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Exploring public views on marine litter in Europe:

Perceived causes, consequences and pathways to change

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Abstract

Marine litter is a global challenge and society plays an important role via lifestyles and behaviour, including policy support. We analysed public perceptions of marine litter and contributing factors, using data from 1133 respondents across 16 European countries. People reported high levels of concern about marine litter, and the vast majority (95%) reported seeing litter when visiting the coast. The problem was attributed to product and packaging design and behaviour rather than lack of facilities or accidental loss of items. Retailers, industry and government were perceived as most responsible, but also least motivated and competent to reduce marine litter, whereas scientists and environmental groups were perceived as least responsible but most motivated and competent. Regression analyses demonstrated the importance of psychological factors such as values and social norms above socio-demographic variables. These findings are important for communications and interventions to reduce inputs of marine litter to the natural environment.

Highlights

- Public perceptions play an important role when devising interventions to reduce marine litter
- This paper analysed over 1000 public survey responses from 16 European countries
- Respondents reported high concern and over 95% of them reported seeing litter when visiting the coast
- Marine litter was attributed to product and packaging design
- Perceived responsibility, motivation and competence of different stakeholders were compared
- Values and norms were more highly associated with concern and behavioural intentions than were sociodemographic variables

Exploring public views on marine litter in Europe:

Perceived causes, consequences and pathways to change

1. Introduction

1.1. Marine Litter and Policy Background

Litter in the marine and coastal environment has emerged as a growing concern at the highest level. For example, in 2015, the Leaders' declaration at the G-7 summit stated "We acknowledge that marine litter, in particular plastic litter, poses a global challenge, directly affecting marine and coastal life and ecosystems and potentially also human health." (https://www.whitehouse.gov/the-press-office/2015/06/08/g-7-leaders-declaration). Marine litter consists of any persistent, manufactured or processed solid material discarded, disposed of or abandoned on the coastline or at sea, and it arises as a consequence of the unsustainable consumption and production patterns of many sectors of society, ranging from industry, fisheries and aquaculture, tourism to individuals. It is a global problem without regard for national borders (Galgani et al., 2010; STAP, 2011; UNEP, 2005). Around 700 species are known to encounter marine debris in the environment, and negative ecological effects include increased harm to marine organisms via ingestion and entanglement (Gall & Thompson, 2015; Gregory, 2009). The socio-economic costs associated with marine litter are increasing, and it is thought to interfere with a range of ecosystem services including cultural services such as psychological and physical health benefits derived from visits to coastal environments (GESAMP, 2015; 2016; Mouat et al., 2010; Wyles et al., 2014). Plastics are regarded as one of the most problematic aspects of marine litter because of their abundance, longevity and the fact that large marine litter items break down into ever smaller parts termed microplastics (Law & Thompson, 2014). Whilst there is substantial scientific literature on the abundance, physical causes and impacts of marine litter, little research to date has examined the public's views on both the problem and the potential solutions.

In Europe, marine litter has received major attention because it is one of the eleven Descriptors within the Marine Strategy Framework Directive (MSFD – European Directive 2008/56/EC). Work by European Regional Seas Conventions aids the development and implementation of Regional Action Plans on marine litter in the context of other EU policy frameworks and legislation, including the Waste Framework Directive, the Packaging and Packaging Waste Directive, the Water Framework Directive, and the Cosmetic Products Regulation (Kershaw, Alcaro, Garnacho, Doyle, Maes, & Painting, 2013). While the problems associated with marine litter are focused in the coastal and marine environment, this debris originates mainly from land and the solutions to the problem lie on land. Therefore, actions to reduce marine litter must involve concerted efforts across nations, disciplines and stakeholder groups, considering a variety of pathways. Actions must involve the general public, commercial users of the ocean and coasts, waste management agencies, industry (e.g., product designers and manufacturers), regulators, educators, environmental NGOs and CSOs, national, regional and local government. Focusing on plastics specifically, this ambition is realised in the first-ever Europe-wide strategy on plastics adopted in January 2018. Marine litter is an issue without borders and understanding public views on marine litter is of crucial importance for the successful implementation of any prevention, reduction and mitigation policy measures.

Human behaviour is the sole source of marine litter, and changing perceptions and behaviour is key to tackling litter escaping into the natural environment (Pahl et al., 2017). The general public plays an important role in addressing marine litter through their lifestyles and consumption patterns, waste management practices, and support or other engagement in the implementation of policies aiming to address marine litter such as the plastic bag directive (European Directive 2015/720/EC; Poortinga et al., 2013). Therefore, understanding public perceptions and responses to the issue of marine litter is a critical step in effectively engaging

society and in developing and implementing widely acceptable solutions to reduce litter inputs into marine and coastal systems.

This paper explores public views on marine litter in Europe, specifically focusing on perceived causes, consequences and pathways to change. The work was done in the context of a wider study on stakeholder perceptions, carried out as part of the European MARLISCO project (Veiga et al., 2016). In this paper we focus on findings related to responses from the general public rather than all stakeholders and offer new insights into how the European public perceives and responds to the issue of marine litter. First, we review relevant social-psychological theories of environmental behaviour and then summarise the (limited) literature on marine litter perceptions that is currently available.

