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Straws, Seals, and Supermarkets: Topics in the Newspaper Coverage of Marine Plastic Pollution

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Conflict of Interest Statement

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Abstract

Media attention to marine plastic pollution is increasing, yet it is unclear which topics are being discussed. This paper analyses all 2019 news articles referencing marine plastics in the four leading UK online newspapers. Examining 943 articles in a structural topic model, this is the first analysis to depict what is being reported and how this varied according to political alignment (right vs. left-wing), type (broadsheet vs. tabloid), and publication date. We identified 36 topics, suggesting a large variety in the coverage, with plastic pollution ranging from the primary focus to only mentioned in passing. Greater emphasis was on explaining current issues of marine plastics, with limited reference to actionable reduction measures or producer responsibility. Many topics' prevalence varied across the media outlets. We discuss how this coverage varies across media outlets, and how it relates to a broader context (i.e. potential links to behaviour and current policy efforts).

Keywords: topic modelling, quantitative text analysis, plastic debris, ocean pollution, media analysis, public opinion

Highlights

- Investigates coverage of marine plastics on four leading UK online news sites
- Quantitative analysis examined 943 articles published in 2019
- Articles reported 36 topics with plastic as primary, secondary or tertiary focus
- Prevalence of topics related to tabloid/broadsheet, political orientation, and date
- Topics are often emotive and there is little focus on consumer responsibility

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1 Introduction

Plastic pollution in marine environments is growing on a global scale (UNEP, 2016). The high durability of many plastics and the massive increase in their production have led to the spread of plastic litter in oceans across the world, with effects on wildlife, human health, and the economy (UNEP, 2016). Three types of plastic are studied in marine environments: macro-plastics, which are pieces larger than 5mm such as packaging, sanitary items, or fishing nets; micro-plastics, which are commonly defined as less than 5mm in size (Law & Thompson, 2014) and stem either from degraded macro plastics (secondary) or are produced (primary) as an ingredient in raw plastic, abrasives, or personal care products (GESAMP, 2015); and lastly nano-plastics, which consist of the smallest of plastic particles ranging from 1 to 1000 nm (Gigault et al., 2018). Microplastic's can cause entanglement, lead to internal obstruction when ingested, and can reduce fish populations via so-called ghost-fishing of discarded fishing equipment (Derraik, 2002; Gall & Thompson, 2015; Gregory, 2009; UNEP, 2016), crossing national and sanctuary boundaries (Ward-Paige & Worm, 2017). The impact of micro- and nano-plastics is not yet fully understood, but research has found that they can carry harmful chemicals (Teuten et al., 2009; Ziccardi et al., 2016) and pathogens (Snoussi et al., 2008), which may cause disease to humans and animals when ingested. Despite the size, marine plastic pollution is an inherently anthropogenic issue, as it is wholly caused by human decisions and behaviours and consequently relies on societal action to address this socio-economic issue (i.e. changing our use and/or disposal of these materials; Pahl et al., 2017). In order to seek a sustainable relationship with this material and the marine environment, it is necessary to know what the current public perception towards marine plastic pollution and the source of this information is. A key vehicle that both represents and shapes public opinion

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and societal action is the media. This paper therefore examines how this growing issue is being portrayed to society.

1.1 Public Perception of Marine Plastic Pollution

Marine plastics have been receiving an increasing amount of attention from scientists and politicians, both on global (UNEP, 2016) and regional levels (e.g. Threadgill, 2019). During the last decade, public perception of marine issues has also been changing. In 2009, only 3.1% of participants in a UK sample mentioned marine litter as a pressing marine issue (Fletcher et al., 2009), and even in 2013, only half of participants in a small-scale survey had heard the term “micro-plastics” before (GESAMP, 2015). Since then, larger-scale public surveys have found that public concern is growing. In a study involving 1133 participants from 16 European countries, Hartley et al. (2018) found that the majority recognised marine litter as both a present and future threat to everyone on the planet. Similarly, a review of available data from public perception surveys around the world found that most participants thought that marine environments were under threat (Lotze et al., 2018). The level of concern varied with socio-demographic variables, with people who are older, female, and more educated expressing more worry (Hartley et al., 2018; Potts et al., 2016). However, growing concern has not been matched with an increase in understanding of the issues at hand, which is often in disagreement with the scientific consensus. For example, the general public often rank pollution from oil and chemical spills as most dangerous to ocean environments, which are of lesser urgency according to experts (Howard & Parsons, 2006; Lotze et al., 2018; Potts et al., 2016). When surveyed about marine plastics, especially micro-plastics, participants were unclear about specifics such as causes (A. G. Anderson et al., 2016; Henderson & Green, 2020), and generally thought that most litter was released directly into the ocean, and not via land as is demonstrated in a wealth of scientific evidence (Hartley et al., 2018). People also tended to appreciate only a small part of the impacts marine plastics can have: it

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was commonly seen as most harmful to marine environments, and less so to human health, tourism, shipping, and fishing, which are in fact equally endangered (Hartley et al., 2018). In conclusion, while public concern about marine plastics is increasing, knowledge is so far incomplete, potentially hindering effective collective and individual action.

1.2 The Influence of Media Reporting on Perception and Behaviour

Media outlets are one of people's main source of information, which is why understanding media output is an important piece of understanding the nature of public opinion and concern. This is especially the case with complex issues that may not be directly observable or explainable in person (Happer & Philo, 2013; Swain, 2012), where people have to more heavily rely on exterior sources for information. The relationship between media and public opinion is likely to work in both directions: growing public concern demands more reporting, but event-focused or otherwise inspired news stories also draw public attention to particular issues (Boykoff, 2007; Sampei & Aoyagi-Usui, 2009).

Other factors besides public interest can influence journalists in what stories they report on. Firstly, news corporations operate within a network that involves funding sources such as advertisers as well as those who provide news content itself, which may lead journalists to self-censor in order to avoid losing funding or news sources (A. Anderson, 2009; Herman & Chomsky, 2008). In the Unites States, such mechanisms, especially through news corporations' ties to the fossil fuel industry, have been shown to have biased climate change reporting for some time which may have hindered citizens' concern and willingness to act (Antilla, 2005; Dispensa & Brulle, 2003). Secondly, journalists have to work within time, space, and budget constraints (Boykoff, 2008), which may lead them to have to favour stories that are deemed newsworthy, relatable, or easier to understand (Berglez, 2011). This phenomenon is cooccurring with the narrative of a declining print newspaper readership

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(Bergström & Wadbring, 2010; Chyi & Tenenboim, 2019; Lucena, 2010; Peters, 2010), and hesitant uptake of digital newspaper concepts (Chyi & Ng, 2020; Chyi & Tenenboim, 2017; Thurman & Fletcher, 2019), which together may lead to further implicit bias towards simpler, more immediately engaging stories. Consequently, tracking coverage can give an insight on public opinion from two perspectives. Coverage acts as a representation of public concern, as journalists will tend to cover stories which respond to public opinion. But, as seen above, which topics are represented in news coverage may also be influenced by other factors, which is why trends in the media may actively influence the direction of public attention.

Besides these large-scale movements in media reporting, it is also important to consider stories on a much smaller scale. For example, whether a journalist focuses on a solution to an issue or on the extent of the issue itself, whether they cover local or global effects, and many other nuances in framing, may have a significant impact on attitudes and behaviour, shaping whether or not concern is translated into action for the readers (Swain, 2012). Research into the portrayal of climate change reports has found that readers can draw different conclusions about who is responsible for environmental issues, depending on how a story is framed. For example, episodic framing, which employs case studies of individual persons or animals, leads to less support for policy than thematic framing, which focuses on general trends and overviews (Hart, 2011). This can be due to people assigning more responsibility to the government in a thematic frame because they are seen as more capable of effecting large-scale changes, which in turn leads to support for policy proposals (Hart, 2011).

Research has investigated these trends and topics in media coverage in relation to other environmental issues such as air pollution (Tvinnereim, Liu, et al., 2017) and wildlife populations (Chandelier et al., 2018). However, only limited data has been gathered on the media's portrayal of marine plastics (GESAMP, 2015). When examining UK media coverage between 2004 and 2014, only 29 articles were published on the topics of micro-plastics or

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microbeads. Of those, most were published in broadsheet or mid-market papers, with little coverage in tabloid newspapers (GESAMP, 2015). It has also been found that many news outlets focus on emotional imaging to draw readers' attention to marine plastics (Koelmans et al., 2014). While this may have increased awareness of the topic in general, it fails to differentiate between impact on individual animals or populations, or to touch on the plastic's origin at all. This emotional entanglement with the issue can bias not only the public's, but also scientists' and politicians' view on how marine plastic pollution should be managed (Koelmans et al., 2017).

In conclusion, observing and understanding media coverage on important topics can help to understand the roots and shape of public perceptions, concern, and action. However, there is currently little insight into the topics prominent in the media coverage of marine plastic pollution, and the limited research to-date implies that news outlets devote varying amounts of attention to it (i.e. more coverage was found in broadsheets compared to tabloids). As seen above, understanding how this issue is reported and where may give indications of current and future trends in public opinion, which can could help inform behaviour change interventions and policy measures aimed at reducing the amount of plastics in waterways and oceans.

1.3 This Study

In this paper we present research which aims to bridge this gap by providing insights into the media coverage of marine plastic pollution, with the goal of describing the content and prevalence of topics currently discussed around the issue and understanding the factors which are associated with how much coverage a topic receives from different outlets. We focus on online news websites because of the increasing usage of digital media and declining usage of print media in recent years (Twenge et al., 2019). Online media can also be more engaging

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with additional materials such as slideshows and interactive graphics (Brainard, 2007), which may additionally lead to a wider reach and integration on other internet platforms such as social media. We sampled from four of the UK's leading online newspapers that each receive between 28 and 40 million readers, both from the UK but also internationally (Comscore, 2020; Newsworks, 2020). All articles published in 2019 that mention marine plastic pollution were included to be able to depict a full year's worth of coverage, accounting for different seasons and events, while at the same time keeping the number of articles and themes within a manageable scope. The articles were examined using an analytical approach, structural topic modelling, which enables researchers to study not only which topics are being reported, but also how these relate to the type of paper, political orientation, and date of publication.

