

Environmental Misinformation and Audiovisual Serial Narratives. An Automatic Analysis of the Twitter Social Discursiveness on *Seaspiracy*

MARTA ROCCHI

Università di Bologna
marta.rocchi5@unibo.it

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Abstract

The ongoing pervasive presence of green media content may increase audience environmental consciousness. Indeed, several authors have highlighted the central role played by visual digital media in bringing environmental issues to public and political attention. Within this context the proliferation of streaming services and audience's everyday use of green media content may facilitate public connections, enhance environmental sensibility, and facilitate behavioural change. This paper explores the insights film and media scholars may get from audience's ongoing debates related to environmental issues when boosted by audiovisual narratives. We investigate the production and circulation of knowledge and environmental misinformation associated with *Seaspiracy* (2021), a Netflix documentary about the impact of commercial fishing. This product was criticized for misrepresentation: NGOs, sustainability labels and experts quoted in the documentary have charged the filmmakers with making 'misleading claims' and using out-of-context interviews and erroneous statistics. The main aim of this study is to explore the role of digital communication – interpersonal and through the media – in the public definition, elaboration and contestation of environmental issues. We focus on tweets related to the documentary *Seaspiracy* to understand how misinformation may spread through audiovisual narratives. We use automatic text analysis tools including sentiment analysis and topic detection to understand how audience responses enable or inhibit the discourse in a shared cultural debate on environmental issues.

Within the contemporary media landscape, environmental communication is rebranding itself through different digital visual media formats such as television programmes and movies, TV series, video games, virtual reality and image-oriented social media. The dissemination of green media content might have a central role in spreading environmental awareness worldwide, enhancing public and political attention (Cox 2006; Hansen 2011; Moore, O’Sullivan 2017; Dibley, Hawkins 2019; Lakew 2020). Since they might facilitate public connection, a concept defined as “an orientation towards a public world where matters of common concern are addressed” (cfr. Nærland 2019), several authors have investigated their possible public impact. For example, Silk et al. (2021) provide an overview of the processes through which different forms of digital visual media may influence human-nature interaction, from the initial production of content, through consumption and engagement. However, understanding what shapes public perceptions of nature and therefore hopefully enhances environment sensibility is difficult (Berenguer 2007; Wright et al. 2015). Conservationist researchers highlight how, in order to achieve effective behaviour change, it is important to understand the cognitive, social and motivational processes that influence human behaviours (Reddy et al. 2017). In addition, providing audiences with green media content that effectively explains how nature and human society interact is an ongoing challenge that can result in trade-offs and unintended consequences (Redpath et al. 2015). Indeed, in environmental communication it is often necessary to maintain a balance between the complexity of nature and socio-ecological system interactions and the need to keep a message simple and engaging (Bickford et al. 2012).

In this context, audiovisual narratives such as nature documentaries represent a traditional tool that has been proposed to increase public awareness. Whiteman (2004) demonstrated how documentary audiovisual content may have a political impact that goes “beyond the typical focus on the opinions of individual citizens” and addresses “substantial impact in two additional arenas: activist groups and decision makers” (ivi: 65). Several different approaches have been applied to studying how nature documentaries shape public perceptions and contribute positively to environment conservation through behaviour changes/intention to change (Barbas et al. 2009;

Beattie et al. 2011; Howell 2011; Lin 2013; Jones et al. 2019; Hofman, Hughes 2018). Reviewing empirical and critical methods to study climate change media, Lindenfeld and McGreavy (2014) identified implications regarding how media representations may help to produce sustainable societies with engaged individuals. For example, audiovisual narratives may help audiences construct meaning; moreover, representations may create a discursive space in which audiences seek information, have preoccupations and interest, and potentially act in ways that collectively result in sustainable development (ivi: 2014). However, there is little evidence proving the efficacy of nature documentaries in adopting pro-environmental behaviours among audiences (Dunn et al. 2020; Fernández-Bellon and Kane 2019) since the links between information provided and changes in behaviour are complex and uncertain (Kollmuss, Agyeman 2002; Braun et al. 2018).

