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Marine litter education boosts children's understanding and self-reported actions

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ABSTRACT

Marine litter is a significant environmental problem inherently linked to individuals' purchasing, use and disposal behaviour. This research examined 176 British schoolchildren's (aged 8–13 years) baseline marine litter understanding and self-reported actions, and tested the impact of an educational intervention. All children participated in the educational intervention and completed a pre- and post-intervention questionnaire. At baseline, children were quite concerned about marine litter and recognised some of the causes and impacts of the problem. Children also reported taking a number of actions to help solve the problem. After the intervention, children were significantly more concerned, had a better understanding of the causes and negative impacts, and reported engaging in more actions to reduce the potential causes of marine litter. Understanding the perceptions and behaviours of children is crucial as they represent current and future actors and a potentially important source of social influence among their peers, parents and community.

1. Introduction

The prevalence of litter in the marine and coastal environment is a worldwide environmental problem and a growing concern. Marine litter consists of any persistent, manufactured or processed solid material discarded, disposed of or abandoned on the coastline or at sea (Galgani et al., 2010). Whilst a wide variety of materials are found, plastic typically constitutes around 75% of all marine litter, and like other materials persists in the marine environment for years because it degrades slowly, if at all (Barnes et al., 2009; UNEP, 2005). Marine litter presents an environmental, economic, human health and safety, and aesthetic problem (STAP, 2011). For example, it can cause injury or death to wildlife which can ingest or become entangled in marine litter, it incurs losses to coastal tourism, shipping and fishing industries, and clean-ups add substantial extra costs (Gregory, 2009; Mouat et al., 2010; Secretariat of the Convention on Biological Diversity and Scientific and Technical Advisory Panel GEF, 2012).

There are many factors which contribute to the accumulation of marine litter, including fishing and shipping activities, tourism and recreational activities, and waste management practices (Galgani et al., 2010; UNEP, 2005). From a life-cycle perspective, the linear use of resources from production to a short-lived single-use stage to disposal is a central underlying cause of the accumulation of waste and the solutions appear to lie in tackling the problem at its source (Thompson et al., 2009; WRAP, 2006). It is increasingly being recognised by industry, academia, civil society and policy makers that actions are required at all stages of the supply chain, reflected in the five R's; Reduce, Reuse, Recycle, Redesign, Recover (STAP, 2011). People affect the entire life cycle of a product via purchasing, use and discard choices (European Commission, 1998). Influencing people's consumer behaviour is becoming a priority in European environmental and consumer policy (Niva and Timonen, 2001). There is evidence that consumers, in general, struggle to relate environmental problems to products, and have difficulty distinguishing between green and conventional products and appreciating the environmental benefit of purchasing eco-labelled products (Leire and Thidell, 2005). However, recent research suggests that consumers are somewhat concerned about packaging that is not recyclable and the amount of packaging used on products as a sustainability issue (Grunert et al., 2014). In addition, there is evidence that individuals are willing to trade off a number of product attributes in favour of environmentally friendly packaging (van Birgelen et al., 2009). Further, supporting the use of eco-friendly packaging is associated with disposal of packaging in an ecologically appropriate way (van Birgelen et al., 2009).

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1.1. Public attitudes and behaviours

The behaviour of individuals and groups is crucial at all stages of the chain and is likely to be influenced by knowledge, attitudes, and level of concern about this environmental issue, along with motivation to engage in solutions. Therefore, understanding social perceptions, attitudes and behaviours is a critical step in attempts to engage society in this environmental concern and move towards more sustainable purchasing, use and disposal behaviours. Rees and Pond (1995) suggest that raising public awareness and initiating a change in attitude is vital for reducing the amount of waste reaching the marine environment. In addition, community or public participation in the production and use of scientific knowledge is receiving increasing attention and is considered highly desirable for environmental management (Kapoor, 2001; Marin et al., 2009; van Asselt and Rijkens-Klomp, 2002). Understanding public perception to environmental problems, such as marine litter, is the first step toward a more inclusive and sustainable approach.

Whilst there is a well-established and expanding literature concerning a number of environmental attitudes and behaviours (Gardner and Stern, 2002; Gifford, 2014; Schultz, 2001; Stern, 2000), there is limited research literature, particularly peer reviewed, assessing public understanding, attitudes and behaviours related to marine litter. Depledge et al. (2013) state that neither politicians nor the public do appreciate the scale of the problem of plastic litter. There is some evidence that marine debris is recognised as a problem and a threat to marine and coastal environments (e.g., Fletcher et al., 2009; Jędrzejczak, 2004; Scott and Parsons, 2005). Research also suggests that the majority of individuals do not admit to littering on the beach and that adults in their 20s and 30s may be more likely to admit to littering than older groups and less likely to report feeling guilt associated with littering (e.g., Campbell et al., 2014; Santos et al., 2005; Slavin et al., 2012). However, somewhat paradoxically, the majority of respondents in such surveys perceive beach users as the main source of beach litter. Santos et al. (2005) also showed that respondents perceived a threat to people's health and safety as the main problem caused by marine litter and education and provision of bins as the most important solutions. In addition, in their survey of over 909 Chilean members of the public, Eastman et al. (2013) found that the majority of participants in their survey endorsed a fine for littering and advocated community-level environmental education as a solution.