Political ties and readership were assumed to have an influence on the newspapers' position in their network and editorial guidance (A. Anderson, 2009; Antilla, 2005; Boykoff, 2008; Dispensa & Brulle, 2003; Herman & Chomsky, 2008). It is therefore possible that newspapers which differ in political orientation will focus on different topics in their coverage. Thus, political orientation (left vs. right leaning) and type of newspaper (tabloid vs. broadsheet) were included as covariates in this study. The terms tabloid and broadsheet stem originally from their printing sizes but have come to define newspapers much more comprehensively: broadsheet newspapers tend to focus on more in-depth coverage, aiming to provide a serious, quality-driven style of reporting. Tabloids on the other hand rely much more on quick stories of popular and commercial interest, emphasising imagery and large headlines (Bastos, 2016). These differences lead to audiences that can be very distinct: readers of tabloid newspapers tend to be younger, less educated, not as interested in politics and less informed on current issues (Andersen, 2003; Rowe, 2011). Including the type of newspaper can thus serve as an indicator for different readerships. Additionally, the date of publication within 2019 was included in the study, as reporting on other environmental issues

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such as climate change has been found to be highly event-related (Boykoff, 2007; Sampei & Aoyagi-Usui, 2009) and it is likely that similar patterns may be found for the topic of marine plastic pollution.

The aim of the study was therefore to depict topics within the coverage of marine plastics in UK online newspapers in 2019, and to examine whether these related to a newspaper's type, political orientation, and an article's date of publication.

2 Method

2.1 Article Sampling

Newspapers were selected based on their perceived political alignment (Smith, 2017) and type of paper, which were later included as covariates as explained below: a left-wing broadsheet paper (the *Guardian*), a left-wing tabloid (the *Daily Mirror*), a right-wing broadsheet paper (the *Telegraph*) and a right-wing tabloid (the *Daily Mail*). All outlets release articles daily and provide free access to online content, which means that articles may be easily shared on social media. Premium content behind a paywall was not considered in this study, as it can be assumed to have severely limited reach. Key characteristics of the newspapers are presented in Table 1.

Table 1

Newspaper Characteristics

Online newspaper	Total unique visitors March 2020[a]	Political orientation[b]	Type	Articles included in corpus (Number in brackets before screening)
MailOnline (UK)	39,658,000	Right-wing	Tabloid	459 (927)
The Mirror Online	27,738,000	Left-wing	Tabloid	112 (218)
The Telegraph Online	28,420,000	Right-wing	Broadsheet	196 (516)
The Guardian Online	35,721,000	Left-wing	Broadsheet	176 (291)

Note. [a]Visitor figures from Comscore (Comscore, 2020; Newsworks, 2020). [b]As perceived by public (Smith, 2017)

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Three of the newspapers – the Mail, the Mirror, and the Telegraph – were searched using the LexisNexis Database (LexisNexis, n.d.) which archives all articles released on the above websites. The Guardian was not indexed on LexisNexis and was therefore searched using the Google custom search engine provided on its website. Both databases were searched using the same terms: (marine OR ocean OR sea OR coastal) AND (plastic* OR microplastic*), identifying articles with a combination of marine and plastic terms. This was a relatively conservative search, since it was not necessary for the two terms "marine" and "plastic" (or equivalents) to appear next to each other in an article, which led to several unrelated articles. However, it was preferred to identify too many rather than too few articles, and manually screen articles for eligibility. In this manual screening, an article was included in the final corpus (selection of texts) if there was a mention of plastic items or particles in a marine context. It did not matter how prominent that theme was in relation to the article, resulting in a corpus which included both articles about marine plastics themselves as well as articles about other topics mentioning marine plastics in passing. This was done to be able to gain a broad overview of topics that lead journalists to include marine plastics – both as a main subject, and as a note of interest. The final corpus included 943 articles, the number of articles per newspaper are displayed in Table 1.

2.2 Analytical Approach

To provide a comprehensive analysis, large amounts of textual data needed to be analysed and interpreted. We therefore chose to implement structural topic modelling (STM), a statistical procedure which allows a researcher to estimate the prevalence of certain topics in a large corpus of texts (Roberts et al., 2019). It uses a procedure based on other topic models such as latent Dirichlet algorithm (LDA, Blei, 2012), where a fixed amount of topics is proposed and words within a text are mapped to these topics, until one article is made up of several smaller topics to which most of its words can be ascribed. An important benefit of

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STM compared to other topic models is that covariates – in this case political alignment, type, and date of publication – can be entered into the model to be used within the estimation and later the interpretation of the topics, which allows inferences as to which topics are prevalent in which newspapers. STM uses unsupervised machine learning to map words onto topics, which means that the researcher specifies only the number of topics based on diagnostics, without any influence on their content or coding (see supplementary materials for more information). This was done to avoid any human bias in the model, which is especially important in a highly politicised and emotional area (Jacobi et al., 2016) such as plastic pollution. As one of the aims of this research was to specifically investigate any difference between coverage on the left and right side of the political spectrum, and between tabloids and broadsheets, removing any biased interference was imperative.

STM originates from political and sociological research, but examples of applications are manifold, and appear in many disciplines. It has been successfully applied to issues such as media coverage on internet regulation in Russia (Shirokanova & Silyutina, 2018) and biases against foreign businesses in Chinese state media (Kim, 2018). In the environmental domain, it has been used to describe participants' opinions on air pollution (Tvinnereim, Liu, et al., 2017) and climate change (Tvinnereim & Fløttum, 2015) and how to respond to it (Tvinnereim, Fløttum, et al., 2017), as well as social representations of the adaption to climate change (Lynam, 2016) and newspaper coverage of wolf repopulation in France (Chandelier et al., 2018).

2.3 Modelling Decisions

In STM, topics are generated based on the co-occurrence of words in the textual data (i.e. the written articles). While STM uses an unsupervised algorithm, it does require the researcher to make some prior decisions while building the model. In the interest of readability, these

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decisions are only briefly summarised here and explained in detail in the supplementary materials to this article.

First, the articles were prepared for analysis by extracting and shortening the words in the corpus to their roots. Then, a model for analysis was built which specified the date of publication, political alignment (left/right), and type of paper (broadsheet/tabloid) as the covariates which were assumed to influence how prevalent a certain topic was. Finally, the number of topics was specified in order to find a model which was both supported by the data and meaningful in its interpretation. This was achieved by running models with different numbers of topics and comparing them to each other according to criteria targeted at the amount of explanation and the semantic coherence provided by the model. A final model including 36 topics was specified and estimated, which returned the topics along with their most common words, overall prevalence, a representative article which is made up to a large part of the topic, and the associated terms describing any influences by the covariates. This information was then used to examine the individual topics.

3 Results

Both authors examined the topics' key words and representative articles to assess each topic's content and to give each topic a meaningful title. The total number of 36 topics suggested that the articles were very diverse, even within the one year and four papers included in this analysis. It was therefore decided that they would be manually grouped into larger themes and subthemes to guide the interpretation and comparison of topics. However, since the topics within a theme were still distinct from each other in content and relation to covariate effects, they are continued to be analysed and interpreted individually.

The 36 topics were grouped into three larger themes that emphasised the stress placed on marine plastics within the overall article, each theme containing further subthemes as

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discussed below. The first theme, called *marine plastics as primary focus* (hereafter referred to as *marine plastics*), consisted of 16 topics which were highly prevalent in articles which discussed marine plastics as a subject in its own right, meaning most of an article was about one of several issues related to marine plastic pollution. A second theme called *sustainability as primary focus* (hereafter referred to as *sustainability*) included twelve topics which discussed other issues of sustainability, with marine plastic pollution mentioned as a related subject. The third theme *other topics (marine plastics mentioned in passing)* comprised of articles which on first sight were unrelated to marine plastic pollution or other sustainability issues, but which mentioned marine plastic pollution as part of the story (n = 8 topics). While they may increase public awareness and are important to detect to determine the overall volume of coverage, we regard these topics as less important to analyse in detail as they contain little to no information about marine plastics themselves. In this analysis, we therefore focused on the two other themes, which expressed more nuanced reports of the issue.

Detailed information on all three themes can be found in the Appendix (with their associated keywords, prevalence, descriptions, and covariate effects). The supplementary materials to the paper also contain further information to facilitate accessible exploration of the topics, in particular representative articles for each topic.

3.1 Marine Plastics

The first theme was that of *marine plastics*, in which the main subject of topics was that of marine plastic pollution itself and consisted of more than half the text in all of the selected 943 articles (53.3% total prevalence). Within this theme, 16 separate topics were identified, with an average prevalence of 3.3% per topic. This was higher than the other two themes, indicating that topics in this theme are on average more prominent than those of the other

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themes. Table 2 gives an overview over included topics and their main statistics, grouped into four subthemes as presented in the first column.

Table 2
Overview of Topics Within the Theme Marine Plastics (MP)

Subtheme	Topic Name (Prevalence in %)	Summary	Covariate Effects[a]
Solutions	Supermarkets reducing plastic (4.9)	Discusses the measures supermarkets are taking to reduce plastic output, such as cutting down on packaging or glitter.	none
Solutions	Ocean and river cleaning devices (3.6)	Addresses devices that clean up waterways and the oceans, thereby mitigating marine plastic pollution.	Political alignment: B = -0.07 (SE = 0.02), p < .001 Type: B = -0.08 (SE = 0.02), p < .001 Interaction: B = 0.09 (SE = 0.02), p < .001
Solutions	British spring clean (3.4)	Reporting on the British Spring Clean, which is sponsored by the Daily Mail among others. A campaign to get people to clean up the countryside and beaches.	Significant on some day spline bins – see graphs
Solutions	Individual persons' clean-up projects (2.9)	Included in articles which report on personal narratives of people removing plastic, abroad and in the UK.	Type: B = 0.04 (SE = 0.02), p = .030
Plastic products	Plastic bottles (4.5)	Addresses problem of plastic bottles and how to counteract it, e.g. with deposit scheme in Scotland.	none
Plastic products	Plastic straws (3.4)	Discusses the issue of plastic straws, legislation targeting these, and some alternatives.	Political alignment: B = -0.03 (SE = 0.02), p = .030 Interaction: B = 0.04 (SE = 0.02), p = .036
Plastic products	Plastic bags (2.7)	Discusses plastic bags and other accessories provided by shops. It also discusses some alternatives like biodegradable bags and their effectiveness.	None
Overview	Data on plastic pollution (3.7)	Consists of objective, scientific reporting on amounts of plastic waste in the ocean. There is a reliance on data and numbers to explain the situation.	none
Overview	Micro-plastics overview (3.1)	Relatively objective reporting on microplastics, their origins, distribution, and potential damage.	Political alignment: B = -0.05 (SE = 0.02), p = .006 Type: B = -0.05 (SE = 0.02), p = .011 Interaction: B = 0.05 (SE = 0.02), p = .034
Impact	Seal rescue stories (3.6)	Discusses stories of individual seals, often given a name, and their rescue and release.	Type: B = 0.04 (SE = 0.02), p = .032
Impact	Plastic kills whales (3.6)	Discusses incidents where whales were killed due to ingested plastic.	none
Impact	Observations of plastic pollution on holiday/travel (3.4)	About plastic pollution combined with holiday/travel stories, such as plastic pollution on formerly idyllic beaches.	none
Impact	Ingesting microplastics (3.2)	Deals with the microplastic that humans and animals ingest, its quantity and effects.	No significant covariate effects.
Impact	Plastic investigated in connection with whale deaths (2.8)	Discusses the death of whales stating explicitly that plastic was not the cause of death.	None
Impact	Impact of micro-plastics on humans and animals (2.5)	Discusses the impact of microplastics on humans and animals such as whales and fish.	Significant on some day spline bins – see graphs

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Impact	Turtles and sea birds (2.3)	Deals with turtles and sea birds generally, showing how these can be negatively impacted by plastics. It is more story- than data-focused, reporting on specific projects, locations, or animals.	None

Note. [a]See Figures 2-4 for interpretations of significant spline regression models.