1.2. Social-psychological theories and research on environmental behaviour

Human behaviour plays an important role in both contributing to and mitigating environmental problems, and it is crucial to understand the determinants of environmental behaviour (Kloeckner, 2013; Pahl & Wyles, 2016). There is a substantial body of theory and research on environmental behaviour and perceptions for different environmental challenges, e.g., climate change and energy use (Gardner & Stern, 2002; Gifford, 2014; Kloeckner, 2013; Schultz, 2001; Stern, 2000). For example, the *Theory of Planned Behaviour* (TPB, Ajzen, 1991), *Norm-Activation-Theory* (NAT, Schwartz & Howard, 1981; Thøgersen, 1996), and *Value-Belief-Norm-Theory* (VBN, Stern, 2000) are some of the most commonly used theories in the environmental psychology domain. Kloeckner (2013) recently tested an integrative model, combining data from 56 data sets targeting different environmental behaviours. He identified intentions, attitudes, perceived responsibility and awareness of consequences as relevant predictors of behaviour. This is in line with Gifford's 2014 review, which listed psychological predictors of behaviour (e.g., knowledge and awareness, concern, perceived control, values, attitudes, personal responsibility, moral and social norms, personal

experience of and proximity to the problem) as well as demographic characteristics (e.g., age, gender, education level). Our study broadly but selectively draws on these underlying theoretical frameworks and factors, but it does not test a specific theory. Instead it is a first exploration of the psychological behaviour change approach as applied to the issue of marine litter in Europe, to identify and describe current understanding and perceptions as well as relevant predictive factors in this novel context.

1.3. Public perceptions of threats to the marine environment

Emerging literature describes public perceptions and understanding of marine environmental issues broadly. Initial studies focused on specific populations or contexts. For example, Fletcher et al. (2009) explored the views of visitors to the UK's National Maritime Museum on marine environment related issues, and Scott and Parsons (2005) explored the opinions of Scottish respondents on cetacean conservation issues. "Pollution" was rated as the most pressing issue in the Fletcher et al. (2009) study, and oil spills, reduction of prey and marine litter (in this order) were perceived as the most serious UK threats in the Scott and Parsons (2005) study. A larger recent survey asked participants in ten European countries to list the three "most important environmental matters" regarding the coastline or the sea. General pollution was the top category with 33% of responses (Gelcich et al., 2014). This category included mentions of water pollution, oil pollution, sewage etc., but not mentions of solid marine litter as defined above. Gelcich et al. (2014) were also the first to present data on perceptions of organisations or societal actors in the complex system of marine environmental matters. They found that scientists and environmental organisations were among the most trusted, with industry and government among the least trusted to provide information on marine environmental issues. These are important insights but the focus of the trust question was on "climate change impacts on the coastline and the sea" (p. 3), and trust itself is determined by a range of different elements including perceived motivation and

competence that are worth exploring further (see Section 1.4). Finally, Potts et al. (2016) report data from a large-scale survey exploring the links between society and the sea in seven European countries. Next to perceived threats they also investigate the perceived value of the ocean, in line with an ecosystems services approach (e.g., Sandifer et al., 2015). Potts et al. (2016) were the first to investigate perceived threat from *specific* marine issues, and pollution from industry, litter, and oil and gas extraction were perceived as the most severe threats by their European respondents. They also distinguished coastal and inland populations in their analysis but intriguingly found little effect of distance to the coast. However, a mere residential distance measure might have been unable to pick up more subtle effects of frequency of actual visits to the coast and of noticing marine litter.

In summary the small academic literature on public perceptions of marine environmental threats is growing but to date there is very little data on one of the biggest societal challenges of our times, marine litter, specifically (Brennan & Portman, 2016). There are a few exceptions. In an early study, Bonaiuto et al. (1996) showed that strong local identity was associated with defensive perceptions of beach quality in the UK. A small-scale study by Wyles et al. (2015) that found that general public respondents rated coastal litter originating from the public (e.g., food packaging) more negatively than they rated fishing litter (e.g., nets). Hartley et al. (2015) showed that British children were more concerned and had higher intentions after a marine litter educational intervention. A qualitative study by Brennan and Portman (2016) focused on a specific group of stakeholders: Arab-Israeli artisanal fishermen. The latter study emphasises the importance of understanding the system and the interconnected drivers that contribute to the problem, including issues of trust and power. It is desirable now to go beyond these locally specific studies of marine litter. Insights and data are missing that connect perceptions of the problem with perceptions of its drivers, both at the societal level (which stakeholder groups are perceived as competent and

motivated to deal with the issue) and at the individual level (are respondents themselves concerned, keen to take action and willing to change their own behaviours).

1.4. Behavioural approaches to littering

Other work has studied littering with a focus on behavioural decisions. The majority of individuals here reported not littering on the beach, but adults in their 20s and 30s were more likely to report littering than were older participants, and less likely to report feeling guilt associated with littering (e.g., Campbell et al., 2014; Santos et al., 2005; Slavin et al., 2012). Despite generally claiming not to be individually responsible, the majority of respondents in such surveys identify beach users as the main source of marine litter. Santos et al. (2005) also showed that beach users believed the main problems caused by marine litter were related to the impact on human health and safety, marine biota, and attractiveness. In terms of solutions, beach users endorsed improved education, provision of more bins, and a fine for littering (Eastman et al., 2013; Santos et al., 2005).

Littering behaviours in general have been shown to be predicted by social norms and self-awareness (Cialdini et al., 1990; de Kort et al., 2008), personal cost-benefit analyses (Sutinen, 1997), and incentives (Baltes & Hayward, 1976). For example, pro- versus anti-littering norms indicate what behaviour is typical (descriptive norm) and acceptable or expected (prescriptive norm) in a given situation. A well established finding from experimental research is that individuals are more likely to litter in a littered, compared to clean, environment, and are less likely to litter after observing someone pick up litter (Cialdini et al., 1990; Cialdini, 2003; Keizer et al., 2008; Schultz et al., 2011).

Positive reinforcement such as rewards for not littering and monetary incentives can also help reduce littering and increase recycling, but they work on the principle of extrinsic motivation. This incurs the risk of the behaviour stopping when the incentives stop (De Young, 1993; Halvorsen, 2012). Specific emotions, such as shame and embarrassment, that

appeal to a sense of conscience, social pressure, or community pride may also act as a deterrent (Grasmick et al., 1991). A parallel line of research on recycling behaviour has similarly shown that social norms, monetary incentives, and sense of moral obligation play a powerful role (Hage et al., 2009; Hornik et al., 1995; Schultz et al., 1995). Although this research has not assessed attitudes and behaviours directly related to marine litter, littering and recycling patterns in general are highly relevant for marine litter.

