (Conejo-Watt and Luisetti, 2019; Newman et al., 2015). For example, McIlgorm et al. (2008) estimate the damage to Asia-Pacific Rim maritime industries to be US$1.26bn per year and Mouat et al. (2010) assess that marine litter costs around €2.4 m per year to the UK ports and harbours industry and between €11.7–€13 m to the Scottish fishing industry. Research on the economic impacts of marine litter is still fragmented, although growing. It does often not account for the loss of ecosystem services provision and other non-market values (Conejo-Watt and Luisetti, 2019; Almroth and Eggert, 2019; Newman et al., 2015), which are a considerable portion of the economic costs caused (Beaumont et al., 2019).

For example, the impact of marine litter in terms of loss of recreational value and provision of cultural ecosystem services is considered a relevant part of the total societal economic cost (Brouwer et al., 2017; Newman et al., 2015). However, there is a paucity of studies specifically addressing this topic (e.g., Abate et al., 2020; Brouwer et al., 2017; Smith et al., 1997). Marine litter can both directly and indirectly affect recreation. Direct impacts include the visual impact of plastic, glass, and

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metals items on beaches and floating in the sea (Surfers Against Sewage, 2014). Indirect impacts originate from loss of biodiversity related to entanglement, ingestion or pathogens spread (Gregory, 2009; Law, 2017; Goldstein et al., 2014). Seascape impacts may in turn influence tourists' welfare and preferences and promote the switch for alternative recreational sites (McIlgorm et al., 2008; Wyles et al., 2016), with consequential local economic losses for the impacted coastal areas (Newman et al., 2015).

Policy and management interventions such as beach clean-ups or upstream interventions such as bans on single-use plastic items can either mitigate or prevent marine litter. Beach clean-ups are short-term interventions that can temporarily reduce the impact of marine litter on beaches and can be undertaken either by the affected municipality at a cost, or on a voluntary basis (Newman et al., 2015). However, without long-term prevention policies addressing the broader causes of marine litter, beach clean-up programmes will not be effective. Indeed, tackling marine litter requires an integrated, life-cycle oriented approach (Vince and Hardesty, 2017; Löhr et al., 2017; Dauvergne, 2018; Fadeeva and Van Berkel, 2021). To this aim, a multitude of international and national policies have been implemented in the last decades (Karasik et al., 2020; Xanthos and Walker, 2017; Chen, 2015). For example, the European Union directive on single use plastic introduces an ambitious set of policies and measures such as ban on single use items, reduction of plastic food and beverages containers and targets on collection of plastic bottles (European Union, 2019). The introduction in 2015 of a plastic bag charge in England resulted in a 95% decrease in the use of single use bags from major retailers between the 2018 and the 2020 (Defra, 2020). The planned deposit return scheme in England, Wales and Northern Ireland[1] could prevent 6600 t of plastic waste entering rivers and the sea by 2030 (Common Seas Initiative, 2019). Other measures such as extended producer responsibility schemes, water refill points, increased penalties for fly tipping and inappropriate flushing are likely to lead to less leakage of plastic waste (Royle et al., 2019). Investments in waste management and improved education on recycling and littering have also proven successful (Willis et al., 2018).

Nonetheless, the willingness to cooperate of the general public and its support for actions tackling the marine litter problem are essential to design effective policies (Hartley et al., 2018; Pahl et al., 2017; Gelcich et al., 2014). General public's consumption and waste disposal patterns have a crucial role in the effort of reducing and preventing litter accumulation, and a better understanding of public preferences is critical in implementing shared and adequate solutions (Hartley et al., 2018). In a context where integrated solutions are needed, examining public support and trade-offs for short-term actions and longer-term prevention policies can be key in tailoring the policy mix required to further contrast marine litter and mitigate its societal costs.

The objective of this paper is to investigate public preferences and trade-offs for marine litter short-term clean-up actions and long-term upstream related policies (ban on single use plastic items and deposit return schemes). We present results from a choice experiment focusing on welfare impacts from marine litter in terms of recreational and cultural services provided by the marine and coastal environment in local tourist areas in England and Ireland. These areas were selected for their tourist and recreation importance. This paper aims to expand on existing literature and provide novel evidence by *i)* examining how the public perceives the trade-off between a range of marine litter management policies with different timescale and scope, *ii)* quantifying the welfare impacts of marine litter on the provision of recreation and cultural ecosystem services, and *iii)* providing a comparison between areas with high tourist and recreation relevance located in different countries. Results of our research can inform policy makers and practitioners in the development of wider cost-benefit analyses of littering and waste management and can contribute to shape integrated approaches to tackle marine litter at local, national and supra-national level.

The paper is structured as follows. Section 1 puts forward the rationale for the study based on the limited literature on the economic impact of marine litter on coastal and marine recreation. Section 2 describes the choice experiment design, including the case study areas and survey administration, as well as the data analysis methodology. Section 3 reports the results of the data analyses undertaken with a mixed multinomial logit model (MMNL) and a latent class logit model (LCL). Section 4 discusses the results and Section 5 concludes the study providing some policy recommendations.

2. Literature review and study rationale

Studies specifically examining the welfare impact of marine litter in coastal and marine environment are scant (Zambrano-Monserrate and Ruano, 2020; Abate et al., 2020; Latinopoulosa et al., 2018; Brouwer et al., 2017; Smith et al., 1997). Most of the research to date considers marine litter as a component of coastal environmental quality (e.g., Aanesen et al., 2018; Phillips et al., 2018; Loomis and Santiago, 2013; Hynes et al., 2013; Östberg et al., 2012; Beharry-Borg and Scarpa, 2010; Blakemore and Williams, 2008).

Within the group of studies specifically targeting marine litter, Abate et al. (2020) administered a contingent valuation survey on a sample of Norwegian residents to elicit willingness to pay to support a marine plastics clean-up and prevention initiative on the Arctic archipelago of Svalbard. Respondents were willing to pay on average US$642 for the initiative through a new household annual tax. In another contingent valuation carried out in Ecuador by Zambrano-Monserrate and Ruano (2020), respondents were asked about their willingness to pay for a public programme to reduce plastic pollution in the Galapagos Islands including clean-up, monitoring and awareness campaigns. Authors estimated a willingness to pay for the programme between US$4.90 and US$14.51 per year in increased income tax. Similarly, Smith et al. (1997) employed a contingent valuation to elicit willingness to pay for reducing marine debris on recreational beaches in New Jersey and North Carolina. Respondents stated a willingness to pay for a debris control

Table 1
Overview of the relevant literature on marine litter.