Even if the real-world impacts of green media content are challenging to quantify, to improve future media content there is a call for robust evaluation in terms of both documentary-making and conservation (Whiteman 2004; Verissimo et al. 2017). An increasing number of filmmakers believe that their “films must provide inspiration for people to act on climate change and biodiversity loss, rather than discouraging them from trying” (Aitchison et al. 2021: 1141). Nature documentaries are not the only available tools that may enhance the spread of environmental sensibility. Different digital visual media formats may activate public engagement that are effective in changing behaviours. For example, Dunn et al. (2021) highlight how digital games can be successful in promoting positive ideas about nature and conservation (Mazur Stommen, Farley 2016) while Zhang and Pinto (2021) demonstrate how exposure to climate change memes may increase individual intentions around online civic engagement regarding climate change. However, nature documentaries are still the predominant media for the circulation of green media content, and they are growing as a popular television genre (Koblin 2020). In this context, Yeo and Silberg (2021: 780) underline how

since 2010, the rise of streaming services and platforms have changed the documentary landscape, altering how documentaries are produced, shared, and discussed. Popular, on-demand streaming platforms provide environmental

documentaries with a broader reach than their predecessors had on broadcast television. The resulting influence and “real-world” consequences can, therefore, also occur at a broader scale, for better or worse.

This study focuses on how environmental audiovisual narratives on an on-demand streaming platform may *participate* in the construction of public discourse. In particular we are interested in unveiling how (and if) environmental principles and scientific knowledge are shaped into visual stories. We focus on the presence of misleading green content that might depict facts and situations incorrectly and therefore create false images of the natural world that might influence audience’s environmental perception. As a case study, we use a Netflix documentary entitled *Seaspiracy* (Netflix, 2021) to investigate how audiences have received the environmental themes it addresses through an analysis of Twitter social discursiveness. Since this product has received criticism from fisheries scientists for potentially distorting evidence (McVeigh 2021) and promoting an anti-fishing Western perspective (Belhabib 2021), we want to investigate and reflect on how audiovisual narratives can spread ecological (dis)information through their networks and how they might generate wider negative impacts.

The paper is divided into sections. First, we introduce *Seaspiracy* as a case study; then, since we focus on Twitter social discursiveness, we underline the role of social media in environmental communication; and finally, we implement automatic text analysis methods on tweets associated with the documentary (i.e., sentiment analysis and topic detection). The statistical analyses were performed using R Statistical Software (version 4.2.1).

Netflix and Seaspiracy: A Case Study

Several authors (e.g. Koblin 2020; Yeo, Silberg 2021) have recently underlined how online streaming services such as Netflix, Disney+ and Apple TV+ are investing heavily in wildlife programming. They consider nature programming to be a “smart bet because it is appropriate for all ages and works well internationally” (Koblin 2020). The increases in green content among streaming services may be explained by traditional broadcasters being deterred from the political stance of certain documentaries, such as *Blackfish* (Netflix,

2013), *Tiger King* (Netflix, 2020-2021) and *Seaspiracy*.

Seaspiracy was released on 24 March 2021. Yeo and Silberg (2021) highlight how *Seaspiracy* can be defined as “documentary” according to the characterization given by Smith and Rock (2014): “a series of visually and/or audibly expressed statements connected by a narrative, and communicated from the author/authors to the viewer with the intention it be received as fact”. It was produced by Kip Anderson – the producer behind *Cowspiracy: The Sustainability Secret* (2014) and *What the Health* (2017) – and starred Ali Tabrizi, a 27-year-old British filmmaker. The documentary aims to discuss the impact of commercial fishing; its core message is that the solution to save our oceans is for everyone to stop eating fish. As mentioned, many scientists and organizations have criticized *Seaspiracy* for being biased and for using statistics, quotes, and scientific results out of context. Some examples include: the mis-interpretation of an outdated research paper arguing that the oceans will be empty by 2048; confusion around the meaning of fish bycatch and discards; misinformation around the claim that 46% of plastic pollution in the oceans comes from lost fishing gear; and, the claim that sustainable fishing does not exist. Daniel Pauly, a marine biologist, underlines several problems that *Seaspiracy* has with facts and how overall it “does more harm than good [...] it twists the narrative about ocean destruction to support the idea that we – the Netflix subscribers of the world – can save ocean biodiversity by turning vegan” (Pauly 2021). Belhabib (2021: 709) emphasises how

the conclusion that the world should turn vegan to protect the oceans is embedded in white privilege and colonialism. It reflects the lack of inclusion of minority groups in ocean research and fisheries, and their under-representation among experts in these fields. The simplistic concept ignores that more than 90% of the global fishing effort is small-scale and coastal in nature but its catch accounts for only a quarter of all fisheries catches globally, and that 3.2 billion people rely on fish as a source of protein.