Researchers have identified many factors that influence littering behaviours in general, including social norms and self-awareness (Cialdini et al., 1990; de Kort et al., 2008), personal cost-benefit analyses (Sutinen, 1997), and incentives (Baltes and Hayward, 1976). For example, pro- versus anti-littering norms are important in describing and prescribing what the common and acceptable behaviour is in a given situation. Experimental research shows 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; Schultz et al., 2011).

Positive reinforcement (e.g., rewards for not littering and monetary incentives) can also be effective in reducing littering and increasing recycling, but when the incentive is removed the behaviour tends to cease (Burgess et al., 1971). There is also evidence that threats of shame (a self-imposed sanction) and embarrassment (a socially imposed sanction) function as a similar deterrent to the threat of legal sanctions in generating compliance with anti-littering laws, by appealing to individuals' conscience or a sense of community pride and moral obligation (Grasmick et al., 1991). A parallel line of research has similarly shown social norms, monetary incentives, and sense of moral obligation to be important drivers of individuals' recycling behaviour (Hage et al., 2009; Hornik et al., 1995; Schultz et al., 1995). Whilst this research has not assessed attitudes and behaviours directly related to *marine* litter, public sources of marine litter are closely linked to people's general littering and waste management behaviours.

1.2. Children's attitudes and behaviours

In contrast to a growing knowledge base concerning adult environmental attitudes and behaviours, there is scant literature on the development of environmental attitudes and behaviours in children. This is surprising given that children are important agents of social change in society. They represent the future citizens and consumers who will develop attitudes and make decisions that will inevitably affect the environment.

Research suggests that young people are aware of various environmental problems, such as pollution, litter, and hazardous waste, but can have greater difficulty understanding the causes of and solutions to environmental issues (Cohen and Horm-Wingard, 1993; Kahn, 1999; Kahn and Lourenco, 2002; Miller, 1975). There is also evidence that children worry about environmental issues and tend to report behaving in an ecologically responsible manner (Evans et al., 2007). However, it is important for young people to feel empowered to effect positive environmental change (Schreiner et al., 2005).

Kahn and colleagues have examined children's moral reasoning about environmental problems, including the impact of throwing garbage into a local river (Kahn, 1999; Kahn and Lourenco, 2002). Findings suggest that children around 6–8 years of age display predominantly anthropocentric moral reasoning (i.e., that affecting the environment affects humans). By 11 years of age children showed more biocentric reasoning, by appreciating a threat to the environment itself and understanding the intrinsic value and rights of nature. Kahn and Lourenco note, however, that whilst adolescents and young adults may be capable of biocentric reasoning, they may seldom employ it. Moreover, a persistent problem in this field is that awareness and concern about environmental issues alone is ineffective unless it can be translated into action.

Whilst children can perform responsible environmental behaviours themselves directly, they also have the potential to bring about change by influencing peers, family and the wider community. Indeed research suggests that children shape the values of their parents and exert strong peer group influence (Knafo and Galansky, 2008; Lee, 2008). Marketing researchers have long recognised children's potential in influencing parental decision making and consumer choices, often termed 'pester power' (Flurry and Burns, 2005; Mangleburg, 1990; Wilson and Wood, 2004). Whilst children may not have direct control over purchasing and disposal behaviours, indirect influence via parents and other adults may be highly effective. Moreover, research on environmental education and intergenerational learning indicates that children can influence the environmental knowledge, attitudes and behaviours of adults in various domains (Ballantyne et al., 1998; Damerell et al., 2013; Duvall and Zint, 2007; Uzzell, 1994).

1.3. The present research

The problem of marine litter is inherently linked to individuals' purchasing, use and disposal behaviours, yet there is surprisingly little empirical research on individuals' attitudes and behaviours in this area, and no quantitative studies assessing children's understanding and behaviours relating to marine litter.

This paper set out to (1) examine children's baseline marine litter understanding, attitudes, and self-reported behaviours, and (2) test the impact of an intervention to raise children's awareness, change their attitudes and increase self-reported litter-reducing

behaviours. The intervention was designed to highlight the types, sources and impacts of marine litter, particularly plastics, and encourage children to engage in actions to reduce the potential causes of marine litter. This research represents the first quantitative assessment of children's attitudes and behaviours specifically related to marine litter before and after participation in an educational intervention.