The following four subthemes could be distinguished: Topics that describe the plastic's impact (combined prevalence = 21.4%), those that cover solutions or mitigation effort (combined prevalence = 14.8%), topics about plastic products (combined prevalence = 10.6%), and those which aim to give an overview over the issue (combined prevalence = 6.8%). Figure 1 further shows how these different subthemes are distributed according to their prevalence overall. It can be seen that, whilst the impacts of plastic were the most prevalent sub-theme, this was distributed across a larger number of topics (7) compared to the other sub-themes, thus individually were less prevalent. In contrast, the solutions subtheme comprises only four topics, yet still captures a relatively large amount of combined prevalence (14.8%) and includes the overall most prevalent topic, *supermarkets reducing plastic*.

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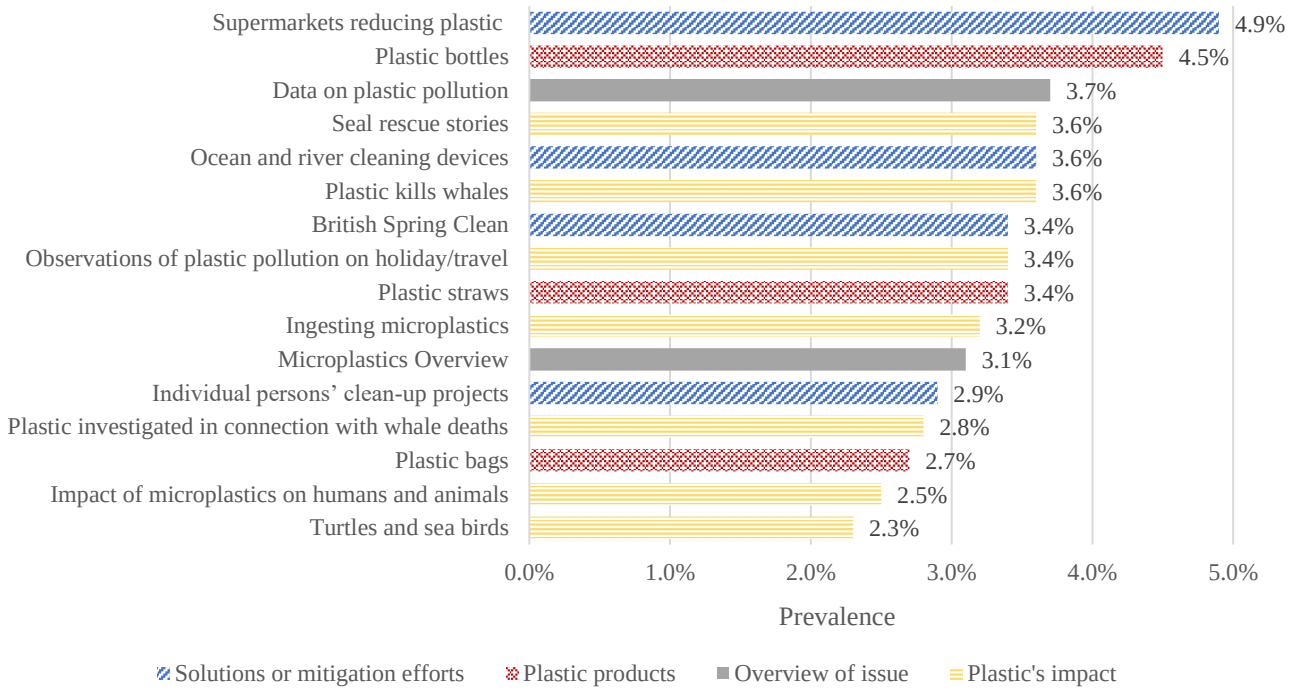
Figure 1

The prevalence of topics within the marine plastics *theme in the 943 articles, categorised by subgroup.*



As indicated by the topics' keywords and representative articles, several topics which portray either the plastic's impact or solution efforts employ episodic framing, i.e. the focus on individual human or wildlife stories. This is particularly the case with the wildlife impact topics, *seal rescue stories*, *plastic kills whales*, and *plastic investigated in connection with whale deaths*, and *turtles and sea birds*, but also with reports on technology such as *ocean and river cleaning devices*, events such as the *British spring clean* or *observations of plastic pollution on holiday/travel*, and *individual persons' clean-up projects*. Topics which employ thematic framing seem to be aiming to provide an overview over the status quo and raising awareness of widespread issues, for example *data on plastic pollution* or *ingesting micro-plastics*.

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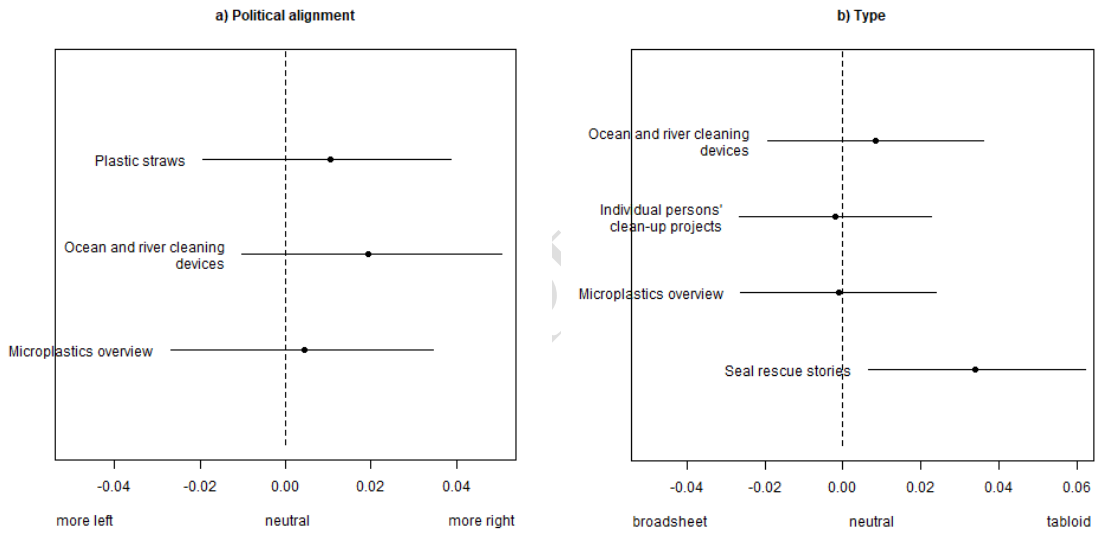
A main feature of a structural topic model is that covariates are integrated into the estimation of the topic prevalence, meaning it can be determined whether a topic's frequency of discussion is related to characteristics of an article. Figure 2 displays the mean difference in topic prevalence for topics that were statistically significantly influenced by political alignment or type of newspaper (see Table 2 for the inferential statistics).

Figure 2

Mean Differences in Topic Proportions in Theme Marine Plastics Based on (a) Political Alignment and (b) Type.



Note. Bars represent 95% confidence intervals of mean differences. Only topics which were statistically significantly influenced by political alignment or type are shown.

Of the 16 topics included in the theme, the prevalence of three topics were influenced by political alignment: *plastic straws*, *ocean and river cleaning devices*, and *micro-plastics overview* were more likely to be covered by right-leaning papers. Four topics were influenced by the type of newspaper, as seen in Figure 2b. The *seal rescue stories* topic in particular was covered much more by tabloids than broadsheet papers, as was *ocean and river cleaning devices*, although less strongly. *Individual persons' clean-up projects* and *micro-plastics*

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overview were slightly more likely to be covered in broadsheets than tabloid papers. There was an interaction effect between political alignment and type for three topics, shown in Figure 3. *Plastic straws* were most likely to be covered in the left-leaning broadsheet paper (the Guardian), but least likely in the right-leaning broadsheet paper (the Telegraph). For both *micro-plastics overview* and *ocean and river cleaning devices*, the difference between broadsheet and tabloid paper seemed to be much more pronounced in left-leaning compared to right-leaning newspaper, where there was less coverage in both types of paper. These findings also show the importance of considering both political alignment and type of paper in analysing news coverage. When controlling for these variables, some topics strongly rose in prevalence in their respective category. For example, *ocean and river cleaning devices* reached a prevalence of almost 9% in left-leaning broadsheets, as opposed to close to 0% in left-leaning tabloids (see Figure 3).