Christina Hicks, an environmental social scientist, is one of the experts quoted in the movie who did not approve of its message, tweeting:

Unnerving to discover your cameo in a film slamming an industry you love & have committed your career to. I’ve a lot to

say about #seaspiracy- but won't. Yes there are issues but also progress & fish remain critical to food & nutrition security in many vulnerable geographies.

Aufderheide et al. (2009) highlighted how documentary filmmakers have "often justified the manipulation of individual facts [...] if it meant telling a story more effectively and helped viewers grasp the main, and overall truthful, themes of a story". Whether deliberately or not, through their narrative choices, *Seaspiracy's* filmmakers contribute to the spread of misinformation and create (false) images of the natural world that might influence audiences' environmental perceptions. Celebrities also contribute to this trend. Bryan Adams urged his 655,600 Twitter followers to watch the show, tweeting, "Watch Seaspiracy on Netflix. #Don'teatfish #Stopkillingfish #Seaspiracy", while four-time Tour de France winner Chris Froome said his mind had "been blown" by the documentary. The consequences of the documentary and its promotion can be seen in how, a month after *Seaspiracy* aired, Sea Shepherd, a non-profit marine conservation activist organization had received around 1,500 crew applications (Aitchison et al. 2021: 1142).

The Role of Social Media in Environmental Communication

Social media (e.g., Facebook, Twitter, Instagram, YouTube) provide the opportunity to generate and collect a huge amount of structured and unstructured data that can be used to extract useful information in many areas. Considering environmental conservation efforts, social media can be a powerful source of data to gain insight into consumption and engagement in relation to visual green media content (Di Minin et al. 2015; Correia et al. 2021; Freund et al. 2021). Even if social media may simply result in further content sharing, it may also have a detectable impact on nature. Kaplan and Haenlein (2010) underline how real-time content and shared information on social media could offer an opportunity to explore innovative strategies to support conservation-focused research, even if, as mentioned earlier, it is hard to understand and measure directly how they enhance real positive conservation outcomes. At the same time, however, social media can have also undesirable effects. For example, Lenda et al. (2020) highlighted how social media can

change peoples' behaviours but they may also contribute to sharing misinformation and facilitate the spread of invasive species (Lenda et al. 2021). In this context, Bergman et al. (2022) investigated how social media can impact threatened species conservation and invasive species management. They found that social media can lead to beneficial outcomes (by increasing pro-conservation human behaviour changes and conservation funding and policy) but also have several risks (they may contribute to wildlife exploitation, increase visitor pressure to protected areas, and the spread of misinformation).

Since in this article we are particularly interested in the spread and perpetuation of misinformation in environmental communication due to engagement mechanisms triggered in the viewers of audiovisual narratives, we briefly explore the question of misinformation to give an overview of one of the major risks to society (Lewandowsky et al. 2017).

There are several definitions of misinformation, although "a common theme is that misinformation pertains to information that is false, inaccurate or misleading; note that to be misleading, the information itself need not be false, but may be presented out of context" (Treen et al. 2020: 3). Misinformation online might be unintentional if the person sharing is not aware that the information shared is inaccurate, and it can "spread farther, faster, deeper, and more broadly than the truth" (Vosoughi et al. 2018: 5). Misinformation can pose a serious issue for conservation efforts since people tend to interact more with users that share similar interests (Yeo et al. 2015; de Lange et al. 2019) and content that supports their pre-existing beliefs (i.e., confirmation bias in Bergman et al. 2022: 367), potentially producing echo chambers (Cinelli et al. 2021; Miller et al. 2021). Within this landscape, "finding content that extends engagement with conservation or pro-environmental messages to more diverse audiences is critical to enhancing impact" (Silk et al. 2021: 1133).

Reception: Textual Analysis

This section deals with the analysis of the secondary text (audiences' tweets) produced by *Seaspiracy's* Twitter community. Twitter is widely recognized as an important platform for public communication (Bruns et al. 2017) and Antonakaki et al. (2021) provide a com-

prehensive review of the major research themes and strategies for data analysis on the platform. Indeed, “by downloading huge number of tweets and using appropriate natural language and sentiment analysis techniques, it is possible to get an idea of the general mood about a specific topic of interest, in a given place and time” (Molteni, De Leon 2016: 221). Antelmi et al. (2018) propose a framework to investigate Twitter communities that is essentially composed of two parts: a *semantic part* that allows for an investigation of the content produced by a given community, developed on three levels (topic modelling, sentiment analysis and cognitive analysis), and a *quantitative part* that provides insights into the behaviour and interaction patterns of users, which is based on the identification of three metrics (activity, visibility and metadata). In this work we focus on how audiences received the themes presented in *Seaspiracy* through the analysis of a corpus of related tweets following two aspects associated with the *semantic sphere*: sentiment analysis and topic detection.