Study	Targets marine litter	Long-term policies	Considers multiple geographical areas	Method[1]
Zambrano-Monserrate and Ruano (2020)	Yes	Monitoring, awareness	No	CV
Abate et al. (2020)	Yes	Prevention	No	CV
Aanesen et al. (2018)	No		No	CE
Phillips et al. (2018)	No		No	CE
Latinopoulosa et al. (2018)	Yes	Ban plastic bag	No	CE
Brouwer et al. (2017)	Yes		Yes	CE
Loomis and Santiago (2013)	No		No	CV, CE
Hynes et al. (2013)	No	Filtration, policing	No	CE
Östberg et al. (2012)	No		No	CV
Beharry-Borg and Scarpa (2010)	No		No	CE
Blakemore and Williams (2008)	No		No	CV
Smith et al. (1997)	Yes	Monitoring	No	CV

Note: [1] CV – contingent valuation, CE – choice experiment

[1] Outcomes of the consultation can be found at https://www.gov.uk/government/consultations/introducing-a-deposit-return-scheme-drs-for-drinks-containers-bottles-and-cans.

and clean-up program ranging between US$21.38 and US$72.18 to be paid through an annual income tax. The study of Brouwer et al. (2017) is the only choice experiment specifically exploring public willingness to pay for beach litter clean-ups in areas located in different European countries. Through in-person interviews at six urban beaches in Bulgaria, Greece and the Netherlands, respondents' preferences for characteristics of clean-ups such as type of litter removed, quantity of litter left after cleaning, origin of marine litter, and crowding were investigated. Authors report an average willingness to pay between €0.67 and €8.25 per visitor/year for clean-ups including the complete removal of plastic litter washed ashore by the sea, and between €0.42 and €7.06 per visitor/year for complete removal of cigarette butts left behind by visitors. Finally, another choice experiment by Latinopoulosa et al. (2018) investigate the effectiveness of information campaigns aimed at reducing the use of plastic bags in Greece and the related preferences for reducing impacts of plastic litter in the marine environment. They found respondents being generally supportive of a ban on plastic bags, and willing to pay between €23.6/year and €32.5/year in additional local taxes for preserving recreational activities, landscape and commercial fisheries.

Another group of studies related to coastal ecosystems does not address marine litter as the specific object of research, but only includes it as one of the indicators of the wider environmental quality. For example, Aanesen et al. (2018), in the context of a choice experiment on the development of economic activities in Arctic Norway, reports a willingness to pay for reducing 50% of marine litter between US$123.10 and US$167.50 in increased annual household local tax. Phillips et al. (2018), examining bathing water quality in Scotland, found an average willingness to pay through increased annual household water charge of £0.44 for each 1% of litter removed from beaches. A choice experiment on coastal water quality improvement in Ireland administered by Hynes et al. (2013) included litter together with health risks and benthic health, finding a willingness to pay extra cost for travelling to the beach of €7.20 visitor/year for additional collection of marine debris. Östberg et al. (2012) used a contingent valuation to assess the willingness to pay for marine environmental improvements in Sweden finding that households are willing to pay between SEK38 and SEK46 a month for less noise and littering. Loomis and Santiago (2013) conducted a combined choice experiment and contingent valuation on recreational beach quality in Puerto Rico, including water clarity, litter on the beach, crowding and wave height. They found an average willingness to pay for absence of litter between US$98 and US$103 per visitor/day in terms of increased travel cost. Finally, in a choice experiment to estimate willingness to pay for coastal waters changes in Tobago which comprised bathing water quality and clarity, presence of boats and snorkellers, etc., Beharry-Borg and Scarpa (2010) found an average value to be contributed through a special fee between TT$15 and TT$50 for having only very little (up to five pieces) plastic debris left on the coastline.

This review highlights a substantial diversity of willingness to pay values reported in the literature. Whilst this might depend on the different circumstances of the studies (methods, objectives, geographical locations, etc.), the transferability of estimates seems problematic if results were to be used in informing policy making. In addition, although some of the studies include both clean-up and litter prevention policies in the valuation scenario (Zambrano-Monserrate and Ruano, 2020; Abate et al., 2020; Latinopoulosa et al., 2018; Hynes et al., 2013; Smith et al., 1997), those measures are usually treated as a bundle without the possibility to explicitly address the trade-offs between short-term clean-ups and specific, policy relevant long-term actions. Only Latinopoulosa et al. (2018) include in their study a plastic bag ban. Based on these results, our study adds to the literature by specifically looking at marine litter clean-ups and expanding on litter reduction and prevention policies such as a ban on single-use plastic and a local deposit return scheme. The use of the choice experiment allows to capture public preferences and trade-offs for both shorter- and longer-term solutions. We focus on selected areas located on English and Irish coasts as these countries have been relatively overlooked and there is a demand to provide a policy-robust comparison between areas with strong tourist and recreation potential located in different countries.

3. Materials and methods

3.1. Survey design and administration

An online survey was administered by a professional survey company[2] between September and November 2019. Online surveys are widely employed in choice experiment (CE) and valuation studies and provide reliable estimates of the welfare measures (Lindhjem and Navrud, 2011; Olsen, 2009). The sample was stratified by gender, age and NUTS[3] areas to reflect population characteristics and ensure representativeness.[4] The survey was administered in the South and South West of England and in the West of Ireland (Fig. 1). These areas are often cited as marine litter hotspots in the wider Atlantic region (OSPAR, 2017)[5] and are renowned recreational and tourist destinations due to a diverse coastal environment including UNESCO World Heritage sites and seaside holiday resorts (Great Britain Tourism Survey (GBTS), 2018; Fáilte Ireland, 2019).[6]

The survey questionnaire was pre-tested on a sample of 129 respondents (42 in South West England, 39 in South England and 48 in West Ireland). Piloting the survey resulted in improvements in readability, refinement of the CE attributes and estimation of coefficients which were used as priors to improve the efficiency of the final experimental design. The sample of the final survey consisted of 1593 respondents (506 in South West England, 508 in South England and 579 in West Ireland). The questionnaire comprised five sections. The first section introduced marine litter and its main impacts on the coastal and marine environment. In the second section, respondents were asked about their experience of visiting the coast and their exposure to marine litter while visiting a beach. The third section was devoted to the CE, with a detailed explanation of attributes and rules to respond to the choice scenarios together with an example choice situation. After the CE, a series of attitudinal questions were asked including perceptions of who is responsible for marine litter removal and prevention policies. Finally, socio-demographic characteristics were collected.

The core part of the survey questionnaire was the CE (Louviere et al., 2000; Hensher et al., 2005; Champ et al., 2017). The selection of relevant attributes and levels was based on the literature review presented in Section 1, stakeholders and experts' advice, and results from the pilot survey. The final list of attributes and levels is summarised in Table 2.

The attribute "Amount of marine litter removed" was described as the varying amount of marine litter that will be removed depending on the chosen beach clean-up program. This attribute was therefore

[2] Qualtrics LLC - www.qualtrics.com

[3] The Nomenclature of Territorial Units for Statistics (NUTS) is a hierarchical classification of administrative areas, used across the European Union (EU) for statistical purposes.

[4] Sample stratified by gender and age with hard cap on the number of respondents required for each quota, by NUTS area with soft cap on the number of respondents required for each quota. Sampling based on ONS (2019) and CSO (2019).

[5] Outcomes from OSPAR surveys report that an average of 1579 marine litter items every 100 m are found on South West England coastline, an average of 139 marine litter items every 100 m are found on the South England coastline, and an average of 102 marine litter items every 100 m are found on the West of Ireland coastline.

[6] Between 2016 and 2018 British holidaymakers spent around 50 million overnight stays in the South West of England with a tourist expenditure of around £3.1 billion and 2.1 million national overnight stays in the South of England with over £170 million tourist expenditure (GB Tourism Survey, 2018). Around 6 million overseas and 5 million domestic tourists visited the West of Ireland in 2018, generating a total of 3.2 billion revenues (Fáilte Ireland, 2019).