1.4. Hypotheses

We predicted that children's attitudes and perceptions about marine litter would change as a consequence of participating in an educational intervention about marine litter (described below). More specifically, we expected children to show greater problem awareness and concern about marine litter, become more accurate in estimating the proportion and longevity of plastic, perceive greater negative impacts and causes, and report an increase in litter-reducing behaviours.

2. Method

2.1. Participants and design

A total of 176 British schoolchildren (76 boys and 99 girls) aged 8–13 years (M_{age} = 10.43) participated in the study from 9 schools in SW England. While 245 children completed a survey, 54 of these completed the pre- but not the post-survey and 15 children completed the post- but not the pre-survey. Therefore, only the 176 matched surveys were included in the study and analyses. In addition, children who completed the post-intervention survey less than 3 days after participating in the intervention were excluded from analyses of items measuring 'Self-reported litter-reducing behaviour' to ensure they had a sufficient period of time to report on their actions performed since the intervention.

Children participated within a repeated measures design; all children participated in the intervention and completed a pre- and post-intervention survey (questionnaire). The dependent variables were: problem awareness and concern about marine litter, perceived proportion of plastic and estimated degradation time, perceptions about the impacts and sources of marine litter, and self-reported behaviours.

2.2. Measures and procedure

Schools provided written consent and children provided verbal assent to participate in the study, and confidentiality of responses was ensured. Children completed a short survey under the supervision of their teacher which took approximately five minutes to complete. Children then participated in the intervention. After the intervention, children completed an identical survey, on average one week later.

2.2.1. Survey of perceptions, attitudes and self-report behaviour

A short (one-page) survey was developed to assess children's perceptions and behaviours regarding marine litter. The categories of questions and specific items in the survey are described below. The survey underwent initial piloting to ensure question items and the response formats were clear and age-appropriate.

2.2.1.1. Problem awareness and concern. Children's problem awareness and concern about marine litter was measured by asking children "Do you think litter on the beach and in the sea is a problem?" and "Are you worried about the problems that litter on the beach and in the sea might cause?" Children responded on a four-point scale, *not at all*, *a little bit*, *quite a bit*, and *a lot*.

2.2.1.2. Perceived proportion of plastic and estimated degradation time. Children's perceptions about the composition of marine litter, specifically, the proportion of marine litter that is plastic, was measured by asking children "What percentage of litter on the beach and in the sea do you think is plastic?" Children had an open response box to provide their estimated percentage. We were confident that children would be capable of understanding and responding to this question on percentages, based on the UK Mathematics National Curriculum for this age group. Children were also asked "How long do you think it takes a plastic bottle to breakdown/decompose?" to assess their perceptions about the longevity of this common item. Children had an open response box to provide their estimated degradation time (it was important not to lead or anchor children's responses to this question by providing options such as days, weeks, months, years).

2.2.1.3. Perceived impacts. Children's perceptions about the negative impacts that marine litter can have were measured with five questions, "Do you think litter on the beach and in the sea is bad for: (a) Marine wildlife? (b) Tourism? (c) Human health? (d) The fishing industry? and (e) The appearance of the coast? Children responded to each of these on a four-point scale, *not at all*, *a little bit*, *quite a bit*, and *a lot*.

2.2.1.4. Perceived causes. Children's perceptions about the possible different causes of marine litter were measured with four questions, "Why is there litter on the beach and in the sea?: (a) Because people drop litter on the beach, (b) Because there are not enough bins, (c) Because businesses (cafes, restaurants, shops) and the fishing industry cause litter at the coast[1], and (d) Because lots of things we buy have too much packaging that is difficult to recycle. Children responded to each of these on a four-point scale, *not at all*, *a little bit*, *quite a bit*, and *a lot*.

2.2.1.5. Self-reported litter-reducing behaviour. Children's self-reported litter–reducing behaviours were measured with five questions, "Have you done the following things in the last week?: (a) Disposed of litter properly? (b) Picked up litter lying around? (c) Recycled? (d) Bought goods with less packaging? and (e) Encouraged family and friends to do any or all of the things above? Children responded to each of these on a four-point scale, *not at all*, *a little bit*, *quite a bit*, and *a lot*.

2.2.2. Intervention

Children participated in a series of interactive activities organised by Plymouth University at the National Marine Aquarium which sought to raise awareness about marine litter and promote understanding about the causes, impacts and solutions to the problem. Across four activities, multiple techniques were used to increase awareness and engage children in the topic, including posters and artwork, demonstrations, and mini-experiments (see Appendix A for photos from the activities). Children took part in each activity (in no particular order) for approximately 8–10 min and in groups of six to eight. The intervention was set within a larger event about raising awareness about the impact that society has on the marine environment. Activities at this larger event included sea kayaking, beach conservation, and a tour of the aquarium.