Aside from littering and recycling behaviours, influencing people's consumer behaviour is becoming priority in European environmental and consumer policy (Niva & Timonen, 2001). There is evidence that consumers are concerned about non-recyclable product packaging and about the amount of packaging (Grunert et al., 2014). In addition, individuals appear willing to trade off a number of product attributes in favour of environmentally friendly packaging (van Birgelen et al., 2009). This research also found that consumers who take ecological packaging into account when purchasing products are more likely to take ecological disposal decisions.

Individual behaviour change, though powerful, cannot be the only pathway to reducing litter entering the marine environment. Earlier we argued that most marine litter stems from land-based sources, and these include different actors in the system who influence the flow of materials and products through society, from production to disposal. In addition to the general public, these actors range from product designers and retailers to environmental NGOs, government representatives, policy makers and industry involved in waste collection and disposal. In order to progress towards a reduction in marine litter, it is important to understand how these actors are viewed by the public, for example who is thought to be competent, responsible and motivated to deal with the issue and who is not. Gelcich et al. (2014) demonstrated that trust in the context of marine environmental problems in general varies considerably and is highest for independent academics and NGOs and lower for

industry and government, in line with other risk perception literature. We take this approach a step further and focus on three aspects. We asked our public sample to rate their perceptions of *responsibility* for the different actors, which should highlight who should be dealing with the issue (e.g., polluter pays principle; fairness), the level of *competence* to deal with the issue (competence is a key factor underlying trust, e.g., Poortinga & Pidgeon, 2003; White & Eiser, 2006) and the level of *motivation* (reflecting how keen the public thought these actors were to deal with the issue).

In sum there is limited research to date assessing public perceptions and behaviours related to marine litter, a pressing global problem. Moreover, research is lacking into the psychological and sociodemographic factors that predict individuals' concern about marine litter and their willingness to act on the problem. The present research is the first to provide a quantitative assessment of individual's attitudes and behavioural intentions regarding marine litter across Europe with the aim of exploring what the public understand about the issue of marine litter and the factors that lead to its accumulation, their concern, perceived responsibility, competence and motivation, and personal intentions to address the problem.

We were led by five research questions, (1) To what extent are people exposed to and notice marine litter and what do they value about the coast? (2) Do the general public recognise marine litter as an important problem and how concerned are they? (3) What are public perceptions of the threats marine litter poses, the pathways by which it reaches the marine environment, and the sources of marine litter? (4) How responsible, competent and motivated does the general public perceive themselves and other stakeholders to be? (5) Which sociodemographic and psychological factors predict behavioural intentions and concern?

2 Methods

2.1 Participants and Design

A total of 1131 individuals (459 male and 672 female) aged 16-89 years (*Mean age* = 36.25, *SD* = 14.53) participated in the survey across 16 European countries. Respondent numbers varied considerably between countries (> 100 from Portugal, France, UK; between 50 and 90 from Denmark, Italy, Romania, Turkey, Germany, Netherlands; between 20 and 50 from Greece, Cyprus, Ireland, Slovenia; < 10 from Spain, Bulgaria, and Belgium), hence no between-country comparison was undertaken. Education level among participants was: 1.6% no formal education or complete primary school, 7.5% incomplete secondary school, 17.9% complete secondary school, 15.0% some university-level education, without degree, and 57.7% university-level education, with degree.

2.2. Procedure and Measures

A survey was developed specifically for this study (see below). After piloting and minor amendments, the survey was translated into the native language by the national MARLISCO partners, and distributed by email, social media, and at engagement events (convenience method). Respondents were invited to take part in a European-wide survey "Perceptions about marine litter" and asked to send the link to friends, family and colleagues to reach a wider and varied sample (snowball method). Participants were told that the survey sought to understand their perceptions about marine litter and comprised questions about where marine litter comes from, what the consequences are, who is responsible and what solutions there are. Individuals provided consent to participate in the research and confidentiality of responses was ensured. Participants generally completed the survey online[1] which took approximately fifteen minutes.

We used a quantitative social survey method whereby respondents selected a response option that was then coded as a number (e.g., 1 – extremely unlikely to 5 – extremely likely). In line with the quantitative social science literature, we report these scores as Means and

[1] Twelve participants completed the survey on paper due to having no access to computer or internet.

provide Standard Deviations in the descriptive part and make statistical comparisons (Sections 3.1 to 3.4). This approach also enables us to apply multivariate methods that can integrate different responses into broader regression analyses (Section 3.5).

2.2.1. Problem awareness and concern. Nine items measured this, including *'Marine litter is a very important problem'*, *'I am concerned about the impacts of marine litter'*, *'Marine litter is a future environmental threat rather than a present one'*, and *'Marine litter is only a problem for coastal communities'*, *'There is not enough evidence to properly conclude that marine litter is a problem'*. Participants indicated their agreement with these statements using response options from 1 (*strongly disagree*) to 5 (*strongly agree*).

2.2.2. Ecological and socio-economic impacts. Five items assessed perceptions about the potential consequences and harmful ecological and socio-economic impacts of marine litter, including effects on the marine environment, tourism, human health, shipping and fishing industries, and the aesthetics of the coast. Participants indicated how large a threat marine litter posed to each of these, in their opinion, with response options from 1 (*no threat*) to 5 (*severe threat*).