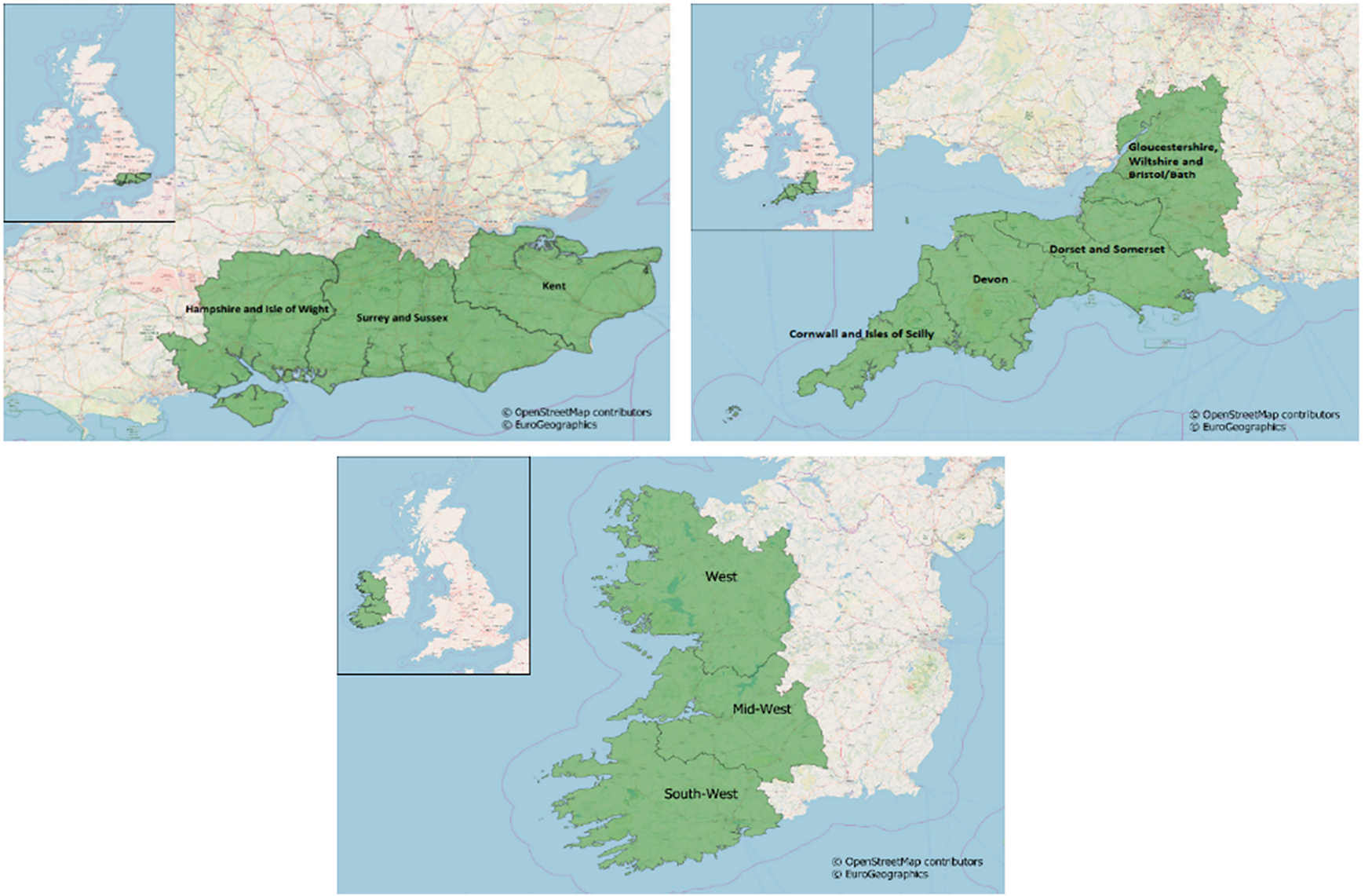

Fig. 1. The study areas in England and Ireland

Table 2
Final list of attributes and levels used in this study.

Attributes	Levels	Status quo
Amount of marine litter removed	0%, 25%, 50%, 75%, 100%	0%
Deposit return scheme	No, Yes	No
Ban on single-use non-recyclable plastic	No, Yes	No
Annual council tax/annual donation	£/€3, £/€6, £/€10, £/€15, £/€25, £/€40	£/€ 0

included to capture preferences for the relative amount of litter removed by short term clean-up actions. Clean-ups are nowadays routinely conducted by local councils in the UK and thus paid for through council taxes.[7] Mouat et al. (2010) estimated that removing litter from beaches weighs on the public finances of the UK local councils for about £18–£19 m per year. Beach litter clean-ups are also increasingly popular community-led initiatives worldwide (Vince and Hardesty, 2017; The Ocean Conservancy, 2020), including in the UK and Ireland.[8] The levels for this attribute were defined as the additional percentage of litter removed from the coastline compared to the current situation.[9] Including this attribute gives respondents a chance to trade-off the use of longer-term marine litter reduction policies with the amount of litter removed in the short term and the associated costs of the litter reduction program chosen. Furthermore, including this attribute allows us to compare results with those of previous studies of marine litter and environmental quality (Aanesen et al., 2018; Phillips et al., 2018). In order to provide a baseline to the relative amount of litter removed, respondents were given the amount of litter present in their area expressed as the number of litter items found on representative beaches as reported by beach surveys conducted using the standardised OSPAR litter survey protocol.[10] An attribute related to the type of litter removed (e.g., plastic, fishing material, glass, etc.) was not included for two reasons: it was not considered realistic that beach clean-up actions could target only one type of litter; and there was the need to avoid confounding effects between the type and the amount of litter removed.

The attributes "Ban on single-use non-recyclable plastic" and "Deposit return scheme" were included to explore preferences and willingness to monetarily support policies that are currently, or are expected to be, implemented at local and national level in England and Ireland, but also worldwide to tackle marine pollution. The plastic ban attribute was described to respondents as the presence or absence in their area of bans on single-use non-recyclable items aimed at reducing the amount of marine litter accumulating on beaches. Bans on single-use plastic items are policies widely implemented globally and they have proven to be effective and are generally supported by the public (Schnurr et al., 2018; Xanthos and Walker, 2017; Heidbreder et al., 2019). The deposit return scheme attribute was presented to respondents as the presence or absence in their area of deposit return schemes for plastic and glass bottles and cans aimed at reducing the amount of marine litter accumulating on beaches. Deposit return and other extended producer responsibility schemes are one of the economic instruments employed in curbing litter and waste accumulation (Abbott and Sumaila, 2019; Newman et al., 2015), and are being phased in, for example, in Europe and the UK (Sheridan et al., 2020; Penca, 2018). These two attributes reflect policy-relevant, longer-term prevention polices to reduce marine litter, and allow respondents to trade-off between clean-ups removing litter from the shoreline in the short term and policies reducing the accumulation of litter over time. The comparison with preferences for short-term clean-ups can provide useful information to policy makers for cost-benefit analysis and taxation purposes, and on the preferred policy mix to implement.

The payment vehicle was framed differently between the two countries to reflect peculiarities and pilot findings. In the UK, respondents were presented with an increase in annual council tax designed to support recurring, targeted and systematic beach clean-up programs and marine litter prevention measures. In Ireland, instead, to support the same measures, an annual donation to local charities was requested. The use of different payment vehicles was primarily supported by results from the pilot survey. In the pilot survey, respondents were directly asked what payment vehicle they would prefer between a tax and a donation to local charities. In addition, participants in each area were randomly assigned a survey version with either the tax or the voluntary based payment mechanism and differences were subsequently tested through models with interaction terms between the payment vehicle and other attributes. Whilst respondents in South and South West England were found to be overall indifferent between an increase in council tax and a donation to local charities, some differences were found in the West Ireland sample, with respondents being more inclined towards a donation.[11] This was further discussed and confirmed with relevant stakeholders. Therefore, to adopt the most neutral payment vehicle, a donation to local charities was proposed to Irish respondents and an increase in council taxes to the British. Nevertheless, the same payment levels were kept for all surveyed areas.