In activity 1, children learnt about macro-litter that had recently been collected from a beach. They observed the main items that comprise marine litter and performed a mini-experiment to sort

[1] In the context of the other items/categories of causes, businesses (cafes, restaurants, shops) and the fishing industry were combined to represent marine litter that can arise from different coastal industries. On reflection, more information could have been gained if the two causes (businesses and the fishing industry) had been separated into two items.

different materials, including plastic, paper, wood, metal, cloth and glass and identify what their source may have been. Children observed that plastic items were the most common and learnt that plastic represents approximately 75% of the litter found worldwide. Children also learnt that marine litter (similar to items in front of them) can have negative consequences: that wildlife can mistake marine litter for food or get entangled in it; that dirty beaches and seawater might discourage tourists from visiting the area; that dirty or sharp objects are dangerous to humans; that marine litter damages fishing boats and the fish they are trying to catch; and that marine litter does not look very nice. Whilst teaching about the negative impacts, this activity also conveyed information about simple actions everyone can take to reduce the potential causes of marine litter, including recycling, picking up litter, waiting until they find a bin to dispose of litter and encouraging people around them to do the same. This information was communicated visually and verbally.

In activity 2, children examined microplastic litter and plankton through microscopes to understand that litter breaks down gradually over time and can become very small, and that plastic takes many years to do this. They also learnt that this microplastic can be ingested by small marine organisms and wildlife. In activity 3, children looked at the global distribution of marine litter to learn how it can travel long distances and even be found in remote unpopulated regions, including the Antarctic. We were confident that children would have learnt about other countries in the world and be aware that some countries are far away, based on the UK Geography National Curriculum for this age group. Appropriate language and visual aids (maps and pictures) were used to make the information accessible for them.

In activity 4, children were presented with a mock shop with products that followed a traffic-light labelling system to represent the environmental and waste footprint of the product. In the traffic light labelling system, the green dot signified a product that used the minimum amount of material, or packaging that uses recycled material, or can be recycled. A red dot represented products that used more material than necessary, or packaging that does not use recycled content, or is difficult to recycle. An amber dot was for material in-between. Children first went through and elected items without realising the significance of the red dots. They were then given a shopping list with the task to 'purchase' products using tokens and at the till received the 'eco-price' of their shop. Children were then required to alter their product choices to decrease the packaging footprint of their shop. This activity conveyed information about simple things to look out for and actions everyone can take when they are shopping that will help reduce marine litter (e.g., buy products with less packaging or with packaging that uses recycled material or that can be easily recycled).

There was a final 10 min interactive question and answer round-up session to summarise the key messages from the activities, namely: Is there any evidence of marine litter and is it a problem? Where does it come from and where is it found? What can be done and how to take action? The total duration of the intervention was 45–50 min.

3. Statistical analyses

Non-parametric statistical methods were used because the survey was predominantly composed of ordinal data (1–4 response scale). Wilcoxon's matched-pairs signed ranks test (Z score) was used to determine whether the intervention influenced children's problem awareness and concern about marine litter, perceived proportion of plastic and estimated degradation time, perceptions about the impacts and causes of marine litter, and self-reported behaviours. Results are described below and figures are provided to highlight pre- and post-intervention changes in attitudes and reported behaviours (for more detail see Appendix B).

4. Results

4.1. Problem awareness and concern

Children's baseline pre-intervention responses indicate that they perceived marine litter as a problem and were concerned about it. Moreover, consistent with hypotheses, children perceived marine litter as a significantly greater problem post-intervention compared to pre-intervention (see Fig. 1 and Appendix B). Similarly, post-intervention, children were significantly more concerned about the problems that marine litter might cause compared to pre-intervention responses.

4.2. Perceived proportion of plastic and estimated degradation time

In line with predictions, children believed plastic represented a significantly greater proportion of marine litter post-intervention compared to pre-intervention (approximately 15% more) (Fig. 2 and Appendix B). In addition, children believed plastic would take significantly longer to degrade post-intervention, than pre-intervention (Fig. 3 and Appendix B).

4.3. Perceived impacts

Children's baseline responses indicate that they perceived marine litter to negatively affect marine wildlife, tourism, human health, the fishing industry, and the appearance of the coast (Fig. 4 and Appendix B). However, a Friedman test indicates that these impacts were perceived differently at baseline χ^2 (4) = 144.57, $p < .001$, thus a series of post hoc Wilcoxon matched-pair tests was conducted. Negative impacts for the fishing industry and appearance of the coast were perceived as significantly greater than negative impacts for tourism and human health ($p < .001$). Impacts on marine wildlife were perceived as significantly greater than all other impacts ($p < .001$).