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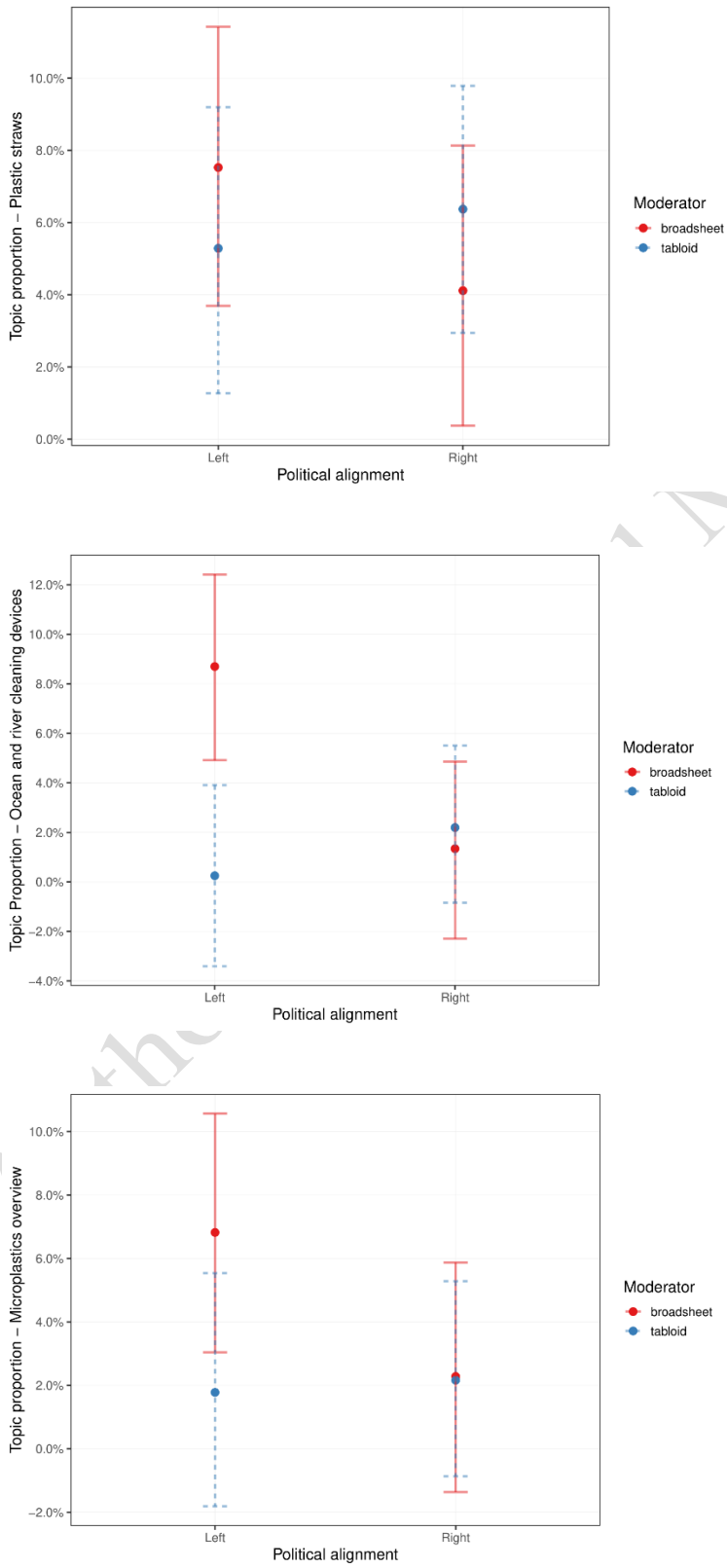
Figure 3

Interaction Effects Between Type and Political Alignment for Plastic Straws (Top), Ocean and River Cleaning Devices (Middle), and Micro-plastics Overview (Bottom).



Note. Bars represent 95% confidence intervals of means. Only topics which were statistically significantly influenced by an interaction between political alignment and type of paper are shown.

Lastly, two topics were significantly influenced by the date of publication, as shown in Figure 4. In the case of the *British spring clean* topic, a rise in coverage is depicted, as expected, before and during spring. The second topic, *impact of micro-plastics on humans and animals*, included a few peaks which coincide with releases of studies or reports which are prominently mentioned in the respective articles. For example, the spike around late August and September involved articles covering a press release and report by the World Health Organization about micro-plastics in water (World Health Organization, 2019).

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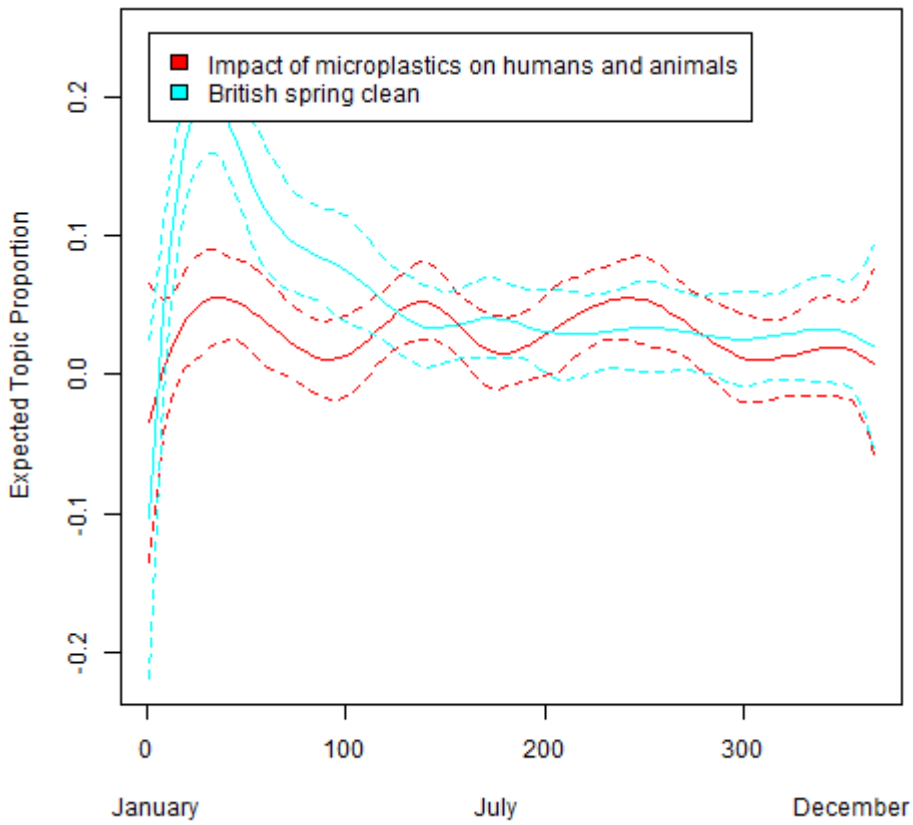
Figure 4

Influence of Day of Publication in Theme Marine Plastics



Note. Ninety-five percent CI displayed around splined regression slopes. Only topics which were statistically significantly influenced by date of publication are shown.

3.2 Sustainability

The second main theme was that of *sustainability as primary focus*, wherein general sustainability issues were discussed with marine plastics as a secondary focus. This theme had a summed prevalence of 29.3%, with an average prevalence of 2.4% among the 12 topics. Table 3 displays the topics within the theme, again grouped in three subthemes, along with their main characteristics. There was one topic, named *unidentified*, in which no semantically coherent subject could be identified (see Appendix for keywords and supplementary materials for representative articles).

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Table 3
Overview of Topics Within the Theme Sustainability.

Subtheme	Topic Name (Prevalence in %)	Summary	Covariate effects[a]
Events	Climate activists (4.1)	Includes reporting about climate activists, mostly Greta Thunberg and David Attenborough.	None
Events	Environmental sustainability in the media (2.7)	Reports on how environmental issues, among them plastic pollution, are portrayed in the media, for example in documentaries or on Instagram.	Significant on some day spline bins – see graphs Interaction: B = -0.05 (SE = 0.02), p = .037
Events	Celebrity environmental campaigns (2.3)	This topic is about celebrities sporting their environmental campaigns.	Alignment: B = 0.03 (SE = 0.01), p = .012
Environmental	Global environmental issues (3.3)	Talks about global environmental issues generally and mentions plastic marine pollution as one of them.	Type: B = -0.04 (SE = 0.02), p = .035
Environmental	Water shortages (2.2)	Talks about future water shortages especially in England.	none
Environmental	Fatbergs (2.1)	Discusses fatbergs, and campaigns and products to combat them.	Significant on some day spline bins – see graphs
Solutions	Sustainable lifestyle (beauty products) (3.2)	Reporting on eco-friendly beauty products.	none
Solutions	Issues with recycling industry (2.8)	Includes detailed, non-sensational reporting on the recycling industry in the UK and abroad, and issues associated with it.	Political alignment: B = -0.04 (SE = 0.02), p = .006 Type: B = -0.07 (SE = 0.02), p < .001 Interaction: B = 0.05 (SE = 0.02), p = .014
Solutions	Sustainable lifestyle (gifts) (2.4)	Lists of gift ideas for Christmas or other occasions, some of which are eco-friendly.	Political alignment: B = 0.05 (SE = 0.01), p < .001 Interaction: B = -0.06 (SE = 0.02), p = .003
Solutions	Sustainable lifestyle (general) (1.7)	Addresses sustainable life choices, especially in regard to flying.	Political alignment: B = 0.03 (SE = 0.01), p = .021
Solutions	Sustainable lifestyle (food) (1.1)	Talks about sustainable food trends, such as vegan January or shops, cafes which specialise in sustainability.	Political alignment: B = 0.02 (SE = 0.01), p = .014
NA	Unidentified (1.3)	N/A	Type: B = 0.04 (SE = 0.01), p = .005 Interaction: B = -0.04 (SE = 0.02), p = .023

Note. [a]See Figures 5-7 for interpretations of significant spline regression models.

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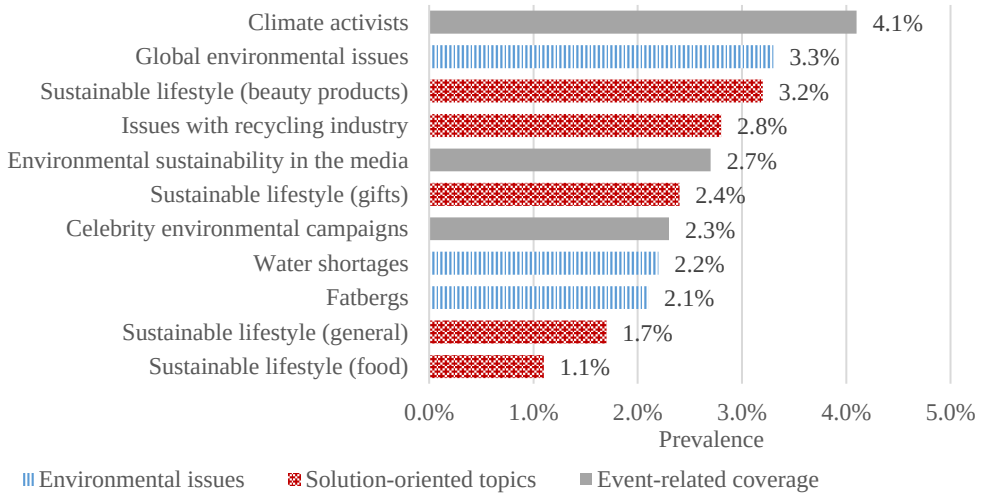
Three subthemes were identified in the s*ustainability* theme: Three topics which were sparked by events (combined prevalence = 9.1%), three topics which covered other, related environmental issues (combined prevalence = 7.6%), and five topics which were oriented towards solutions (combined prevalence = 11.2%). As in the *marine plastics* theme, a subtheme comprising of a larger number of smaller topics held the highest prevalence within articles. This is also illustrated in Figure 5, which presents topics sorted by overall prevalence.

