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Who cares about ocean acidification in the Plasticene?

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ABSTRACT

Plastics is all the rage, and mitigating marine litter is topping the agenda for nations pushing issues such as ocean acidification, or even climate change, away from the public consciousness. We are personally directly affected by plastics and charismatic megafauna is dying from it, and it is something that appears to be doable. So, who cares about the issue of ocean acidification anymore? We all should. The challenge is dual in the fact that is both invisible to the naked eye and therefore not felt like a pressing issue to the public, thereby not reaching the top of the agenda of policy makers; but also that it is framed in the climate change narrative of fear - whereby it instills in a fight-or-flight response in the public, resulting in their avoidance of the issue because they feel they are unable to take action that have results. In this article, we argue that the effective global environmental governance of ocean acidification, though critical to address, mitigate against and adapt to, is hindered by the both this lack of perception of urgency in the general public, fueled by a lack of media coverage, as well as a fight-or-flight response resulting from fear. We compare this to the more media friendly and plastics problem that is tangible and manageable. We report on a media plots of plastics and ocean acidification coverage over time and argue that the issue needs to be detangled from climate change and framed as its own issue to reach the agenda at a global level, making it manageable to assess and even care about for policy makers and the public alike?

1. Introduction

During the Weekend Update of Saturday Night Live (SNL) on October 13th' 2018 (2018), cast member Michael Che says in response to the recent IPCC report on climate change (IPCC, 2018) that: "*… I keep asking myself ´why don't I care about this?´ Don't get me wrong, I 100 percent believe in climate change, yet I'm willing to do absolutely nothing about it. I think it's because they keep telling us we're gonna lose everything, and nobody cares about everything. People only care about* <u>*some*</u> *things …*". Though said in a comedy setting, this statement rings true when it comes to public perceptions of climate change policy and action globally generally and ocean acidification specifically. At the same time, another issue - marine plastics - is gathering global support and media attention daily and calls for action are frequent and vocal. This is despite the fact that we know that human activities are quickly changing the trace gas composition of Earth's atmosphere, which is dramatic at a level that far surpasses the effects of increasing levels of marine plastics (Jambeck et al., 2015); though that too is a dangerous response to increase in human consumption. In fact, the discourses around sustainability that are frequent today are considered for some as only a proxy for continuous growth, rather than attempts to reduce consumption and living within the limits of the ecological realities that we see today (Jacques and Lobo, 2018). The public is also informed about the consequences of this overconsumption, as well as the dangers of climate change. The current concentration of carbon dioxide (CO_2) in the atmosphere has increased by 40% since the 277 parts per million (ppm) estimated in 1750 (Le Quéré et al., 2017). At the same time, the current decline in ocean pH is happening at an unprecedented rate compared to the last 300 Myr of the Earth's history (Hönisch et al., 2012; Pearson and Palmer, 2000). This decrease corresponds with the industrial revolution and increase in anthropogenic CO_2 emissions, and future projections suggest that this decrease will continue (Turley et al., 2010;

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Zeebe and Ridgwell, 2011).

The reason for this decline in the pH level of the ocean as a response to increased CO_2 emissions is that the ocean absorbs a significant part (around one-third) of anthropogenic emissions of CO_2 from the atmosphere, contributing to reducing the concentration of this gas and the consequent greenhouse effect (Sabine et al., 2004). Though this intuitively sounds like as a good thing, the dissolution of CO_2 in the oceans also causes an alteration of the carbonate system, and an increase in acidity, measured as the aforementioned decrease in pH in the sea water, also known as ocean acidification. Furthermore, results of numeric simulations show that even if the emission rate of CO_2 is greatly reduced, it would take a long time for the marine environment to return to pristine conditions (Caldeira and Wickett, 2003). The impact of ocean acidification on the biological, biogeochemical and ecological components of the oceans, and the consequences of these impacts on the socio-economic dimensions in turn, are only partially known, and poorly quantified, but potentially very dramatic for life in the ocean as we know it. Some organisms are more sensitive to acidification; others, even similar species, compensate the effect of acidification through some internal mechanisms (Heuer and Grosell, 2014; Pan et al., 2015). However, such a compensation induces stress, or at least a different allocation of the energetic resources of the organism (Heuer and Grosell, 2014; Pan et al., 2015). In turn, this impacts on other vital processes (Wood et al., 2008) and, at last, reduces resilience to environmental alterations. These effects in turn alter the interspecific relationships occurring in the food web (competition, grazing, symbiosis), leading to changes in the structure and functioning of the ecosystems (Doney et al., 2009; Hall-Spencer and Allen, 2015; Kroeker et al., 2011).