Respondents were presented with eight repeated choice situations, each including two unlabelled alternative marine litter programs (options A and B) and a status quo. The inclusion of a status quo (opt out) alternative, generally recommended for public goods (Johnston et al., 2017), improves realism and incentive compatibility and avoids forcing participants to choose one of the proposed programs. Choice situations were obtained using a D-efficient Bayesian experimental design (Ferrini and Scarpa, 2007) generated through Ngene (ChoiceMetrics, 2018). The D-efficiency criterion of the final experimental design is equal to 0.0039. After 461 observations the experimental design has been checked but no significant gains in D-efficiency were found. Therefore, there was not updated version of the design. The experimental design was developed

[7] The responsibilities of local councils in the UK in relation to litter clean up on land including beaches are outlined in the Environmental Protection Act 1990 (Defra, 2019).

[8] Nowadays a number of volunteering and environmental associations in the UK and Ireland organise clean up actions, for example Clean Coasts (www.cleancoasts.org), Surfers Against Sewage (www.sas.org.uk), Marine Conservation Society (www.mcsuk.org).

[9] Whilst 100% removal of all marine litter might seem unrealistic, the international Blue Flag award for beaches includes criteria for a clean beach with litter not being allowed to accumulate. With many municipalities motivated by the Blue Flag award (Mouat et al., 2010), collecting preferences for 100% litter removal is of relevance for local decisions makers. Furthermore, similar attributes have successfully been used in previous choice experiments (e.g., Brower et al., 2017) and our piloting of attributes and levels revealed no critical comments about the "amount of marine litter removed" attribute.

[10] The baseline amount of marine litter present on beaches in the targeted areas and provided to respondents was the average number of litter items retrieved from information recorded by OSPAR related to the beach litter monitoring surveys undertaken following the standard OSPAR protocol (OSPAR, 2010; Schulz et al., 2017). Information recorded in all the surveys carried out on beaches located in the targeted areas were considered. For the South West of England, surveys were undertaken in Burnham-on-Sea, Polhawn, Porth Kidney Sands, Sand Bay, Seatown and St Marys Beach; for the South East of England, surveys were undertaken in Margate, Hastings, and Chilton Chine; for the West of Ireland, surveys were undertaken in Silver Strand and Long Strand.

[11] Taxation systems in the two countries are different. Irish taxpayers do not face payments directly comparable to English council tax. The Irish tax that is closer in terms of general scope to a council tax, that is the property tax, is lower in the payable amount (therefore relative increases are larger), is based on a different type of assessment of the property value (owners' assessment versus council assessment in England), is subject to a higher number of exemptions, and has been introduced more recently.

using the software Ngene ver. 1.2 (ChoiceMetrics, 2018). The 24 choice situations were divided into 3 blocks of 8 cards with balanced levels for each attribute. Both the blocks and the choice situations were randomised in the questionnaire (Caussade et al., 2005; Bliemer and Rose, 2011; Meyerhoff et al., 2015; Rose and Bliemer, 2008). The experimental design used in the main survey was based on priors from the parameters estimated on the survey pilot data.[12] The pilot was administered to respondents in all the three study areas. Differences in preferences between targeted areas were tested by estimating models with interaction terms, revealing no to inconclusive evidence justifying the use of two different experimental designs. Therefore, to increase consistency and robustness of our empirical application, the same experimental design was employed, although the Bayesian design accommodated parameters' uncertainty. Fig. 2 shows an example choice situation.

3.2. Econometric models

A mixed multinomial logit model (MMNL) and a latent class logit model (LCL) were estimated.[13] Following McFadden (1974), the utility that individual n derives from the alternative i in the choice card t can be defined through an observable deterministic part V_{nit} and an unobserved random component ε_{nit}

$$U_{nit} = V_{nit} + \varepsilon_{nit} = \beta_n x_{nit} + \varepsilon_{nit}$$

where the deterministic part is defined as a linear function of the alternative specific attributes x_{nit} and the corresponding taste parameters β_n. To accommodate differences in preferences across respondents, a MMNL in preference space with correlated taste parameters was first estimated (McFadden and Train, 2000). All taste parameters were allowed to be normally distributed over individuals, except the payment vehicle parameter which was assumed to follow a negative log-normal distribution. The MMNL probability for individual n of choosing alternative i among j alternatives in the choice card t is (McFadden and Train, 2000):

$$P_{nit} = \int \frac{e^{\beta_n x_{nit}}}{\sum_{j=1}^{J} e^{\beta_n x_{njt}}} f(\beta|\Omega) d\beta$$

with $f(\beta|\Omega)$ representing the density function of the vector of taste coefficients.

To group respondents based on individual characteristics (socio-demographics, experience of the coast, behaviours), and due to the policy-oriented nature of this study, a LCL was also estimated (Hess et al., 2009). In LCL, respondents are allocated into different classes with different values of the taste coefficients β_c across classes. The probability for individual n of choosing option i among j alternatives in the choice card t conditional on falling in class c can be written as (Hess et al., 2009):

$$P_{nit} = \pi_{nc} \frac{e^{\beta_c x_{nit}}}{\sum_{j=1}^{J} e^{\beta_c x_{njt}}}$$

where π_{nc} is the class allocation probability. The flexibility of the LCL arises when a class allocation model is used to link these probabilities to the characteristics, usually socio-demographic information, of respondents (Hess et al., 2009; Green and Hensher, 2003), such that:

$$\pi_{nc} = \frac{e^{\delta_c + g(\omega_c, z_n)}}{\sum_{l=1}^{C} e^{\delta_l + g(\omega_l, z_n)}}$$

With C the total number of classes, δ_c a class-specific constant, z_n the vector of individual characteristics, ω_c the related parameters, $g(.)$ the functional form specifying how individual characteristics enter the class allocation model, and l the generic latent class as identified in the LCL model.

Marginal willingness to pay (WTP) estimates from the MMNL model are usually derived as the ratio of an attribute coefficient to the negative payment vehicle coefficient. The use of a negative log-normal distribution for payment vehicle parameter ensures that the WTP moments exist and are finite (Daly et al., 2012). However, the resulting WTP estimates can be highly skewed and unrealistic (Train and Weeks, 2005; Hole and Kolstad, 2012). Therefore, to avoid this issue the WTP estimates were obtained re-parametrising the model in willingness to pay space (Train and Weeks, 2005) as:

$$U_{nit} = \alpha_n(\omega_n x_{nit} - p_{nit}) + \varepsilon_{nit}$$

where α_n is the ratio between the payment vehicle coefficient and the scale parameter, and ω_n are the coefficients of the non-payment vehicle parameters that can be directly interpreted as WTP values for the corresponding parameter.