Figure 5

Topics within the Sustainability *theme, categorised by subgroup.*



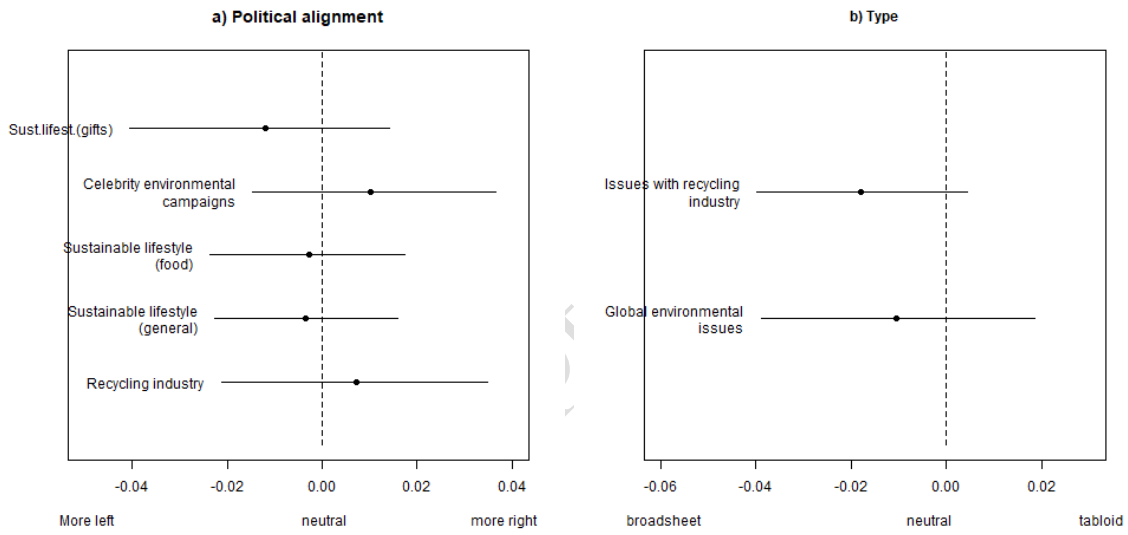
Examining topic keywords and representative articles, we see that both episodically and thematically framed topics are present, with episodic framing slightly more frequent (e.g. *climate activists, sustainable lifestyle* topics, *celebrity environmental campaigns*) than thematic. Especially individual-centred coverage as represented in *climate activists* and the *celebrity environmental campaigns* can be seen to receive a lot of coverage.

Topics in the sustainability theme were affected by political alignment more than by type of newspaper, as shown in Figure 6: Two topics were more prevalent in right-leaning

newspapers, namely *celebrity environmental campaigns* and *issues with recycling industry*. Three topics were more likely to be reported in left-leaning newspapers: *sustainable lifestyle (gifts)*, *sustainable lifestyle (food)*, and *sustainable lifestyle (general)*. Regarding the type, there were two topics which were more prevalent in broadsheet compared to tabloid newspapers (*issues with recycling industry* and *global environmental issues*).

Figure 6

Mean Differences in Topic Proportions in Theme Sustainability

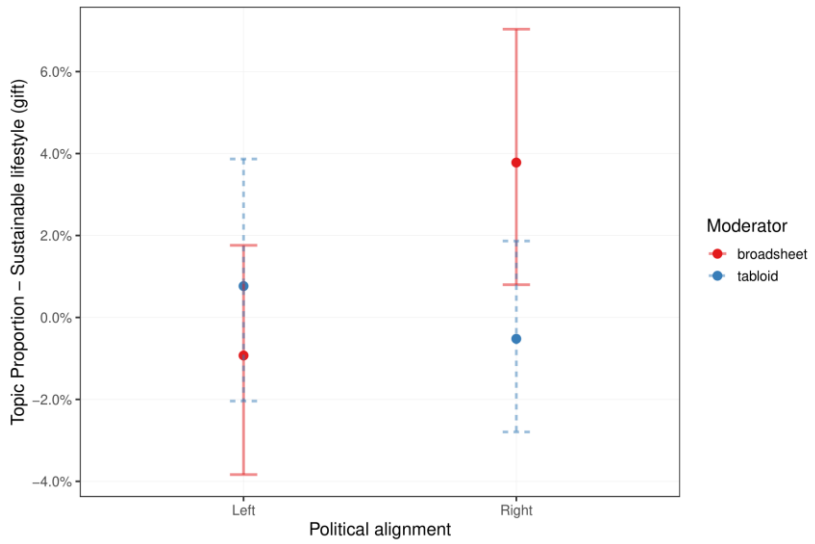


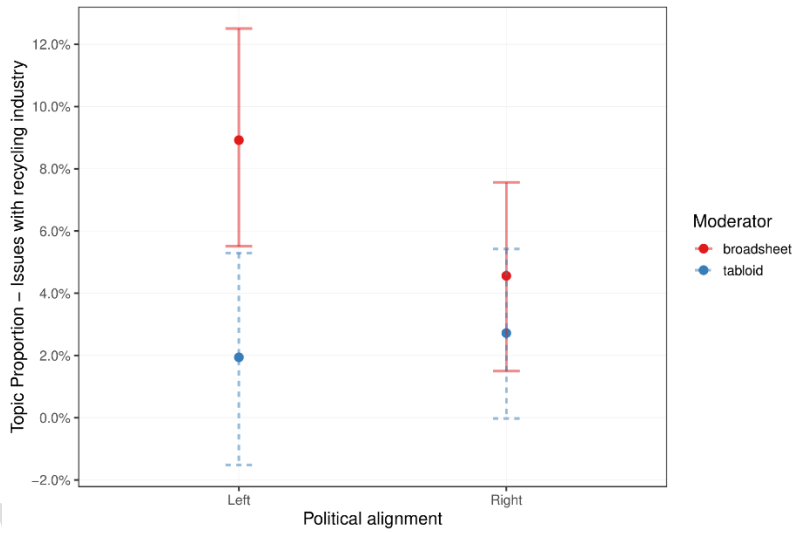
Note. Bars represent 95% confidence intervals of mean differences. Only topics which were statistically significantly influenced by political alignment or type are shown.

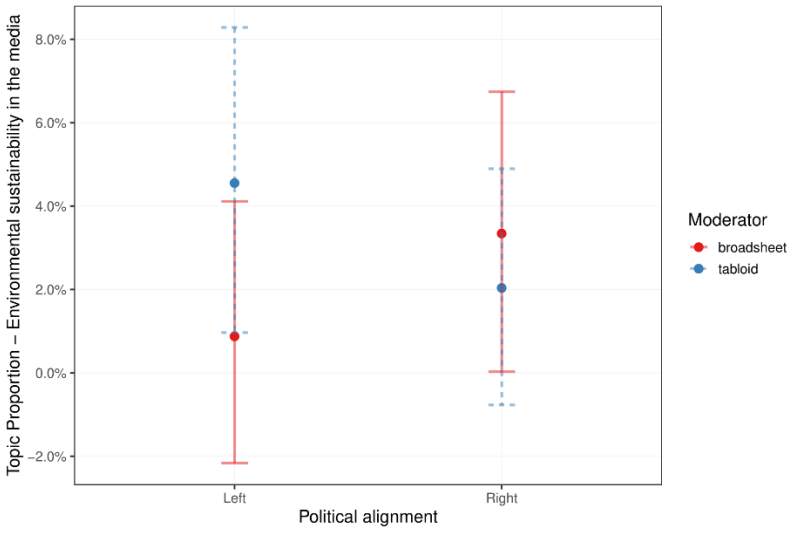
As in the marine plastics theme, interaction effects between these two covariates were found for three topics, which are displayed in Figure 7. *Sustainable lifestyle (gifts)* were most prominent in the right-leaning broadsheet (Telegraph), followed by the left-leaning tabloid (Mirror); *issues with recycling industry* was most often covered by left-leaning broadsheets (Guardian), followed by right-leaning broadsheets (Telegraph); *environmental sustainability in the media* was most prevalent in left-leaning tabloids (Mirror), followed by right-leaning broadsheets (Telegraph).

Figure 7

Interaction Effects Between Type and Political Alignment for Sustainable lifestyle (gifts) (Top), Issues With Recycling Industry (Middle), and Environmental Sustainability in the Media (Bottom).







Note. Bars represent 95% confidence intervals of means. Only topics which were statistically significantly influenced by an interaction between political alignment and type of paper are shown.

Lastly, two topics' prevalence changed over the course of 2019, as shown in Figure 8. Fatbergs experienced several highs, most of which were related to companies declaring that they will forego wet wipes, and a campaign starring Andy Serkis raising awareness of the issue (e.g. Jenkin, 2019). The spike in *environmental sustainability in the media* around the end of March 2019 was related to the release of the Netflix documentary "Our Planet", starring Sir David Attenborough. As with the previous theme, there were no effects observed that would suggest an increase of coverage over time. Rather, spikes are observed which related to specific events.

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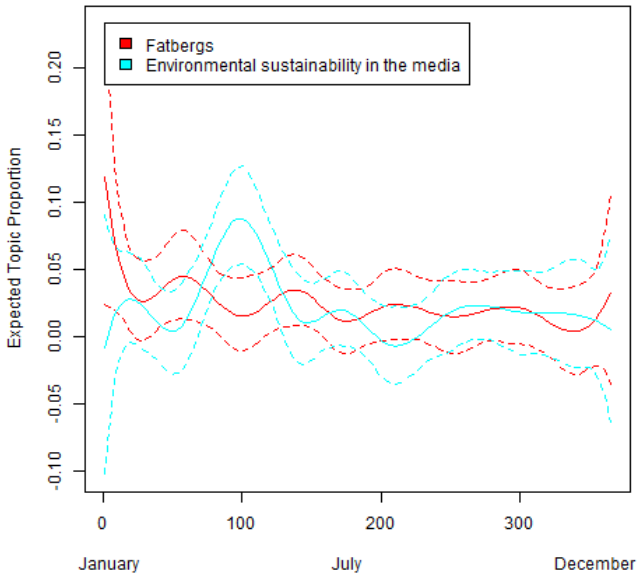
Figure 8

Influence of Day of Publication in Theme Sustainability



Note. Ninety-five percent CI displayed around splined regression slopes. Only topics which were statistically significantly influenced by date of publication are shown.