Recently, Twitter has made it easy to gather large-scale datasets on user activities for academic research through its Developer platform.¹ First, we obtained API access from Twitter and collected text data containing the official documentary hashtag (#Seaspiracy) from 1st Feb 2021 to 7th Aug 2022 to obtain a representative collection of the social engagement on Twitter. We collected 35,806 organic tweets (excluding retweets and replies) from 20,314 different users and we selected only the 27,622 English language tweets as the corpus of investigation. **Figure 1** shows user activity and the engagement pattern. The highest point of engagement can be traced back after the release of the documentary where we observe a period of strong user interest. After that the curve slows and we note a solitary peak at the beginning of 2022.

Our first goal was to analyse the tweets’ text from a semantic perspective through sentiment analysis. Since Bollen et al. (2011) found that events in the social, political, cultural, and economic spheres have a significant, immediate, and highly specific effect on various dimensions of public mood, suggesting that large-scale mood analysis can provide a robust platform for modelling collective emotional tendencies, we decided to explore this method in relation to the Twitter reception of *Seaspiracy*. This technique refers to a family of tools at the crossroads of statistics, natu-

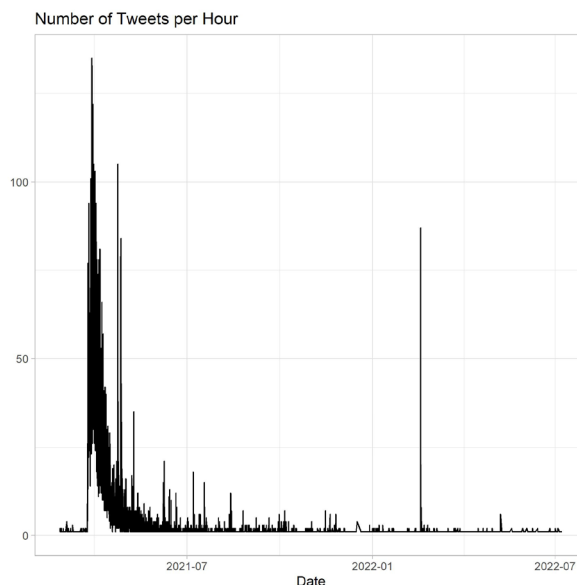


Fig. 1 | Temporal distribution of the organic tweets of the corpus



Fig. 2 | Word cloud showing the results of sentiment analysis at word level using *bing* lexicon