2.2.3. Pathways and factors contributing to marine litter. Five items measured this, including direct release on the coast, direct release in the sea, via rivers, from sewage overflows, and blown from landfills. Participants indicated how much each pathway contributed using response options from 1 (*none*) to 5 (*a large amount*). A further seven items assessed perceptions about the importance of different factors in contributing to marine litter, with response options from 1 (*not at all important*) to 5 (*very important*). Items included factors such as the behaviour of the public when disposing of litter, lack of bins, lack of enforcement, losses in transport, and excess product packaging.

2.2.4. Perceived responsibility, competence, and motivation of self and others. Participants rated how responsible, competent, and motivated they perceived themselves and 11 other

stakeholder groups to be, using response options from 1 (*strongly disagree*) to 5 (*strongly agree*). The 11 stakeholders were: The general public, environmental groups, independent scientists, Government and policy makers, industry that design and make products, retailers, commercial users of the coast and sea, organisations that collect waste, organisations that process waste, educators, and the media.

2.2.5. Social norms. Participants indicated their agreement with two statements from 1 (*strongly disagree*) to 5 (*strongly agree*); *'Most of my family and/or friends think it is important to reduce marine litter'* and *'Most of those close to me will support me in taking steps to reduce marine litter'*.

2.2.6. Value of the coast. Ten items measured the value that participants placed on the coast and sea. Participants indicated how valuable the coasts and seas are to society in a number of ways, on response options from 1 (*not at all valuable*) to 5 (*very valuable*). The items included values that tend to be perceived as more egoistic in nature - serving the self or society for physical or monetary value (for recreation and tourism; as a source of food; for trade and shipping; for employment; as a source of energy) and values that tend to be perceived as more altruistic or biospheric, in nature - serving others and the environment (as part of your culture and identity; for education and science; for its scenery and aesthetics; for its role in supporting biodiversity in plants and animals; as a legacy to preserve for future generations).

2.2.7. Behavioural intentions. Four items measured participants' willingness to take action to reduce marine litter and effect change (behavioural intention); *'Buy re-useable rather than single-use "disposable", non-biodegradable products'*, *'Ask people to pick up their litter if you see them littering'*, *'Support Government policy/legislation on marine litter'*, and *'Pick up litter that you see at risk of entering the sea'*. Participants rated how likely they would be to perform each of these behaviours, from 1 *(extremely unlikely*) to 5 (*extremely likely*).

Participants also provided socio-demographic information including age, gender, country of residence, highest level of education attained, and proximity to the coast (standardised in km).

3. Results

The results are presented in five sections. First, we present contextual information about our sample in terms of proximity to the coast, frequency of coastal visits, frequency of noticing litter on visits to the coast, and value placed on the coast (Section 3.1). Second, we present overall problem awareness and concern about marine litter (Section 3.2). Third, we present perceptions of the negative impacts, the pathways and factors that contribute to marine litter (Section 3.3). Fourth, we examine the level of responsibility, competence and motivation the general public attribute to themselves and other stakeholders (Section 3.4). Finally, we present results from two hierarchical linear regression analyses examining which factors predict (a) individuals' behavioural intentions and (b) individuals' level of concern (Section 3.5).

3.1. Distance to the coast, coastal experience, and perceived value of the coast

Respondents to the survey lived between 0 and 1000 km from the coast (M = 58.20km, SD = 121.83) and over 65% reported visiting the coast monthly or more frequently, and less than 1% reported they never visit the coast (see Fig. 1a). In addition, over 95% had noticed marine litter on at least some visits to the coast, and less than 5% reported that they had never or rarely noticed marine litter (see Fig. 1b).

Participants thought that the coasts and seas were valuable to society for a number of reasons (Table 1). We conducted a factor analysis (with varimax rotation) on the 10 'value of the coast' items which resulted in a two-factor solution with 5 items in each factor. We labelled the two factors 'egoistic coastal value' (Cronbach's α = .78) and 'altruistic-biospheric coastal value' (Cronbach's α = .82) (Table 1). In sum, participants visited the

coast and noticed marine litter frequently, and perceived different aspects of the coast as highly valuable.

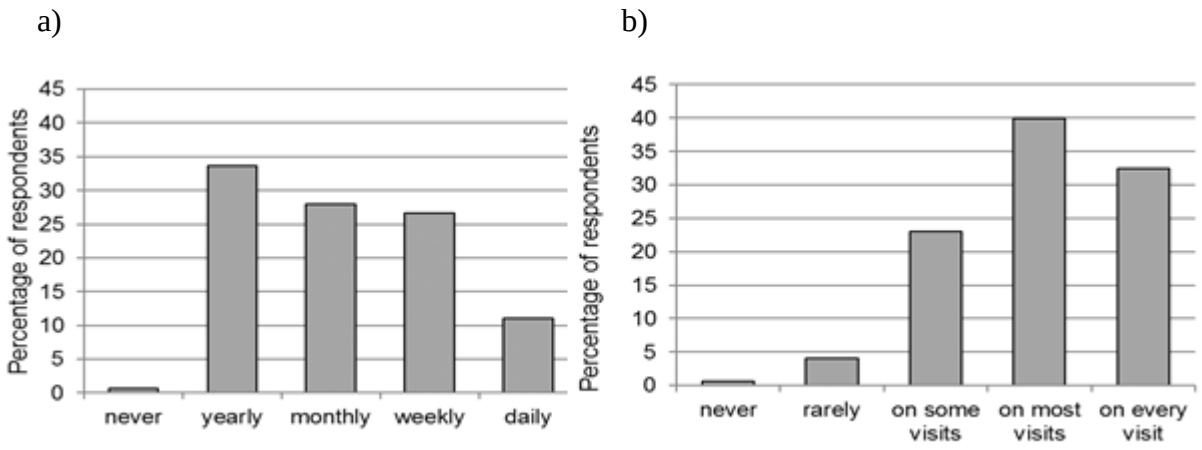


Fig. 1. Percentage of participants reporting a) visiting the coast and b) noticing marine litter on their visit

Table 1. Means and standard deviations for altruistic-biospheric and egoistic value of the coast (N=1128). Means represent responses from 1 - not at all valuable to 5 - very valuable.