4 Discussion

4.1 Discussion of Results

Investigating the media coverage of a certain issue can contribute to understanding the present and future shape of public opinion. In the context of marine plastic pollution, this is particularly important since public opinion informs behaviour intervention and policy measures that aim to mitigate this anthropogenic issue (Pahl et al., 2017). Nevertheless, little was known about the extent of the coverage, which topics are covered, and whether these vary with different media outlets. The aim of this study was to address this gap in regard with British media by investigating which topics online newspapers cover around marine plastic pollution, and whether the prevalence of these topics is associated with newspapers' political

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alignment, type, and the date of publication. A total of 943 articles from four UK online news sites (Guardian, Telegraph, Mirror, Daily Mail) was identified as having mentioned marine plastics in the year 2019 and entered into a structural topic model, which resulted in 36 distinct topics that were covered within the texts. The political alignment (left vs. right-leaning), type (broadsheet vs. tabloid), and day of publication were entered as covariates and found to significantly correlate with the coverage of particular topics.

In general, it was found that the newspaper coverage is much more extensive than even a few years ago, especially in tabloids, which in 2014 had very little coverage of marine plastic pollution (GESAMP, 2015). Using a quantitative text analysis to examine this coverage thus enabled us to uncover the breadth of topics being discussed.

The 36 diverse topics were clustered into three themes, according to the extent to which marine plastics are mentioned: *marine plastics*, with articles focusing on the issue as its primary objective, *sustainability*, with articles focussing on sustainability issues but discussing marine plastics as one of them, and *other*, which reports unrelated stories mentioning marine plastics in passing. The analysis focuses on topics within the former two themes, as these were more frequent, prevalent, and nuanced in their treatment of marine plastics.

The publication date was not found to influence the majority of the topics in the themes. There was no significant rise in coverage over 2019. For some topics, there were spikes in the reporting associated with events like report releases (*impact of micro-plastics on humans and animals*) and campaigns (*British spring clean* and *fatbergs*). These supports the general trend of media reporting on environmental issues being very events-focused, which helps journalists anchor stories to a particular point (Boykoff, 2007; Sampei & Aoyagi-Usui, 2009). There was also a major spike in reports on other media covering marine plastics from around

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0-5% to 15% which can be traced back to the Netflix release of the "Our Planet" documentary in April 2019 (Gill, n.d.). This could potentially be related to the often-mentioned Attenborough effect, according to which there was an increase in coverage of environmental issues following David Attenborough's campaigning on plastic pollution (Mahmood, 2019). The increase in prevalence suggests that the topic of marine plastics is now heavily associated with the TV presenter and his projects which translate into increased coverage and increased awareness of the topic during the release.

4.1.1 Marine Plastics

Marine plastics comprised 16 individual topics. The most prevalent topic focused on supermarkets' efforts to reduce the amount of plastic sold, thereby aiming to stop plastic from entering the ocean in the first place. The topic communicates to potential customers that limiting plastic is important to major supermarkets, which could increase the awareness and sense of urgency in readers. However, it is unclear to what extent this topic reflects the supermarkets trying to promote their own sustainability efforts. While there is no official relationship between editorial choices and corporations, it must be noted that supermarkets may be indirectly useful to newspapers: they are an important advertiser, they contribute to stories by giving interviews, and those supermarkets frequently mentioned in the topic are (at the time of the study) among the few still selling physical newspapers, while others are stopping (e.g. Tobitt, 2019). In fact, WH Smith, a UK news and stationary retailer, has recently relocated the Telegraph (the right-wing broadsheet in this study) further back in their shops to increase the pressure on the newspaper in negotiations (Sweeney, 2020). This suggests that newspapers are aware of the reciprocal relationship between the two businesses and is representative of research finding that newspaper content is often unconsciously or consciously self-censored by journalists to retain useful relationships with advertisers or sources (A. Anderson, 2009; Antilla, 2005; Dispensa & Brulle, 2003; Herman & Chomsky,

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2008). It is therefore possible that a topic involving supermarkets is so prevalent partly because newspapers wish to avoid shedding a bad light on these corporations, and therefore engage in stories which benefit supermarkets by highlighting their ecological decisions.

Related to this topic are those which focus on one form of plastic at a time, such as plastic bottles, straws, or bags. These topics show that a selected set of plastic items has become the focus of the media as well as that of policy (Xanthos & Walker, 2017), perhaps because they are most visible and recognisable in connection with topics on affected animals and can be targeted with specific policies. This could have positive and negative effects on readers: On the one hand, it can raise awareness of certain plastic products and potentially reduce the amount of those products entering the ocean. On the other hand, it reflects the focus on a few exemplary products which are reduced, while the overarching issues – such as other items, or the global nature of marine pollution – might receive less attention (Villarrubia-Gómez et al., 2018). Similar to the topic on supermarkets, this might give the impression that necessary preventative measures have already been taken, thereby reducing readers' feelings of urgency and responsibility. This is related to challenges such as the single-action bias (Weber, 1997) which has long been recognised in environmental psychology: people can be led to think that they have done "their share" after a single action such as using a reusable shopping bag, which can inhibit them from performing other pro-environmental behaviours such as using less plastic packaging. On the other hand, it is also possible that showing readers how to change one particular behaviour may lead to spill-over effects to other pro-environmental behaviours (Truelove et al., 2014). The data in this study does not allow any definite conclusions as to which of these mechanisms may be more prominent, but future research could investigate these questions by means such as interviewing participants after presenting them with these stories.

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Topics reporting immediate solutions to spoiled beaches and ocean patches (such as *ocean and river cleaning devices*, *British spring clean*, and *individual persons' clean-up projects*) may also be sending ambiguous messages. They tell hopeful, positive stories emphasising self-efficacy, which might engage readers with the issue (Höijer, 2010; Markowitz & Shariff, 2012), but on the other hand they suggest that the issue of marine plastics may be tackled by cleaning up after the pollution, rather than preventing it, with which scientists heavily disagree (Vince & Stoett, 2018). The topic *ocean and river cleaning devices*, which received almost 9% of coverage in a left-leaning broadsheet as compared to 0-2% in the remaining papers, can be seen as an example of this narrative which may seem less emotive than *individual persons' clean-up stories* or campaigns, but suffers from the same effect. This suggests that while newspapers may treat different subtopics according to their style, they overlap on the general messages they portray.

The remaining topics can be seen to fulfil two functions. Firstly, topics report on the status quo, giving information and data on marine plastic pollution and micro-plastics, as well as the impact on marine animals. This coverage reflects on the public's current uncertainty regarding the impact of both macro- and micro-plastics, which the newspapers try to address by explaining factors surrounding the issue. For one topic, *microplastics overview*, this is more often reported in the left-leaning broadsheet compared to the remaining papers, perhaps reflecting the relative novelty in the issue causing it to be less of a focus for conservative papers and tabloids. This novelty is similarly reflected in the selection of topics identified by the STM model overall: The topics cover very broad, visible subjects, whereas little coverage of more detailed challenges connected with marine plastics was detected. Issues such as health risks through pathogens carried by debris or threats to fishing business, were underrepresented, possibly leading to a skewed image of the socio-environmental risk of marine plastic pollution in readers.

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Secondly, the topics involving animals additionally reflect on the emotional coverage which Koelmans et al. (2014, 2017) argue is used to draw readers' attention, and may influence which aspects of marine plastics are being tackled. The covariate analysis showed that the topic *seal rescue stories* in particular was much more portrayed by tabloids than broadsheets, which reflects the more immediate attention seeking nature of tabloid reporting. Journalists may feel like these stories are more relatable than abstract reporting and therefore of higher interest to readers (Berglez, 2011; Höijer, 2010). Especially with the pressure faced by newspaper companies to engage readers, resulting from declining readership narratives and limited digital success (Chyi & Tenenboim, 2017), these emotional stories could therefore be seen as preferable to more neutral reporting. This might in turn lead tabloid readers to be more aware of individual animal stories, which could increase the associated emotions, but not necessarily the knowledge about the threats of marine plastics to animal populations or humans (Hart, 2011). Similarly, animal topics may not lead to an understanding of whether and what kind of action is required. Emotions related to environmental issues, especially guilt, have been found to contribute towards pro-environmental intentions and behaviours (Ferguson & Branscombe, 2010; Harth et al., 2013; Kaiser, 2006; Mallett, 2012; Mallett et al., 2013; Rees et al., 2015). However, it is unclear whether negative emotions such as sadness or compassion with a seal will translate into guilt and/or action. The exact nature of the effect of these animal stories on readers can only be determined by further investigation of these stories, for example by taking an in-depth look at the framing and language used in these topics using thematic or other qualitative text analysis, or by analysing participants' responses to these stories as mentioned above.

4.1.2 Sustainability

There were 12 topics within the sustainability theme. The most important topic was *climate activists*, which mostly comprised stories about Greta Thunberg and David Attenborough.

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Both received attention due to their campaigning on environmental issues, among them marine plastics, independent from political alignment or type. The documentary "Our Planet" involving Attenborough was also heavily featured in the topic *environmental sustainability in the media*, which was most prominently picked up by the left-leaning tabloid paper, followed by the right-leaning broadsheet. As discussed above, this topic may have been particularly prominent in 2019 due to the release of the documentary in April of that year (Gill, n.d.), showing how output of the entertainment industry can play a significant role in raising general awareness for a topic which is also then picked up by the news media. However, the extent of the effect of this increased coverage on attitudinal or behavioural change remains to be determined in future research.