As for the LCL model, class specific marginal WTP estimates were obtained as the ratio between the class specific coefficient of an attribute β_c and the negative of the class specific payment vehicle coefficient $\beta_{pay,c}$:

$$WTP_c = -\left(\beta_c / \beta_{pay,c}\right)$$

4. Results

4.1. Respondents' profile

Socio-demographic characteristics are summarised in Table 3. In the West Ireland sample respondents are slightly younger than respondents from the South and South West England, and generally are more likely to live in households with children. Most of the respondents in West Ireland state to hold a university degree or a post graduate certification (58.2% in West Ireland, 38.6% and 35.0% in South and South West England respectively). In all the targeted areas, most respondents are employed. As for household disposable income, 60.2% of West Ireland respondents reported more than €30,000 gross/year, while 50% of respondents from South England and 39.4% of respondents from South West England declared a disposable income higher than £30,000 gross/year. Sample characteristics seem in most cases to sufficiently reflect the population across all the areas. There are some discrepancies. For example, holders of a university or higher education degree are to some extent over-represented in the Irish sample. Households without children are over-represented, while single person households are underrepresented. Looking at the working status, unemployed and inactive individuals are overrepresented in South West England and underrepresented in West Ireland. Gross household income is generally overestimated. This is not unexpected as economic status and income can be subject to a range of well acknowledged measurement issues in surveys, especially overstating income levels (Bound et al., 2001). Discrepancies might be also partly linked to the survey mode, even if effects of web-based surveys are not usually found in stated preference studies (Menegaki et al., 2016) and online surveys are found to yield reliable estimates (Lindhjem and Navrud, 2011; Olsen, 2009).

Fig. 3 summarises the distance to the closest coastal area from respondents' residence and the frequency of visiting the coast. A substantial share of respondents live within 10 miles of the coast (44.7% in South England, 51.2% in South West England and 43.5% in West

[12] Researchers often make use of prior information available (known as priors, i.e., any knowledge on the sign and magnitude of parameters from literature, experience or pilot studies) to generate efficient experimental designs. In Bayesian efficient designs, priors are defined by accounting for the uncertainty about the parameter priors and using random priors (i.e., randomly distributed) instead of fixed priors (ChoiceMetrics, 2018).

[13] Models were estimated using the packages *mixlogit* (Hole, 2007), *mixlogitwtp* (Hole, 2007; Hole and Kolstad, 2012) and *lclogit* (Pacifico and Yoo, 2013) in Stata 16.1 (StataCorp, 2019).

	Option A	Option B	Option C
Amount of marine litter removed	50% litter removed	100% litter removed	No additional clean-up programs or marine litter reduction measures
Deposit return scheme	Absent	Present	
Ban on single use plastic	Present	Present	
Increase in annual council tax	£6	£20	
Which would you choose	○	○	○

Fig. 2. Example of a choice card used in the choice experiment.

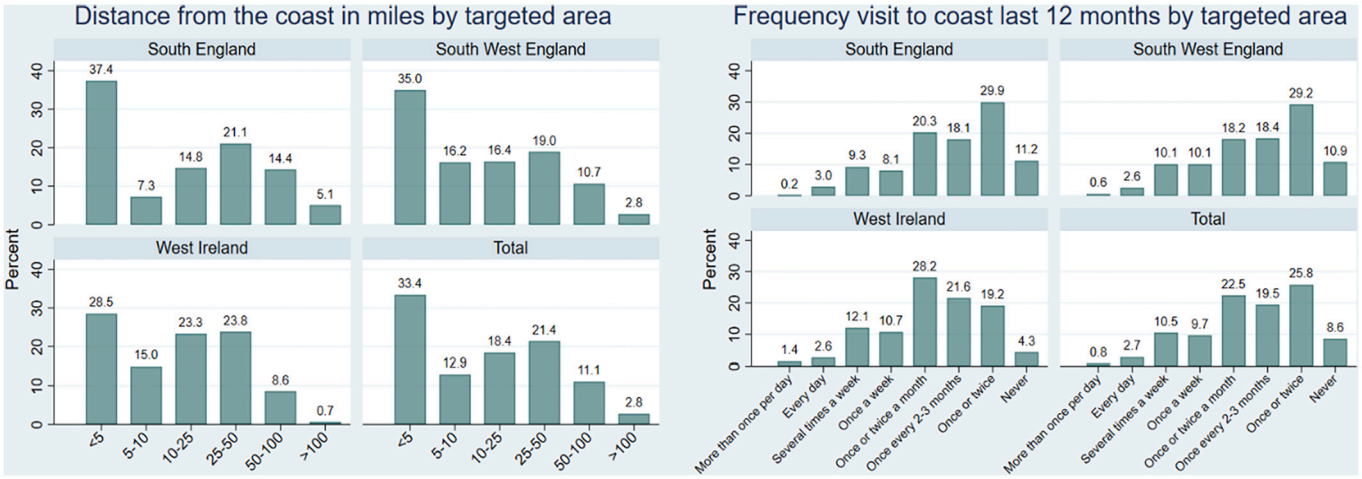

Fig. 3. Distance from coast and frequency of visits by area.

Ireland) and visit the coast at least once a month (41% in South England, 42% in South West England and 55% in West Ireland). Respondents living in West Ireland tend to visit the coast more frequently than those living in South or South West England.

Overall, the main motivations for visiting the coast are to enjoy fresh air or pleasant weather, to relax and unwind, to enjoy the scenery, and to spend time with family or friends. Fewer respondents stated they visit the coast for health benefits or enjoying wildlife. However, respondents in West Ireland appear to be particularly motivated by health benefits (36.1% in West Ireland, 18.5% in South England and 21.7% in South West England). In contrast, respondents in South and South West England seem to be highly motivated by spending time with family and friends (43.3% and 44.3% in South England and South West England respectively, 34.5% in Ireland). Coastal areas are generally preferred if they are clean (45.5%), close to home (43.9%), and not crowded (42.8%). Fewer respondents state that the natural environment (17.2%) and the presence of wildlife (10.4%) are important when choosing which beach to visit. West Ireland respondents are on average interested in less crowded and more pristine beaches; South and South West England respondents favour the presence of recreational facilities.

Respondents generally do not notice large amount of marine litter when visiting a beach in their area.[14] The most noticed types of marine litter are plastic and polystyrene (~37%–38% – frequently or very frequently noticed), followed by paper and cardboard (~20%–25% – frequently or very frequently noticed), and fishing materials (~16%–22% – frequently or very frequently noticed).[15] As reported in Fig. 4, banning single use plastic items stands out as being considered the potentially most effective policy for reducing the amount of litter on beaches. In addition, a crucial role in reducing marine litter is attributed to individual behaviours. On that regard, over 90% of respondents across the targeted areas are not currently active members of an environmental organization, but frequently watch nature documentary programs. West Ireland respondents on average appear to participate more in environmentally oriented events and beach clean-ups, and also donate more to environmental campaigns.

4.2. *Preferences for beach clean-up actions and prevention policies*

Modelling results on preferences for shorter-term clean-ups and longer-term prevention policies are reported in Table 4, with estimated parameters from both the MMNL in preference space and LCL. Preliminary analysis showed no statistically significant differences in preferences between South England and South West England respondents, therefore responses for the two areas are grouped together in the subsequent analysis. In contrast, statistically significant differences were observed between West Ireland and the two areas in England.

Considering the MMNL in preference space, respondents on average express strong, positive preferences for removing additional litter from the coast. The pattern is analogous across surveyed areas. The more litter is removed as part of a potential clean-up policy, the more respondents would be willing to support it. Similar preferences are also

[14] It is worth noting that this information reflects a subjective judgement of the quantity of litter encountered and depends upon many different factors (e.g., the specific beach visited, the motivation driving beach visits, the frequency of experiencing coastal environment, etc.).

[15] Fishing materials are slightly more often found on the beaches of South West England.