	Mean	***SD***
Altruistic-Biospheric coastal values:		
For its role in supporting biodiversity in plants & animals	4.79	0.59
As a legacy to preserve for future generations	4.77	0.60
For its scenery, aesthetics	4.62	0.71
As part of your culture & identity	4.44	0.88
For education & science	4.44	0.82
Egoistic coastal values:		
For recreation & tourism	4.64	0.70
As a source of food	4.63	0.72

For trade & shipping	4.47	0.80
For employment	4.24	0.88
As a source of energy	4.18	0.98

3.2. Overall problem awareness and concern

Participants perceived marine litter to be an important problem and were concerned about it (average of the nine items in the scale: M=4.32, SD = 0.57). More specifically, participants agreed that the quantity of marine litter is increasing (M=4.35, SD = 0.93), that it represents a present threat, not just a potential future concern (M=3.67, SD = 1.39), that will cause lasting damage (M=4.58, SD = 0.92), and is a problem for all - not just coastal communities (M=4.48, SD = 0.90) or other countries (M=4.51, SD = 0.94).

3.3. Perceptions of threats, pathways and sources

We conducted a series of one-way repeated measures ANOVAs with pairwise comparisons to examine participants' understanding about the different negative impacts, pathways, and causes of marine litter, and to determine which impacts, pathways, and causes participants perceived as more important (Table 2).

3.3.1. Ecological and socio-economic impacts. Participants thought marine litter posed different levels of threat to the marine environment, the appearance of the coast, human health, tourism at the coast, and the shipping and fishing industry (repeated measures ANOVA $F(4, 4504) = 494.31$, $p<.001$, $\eta^2 = .31$). Pairwise comparisons indicated that participants perceived marine litter as posing the greatest threat to the marine environment (significantly greater than the threat posed to the appearance of the coast, $p<.001$)[2].

[2] Bonferroni correction for multiple comparisons was applied here and in all subsequent pairwise comparisons by diving the conventional significance level .05 by the number of comparisons made.

Participants perceived marine litter as posing the least threat to the shipping and fishing industry (Table 2).

3.3.2. Sources, pathways[3] *and factors contributing to marine litter.* Participants rated different factors as differing in importance for litter reaching the marine environment (repeated measures ANOVA $F(4, 4500) = 195.00$, $p < .001$, $\eta^2 = .15$. Pairwise comparisons show that participants thought most litter reaches the marine environment via direct releases in the sea (significantly greater than direct release on the coast, $p < .001$). Participants thought that the least litter reaches the marine environment via litter blown from landfill or landfill collapses and via sewage overflows.

Participants distinguished between factors contributing to marine litter (repeated measures ANOVA $F(6, 6756) = 255.72$, $p < .001$, $\eta^2 = .185$). Pairwise comparisons indicated that extensive use of plastic in everyday products and packaging and the behaviour of the public were perceived as the most important causes of marine litter (significantly more important than other causes $p < .001$). Participants perceived a lack of bins in public areas and losses during transport of products or waste as the least important pathway of marine litter.

3.4. Perceived responsibility, competence and motivation of different stakeholders

To explore factors underlying trust, Figure 2 shows how responsible, competent and motivated participants perceived stakeholders to be in reducing marine litter. A series of *t*-tests, with Bonferroni correction for multiple comparisons, showed that the majority of sectors were rated as being significantly more *responsible* than *competent* and more *competent* than *motivated* (*ps* < .001). Some groups were rated in the opposite direction: environmental groups were rated as significantly more *motivated* than *competent* and

[3] Technical definitions of these terms have been suggested (Veiga, Fleet et al., 2016) but we largely keep the common sense usage here.

significantly more *competent* than *responsible*, and independent scientists were rated as significantly more *competent* and *motivated* than *responsible* ($p < .001$). Participants rated themselves as equally responsible and motivated but lower in competence. In addition, organisations that collect waste, organisations that process waste, and educators were rated as equally responsible and competent.

Table 2. Perceived negative impacts, pathways and sources of litter (N=1127). Subscripts indicate significantly different pairwise post-hoc comparisons within each category.

	M	***SD***
Impacts (1-no threat to 5-severe threat):		
Marine environnement	4.73[a]	0.68
Appearance of the coast	4.08[b]	0.94
Human health	3.85[c]	0.99
Tourism at the coast	3.57[d]	0.96
Shipping and fishing	3.46[e]	1.01
Sources and pathways (1-none to 5-a large amount):		
Direct release in the sea	4.14[a]	0.87
Direct release on the coast	3.74[b]	1.08
From rivers and estuaries	3.70[b]	0.96
Sewage overflows	3.35[c]	1.08
Landfill collapses or blown from landfill	3.20[d]	1.07
Contributing factors (1-not at all important to 5-very important):		
Extensive use of plastic in products & packaging	4.35[a]	0.92
Behaviour of public when disposing of litter	4.35[a]	0.92
Single-use nature of products & packaging	4.12[b]	0.97
Behaviour of coastal industries	4.06[b]	0.94
Lack of waste disposal enforcement	4.02[b]	0.98
Losses during transport of products or waste	3.65[c]	1.10
Lack of bins in public areas	3.23[d]	1.09

---Figure 2 about here---

3.5.Which variables predict individuals' behavioural intentions and concern?