If that is not convincing in proscribing importance to the issue, bear in mind that the socio-economic implications of ocean acidification are also potentially high (Turley and Boot, 2011). Direct and indirect effects of ocean acidification impact ecosystem goods and services provided by marine ecosystems. This includes effects changes have on both aquaculture and commercial fisheries, among others through impacts on the phyto- and zooplankton communities and resultant transfers to the whole trophic web. Commercial fishers are aware of this themselves and worry about the implications for futures fisheries (Tiller and Richards, 2018). Ocean Acidification also affects the tourism industry through modification of the sea bottom and the threat to corals, as well as affecting coastline protection against natural hazards through reduction of rocky substrata which constitute a natural defence. In addition, it could affect climate regulation by altering the fluxes of sequestering anthropogenic carbon dioxide from the atmosphere in the deep ocean through the biological pump (Sarmiento and Gruber, 2002), as well as affecting oxygen production, nitrogen fixation, nutrients and organic matter recycling to name a few (Melaku Canu et al., 2015; Sunday et al., 2017).

To combat ocean acidification, we need to see a significant reduction in the atmospheric CO_2 concentration within a very short timeframe, as specified by among others the Monaco Declaration and the latest IPCC report (IPCC, 2018; Monaco Declaration, 2009). We also need the adoption of strategies for the mitigation of damages (Bradly and Moorhouse, 2015; Turley et al., 2011), including the definition of strategies for the adaptive management applied to different economic sectors potentially impacted (Cicin-Sain et al., 2011). Though scientists are increasingly alarmed by the effects of ocean acidification, and publish a rising number of scientific papers that cover the topic, the topic still continues to receive limited attention from governments (Gallo et al., 2017). In light of this, the following article will discuss this phenomenon and compare it with that of marine plastics, assessing what it is that makes the environmental challenge of marine plastics reach the media to the degree that it does and fosters such global outrage with resultant policy replies, when ocean acidification appears to suffer from a lack of public interest and levels of action. To what degree does an increased level of media attention affect policy intervention on any given environmental challenge? Also, is the focus on fear of the consequences resulting in a fight-or-flight response in the public, resulting in their avoidance of the issue because they feel they are unable to take action that have results (McAfee et al., 2019)? Would elevating the status of ocean acidification to that of climate change itself ensure that it was not only discussed as merely a symptom but rather as a threat concurrent with climate change, or plastics (Harrould-Kolieb and Herr, 2012)? Or is it the way in which the threat that is communicated that is challenging the public's perception of the efficacy of their actions should they get involved?

If it holds true that most people only care about some things, and not everything, then framing ocean acidification as its own issue would make it “a” thing, like plastics, rather than just a symptom of the all-encompassing concept of climate change. However, the reframing of the issue in media and scientific literature towards an issue that is manageable, like plastics, may also sway the public towards action. We draw upon the theoretical framework of agenda setting theory and the media and apply it to the two different environmental challenges, examining what induced different actors in global governance, including the media, to focus on either in the period from 1990 to 2017, whether it be problem indicators, focusing events or scientific feedback. We explore this by first giving a more in-depth analysis of ocean acidification as a global environmental challenge, followed by the methods and theoretical framework of the paper. This is followed by an examination of media and academic literature plots of the two issues over time within the agenda setting media framework. We then assess the implications for environmental governance, looking at the issue from a global perspective and explore what mechanisms at this arena could emphasize and bring ocean acidification to the top of the agenda for global policy makers.

2. Background

2.1. Is ocean warming the evil twin of acidification?

According to recent estimates, world's oceans have absorbed over 90% of excess heat caused by greenhouse gas warming and more than a quarter of anthropogenic CO_2 emitted into the atmosphere since the mid-20th century (Jewett and Romanou, 2017; Levitus et al., 2012; Pörtner et al., 2014). Worldwide, most ocean basins including the North Atlantic Ocean had higher-than-average heat content in 2017, consistent with the long-term trend of ocean heat uptake due to global warming. Historical measurements of the atmospheric concentration of CO_2 in the Azores also show an increasing trend from about 340 μatm in 1979 to the highest record of 410 μatm registered in 2017 (Fig. 1).

All organisms, including marine ones, have limited temperature ranges within which they live and function and ocean warming affects the functioning at species-specific levels and has an impact on the geographical distribution of a number of marine species, organism physiology and ecology. Temperature-driven changes will also influence trophic interactions, community assemblages, biogeochemical cycling and ecosystem functioning. Ocean warming is as such having tangible impacts on marine fish and invertebrates, already resulting in altered phenology and geographical range shifts of species with important implications on commercially important fisheries worldwide and on the societies that depend on them. Recent rapid warming in the northeast Atlantic coast for example has played an integral role in driving the American lobster population farther offshore and into more northern waters resulting in the boom in the American lobster fishery in the Gulf of Maine and its collapse in the warmer Southern New England (SNE) region (Le Bris et al., 2018; Rheuban et al., 2017; Wahle et al., 2015).