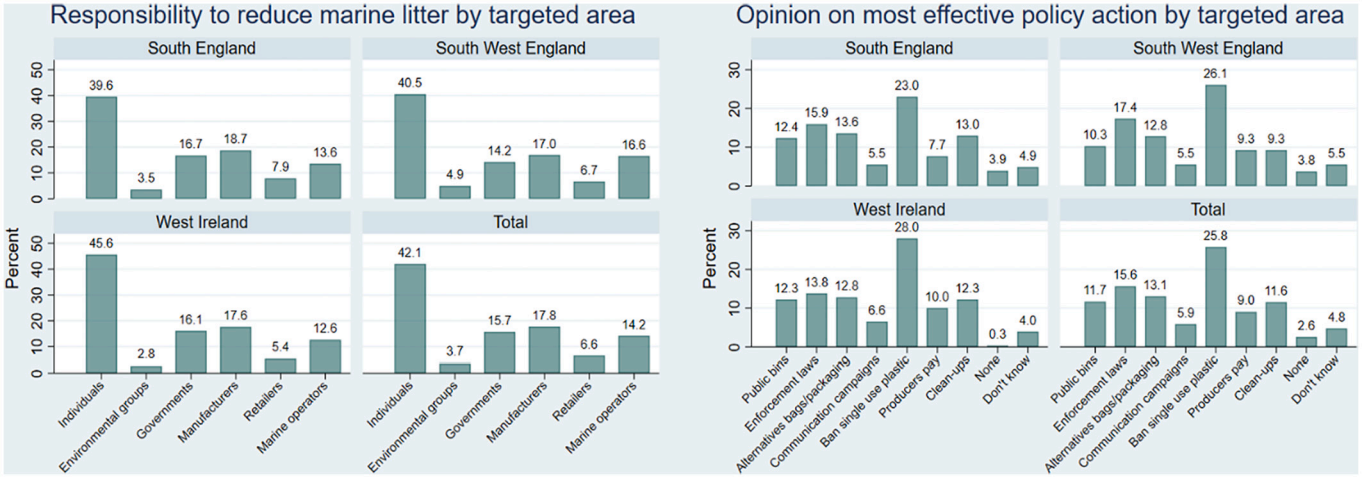

Fig. 4. Groups responsible for reducing marine litter and most effective policies.

found regarding the long-term reduction and prevention measures, which are both favoured. A ban on single-use non-recyclable plastic has the strongest support compared to a deposit return scheme. As for the payment vehicle, the coefficients are of the expected sign, which shows the negative effect of cost on respondents' choices. Finally, respondents seem to be averse to not implementing any additional short- or long-term policies as shown by the negative coefficient of the status quo option.

Results from the MMNL in preference space in Table 4 show a substantial heterogeneity in preferences across respondents. To further examine the drivers of heterogeneity, a LCL model is estimated which allows respondents to be clustered around common individual characteristics. Different individual-level characteristics were used in the class allocation model in order to explore the combined effect of experience with coastal environments (distance and number of visits), experience with marine litter (amount of litter noticed and whether it is mostly plastic), active involvement in environmental initiatives (participation in environmental awareness events and clean-ups), general disposition towards eco-friendly behaviours (proxied by an indicator summarising activities such as being part of an environmental organization, watching nature documentaries and shows, and donating to environmental causes), and socio-demographic characteristics (gender, age, and education level). The choice of the number of classes in LCL models is guided by goodness of fit criteria such as the Consistent Akaike Information Criterion (CAIC) or the Bayesian Information Criterion (BIC) (Louviere et al., 2000). However, as noted in Scarpa and Thiene (2005), the choice of the number of classes needs to account for the interpretability and meaningfulness of results. This is also discussed in the literature on latent class analysis and structural equation models (Weller et al., 2020). As our analysis is strongly policy-oriented, our approach on defining the number of classes is to favour models with easier interpretation and greater policy relevance of outcomes. Therefore, LCL models suggesting that preferences can be clustered in two homogeneous groups are used.[16] LCL models are presented in Table 4, with Class 2 always representing the reference class, therefore class allocation parameters are not estimated for it.

Results from the class allocation model regarding the effect of individual characteristics on segmenting respondents' preferences echo the mixed and case specific findings in previous studies on welfare impacts of marine litter (see Table 1). In all the study areas, age is the only socio-demographic characteristic to have a significant effect on class allocation. This is in line with Latinopoulosa et al., 2018), Brouwer et al. (2017), and Zambrano-Monserrate and Ruano (2020). Living closer to the coast impacts preferences' segmentation only in South and South West England, which might be interpreted considering that more respondents in these two areas, especially in the South West, report to live within 10 miles of the coast than the West Ireland respondents. Visit frequency has no significant effect on preferences segmentation, generally in line with findings reported by Latinopoulosa et al. (2018) and Östberg et al. (2012) who find a significant effect of visit frequency on preferences but only for the status quo option and for specific study areas. Interestingly, the amount of plastic and litter noticed on beaches is significant only in South and South West England, which might be related to West Irish respondents favouring less crowded and more pristine beaches compared to English respondents. Finally, in line with Zambrano-Monserrate and Ruano (2020), Latinopoulosa et al. (2018), Brouwer et al. (2017) and Abate et al. (2020), environmental attitudes and participation in environmentally friendly activities significantly impact preferences segmentation, particularly in West Ireland where respondents on average participate more in beach clean-ups and similar events than in South and South West England. In studied areas, younger respondents (Class 1) are more averse to not taking additional actions to tackle marine litter and less sensitive to the monetary support required. However, other individual characteristics highlight some interesting insights. Experience with the coast and with marine litter noticed only influences preferences in South and South West England. Interestingly, in those areas respondents living closer to the beach (within 10 miles, Class 2) show stronger support for increased clean-ups while being less supportive for litter reduction and prevention policies, being indifferent to the introduction of a deposit return scheme. Respondents noticing a higher amount of litter and plastic items (Class 1) are more supportive of additional reduction and prevention policies, but still would prefer additional clean-ups. In West Ireland, participation in environmentally oriented activities and eco-friendly attitudes positively influence preferences towards marine litter clean-ups and policies. Preferences for long-term policies show other noteworthy differences. In all areas, Class 1 respondents support both a ban on single-use plastic and a deposit return scheme. In contrast, while Class 2 South and South England respondents hold lower preferences for the ban and are indifferent to the deposit scheme, West Irish Class 2 respondents hold stronger preferences for the long-term measures, particularly for the deposit return scheme.

[16] Several LCL models with different number of classes were estimated for each country separately. The number of optimal latent classes was iteratively investigated by examining the CAIC and the BIC. For the two areas in England, CAIC and BIC were minimised with 5 latent classes. In West Ireland, CAIC and BIC were minimised with 4 latent classes. However, the interpretation of taste and class allocation parameters resulted difficult or not meaningful in models with 3 to 5 latent classes.

Table 3
Socio-demographic characteristics of respondents by targeted area

		South England		South West England		West Ireland	
Variable	Categories	Sample ($N = 508$)	Population	Sample ($N = 506$)	Population	Sample ($N = 679$)	Population
Gender[a](%)	Female	53.1	51.3	53.8	51.5	52.0	50.7
	Male	46.9	48.7	46.2	48.5	48.0	49.3
Age[a](%)	18–24	11.5	10.4	10.1	10.4	8.6	8.1
	25–39	22.2	22.0	20.8	22.8	29.0	26.5
	40–54	22.2	24.2	22.1	25.7	29.4	28.8
	> 55	44.1	43.3	47.0	41.1	33.0	36.6
Education[b](%)	Higher education	38.6	40.6	35.0	39.2	58.2	45.7
Working status[c](%)	Employed	60.4	63.7	53.0	62.3	63.9	52.1
	Unempl/Inactive	39.6	36.3	47.0	37.7	36.1	47.9
Household composition[d](%)	One person	18.7	30.2	21.7	26.8	14.3	28.0
	Without children	51.9	42.2	49.6	37.3	45.2	27.0
	With children	29.4	27.5	28.7	21.5	40.5	45.0
Household income[e](national currency)	Mean value	31,775	24,715	26,717	21,222	34,115	28,598
	Missing (%)	7.9		8.3		13.6	

Notes: population data from [a] ONS and CSO population estimates 2018, [b] ONS Annual Population Survey 2019 and CSO Educational Attainment 2019, [c] ONS Regional headline indicators Labour Force Survey 2019 and CSO Census 2016, [d] ONS Household Projections 2018 and CSO Labour Force Survey Households and Family Units 2018, [e] ONS Regional GDHI 2019 and CSO County Incomes and Regional GDP 2018.