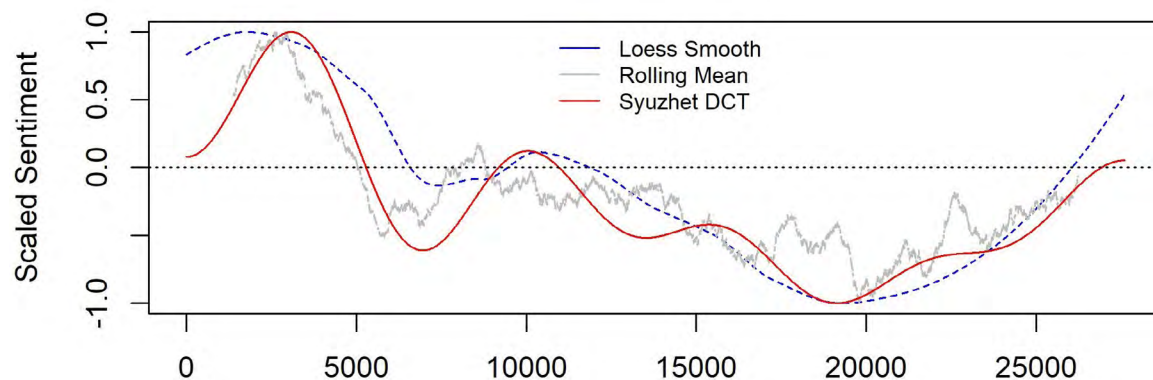


Fig. 3 | Plot of the sentiment trajectory of the *Seaspiracy* tweets

ral language processing, and computational linguistics that are useful for detecting the semantic orientation of individual opinions and comments expressed in written texts (see Giachanou, Crestani (2016) and Zimbra et al. (2018) for a review of techniques and algorithms that have been proposed for sentiment analysis on Twitter¹). Its main goal is to classify texts written in natural language, considering their semantic polarity and distinguishing positive and negative forms through lexicon-based and machine learning-based approaches. In this paper, for the sentiment extraction we chose to perform the analysis both at word level using the methods *bing* (a lexicon-based approach which assesses the polarity of each word) and at full tweet level using the *sentimentr* library that examines full tweets and assesses a mean sentiment score instead of word-by-word classification. Before the implementation of sentiment extraction, we performed classic pre-processing steps (tokenization, expansion of abbreviations, removal of stop words and other elements without lexical value, like URLs and mentions; see Pano, Kashef 2020).

Considering the results of the analysis at the word level we found that the majority of words are considered negative (1,559 negative words versus 734 positive words). In **Figure 2**, we show a word cloud to demonstrate how words in our corpus are categorized. We can see words such as 'like', 'sustainable', 'good', 'protect', and 'right' are positive, while words like 'killing', 'problem', or 'shocking' are negative. Without further examination, the classification of these words could

be misconstrued as it may depend on the context of the full tweet or sentence to understand its meaning.

If we consider the results of the analysis at the full tweet level, we can examine a mean sentiment score instead of word-by-word classification. Seeing the progression of *Seaspiracy*'s social discourse on Twitter over time (from 1st Feb 2021 to 7th Aug 2022) and applying sentiment analysis to each individual tweet,² we can visualize³ the variation of the public sentiments.

Figure 3 shows the emotional arc related to the progression of tweets in time using three different superimposed smoothing techniques to extract a meaningful underlying signal from noisy data: LOESS (local regression), Rolling Mean and DCT (Discrete Cosine Transform).⁴ It can be seen that after a neutral situation there is an increase and then a decrease in the sentiment scores. For example, the most negative tweet sentiment (score = -1.809) is related to the following tweet "Slavery, cold blooded murders, diseases, corruption, deception, ignorance, and greed #Seaspiracy", while the most positive one (score = 1.385) is associated with "Seaspiracy (yes the name is ridiculous) is definitely somewhat sensationalist (every film has to be to grab attention), but it does have some really good info and is well worth a watch and considering food choices".

Figure 4 shows how 45% of tweets are negative (12,429), 16% neutral (4,481) and 39% positive (10,722). These results lead us to reflect on some limits of sentiment analysis. For example, it is clear that both twe-

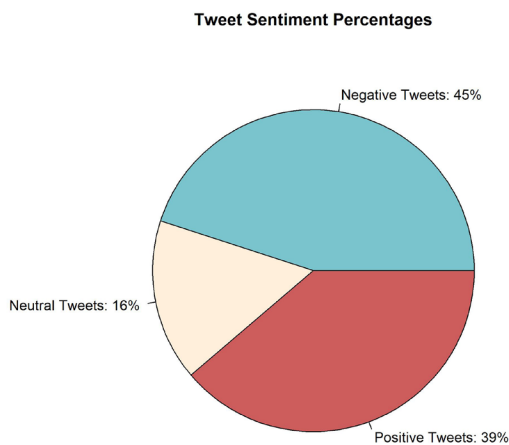


Fig. 4 | Percentages of tweets with positive, neutral and negative sentiments

ets refer to a positive evaluation of the documentary, even though their sentiment results are the opposite in score values. The tweet with a negative sentiment owes its negative connotation to the terminology chosen by the user who probably wanted to emphasise their strong indignation after watching the documentary, but this implies an appreciation of the work. The tweet with the most positive sentiment in the corpus also presents a clear appreciation of *Seaspiracy* and it is interesting to note that the user perceives the presence of “really good information” in it. Hence, we can consider the results of the sentiment analysis reliable on 39% of the tweets with positive sentiment; the situation is more complex for the 45% of tweets expressing negative sentiment. At this point we need to round off the textual content, and so we move on to another type of tool to analyse the tweets’ text from a semantic point of view: topic detection.