3.5.1. Predicting behavioural intentions to reduce marine litter

We conducted a hierarchical linear regression analysis with five steps to examine variables associated with people's intentions. Demographic variables (age, gender and education level) were entered first, then accessibility and experience variables in three separate steps (proximity to the coast in km[4], then frequency of coastal visits, and then frequency of noticing litter at the coast), and finally psychological variables were entered (concern, perceived responsibility competence and motivation for the self and general public, altruistic-biospheric and egoistic coastal values, and social norms). This step-wise approach allowed us to isolate the effect of the psychological variables, controlling for demographics and exploring accessibility and experience factors.

All five models were significant (see Table 3). We focus on the results from model 5 where all demographic, context and psychological variables are considered. Age, gender and education level significantly predicted intentions. Women, individuals with a higher level of education, and older participants were significantly more likely than were men, individuals with a lower level of education and younger participants to report behavioural intentions to reduce marine litter. Noticing litter on visits to the coast also still significantly predicted behavioural intentions, such that those who noticed litter more frequently reported higher intentions to reduce it.

Moreover, concern and perception of risk surrounding marine litter positively predicted behavioural intentions. Whilst perceptions about the level of general public responsibility, competence and motivation to reduce marine litter did not significantly predict behavioural intentions, perceiving oneself as competent and motivated was positively associated with intentions. In addition, perceiving that the marine environment had both

[4] Two dummy variables were created for the 'Proximity to the coast' variable; 0-5km and >5-20km, with >20km as the reference category (cf. White et al., 2012).

altruistic-biospheric *and* egoistic value positively predicted intentions. Perceiving that family and friends think it is important to reduce marine litter (Norm – important) did not predict behavioural intentions, however, perceived support (Norm – support) from close others positively predicted intentions, such that participants who perceived greater support from people around them reported being significantly more likely to take action to reduce marine litter.

Whilst other variables appeared as significant predictors of behavioural intentions at earlier stages of the regression, they did not remain independent predictors when other factors were taken into account in subsequent models (Table 3). Specifically, aspects of accessibility and experience of the coast and marine litter were significant predictors of behavioural intentions in model 2. Compared to participants living >20km from the coast (reference category), those living between 5-20km reported being significantly more likely to take action to reduce marine litter. However, when accounting for frequency of coastal visits (in model 3), proximity to the coast no longer significantly predicted behavioural intentions, but participants who visited the coast more frequently reported being significantly more likely to take action than less frequent visitors (an effect that was then accounted for by frequency of noticing litter on visits to the coast in model 4).

---Table 3 about here---

3.5.2. Predicting concern about marine litter

We conducted a second hierarchical linear regression with the same five steps to examine which variables predicted participants' level of concern regarding marine litter (the analysis was identical to the previous regression, but with concern as the outcome variable, Table 4). Again, we focus on the results from model 5 where all demographic, context and psychological variables are considered. Education level significantly predicted concern, such

that people with a higher level of education reported more concern about marine litter than people with a lower level of education. Accessibility and experience of the coast and marine litter also significantly predicted concern; those who visited the coast and noticed litter more frequently reported greater concern.

Moreover, perceiving oneself as responsible and motivated was associated with greater concern, whilst perceiving the general public as motivated was associated with less concern. In addition, perceiving the marine environment as having altruistic-biospheric value positively predicted concern, whereas perceiving the marine environment as having egoistic value did not. Perceiving that family and friends think it is important to reduce marine litter and that participants had support from close others positively predicted concern.

---Table 4 about here---

4. Discussion

Marine litter has been acknowledged as a major and growing issue of concern worldwide. The present research fills an important gap in research about public perceptions and social drivers related to the issue. We found that marine litter was recognised as an important problem and associated with high levels of concern; the public have a mixed understanding of the pathways and impacts associated with marine litter; the public hold differential perceptions about the responsibility, competence and motivation of various stakeholders. Finally, we ran integrative analyses demonstrating the relative importance of psychological and socio-demographic factors for behavioural intentions to act against marine litter, and levels of concern. A key finding here was that the more litter people noticed on the

coasts, the higher was their concern and willingness to act, even after controlling for all other variables.

4.1. Levels of concern and perceptions of causes and impacts

Our respondents expressed considerable concern about marine litter and perceived it as an important problem. There was no evidence for scepticism or distancing, which would have been easy to express (e.g. by stating it is a future rather than present problem in the relevant question). This concern is consistent with previous studies documenting perceptions of broader marine environmental issues (e.g., Fletcher et al., 2009; Gelcich et al., 2014; Scott and Parsons, 2005) but ours is the first study to focus explicitly on marine litter.

Respondents rated impacts on the marine environment higher than impacts on human health, tourism, shipping and fishing. The same pattern was found in Hartley et al.'s 2015 study on school children and indicates either that there is simply more information available about effects on wildlife (e.g., the widely disseminated images of turtles or seals caught in marine litter), or that people place more weight on those types of impact than on others (e.g., fishermen bearing extra repair costs due to marine litter damaging equipment). This is broadly consistent with the marine science literature that has over many years established the impacts of marine litter on marine and coastal wildlife (e.g., Gregory, 2009; Gall and Thompson 2015; Werner et al., 2016). Much less work is currently available on the factors that drive marine litter pathways and solutions to reduce it than there is on the impacts. Our work is hopefully a step towards developing publicly acceptable solutions to reduce marine litter. The impacts of litter on the marine environment might function as a powerful motivator when linked to behaviour and systems on land. While most people are perhaps not too keen on engaging in waste management, the lure of the sea is strong and many communities are

very active in protecting marine life and cleaning beaches. This enthusiasm has the potential to change land-based processes (Pahl et al., 2017).