4.3. Willingness to pay for clean beaches

Table 5 summarises the marginal WTP values representing the amount that individuals would be willing to pay in relation to a specific attribute.[17]

Generally, respondents would be willing to monetarily support the implementation of both short-term clean-ups and longer-term prevention policies. Considering that both short- and long-term policies were presented as certain, the estimated welfare values show that short-term removal actions are favoured to longer-term policies in terms of the amount that respondents would be willing to pay or donate to see them implemented. Mean WTP calculated from the MMNL for removing an additional 50% to 100% of marine litter ranges between €33.04 and €52.96 in South and South West England and between €30.00 and €48.41 in West Ireland. Values are lower for prevention policies. Respondents living in the two English areas are on average willing to pay additional €18.73 in council tax to see implemented a ban on single use plastic, and additional €10.93 for a deposit return scheme being introduced in their residence area. Similarly, respondents living in West Ireland would be on average willing to monetarily contribute with €17.93 for a ban on single-use plastic and €9.72 for the implementation of a deposit return scheme. It is worth noting that WTP ranges appear to be wider for West Irish respondents than South and South West England ones. This is emphasised by the WTP calculated from the LCL. Confidence intervals generally overlap between the areas, with average willingness to pay estimates which appear to be in some cases higher for the West Ireland sample than for the South and South West English (e.g., for a ban on single-use non-recyclable plastic in Class 1). A marked difference is found between the two classes in all the areas, with older respondents who notice less litter and have lower eco-friendly attitudes willing to pay substantially less for actions tackling marine litter.

5. Discussion

Our results suggest that in the targeted areas marine litter is considered a relevant issue needing additional actions aimed at tackling it. Around 90% of respondents state to notice litter on beaches in their local area, mostly plastic, paper and cardboard items. Measures like bans on single use plastic items are thought to be most effective in reducing litter on beaches by 26% of respondents, followed by enforcement anti-littering laws (16%), alternative packaging and bags (13%), increased public bins for litter (12%), beach clean-ups (12%) and producers' responsibility (9%). Respondents identify individual behaviours as important to reduce marine litter (over 40%), but also call for more government policies and corporate social responsibility measures for manufacturers and marine operators. This, on the one hand, reinforces the urgency perceived by the general public about the problem (Lotze et al., 2018; Hartley et al., 2018; Gelcich et al., 2014), on the other resonates the need to tackle marine litter with more concerted and coordinated approaches involving both public and private sectors (Dauvergne, 2018; Vince and Hardesty, 2017). Indeed, litter removal, albeit not a definite solution to the marine litter problem, if coupled with additional preventive measures would help tackling the issue both in the short and long term by removing the litter existing and accumulating on beaches, decreasing the amount produced, and reducing the circulation of items that become marine litter.

Our findings on public preferences elicited in the choice experiment survey suggest that society would favour the implementation of an integrated policy mix including additional short-term efforts in removing litter from coastal habitats and long-term measures such as a ban on single-use non-recyclable plastic and local level deposit return schemes. In particular, the strongest preferences are found for clean-up actions on local beaches removing additional 50% or more of existing litter. This confirms strong public support for litter removal, echoing findings from other studies (e.g., Brouwer et al., 2017; Abate et al., 2020). As for long-term prevention policies, a ban on single-use non-recyclable plastic is preferred over a deposit return scheme. This may depend on higher familiarity with a policy instrument such a ban on plastic that is extensively enforced in the study areas and worldwide (Schnurr et al., 2018; Xanthos and Walker, 2017), but also on higher perceived inconvenience of a deposit return scheme (Roca i Puigvert et al., 2020). Crucially, considering that both short- and long-term policies are presented as certain in the choice experiment scenarios, short-term solutions are generally favoured over longer-term policies in terms of respondents' preferences in all cases except for the lowest clean-up level in the West Irish sample. Therefore, our findings indicate that society weighs immediate gains more than future-oriented prevention policies, possibly because of the effect of direct experience and distance of future outcomes, echoing findings related to other environmental consequences such as climate change (Pahl et al., 2014). Higher levels of perceived uncertainty attached to longer-term policies can also help explaining this difference in preferences, which might be influenced by respondents overweighting outcomes that are perceived to be certain (short-term litter removal) relative to outcomes that appear to be less certain or uncertain (ban and deposit scheme) which are underweighted

[17] WTP values in national currency are converted in Euro Purchase Power Standard. Purchase Power Parities considered are with Euro EU28 referred to household final consumption and are retrieved from Eurostat (2019).

Table 4
Results from the mixed multinomial logit model in preference space and the latent class logit model

	MMNL		LCL			
	South and South West England	West Ireland	South and South West England		West Ireland	
			Class 1 (81.3%)	**Class 2** (18.7%)	**Class 1** (82.4%)	**Class 2** (17.6%)
Class allocation						
Female			0.049		−0.0001	
			(0.186)		(0.251)	
Age			−0.378**		−0.359**	
			(0.098)		(0.145)	
Higher education			0.225		0.078	
			(0.189)		(0.256)	
<10 miles from coast			−0.598**		−0.057	
			(0.207)		(0.284)	
Visit rarely			−0.232		−0.249	
			(0.219)		(0.314)	
Visit often			−0.205		0.048	
			(0.276)		(0.415)	
Plastic noticed most			0.249*		0.068	
			(0.139)		(0.179)	
Amount litter noticed			0.642**		0.049	
			(0.181)		(0.209)	
Environment events			0.126		1.221*	
			(0.384)		(0.644)	
Litter clean-ups			0.451		0.786**	
			(0.310)		(0.325)	
Eco-friendly behaviours			0.362**		0.464**	
			(0.144)		(0.208)	
Mean coefficients						
Status quo	−0.732**	−1.580**	−0.541**	2.135**	−1.055**	2.225**
	(0.215)	(0.317)	(0.094)	(0.499)	(0.141)	(0.473)
25% marine litter removed	1.390**	0.924**	0.798**	1.313**	0.512**	1.052**
	(0.138)	(0.148)	(0.070)	(0.341)	(0.087)	(0.318)
50% marine litter removed	2.484**	1.782**	1.655**	1.003**	1.140**	1.085**
	(0.171)	(0.170)	(0.084)	(0.433)	(0.104)	(0.395)
75% marine litter removed	3.710**	2.771**	2.639**	2.413**	1.908**	2.225**
	(0.193)	(0.194)	(0.089)	(0.377)	(0.110)	(0.355)
100% marine litter removed	4.577**	3.267**	2.529**	3.259**	1.935**	2.690**
	(0.240)	(0.224)	(0.093)	(0.461)	(0.117)	(0.429)
Deposit return scheme	0.551**	0.569**	0.360**	0.309	0.317**	0.664**
	(0.087)	(0.091)	(0.040)	(0.196)	(0.049)	(0.212)
Ban single-use non-recyclable plastic	1.070**	0.986**	0.754**	0.586**	0.766**	0.820**
	(0.104)	(0.109)	(0.050)	(0.282)	(0.061)	(0.255)
Annual council tax/donation	−0.297**	−0.407**	−0.060**	−0.247**	−0.028**	−0.106**
	(0.027)	(0.109)	(0.002)	(0.028)	(0.003)	(0.012)
Standard deviations						
Status quo	2.407**	2.977**				
	(0.307)	(0.472)				
25% marine litter removed	1.298**	0.701**				
	(0.321)	(0.188)				
50% marine litter removed	1.517**	1.175**				
	(0.249)	(0.154)				
75% marine litter removed	1.985**	1.505**				
	(0.209)	(0.165)				
100% marine litter removed	2.717**	2.258**				
	(0.214)	(0.248)				
Deposit return scheme	0.944**	0.732**				
	(0.126)	(0.128)				
Ban single-use non-recyclable plastic	1.385**	1.443**				
	(0.137)	(0.098)				
Annual council tax/donation	1.188**	9.377				
	(0.269)	(7.054)				
N	1014	579	1014		579	
Log-likelihood	−5477.254	−3349.780	−5918.556		−3653.965	