Another notable topic is *issues with recycling industry*, most commonly portrayed in the left-leaning broadsheet paper with 9% prevalence. The topic discusses problems with the recycling process in the UK and overseas, portraying one of the causes underlying marine plastic pollution. Since exporting plastic waste can create psychological distance between persons and the impact of the waste they produce (Barnes, 2019), this topic may raise awareness and contribute to closing this gap and increasing perceived responsibility (Barnes, 2019) when encountered by readers. Coverage of this topic in right-leaning papers and the left-leaning broadsheet is significantly lower, although still between 2% and 5%, indicating that it is indeed portrayed across the political spectrum and different types of newspapers included in this study.

Finally, the topic *sustainable lifestyle (gifts)* was strongly featured in the right-leaning broadsheet, and almost not at all in all other newspapers. This observation is potentially explained by differences in newspapers' business models, or in the way they conduct themselves in relationship to PR departments of corporations. Some newspapers might be more open than others to writing "list" articles involving certain products, which is reflected

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in this case by the stark difference between the newspapers. While this effect was only found for one, less prevalent, topic, it does suggest that possible industry connections may play a meaningful role in shaping news output. *Sustainable lifestyle (beauty products)* on the other hand was equally featured in all papers, which might indicate that there is a market for eco-consumerism (or the appearance thereof) across the spectrum. The presence of beauty products in particular may be due to the microbeads ban in 2018 (Department for Environmental, Food & Rural Affairs & Gove, 2018), which might have raised public awareness of environmental issues in this sector.

4.2 Limitations and Directions for Future Research

This study is the first to systematically research the coverage of marine plastics in online newspapers. As such, there are several limitations. As this paper's focus was on what is being reported and how this relates to factors such as political orientation and newspaper type, it was necessary to adopt an approach that enabled a broad systematic overview of topics (i.e. structural topic modelling) and have large enough samples within the covariate groups (i.e. publication type and political orientation) to make meaningful interpretations whilst reducing the effects of other covariates. Consequently, the largest British online newspaper to represent each of the categories (see Table 1) were chosen in a focused time period (2019). Whilst the conclusions can only be generalised to a limited degree, this has meant we have successfully demonstrated the novel application of this analytical approach in a new area and effectively addressed our research questions. The methods presented in this paper can therefore be used to extend analysis to an even wider range of papers, locations, and time frames depending on specific research questions. In light of the many individually interesting topics identified in this study, one such application could be to focus in on one of the prominent topics such as supermarkets. This could be achieved by sampling articles

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involving keywords related to that topic either across a longer time frame and/or from a larger variety of news outlets.

Since the aim of the paper was to provide the first overview over *what* was portrayed, it was beyond its scope to look at *how* topics were discussed in great detail. This is a logical next step for research to take, building on the basis of prevalent topics presented in this study. Qualitative analysis of articles representing prevalent topics could shed valuable light on how these issues are framed and what particular language is used to portray them. This could be achieved by narrowing the sampling criteria and applying thematic analysis to provide a more in-depth look at a topic of interest. For instance, the choice of words, different frames, or portrayals of uncertainty could be examined which have been shown to impact readers' willingness to change their behaviours (Bellotti & Panzone, 2016; Corbett & Durfee, 2004; Happer & Philo, 2013).

One important question going forward is whether the messages conveyed in the topics are enough to motivate behavioural change. The data resulting from this study cannot speak to these links, but it would be valuable to find out how people react to different topics, and different portrayals of one topic, in an experimental setup. For example, researching whether human- or wildlife-focused portrayals of marine plastics are more effective in reducing plastic consumption could be used to predict whether current media coverage is more or less effective in motivating behavioural change.

Finally, this study can only make conclusions regarding online newspaper articles. There are many other sources of information, in particular social media, which are an integral part in building public opinion. The technique demonstrated in this study could be used to extend the analysis to other textual information such as social media, which would complement this picture of public discourse.

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4.3 Conclusions

This study demonstrated how quantitative text analysis can be used to gain an overview of the topics portrayed in a large corpus of text, in this case all newspaper articles mentioning marine plastic pollution in four leading British online newspapers across the year 2019. It is the first time this technique has been applied to the coverage of marine plastics and thus delivers a valuable overview of themes prevalent throughout 2019. In particular, it presented an approach through which potentially politically influenced coverage can be investigated, removing researchers' conscious and unconscious biases to an extent which would not be possible with other methods of analysis. Overall, there was a large variety of topics portrayed in the articles. Currently, most topics demonstrate episodic framing, focusing on case studies and relatable stories. While this is necessary to engage readers, a balance can be struck between these and topics with thematic framing, which may be better able to portray the larger picture necessary to understand and support measures beyond individual behavioural change (Hart, 2011). These findings suggest different take-away messages for different actors. Experts agree that sustainable change requires that policy, producers, and consumers do their part, with a need for stronger regulation and transnational agreements (Dauvergne, 2018). Current policy measures, such as the European Commission's strategy on circular economy (European Commission, 2018), focus heavily on producers' responsibility to minimise plastic waste. An important role the newspapers can play is to report on the origin of marine plastics and make readers aware of who is responsible for changing the situation. On the other side of the coin, readers can stay aware of newspapers' potential biases in their editorial choices, which, as shown above, may be associated with the prevalence of certain topics. Finally, policy makers, communicators, and behavioural intervention designers will benefit from understanding how marine plastic pollution is portrayed in different online newspapers, potentially leading to a different understanding and response to the challenge by

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readers of different papers. This study provides a context and basis to further study the topics prominent in this coverage and to investigate the effect they can have on readers.

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Appendix

Overview of Individual Topics

Name	Prevalence (%)	Words[a]	Summary	Covariate effects[b]	Theme[c]
Supermarkets reducing plastic	4.9	Highest Prob: plastic, packag, will, supermarket, custom, said, year FREX: fruit, trial, supermarket, loos, waitros, custom, tesco	This topic discusses the measures supermarkets are taking to reduce plastic output, such as cutting down on packaging or glitter.	none	MP
Plastic bottles	4.5	Highest Prob: plastic, bottl, recycl, said, will, wast, year FREX: scheme, deposit, bottl, coca-cola, tax, return, drink	This topic addresses problem of plastic bottles and how to counteract it, for example with deposit scheme in Scotland.	none	MP
Data on plastic pollution	3.7	Highest Prob: plastic, ocean, found, island, research, studi, said FREX: crab, entangl, debri, trench, coco, pacif, data	Consists of objective, scientific reporting on amounts of plastic waste in the ocean. There is a reliance on data and numbers to explain the situation.	none	MP
Seal rescue stories	3.6	Highest Prob: seal, plastic, said, around, anim, net, neck FREX: seal, neck, frisbe, pup, rescu, rspca, norfolk	*Seal rescue stories* discusses stories of individual seals, often given a name, and their rescue and release.	Type: $B = 0.04$ ($SE = 0.02$), $p = .032$	MP
Ocean and river cleaning devices	3.6	Highest Prob: plastic, wast, ocean, countri, pollut, year, said FREX: cleanup, pacif, boom, trash, slat, devic, garbag	This topic addresses devices that clean up waterways and the oceans, thereby mitigating marine plastic pollution.	Political alignment: $B = -0.07$ ($SE = 0.02$), $p < .001$ Type: $B = -0.08$ ($SE = 0.02$), $p < .001$ Interaction: $B = 0.09$ ($SE = 0.02$), $p < .001$	MP
Plastic kills whales	3.6	Highest Prob: plastic, found, whale, said, bag, stomach, turtl FREX: stomach, dugong, dead, die, philippin, turtl, beak	This topic discusses incidents where whales were killed due to ingested plastic.	none	MP
British Spring Clean	3.4	Highest Prob: litter, plastic, clean, great, year, spring, british FREX: spring, litter, tidi, mail, volunt, litter-pick, pick	This is reporting on the British Spring Clean, which is sponsored by the Daily Mail among others. A campaign to get people to clean up the countryside and beaches.	Significant on some day spline bins – see graphs	MP
Plastic pollution on holiday	3.4	Highest Prob: beach, plastic, rubbish, island, year, wast, local	This topic is about plastic pollution combined with holiday/travel stories, such	none	MP

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		FREX: beach, tourist, bali, sand, rubbish, indonesia, sas	as plastic pollution on formerly idyllic beaches.		
Plastic straws	3.4	Highest Prob: plastic, straw, ban, said, use, will, single-us FREX: straw, ban, bud, stirrer, legisl, trump, canada	This topic discusses the issue of plastic straws, legislation targeting these, and some alternatives.	Political alignment: B = -0.03 (SE = 0.02), p = .030 Interaction: B = 0.04 (SE = 0.02), p = .036	MP
Ingesting microplastics	3.2	Highest Prob: plastic, pollut, river, microplast, found, per, said FREX: river, microbead, nurdl, lake, piec, nose, comic	This topic deals with the microplastic that humans and animals ingest, its quantity and effects.	No significant covariate effects.	MP
Microplastics Overview	3.1	Highest Prob: plastic, microplast, research, particl, studi, found, said FREX: tyre, particl, fibr, snow, dust, arctic, microfibr	Relatively objective reporting on microplastics, their origins, distribution, and potential damage.	Political alignment: B = -0.05 (SE = 0.02), p = .006 Type: B = -0.05 (SE = 0.02), p = .011 Interaction: B = 0.05 (SE = 0.02), p = .034	MP
Personal cleanup projects	2.9	Highest Prob: plastic, bottl, use, peopl, can, one, everi FREX: realis, ive, nicol, kay, buy, paddl, cancer	This topic includes articles which report on personal narratives of people removing plastic, abroad and in the UK.	Type: B = 0.04 (SE = 0.02), p = .030	MP
Plastic investigated in connection with whale deaths	2.8	Highest Prob: whale, dolphin, said, water, found, strand, marin FREX: strand, dolphin, humpback, cetacean, whale, sperm, calf	This topic discusses the death of whales stating explicitly that plastic was not the cause of death.	None	MP
Plastic bags	2.7	Highest Prob: bag, plastic, paper, year, use, one, said FREX: bag, boot, carrier, paper, biodegrad, tea, retail	This topic discusses plastic bags and other accessories provided by shops. It also discusses some alternatives like biodegradable bags and their effectiveness.	None	MP
Impact of microplastics on humans and animals	2.5	Highest Prob: microplast, plastic, research, water, food, studi, health FREX: bacteria, baleen, salmon, microplast, drinking-wat, plankton, treatment	Articles in which this topic appears discuss the impact of microplastics on humans and animals such as whales and fish.	Significant on some day spline bins – see graphs	MP
Turtles and sea birds	2.3	Highest Prob: turtl, island, bird, said, shark, sea, fish FREX: ranger, shark, gull, puffin, nest, seabird, turtl	This deals with turtles and sea birds generally, showing how these can be negatively impacted by plastics. It is more story- than data-focused, reporting on specific projects, locations, or animals.	None	MP