Participants thought most litter reached the marine environment via direct releases in the sea, which is somewhat at odds with scientific literature that the majority of marine litter originates from human activities on land (GESAMP, 1990; Thompson et al., 2009). It is therefore important to raise public awareness about the variety of sources and pathways land-based and riverine by which litter reaches the marine environment. That said, participants did connect some general activities carried out on land as important sources of marine litter, including extensive use of plastic in everyday products and packaging and the behaviour of the public when disposing of litter. In addition, the causes participants identified as most important arguably reflect factors that are easier for the public and individual to prevent, compared to other factors which were rated as less important causes and which tend to implicate others sectors more (e.g., a lack of bins, lack of enforcement of waste management, losses during the transport of products or waste; behaviour of coastal industries).

4.2 Perceptions of stakeholder responsibility, motivation and competence

Solutions to marine litter require concerted and coordinated efforts across multiple stakeholder groups and sectors. Any efforts by particular sectors or stakeholders will be interpreted in light of perceptions about their motivation, responsibility, and competence. In our research participants perceived all stakeholder groups as somewhat responsible and competent (with significant variation), but some groups were perceived relatively low in terms of their motivation to effect change. In particular, retailers, industry, government and policy makers, the wider general public, commercial users of the coast, and the media were perceived to have the lowest motivation, yet they were perceived to have high levels of responsibility and competence. In contrast, participants perceived themselves, environmental groups, independent scientists and educators as being more motivated to reduce marine litter

(and at levels that were more comparable with responsibility and motivation attributed to these groups). Therefore, groups that are perceived as highly responsible (and competent) but less motivated may be regarded as being particularly problematic by the general public, and by implication less trusted. This is an important extension to previous research on trust (Potts et al., 2016) that provides important insights into what underlies overall levels of trust. It could be worthwhile for organisations that are less trusted to remedy these perceptions and communicate their efforts in order to change the public's perception of them and move to joined-up action.

4.3 Integrating socio-demographic, contextual and psychological factors to predict concern and behavioural intentions

Finally, a key purpose of this study was to combine different aspects in an integrative analysis to understand the factors predicting individual concern and behavioural intentions for reducing marine litter, which is a first in the literature on marine environmental threats. Participants who were older, female, had a higher educational level, accessibility to and experience of the coast and marine litter, reported greater concern, personal motivation, competence, social support, and who placed higher value on the coast, reported greater willingness to act. These factors are consistent with theories of environmental behaviour and empirical research into other environmental issues (e.g., Gifford, 2014; Kloeckner, 2013).

This opens up the possibility of targeting engagement to individuals who are younger, men, have lower levels of education and less experience of marine litter, and investigate further whether lower concern, motivation, competence, social support, and value in the coast is causally linked to action. For example, strategies which increase an individual's personal exposure to marine litter, perceived value in the coast, or sense of personal responsibility, motivation, and competence may in turn increase their concern about marine litter and

willingness to act. However, further research is needed to understand the *causal* relationships between these variables.

The findings from this study contribute to theoretical and empirical literature on marine litter specifically and in environmental psychology more broadly. In a field where there is surprisingly little empirical research on individuals' views on the problem of marine litter, how it enters the marine environment and corresponding solutions, this paper offers new insights into how the European public understand and respond to the issue of marine litter across Europe.

4.4 Implications and limitations

Although it is tempting to formulate recommendations for effective communication based on these associations, we need to be cautious about inferring causality. The link between coastal visits and direct experience of litter is in line with outdoor education and experiential learning approaches on the one hand and psychological distance as a barrier on the other hand (e.g., Pahl et al., 2014). Thus, it seems reasonable to conclude from the present study and the wider evidence that giving people first-hand experience of marine litter and its impacts is likely to be connected to higher concern and intentions. There is also emerging evidence that engaging in beach cleans supports future intentions and has other psychological benefits (Wyles et al., 2016). Biospheric values have been linked to pro-environmental action elsewhere (de Groot & Steg, 2008) so strengthening these would also be desirable and in line with our findings on marine litter.

Perception research is based on self-report measures and so it is possible that participants' concern, perceptions about causes and negative impacts, and behavioural intentions were somewhat higher because of a social desirability bias (responding in a manner which will be viewed favourably by others). The convenience and snowball sampling methods we used may have led to greater participation from individuals who were more

aware and/or concerned about marine litter than were non-participants. The sample consisted predominantly of higher educated individuals who tend to report more pro-environmental attitudes and behaviours in general (Gifford, 2014). However, Potts et al. (2016) used a random sampling strategy and had similar levels of university-educated participants (47.5% against our 57%).

As the focus of this research is on perceptions, it is also useful to consider whether perceptions can change. In general, the answer is yes, for example, public perceptions can change in response to new information in the media, targeted campaigns and policy change but also through informal peer and group influence. In the scientific literature, Poortinga et al. (2013), for example, showed how public opinion became more favourable following the introduction of a plastic bag charge in Wales. Although not systematically researched to date, a 'Blue Planet II' effect has recently been discussed in the UK. This TV programme, presented by trusted communicator and naturalist Sir David Attenborough, documented the beauty of our seas and oceans but then also highlighted the threat from human impact, e.g., through plastic pollution. Since the programme was broadcast, there has been a lot more media exposure of the issue, hand in hand with public reaction and demand for change. Thus, public perceptions does and will change over time.

Therefore it remains important to conduct research using different populations and methods, also longitudinally, and also explore these issues beyond Europe. For example, some regions have been highlighted globally as hotspots for plastic litter (e.g., Asia; Jambeck et al., 2015), and it will be important to conduct research on the social and behavioural processes contributing to plastic pollution in those cultural contexts – not to apportion blame but to develop acceptable and successful solutions.

4.5. Conclusions

This large-scale European public survey is the first to focus completely on marine litter, a problem of growing global concern. We have shown that people across Europe are aware of the problem but awareness is higher for the effects on marine life than for wider impacts. Respondents appreciated that marine litter is a current rather than future problem, and that it does not only affect coastal communities. Experiencing litter on the coast was associated with higher concern and behavioural intentions. These insights can be used to motivate action on land to address the sources of marine litter, potentially building on people's strong affinity to coastal environments.