Note: ** statistical significance 5% level; * statistical significance 10% level; Standard Errors in parenthesis.

(Kahneman and Tversky, 1979).

On average, preferences across the targeted areas are consistent, highlighting that marine litter is a dispersed issue and that policies tackling it, and the associated social costs, may be transferable between local areas and countries with similar socio-cultural and geographical circumstances. However, in line with Brouwer et al. (2017), differences across the study areas exist. Differences in individual characteristics also contribute to shape preferences for clean-ups and policy measures. The only socio-demographic variable associated with preferences segmentation is age. Younger respondents back clean-ups and prevention

Table 5
Marginal willingness to pay for beach clean-ups and prevention measures (in € Purchase Power Parity)

	MMNL in WTP space		LCL			
	South and South West England	West Ireland	South and South West England		West Ireland	
			Class 1	**Class 2**	**Class 1**	**Class 2**
25% marine litter removed	14.47	14.72	12.97	5.18	13.72	7.60
	[9.22–21.85]	[8.90–25.31]	[10.57–15.37]	[2.28–8.07]	[8.53–18.91]	[2.77–12.43]
50% marine litter removed	33.04	30.00	26.91	3.95	30.57	7.84
	[25.94–44.22]	[21.05–47.68]	[24.38–29.44]	[0.53–7.38]	[23.91–37.23]	[1.89–13.79]
75% marine litter removed	49.70	44.89	42.90	9.51	51.14	16.08
	[39.07–67.35]	[30.72–75.46]	[39.87–45.93]	[6.08–12.93]	[41.42–60.86]	[9.69–22.47]
100% marine litter removed	52.96	48.41	41.11	12.84	51.84	19.44
	[40.62–74.42]	[30.34–87.56]	[36.72–45.49]	[8.82–16.87]	[39.13–64.55]	[11.65–27.23]
Deposit return scheme	10.93	9.72	5.86	1.22	8.49	4.80
	[7.34–15.64]	[4.01–20.65]	[4.44–7.27]	[−0.37–2.81]	[5.13–11.85]	[1.39–8.21]
Ban single-use non-recyclable plastic	18.73	17.83	12.26	2.31	20.52	5.93
	[13.61–27.09]	[9.94–35.73]	[10.35–14.18]	[0.08–4.53]	[14.81–26.22]	[1.92–9.93]

Note: Confidence Intervals in parentheses.

policies more strongly, as also reported in Abate et al. (2020) and Latinopoulosa et al. (2018). In South and South West England, the more litter and plastic are found on local beaches, the higher is the support for additional measures against marine litter, mirroring the findings in Brouwer et al. (2017). Interestingly, respondents in those areas who live closer to the coast are also less likely to pay for additional clean-ups and prevention policies. A possible explanation could be related with the finding that respondents living closer to the beach also report a lower amount of litter noticed. For this reason, even if they have positive preferences for additional clean-ups and policy measures, they do not strongly feel the need for paying a higher amount of local taxes. Experience with the coast and marine litter does not influence preferences of West Ireland respondents. This could find a possible explanation in different uses of the coastal environment across the targeted areas. Indeed, there are statistically significant differences across samples in terms of beach visit frequency and motivations. Respondents living in West Ireland tend to visit the beach on average more than those in the two English areas and appear to be more interested in health benefits of visiting pristine and not crowded beaches.[18] Environmentally oriented activities and behaviours have an effect on framing respondents' preferences for litter clean-ups and additional policy measures, especially in West Ireland. This result suggests that raising awareness and improving information and education about the negative impacts of marine litter can boost societal preferences and willingness to contribute to tackle the problem (Pahl et al., 2017).

In conclusion, our findings reveal that households are prepared to pay more in council tax (€33–€53 in South and South West England per year per household) or donate to local organizations (€30–€48 in West Ireland) for marine litter removal actions, but are prepared to pay slightly less to introduce a single-use plastic ban (€19 in South and South West England and €18 in West Ireland) and a deposit return scheme (€11 in South and South West England and €10 in West Ireland).

6. Conclusions

Beach litter surveys conducted in the OSPAR region show an increase of litter, especially plastic, accumulating on the coast and call for more concerted and coordinated policy response. Our results show that marine litter is highly noticed on beaches and that there is a substantial desire to do something about it, starting with beach clean-ups (on a voluntary measure or managed by the municipality) but also tackling single-use plastic and other disposable materials. Understanding what the societal preferences towards marine litter are and the monetary value of the welfare benefits of not having marine litter on beaches is key to understand the welfare benefits loss related to the impacts that marine litter has on coastal and marine ecosystem services, such as coastal recreational activities. These economic results are useful to aid the comparison of costs and benefits of different options for public policies and management actions like beach clean-ups or combined policy/management actions to support decision making, which we find would encounter strong support from the public. Indeed, we find that a combination of short-term actions (litter removal) and long-term policies (ban and deposit return schemes) seems to be the preferred option. This seems logical as respondents may favour both actions with the immediate removal of existing marine litter together with wider policies in an attempt to limit the amount of new accumulating litter. Willingness to pay values can be taken as a benchmark for the choice about the prospective payments that could be introduced for funding clean-ups and additional measures: increased taxation, special purpose fees, entrance fees, etc. At a local level, also considering the differences between socio-demographic segments and locations is useful when framing such payments. Our results on increased awareness and information also highlight that policies accompanied by a more structured and clearer communication could lead to a more harmonised set of policies and actions tackling marine litter in wider geographical areas. The challenge for policy makers both at local, national and international level, therefore, lies in increasing communication of the damages marine litter produces on the environment, including human health and welfare, so to promote a future of 'litter free' behaviours both locally and upstream whilst acting on mitigating the effects of the already circulating marine litter in the oceans. Future research may consider investigating the level of knowledge about marine litter worldwide, and how this knowledge can be improved and influences public preferences. Exploring how appropriate international and local policies can be applied based on the monetary contribution affordable by different populations which are affected and contribute to increasing marine litter will be key. Therefore, robust comparative studies between different areas and countries are needed. Finally, the role of uncertainty around marine litter policy outcomes needs further exploration as well as the individual strategic behaviour in implementing public policy projects and in responding to choice experiment options.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

[18] A Chi-squared test reveals differences across the study areas with respect of the comparisons considered in terms of visit frequency and motivations.

Data availability

Data will be made available on request.

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