Moreover, in line with predictions, children's perceptions about all negative impacts of marine litter (except on the fishing industry) significantly increased after taking part in the intervention (Fig. 4 and Appendix B).

4.4. Perceived causes

Children perceived that dropping litter, a lack of bins, behaviour of businesses and the fishing industry, and too much packaging all contribute somewhat to causing marine litter (Fig. 5 and Appendix B). A Friedman test indicates that these causes were perceived differently at baseline χ^2 (3) = 209.84, $p < .001$, thus a series of post hoc Wilcoxon matched-pair tests was conducted. People dropping litter on the beach was perceived as a significantly greater cause of marine litter than overuse of packaging and a lack of bins ($p < .001$). The role of businesses and the fishing industry was perceived as significantly less than all other causes ($p < .001$).

In addition, children's perceptions about the extent that dropping litter and a lack of bins contribute to marine litter remained the same after the intervention (there was no significant difference between pre- and post-intervention responses). However, their perceptions about the role of businesses and fishermen and of too much product packaging significantly increased after taking part in the intervention (Fig. 5 and Appendix B).

4.5. Self-reported litter-reducing behaviour

Pre-intervention responses show that children reported performing a number of litter-reducing behaviours (Fig. 6 and Appendix B). A Friedman test indicates that there were differences

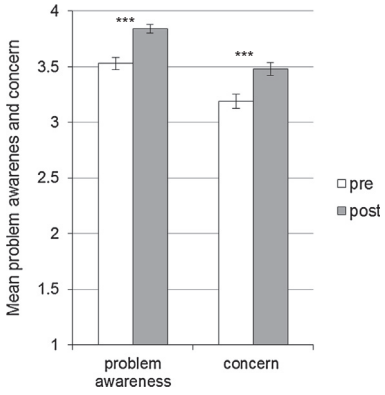

Fig. 1. Children's problem awareness and concern about marine litter pre- and post-intervention (1–4 scale: not at all – a lot). *Note.* Error bars represent standard error. $^{***}p < .001$.

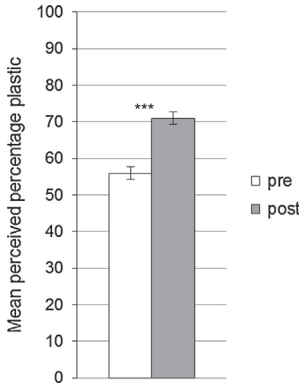

Fig. 2. Children's belief about the percentage of marine litter that is plastic pre- and post-intervention. *Note.* Error bars represent standard error. $^{***}p < .001$.

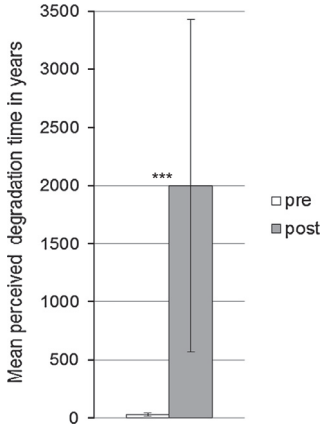

Fig. 3. Children's belief about the time it takes a plastic bottle to degrade (in years) pre- and post-intervention. Means are presented. Median values for perceived degradation time pre-intervention were 2 years and 100 years post-intervention. *Note.* Error bars represent standard error. $^{***}p < .001$.

between the self-reported actions at baseline χ^2 (4) = 128.53, $p < .001$, thus a series of post hoc Wilcoxon matched-pair tests was conducted. Children reported significantly greater levels of recycling and appropriate litter disposal than all other actions (buying goods with less packaging, encouraging friends and family to act, and picking up litter; $p < .001$).

Furthermore, consistent with hypotheses, post-intervention there was a significant increase in the extent that children reported they picked up litter, bought goods with less packaging and encouraged

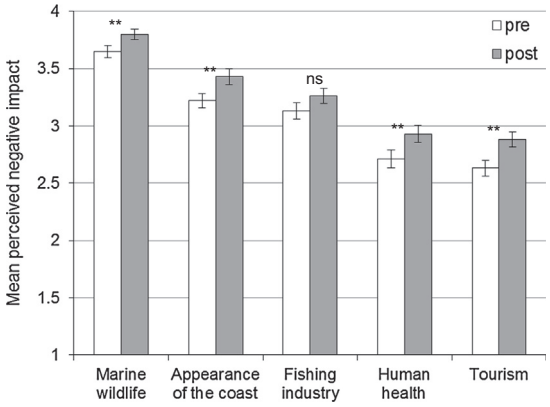

Fig. 4. Children's perceptions about the negative impacts of marine litter pre- and post-intervention (1–4 scale: not at all – a lot). *Note.* Error bars represent standard error. $^{**}p < .01$.