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Table 3. Hierarchical Regression Analysis for Variables Predicting BEHAVIOURAL INTENTIONS (N=1118)

	Model 1				Model 2				Model 3				Model 4				Model 5			
Variable	*B*	*SEB*	*β*	*t*	*B*	*SEB*	*β*	*t*	*B*	*SEB*	*β*	*t*	*B*	*SEB*	*β*	*t*	*B*	*SEB*	*β*	*t*
Demographics:																				
Age	0.01	0.00	0.15	5.12***	0.01	0.00	0.15	5.09***	0.01	0.00	0.14	4.98***	0.01	0.00	0.11	3.99***	0.00	0.00	0.06	2.39*
Gender (1=M, 2= F)	0.25	0.05	0.15	5.39***	0.26	0.05	0.16	5.56***	0.27	0.05	0.17	5.76***	0.26	0.05	0.16	5.61***	0.15	0.04	0.09	3.60***
Education level	0.13	0.01	0.27	9.74***	0.12	0.01	0.26	9.07***	0.12	0.01	0.25	8.81***	0.12	0.01	0.24	8.50***	0.06	0.01	0.12	4.33***
Accessibility & experience:																				
Proximity to the coast 0-5km					0.10	0.05	0.06	1.91†	0.03	0.06	0.02	0.49	0.03	0.06	0.02	0.45	-0.03	0.06	-0.01	-0.44
Proximity to the coast >5-20km					0.12	0.06	0.06	2.01*	0.08	0.06	0.05	1.38	0.09	0.06	0.05	1.54	0.06	0.05	0.03	1.17
Freq. of coastal visits									0.06	0.03	0.07	2.02*	0.03	0.03	0.03	1.00	-0.01	0.02	-0.01	-0.32
Freq. notice litter at coast													0.16	0.03	0.17	6.06***	0.09	0.02	0.10	3.78***
Psychological variables:																				
Concern and perceived risk																	0.21	0.04	0.15	5.10***
Responsible (self)																	-0.03	0.02	-0.04	-1.37
Competent (self)																	0.06	0.02	0.09	2.77**
Motivated (self)																	0.13	0.02	0.18	6.11***
Responsible (general public)																	-0.01	0.02	-0.01	-0.43
Competent (general public)																	0.00	0.02	0.00	-0.07
Motivated (general public)																	0.00	0.02	0.00	0.10
Altruistic-biospheric value																	0.19	0.05	0.13	3.72***
Egoistic value																	0.14	0.04	0.11	3.22**
Social norm – important																	0.00	0.02	0.00	-0.06
Social norm – support																	0.09	0.02	0.11	3.87***
R^2		0.125				0.129				0.132				0.160				0.332		
F for change in R^2		53.08***				2.65†				4.07*				36.78***				25.76***		
Model F		53.08***				33.00***				28.26***				30.26***				30.39***		

†p<.10. *p < .05. **p < .01. ***p < .001.

Table 4. Hierarchical Regression Analysis for Variables Predicting CONCERN (N=1118)

	Model 1				Model 2				Model 3				Model 4				Model 5			
Variable	*B*	*SEB*	*β*	*t*	*B*	*SEB*	*β*	*t*	*B*	*SEB*	*β*	*t*	*B*	*SEB*	*β*	*t*	*B*	*SEB*	*β*	*t*
Demographics:																				
Age	0.00	0.00	0.01	0.42	0.00	0.00	0.01	0.32	0.00	0.00	0.00	0.09	0.00	0.00	-0.03	-1.01	0.00	0.00	-0.10	-3.74***
Gender (1=M, 2= F)	0.05	0.03	0.05	1.62	0.06	0.03	0.05	1.79†	0.08	0.03	0.07	2.32*	0.07	0.03	0.06	2.11*	0.01	0.03	0.01	0.34
Education level	0.08	0.01	0.25	8.43***	0.08	0.01	0.23	7.87***	0.07	0.01	0.22	7.38***	0.07	0.01	0.21	7.04***	0.04	0.01	0.12	4.25***
Accessibility & experience:																				
Proximity to the coast 0-5km					0.09	0.04	0.07	2.28*	-0.03	0.05	-0.03	-0.65	-0.03	0.04	-0.03	-0.70	-0.07	0.04	-0.06	-1.67†
Proximity to the coast >5-20km					0.05	0.04	0.04	1.10	-0.01	0.04	-0.01	-0.22	0.00	0.04	0.00	-0.08	-0.01	0.04	-0.01	-0.32
Freq. of coastal visits									0.09	0.02	0.17	4.69***	0.07	0.02	0.13	3.60***	0.05	0.02	0.09	2.77**
Freq. notice litter at coast													0.12	0.02	0.20	6.63***	0.08	0.02	0.13	4.67***
Psychological variables:																				
Responsible (self)																	0.04	0.01	0.08	2.54*
Competent (self)																	-0.02	0.01	-0.05	-1.37
Motivated (self)																	0.11	0.02	0.23	7.40***
Responsible (general public)																	-0.02	0.02	-0.04	-1.50
Competent (general public)																	0.00	0.01	0.00	-0.16
Motivated (general public)																	-0.07	0.01	-0.13	-4.68***
Altruistic-biospheric value																	0.17	0.04	0.17	4.70***
Egoistic value																	0.04	0.03	0.04	1.10
Social norm – important																	0.05	0.02	0.10	3.36***
Social norm – support																	0.05	0.02	0.09	2.85**
R^2		0.065				0.069				0.087				0.122				0.258		
F for change in R^2		25.68***				2.61†				21.98***				43.95***				20.10***		
Model F		25.68***				16.50***				17.67***				22.01***				22.44***		

†p<.10. *$p < .05$. **$p < .01$. ***$p < .001$.