Topic detection is a common procedure in machine learning and natural language processing, and it aims to automatically discover the main topics within a given selection of documents (Mottaghinia et al. 2021). A commonly used method for fitting topic modelling within text data derived from social networks is Latent Dirichlet Allocation (LDA). LDA is a probabilistic model (Ibrahim et al. 2018) that treats each document

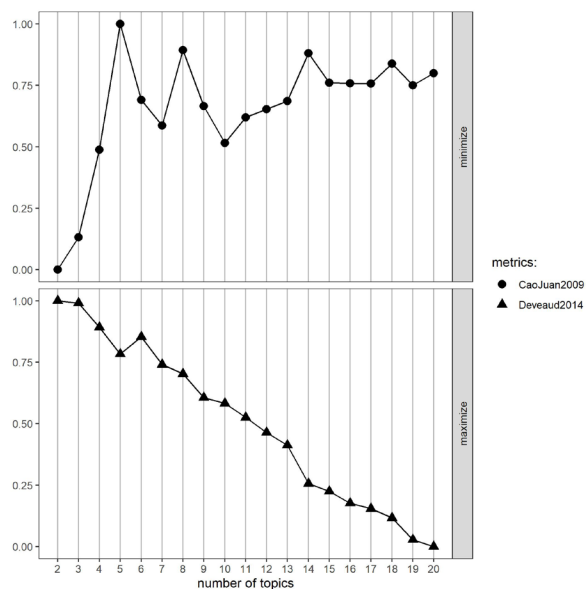


Fig. 5 | Visualization of the optimal number of topics following two metrics (CaoJuan 2009 and Deveaud 2014)

(e.g., each tweet on Twitter, each post on Facebook) as a mixture of topics, and each topic as a mixture of words and, through a mathematical method for estimating both of these features, aims to find the mixture of words associated with each topic, while also determining the mixture of topics that describes each document. In order to implement topic modelling, we need to consider several steps: having established a Twitter API connection through R and extracted our corpus of tweets for *Seaspiracy*, to set up a proper text for analysis we carried out some data preparation (e.g., removing html links and punctuation, converting to lower case, removing stop words) and created a *document-term matrix* (DTM), which is a common format for representing a bag-of-words-type corpus, that is used by many R text analysis packages. In our data we find that DTM’s sparsity is very close to 100, meaning that many words appeared only in a few tweets. An important passage relates to the number of topics, K , that we need to define in advance to implement LDA. As highlighted by Schweinberger (2022), “how an optimal K should be selected depends on various factors. If K is too small, the collection is divided into a few very general semantic contexts. If K is too lar-

a) TOPIC 1



b) TOPIC 2



c) TOPIC 3



Fig. 6 | Topics when LDA and K=3. Topics visualised as word clouds with the most frequent words for each topic.

ge, the collection is divided into too many topics of which some may overlap and others are hardly interpretable". The determination of the optimal number of topics can be done following Murzintcev (n.d.) and we used two of the metrics proposed (CaoJuan2009 and Deveaud2014). Since the best number of topics shows low values for *CaoJuan2009* and high values for *Deveaud2014*, according to **Figure 5** we decided to test a thematic resolution of $K=2$ and $K=3$.

After the application of LDA with both coefficients ($K=2$ and $K=3$) we observed that a common topic refers to the media platform where the documentary can be found – Netflix – that contains terms that can have a dual function (Topic 1 in **Fig. 6a**). On the one hand, this topic would act as word of mouth, providing the main information about *Seaspiracy's* genre ("documentary"), how to engage with it ("watch") and where to find it ("Netflix"); on the other hand, they would create an urgency in the user (e.g., 'need', 'now', "please"). With $K=2$ the other topic is a general one connected to protection of the ocean and the need to stop eating fish and turn vegan. This topic can be better explained if split into two topics, which is what happens with $K=3$. When $K=3$, Topic 2 (**Fig. 6b**) refers to the topic of fishing and specifically to the question of possible action (i.e., 'can') suggested by the documentary: to achieve a more sustainable behaviour people can change their diet and turn vegan (e.g., "sustainable", "change", "time", "vegan", "people"). Topic 3 (**Fig. 6c**) refers to the question of protecting the ocean, saving the planet and the need to stop eating fish (e.g., "stop", "fish", "industry", "plastic", "kill"). With LDA and $K=3$, Topic 1 is the prevailing one with 10,725 tweets, Topic 2 has 6,665 tweets, while Topic 3 includes 6,302 tweets. Through the application of LDA we find the mixture of words that is associated with each topic, but also the mixture of topics that describes each document.