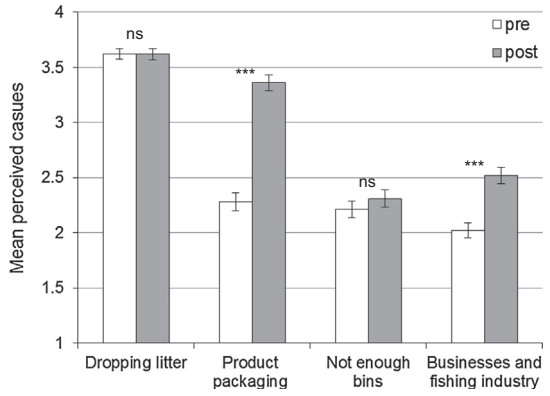

Fig. 5. Children's perceptions about the causes of marine litter pre- and post-intervention (1–4 scale: not at all – a lot). *Note.* Error bars represent standard error. $^{***}p < .001$.

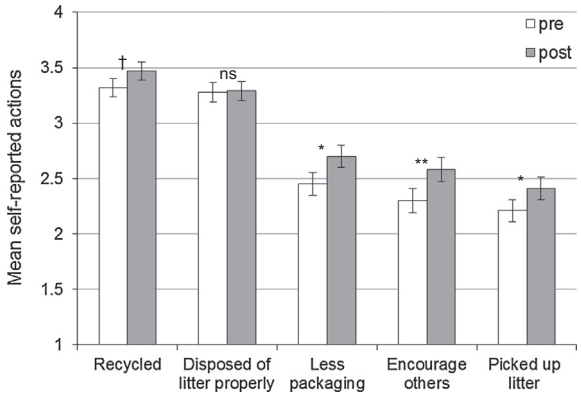

Fig. 6. Children's reported actions to reduce the potential causes of marine litter pre- and post-intervention (1–4 scale: not at all – a lot). *Note.* Error bars represent standard error. $^{\dagger}p < .10$; $^{*}p < .05$; $^{**}p < .01$.

family and friends to take action. Children's reported recycling behaviour was also somewhat higher post-intervention, but this failed to meet conventional levels of significance, and there was no significant difference between children's pre- and post-intervention reports of disposing of litter properly (Fig. 6 and Appendix B).

5. Discussion

This research assessed children's baseline marine litter awareness, attitudes, and self-reported behaviours, and tested the impact

of an intervention to raise awareness, change perceptions and increase self-reported litter-reducing behaviours. Specifically, the intervention was designed to highlight the types, sources and impacts of marine litter, particularly plastics, and encourage children to take action. The findings demonstrate that children recognise that marine litter is an important problem which has a negative impact on the environment, coastal industries, and human health. Children were somewhat aware of the composition and causes of marine litter and reported engaging in a number of behaviours that may reduce marine litter. It is encouraging to see that children showed some level of problem awareness and sustainable behaviour prior to participating in the educational intervention. Some of the children's responses appeared consistent with responses provided by adults in previous research, for example, in perceiving beach users or people dropping litter as the main source of beach litter (e.g., Campbell et al., 2014; Santos et al., 2005). Other responses that children gave bore less resemblance to findings from previous research with adult samples. For example, children in the current study perceived that marine litter posed the greatest threat to marine wildlife and viewed the threat to human health as one of the lowest impacts, whereas Santos et al. (2005) found that adults perceived the threat to human health and safely as the main problem caused by marine litter. Whilst these simple comparisons are interesting, it is important to keep in mind that the questions and response options in the current study were not identical and therefore not directly comparable with previous surveys of adults.

Consistent with our hypotheses, after participating in the intervention, children's perceptions changed as they learnt more about the topic of marine litter and came to understand the causes, impacts and solutions. More specifically, children's recognition of the problem significantly increased after taking part in the intervention, as did their concern about the issue (cf. Wyles et al., 2013 for similar findings for adults). Children perceived greater negative impacts of marine litter and viewed certain sources (coastal industries and too much product packaging) as more important following the intervention. Children also became more accurate regarding the predominance and longevity of plastic. Indeed, children's post-intervention responses came to closely resemble figures which were communicated in the intervention, and which are commonly reported in the literature (cf. Barnes et al., 2009; UNEP, 2005).