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Climate activists	4.1	Highest Prob: climat, chang, peopl, said, say, world, think FREX: greta, climat, thunberg, attenborough, ice, strike, voic	This topic includes reporting about climate activists, specifically Greta Thunberg and David Attenborough.	None	S
Global environmental issues	3.3	Highest Prob: climat, ocean, chang, report, world, natur, speci FREX: climat, biodivers, speci, restor, fossil, fuel, threat	This topic talks about global environmental issues generally and mentions plastic marine pollution as one of them.	Type: B = -0.04 (SE = 0.02), p = .035	S
Sustainable lifestyle (beauty products)	3.2	Highest Prob: use, product, cloth, recycl, fashion, sustain, plastic FREX: fur, hair, fashion, cloth, skin, soap, shampoo	This topic has reporting on eco-friendly beauty products.	none	S
Issues with recycling industry	2.8	Highest Prob: recycl, plastic, wast, say, packag, materi, said FREX: recycl, inciner, compost, sent, landfil, materi, facil	This topic includes detailed, non-sensational reporting on the recycling industry in the UK and abroad, and issues associated with it.	Political alignment: B = -0.04 (SE = 0.02), p = .006 Type: B = -0.07 (SE = 0.02), p < .001 Interaction: B = 0.05 (SE = 0.02), p = .014	S
Media and sustainability	2.7	Highest Prob: planet, seri, world, david, one, natur, blue FREX: vescovo, seri, hole, netflix, attenborough, cameron, david	This topic is about how environmental issues, among them plastic pollution, are portrayed in the media, for example in BBC and Netflix documentaries, in the Instagram accounts of royals or during a feud about deep ocean diving between Cameron and Vescovo.	Significant on some day spline bins – see graphs Interaction: B = -0.05 (SE = 0.02), p = .037	S
Sustainable lifestyle (gifts)	2.4	Highest Prob: can, like, new, will, use, buy, christma FREX: flask, kit, gift, christma, wardrob, youll, hot	These articles have lists of gift ideas for Christmas or other occasions, some of which are eco-friendly.	Political alignment: B = 0.05 (SE = 0.01), p < .001 Interaction: B = -0.06 (SE = 0.02), p = .003	S
Celebrity environmental campaigns	2.3	Highest Prob: travel, one, say, will, year, princ, peopl FREX: princ, privat, shes, queen, beckham, tourism, duke	This topic is about celebrities sporting their environmental campaigns.	Alignment: B = 0.03 (SE = 0.01), p = .012	S
Water shortages	2.2	Highest Prob: water, will, year, need, emiss, new, environ FREX: emiss, economi, vehicl, suppli, nhs, road, budget	This topic talks about future water shortages especially in England.	none	S
Fatbergs	2.1	Highest Prob: wipe, wet, plastic, flush, said, cole, sewer	This topic discusses fatbergs, and campaigns and products to combat them.	Significant on some day spline bins – see graphs	S

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		FREX: fatberg, sewer, cole, flush, wipe, wet, lens			
Sustainable lifestyle (general)	1.7	Highest Prob: per, can, cent, carbon, year, save, energi FREX: carbon, footprint, energi, save, fli, flight, emiss	This topic addresses sustainable life choices, especially in regard to flying.	Political alignment: *B* = 0.03 (*SE* = 0.01), *p* = .021	S
Unidentified	1.3	Highest Prob: plastic, said, council, recycl, wast, bin, bag FREX: hugh, council, cliff, brisban, bin, contractor, mound	N/A	Type: *B* = 0.04 (*SE* = 0.01), *p* = .005 Interaction: *B* = -0.04 (*SE* = 0.02), *p* = .023	S
Sustainable lifestyle (food)	1.1	Highest Prob: shop, tree, say, food, plant, plastic, wast FREX: receipt, tree, zero-wast, jan, milk, shop, dairi	This topic talks about sustainable food trends, such as vegan January or shops, cafes which specialise in sustainability.	Political alignment: *B* = 0.02 (*SE* = 0.01), *p* = .014	S
Celebrity outfits	3.6	Highest Prob: ocean, bottl, star, look, water, plastic, one FREX: sequin, glastonburi, kendal, star, wore, festiv, actor	Discusses the appearance of celebrities at events or in public, with a small mention of plastic pollution as part of something they have been engaging with or similar.	Significant on some day spline bins – see graphs Interaction: *B* = 0.05 (*SE* = 0.02), *p* = .025	O
Elections	2.8	Highest Prob: will, labour, brexit, parti, corbyn, tax, new FREX: labour, corbyn, manifesto, brexit, elect, tori, pension	This topic reports on election campaigns by conservatives and labour, and mentions ocean plastics in relation to campaign plans and associations with the campaigns.	Type: *B* = 0.04 (*SE* = 0.02), *p* = .045	O
Landscapes and arts	2.4	Highest Prob: like, sea, one, fish, water, can, first FREX: beliz, artist, paint, jellyfish, exhibit, underwat, palm	This topic appears in articles which involve picturesque descriptions of landscapes and activities, which have something to do with plastic pollution (e.g. plastic free holiday resort). The plastic is not the focus of the story.	Political alignment: *B* = 0.03 (*SE* = 0.02), *p* = .040	O
Celebrities - drama	2.2	Highest Prob: johnson, said, symond, miss, carri, bori, like FREX: symond, bori, johnson, down, miss, leadership, tori	This topic only mentions plastic pollution in a sentence or two, the main article is about celebrities and drama, such as divorces.	Interaction: *B* = -0.04 (*SE* = 0.02), *p* = .045	O
Notable people	2.0	Highest Prob: ship, said, team, compani, year, will, world FREX: cruis, carniv, ineo, ratcliff, brailsford, crash, sky	This is reporting about incidents involving notable people who are mentioned in combination with plastics. One example is a polar tourism expert who died in a plane crash, and Jim Ratcliff, who took over a cycling team and is mentioned as a climate change/plastic pollution sceptic.	No significant covariate effects.	O

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Life stories	1.6	Highest Prob: one, anim, help, like, dog, cat, children FREX: cat, dog, calendar, baker, peta, song, advent	Narratives and biographies of somewhat notable people, mention ocean plastics as a side note.	Type: B = 0.07 (SE = 0.02), p < .001 Interaction: B = -0.08 (SE = 0.02), p < .001	O
Royals on tour	1.4	Highest Prob: will, harri, meghan, visit, africa, south, said FREX: meghan, cape, harri, archi, africa, abalon, mental	This topic has reporting on officials (especially royals) visits to other countries. Plastic pollution gets mentioned in connection to local initiatives and activities, although the focus is much more on the officials.	Significant on some day spline bins – see graphs	O
Wimbledon	0.9	Highest Prob: plastic, will, wimbledon, tenni, rebellion, extinct, protest FREX: wimbledon, tenni, rebellion, tee, queue, extinct, club	Topic 4 is about Wimbledon. There was an extinction rebellion protest about marine plastics which sparked some reporting.	Significant on some day spline bins – see graphs	O

Note. [a]Highest Prob = words with the highest probability to appear in topic. FREX weights words by their overall frequency and how exclusive they are to the topic. [b]See graphs for interpretations of significant spline regression models. [c]MP = Marine Plastics, S = Sustainability, O = Other.

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Straws, Seals, and Supermarkets: Topics in the Newspaper Coverage of Marine Plastic Pollution

Supplementary materials: Modelling decisions

Firstly, the data was pre-processed in R by reducing all words to their base or root (e.g. “taking”, “take”, “takes” all become “tak”), dropping stop words (e.g. and, or, etc.) and removing punctuation. As part of this process, a lower cut-off needed to be set which defines whether a word is considered in the analysis. The lower cut-off describes how many texts a word needs to appear in in order to be included, which excludes very rare words that do not add information to the analyses. Trying different cut-off points revealed that there were a fairly large number of rare words. In an effort to retain both a large vocabulary and also common enough words that that would allow meaningful, overarching topics, a lower threshold of three articles was selected, meaning that a word would be included in the analysis when it is mentioned in at least three articles.

Secondly, the covariates needed to be defined. Political alignment (left/right) and type of paper (broadsheet/tabloid) were entered as topical prevalence covariates, meaning that they are assumed to influence how often a topic would occur. For example, this means that the model includes terms which describe how much more likely topic X is to occur in a broadsheet versus a tabloid newspaper, or in a right-leaning versus a left-leaning newspaper. In addition, an interaction term between the two covariates was entered to explore any moderation effects, which would indicate that certain combinations of political alignment and type of paper may have specific topic profiles. Lastly, the date of publication (coded as day 1 to 365 within 2019) was entered to account for any events which may have influenced media coverage. This variable was entered as a spline, meaning that it could vary non-linearly, for example representing a rise in prevalence in the first half of the year and a decline in the

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second half. Any effects for the date of publication in 2019 were later interpreted by manually researching relevant events that were mentioned in the articles that included the topic. This led to the following regression model to be estimated for each of the topics:

$$\text{Topic proportion}_k \sim \text{political alignment} + \text{type} + \text{political alignment*type} + \text{s(day)} + \text{constant}_k + \text{error}_k$$

Thirdly, the number of topics needed to be specified. As pointed out by the R package authors, the number of topics (*k*) is, to an extent, always an analytic choice that stems from a compromise of meaningfulness, interpretability and comprehensiveness (Roberts et al., 2019). There are however some model statistics which may help the researcher narrow down on a suitable number of topics. For the present study, models using $k = 30, 50, 70, 90, 110$ topics were compared along the following measures: the held-out likelihood estimation, which is the probability of the trained model against a random selection of held-out documents (Wallach et al., 2009), residuals (Taddy, 2012), and semantic coherence (Mimno et al., 2011). There was an almost linear decline in held-out likelihood with a rise in topics, but a sharper rise in residuals in $k > 50$. Therefore, models using $k = 10$ to $k = 50$ (10, 15, 20, 25, 30, 35, 40, 45, 50) were examined more closely, revealing an optimal compromise between likelihood, residuals and semantic coherence around $k = 40$. A last comparison of models between $k = 35$ and $k = 45$ resulted in the choice of 36 topics for this model, which provided a solution which was meaningful, relatively exhaustive, and concise enough to deliver an overview over coverage.

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