Conclusion

As suggested by Jones et al. (2019: 423), "the time is therefore right to tackle the questions around the extent to which representations of nature on screens affects people in ways which might, ultimately, contribute to conserving that nature". Visual media can play a central role in shaping public attitudes, behaviours and norms in environmental communication. We underline how there is a call both for the investigation of

the robust impact evaluation of green media content (Boissat et al. 2019) and “an urgent need to understand how best to include” more environmental information in audiovisual products (Aitchison et al. 2021: 1139). In particular, Lindenfeld and McGreavy (2014: 124) highlight how audiovisual narrative “as a form of communication, is important to study because how we communicate about environmental issues shapes our perception of them and our ability and desire to take action”. To analyse and discuss the interplay between society, attitudes towards environmental issues and media technologies, we conducted an exploratory investigation on Twitter social discursivity connected to *Seaspiracy* through the application of automatic tools (using sentiment analysis and topic detection). We have seen how the dictionary algorithms of sentiment analysis do not allow for effective use of this tool at present due to the ambiguities identified, but the use of deep learning is encouraged in the future.

As suggested by several authors, *Seaspiracy*, as with other documentaries, has the potential to spread misinformation and promote an overly simplistic message. Pauly underlines (2021) how “[t]he most glaring factual error is the film’s claim that sustainable fishing does not exist”. Our analysis shows how *Seaspiracy*’s social discursiveness on Twitter has promoted the creation of online echo chambers that help spread misinformation in a twofold way. First, since one of the main topics that emerged from the text analysis is the call to watch the documentary it may perpetuate the hype. Indeed, the ongoing presence of the documentary on Netflix and Twitter discursiveness (Fig. 1) shows how, after many months in which articles have pointed out the inaccuracies in the documentary, this audiovisual narrative still has the power to impact people’s intentions to share information online. As underlined by Yeo and Silberg (2021: 781), “whether intended by the filmmakers or not, the spread of misinformation and formation of misconceptions from documentaries is not restricted to those who watch the film”. Second, the topic detection shows how Twitter audiences have been exposed to a background of misinformation about all fishing since they support the end of fishing and the call to turn vegan. As Yeo and Silberg (2021: 782) observe, “such a reductionist solution ignores the diversity of epistemologies that exist and sidelines issues of food security, culture, and systemic inequalities that are intertwined within ocean conserva-

tion”. Millions of people rely on sustainable small-scale commercial, artisanal, and subsistence fisheries. Not giving a voice to these realities in a documentary that aims to denounce the impact of industrial commercial fishing is unethical.

Several authors highlight how it is necessary that those involved in the production of green audiovisual narratives work with conservationist scientist not only to promote the spread of correct ecological content but also to produce measurable, positive conservation impacts (Reinermann et al. 2014; Jones et al. 2019; Dunn et al. 2020; Silk et al. 2021; Yeo and Silberg 2021). It is fundamental that factually correct information is presented to audiences. For example, Somerville et al. (2021) underline how portraying wild animals as soap opera-style characters is neither honest nor helpful.

An important issue that we would like to underline with this paper is the need for ethical standards in green audiovisual narratives. As Yeo and Silberg (2021) suggest, “there is no regulatory body or ethical code that governs the reliability and validity of information presented in documentary films [...] But to have ethical standards for documentary filmmakers, we must first define what we mean by ‘documentary’”. The analysis that we have presented provides a starting point for studying communication and propagation of discourses related to green audiovisual narratives (i.e., monitoring social engagement mechanisms and environmental sensibility), and more broadly of all forms of green media content, that are useful to shed light on and enhance ethics of communication. These approaches might be useful for future large-scale comparative investigations of environmental communication (which can also be done by considering different genres; Bilandzic and Kalch 2021) and need to be combined with experimental study to promote and measure the real impact that may effectively trigger audience interest into urgent conservation action.

Notes

¹ See <https://developer.twitter.com/en/products/twitter-api/academic-research>.

² We focus on sentiment analysis on a document level where each tweet is considered as a single document, and we intend to determine its sentiment score (polarity) by identifying its semantic orientation.

³ See Kucher et al. 2018 for a discussion about insights and opportunities in sentiment visualization.

⁴ See Elkins, Chun 2019 for a detailed discussion about the three different superimposed smoothing techniques.

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