Participating in the intervention not only changed children's attitudes and perceptions about marine litter, children also reported performing more litter-reducing behaviours. The intervention exposed children to a combination of mitigation actions (e.g., appropriate disposal of waste, recycling, beach cleans etc.) and prevention actions (e.g., buying items that are recyclable and which have less single-use disposable packaging). Such prevention actions represent a life-cycle approach and are critical for concepts of a circular economy (European Commission, 2012). In addition to engaging in more responsible environmental behaviours themselves, children also reported encouraging family and friends to perform more litter-reducing behaviours after the intervention. This is consistent with previous research on environmental education and intergenerational learning which has shown that children can influence the environmental knowledge, attitudes and behaviours of adults in various domains (Ballantyne et al., 1998; Damerell et al., 2013; Duvall and Zint, 2007; Uzzell, 1994). Similarly, this highlights children's potential "pester power", something that has been long been recognised by marketing and consumer researchers (Flurry and Burns, 2005; Mangleburg, 1990; Wilson and Wood, 2004). Indeed, environmental education that encourages young people to become concerned, informed and competent agents of change may influence family members, peers and the wider community. As such, educational interventions may have a wider impact and added value, whereby children act as messengers for important environmental issues which could then become self-reinforcing. However, it should be noted that we did not measure parental attitudes and behaviours in the current study. Further work is needed to examine the relationship between children's marine litter perceptions and behaviours and those of their parents and peers.

This paper provides the first quantitative assessment of children's attitudes and behaviours related to marine litter before and after participation in an educational intervention specifically designed to raise awareness and inspire action. In particular, the findings contribute to growing evidence that from a young age, children show an awareness and concern about environmental issues and tend to report behaving in an ecologically responsible manner (Kahn, 1999; Kahn and Lourenco, 2002; Cohen and Horm-Wingard, 1993; Miller, 1975; Evans et al., 2007). Whilst the current study was unable to shed light on any age differences or developmental trends in children's marine litter perceptions or establish whether the intervention influences certain age groups differently, this is an interesting question for future research.

The findings also contribute to an expanding literature on environmental education (Palmer, 2002). Indeed, these findings have important implications for strategies to engage children in the topic of marine litter and attempts to raise awareness and promote actions that will reduce marine litter. Other educational activities that promote understanding about the causes, impacts and solutions regarding marine litter may increase children's problem awareness and encourage them to take action. Citizen science projects provide another method of engaging children with the topic of marine litter and encouraging them to participate in future activities (Hidalgo-Ruz and Thiel, 2013). It is important that such educational activities and interventions are evaluated in order to gauge their success. Although there have been numerous campaigns and educational activities designed to raise awareness of the impacts of and solutions to marine litter (e.g., Keep Britain Tidy; Adopt-a-Beach; Bag it and Bin it!), these are seldom evaluated (but see our MARLISCO project for an exception, www.marlisco.eu). Sometimes, brief anecdotes or quotes from participating individuals or communities are recorded, but this is often not sufficient to understand whether the initiative was effective in changing social attitudes about marine litter and influencing individuals' behaviour. The research methodology in the current study provided a concise evaluation to measure the short term effectiveness of the marine litter educational activity, but longer term studies are needed too.

Because this research may have important implications for education and engagement activities, it is important to note its methodological limitations. First, the results of this research are based on self-report measures of children's perceptions and behaviours. Therefore, it is possible that children's problem awareness, concern, perceptions about negative impacts, and litter-reducing behaviours were artificially inflated because of a social desirability bias (responding in a manner which will be viewed favourably by others). Self-reports are widely used in academic and commercial research as proxies of behaviour, and whilst they may not perfectly predict actual or observable behaviours, research suggests that self-reports represent fairly stable and valid indicators of ecological behaviours, particularly when individuals are asked to report on specific past or present (rather than intended or future) pro-environmental behaviour (Frick et al., 2004; Kaiser et al., 2001). This literature suggests that asking for reports on specific past behaviours is a more robust approach, as we did in the current study. Further work could measure actual or observed behaviour, but there are many challenges to achieving this.

Second, schools volunteering to allow their children to participate in the intervention and survey may have been more environmentally aware and concerned than the 'average' school and were

also within close proximity to the coast. This may have affected children's baseline perceptions and behaviours, but it cannot explain the difference between pre- and post-intervention responses. A related point is that the intervention was set within a larger event with activities such as sea kayaking, beach conservation and a tour of the aquarium which have the potential to influence children's environmental attitudes. Participation in additional activities alongside a targeted intervention may be beneficial, but research is required to explore this possibility. Most importantly, future research should include an additional control group where a different set of children complete the survey at two time points but without participating in the intervention.

Third, despite children being exposed to the same information and activities during the intervention, there was a period of time between when children completed the pre- and post-intervention surveys that was outside of the researchers' direct control. As such, children could have sought out or been exposed to more information about marine litter, which would have the potential to influence their post-intervention survey responses. However, children and teachers were not given any additional materials or information to take away with them after the intervention. Moreover, any further learning that may have occurred outside the intervention could be viewed as an additional outcome of participating in such an activity. It would be beneficial for future research to control the exact length of time between pre- and post-surveys and conduct additional follow-up surveys to examine whether changes in attitudes and behaviours persist over time.

It is also important to consider potential negative side effects of learning about marine litter and other environmental issues. In the current study children became more worried about the problem of marine litter and the impacts it can have after taking part in the intervention. Whilst it is hoped that this might encourage children to engage in more actions to reduce marine litter, there is a risk that children who feel very worried about the problem may feel powerless to do anything. However, our findings do not appear to support this concern, because children also reported engaging in more actions to reduce the potential causes of marine litter. Nevertheless, awareness raising programmes should be applied sensitively and offer ways forward, taking into account that some children will worry a great deal about these issues, especially if they do not see any solutions, and that they (and adults) have a "finite pool of worry" (e.g., Centre for Research on Environmental Decisions, 2009).

In summary, this paper shows that by 8 years of age, children show a degree of concern and awareness about causes and impacts of marine litter, and report taking a number of actions to help solve the problem (research question 1). Moreover, we found that an educational intervention boosts children's awareness, perceptions of consequences and self-reported action (research question 2). Given that the problem of marine litter is inherently linked to society's production, purchasing, use and disposal behaviours, more empirical research is needed to assess people's attitudes and behaviours in this area. Research with younger children could examine the age at which children first begin to understand the issue. In addition, it is important to extend recent research which has begun to explore adults' attitudes and behaviours (e.g., Eastman et al., 2013) because this remains a surprisingly understudied area. Furthermore, future research should provide a more in-depth assessment of the perceptions and behaviours of children (and how they might influence adults) who represent current and future actors and a potentially important source of social influence.

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Appendix A

Photographs from the educational activity intervention (*Credit to SportEnvironment.com*).

Appendix B

Children's pre- and post-intervention attitudes and self-report behaviours about marine litter. Means (and standard deviations), number of participants, Wilcoxon *Z* statistic, *p* values, and effect size *r* are presented comparing pre- and post-intervention responses. Means represent responses on a 1–4 scale: (1) not at all to (4) a lot.

	M (SD) pre-intervention	*M* (SD) post-intervention	*N*	*Z*	*p*	*r*
Problem awareness	3.53 (0.73)	3.84 (0.50)	174	4.94	<.001	.38
Concern	3.19 (0.84)	3.48 (0.77)	174	4.17	<.001	.32
Impacts						
Marine wildlife	$3.65\ (0.70)_a$	$3.80\ (0.57)_a$	172	3.10	.002	.24
Appearance of the coast	$3.22\ (0.82)_b$	$3.43\ (0.87)_b$	165	2.76	.006	.22
Fishing industry	$3.13\ (0.93)_b$	$3.26\ (0.87)_c$	171	1.64	.101	.13
Human health	$2.71\ (1.00)_c$	$2.93\ (0.96)_d$	166	2.75	.006	.21
Tourism	$2.63\ (0.89)_c$	$2.88\ (0.86)_d$	170	3.16	.002	.24
Causes						
Dropping litter	$3.62\ (0.65)_a$	$3.62\ (0.69)_a$	175	0.04	.972	.00
Too much product packaging	$2.28\ (1.04)_b$	$3.36\ (0.90)_b$	166	8.62	<.001	.67
Not enough bins	$2.21\ (0.97)_b$	$2.31\ (1.05)_d$	169	1.21	.226	.09
Businesses and fishing industry	$2.02\ (0.89)_c$	$2.52\ (0.98)_c$	166	4.90	<.001	.38
Actions						
Recycled	$3.32\ (0.85)_a$	$3.47\ (0.88)_a$	108	1.78	.076	.17
Disposed of litter properly	$3.28\ (0.90)_a$	$3.29\ (0.87)_a$	105	0.34	.738	.03
Less packaging	$2.45\ (1.06)_b$	$2.70\ (1.03)_b$	105	2.09	.037	.20
Encourage others	$2.30\ (1.11)_b$	$2.58\ (1.13)_b$	106	2.61	.009	.25
Picked up litter	$2.21\ (0.99)_b$	$2.41\ (1.04)_b$	105	2.03	.042	.20
Estimated% plastic	55.95 (22.50)	70.92 (23.04)	173	7.01	<.001	.53
Estimated degradation time (in years)	35.59 (145.79)	2000.34 (16109.63)	127	8.37	<.001	.74

Note. Subscripts indicate results from the Friedman and follow-up Wilcoxon test for item means that are significantly different at pre-intervention and item means that are significantly different at post-intervention within each category of questions; impacts, causes, and actions.

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