Long-term Sea Surface Temperature (SST) increases do not only affect organisms and ecosystems though. Episodic heat waves in Australia in 2016 for example also resulted in massive heat-stress mortality of corals of the Great Barrier Reef (Hughes et al., 2018) and

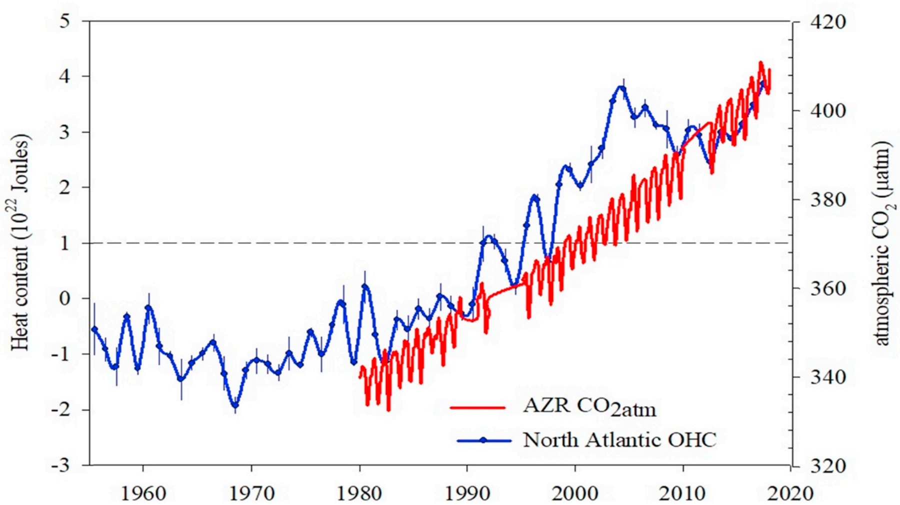

Fig. 1. North Atlantic Ocean time series. a) Ocean Heat Content (OHC) from 0 to 700 m depth (blue) (Levitus et al., 2012); b) monthly average CO2 trends (red) recorded at the reference observatory of Terceira Island (AZR) in the Azores (38.77° N, 27.38° W) of the NOAA/ESRL Global Monitoring Division (http://www.esrl.noaa.gov/gmd/dv/iadv/). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

are expected to have an increasingly large impact on low motile organism (Galli et al., 2017). Ocean acidification impacts both the organism's physiology and its behaviour and will affect marine ecosystems functioning for centuries if CO_2 emissions continue at the current rate, resulting in lower survival in early life stages of fish and, as a consequence, the recruitment of populations including commercially important species. (Pörtner et al., 2014). Other organisms in turn, such as jellyfish and diatoms (Hall-Spencer and Allen, 2015; Valenzuela et al., 2018), may benefit from ocean acidification. Also, a pelagic food web mesocosm suggested that Atlantic herring larvae as well may benefit from CO_2-stimulated increases in primary production (Sswat et al., 2018). However, for some commercially and ecologically valuable species today, such as corals and molluscs that use calcium carbonate in their structures, ocean acidification has been shown to cause considerable direct harm. For example, studies. have shown that juveniles of the edible mussel *Mytilus edulis* is able to overcome increased temperatures. It does not overcome increased increments of CO_2 levels, though, nor the combined effect of the two (Duarte et al., 2014). Therefore, the negative effects of a CO_2 increase could have significant ecological consequences, especially in those habitats where affected species are dominant in terms of abundance and biomass.

While the chemical processes underlying ocean acidification are well understood and accepted, we are just beginning to understand the wide-ranging effects acidification is likely to have on marine wildlife (Harrould-Kolieb and Savitz, 2009). Given that seawater carbonate chemistry can be highly variable, conditions that organisms are actually exposed to are difficult to measure. Furthermore, the sensitivity of organisms can vary across life history stages and in conjunction with other stressors (Waldbusser and Salisbury, 2014). What we know is that the potential risks to marine systems from the current period of ocean acidification remain to be quantified; as yet, there are few robust indicators of the long-term biological consequences (Fitzer et al., 2014). Evidence from the geological records, however, show that previous periods of intense ocean acidification, e.g. at the Permo-Triassic boundary, coincided with mass extinction events (Clarkson et al., 2015).

2.2. *Feeling the effects of ocean acidification*

Mass extinction events and other consequences of ocean acidification will have effects that will be felt across ecosystem, communities, populations and organism levels. There is evidence for example that ocean acidification will affect microbial population, and substantial changes have been observed at population levels, such as dominance of small size phytoplankton or cyanobacteria, as well as changes in community composition of bacteria and archaea (Liu et al., 2010). We have also seen changes in microbial metabolism, specifically in enzymatic activity, respiration rates, and bacterial production (Alvarez-Fernandez et al., 2018; Burrell et al., 2016; Chauhan et al., 2015; Sala et al., 2015). Also, benthic marine communities have been documented to have its community structure altered, with decreased biodiversity, biomass and trophic complexity (Zunino et al., 2017). In fact, in naturally acidified locations, communities tend to change from being dominated by calcareous to non-calcareous organisms (Kroeker et al., 2013), with non-calcareous organisms and carbon limited autotrophs being expected to be the biggest winners in an acidified world. The latter observation is important since one of the most important uses of carbonate in the ocean is the formation of calcium carbonate or limestone structures such as corals skeletons, and the shells of coccolithophores, foraminiferans, pteropods or bivalves, i.e. the calcifiers (Cao et al., 2007; Cartaxana et al., 2015; Dias et al., 2010; Dove et al., 2013). Calcification is physiological parameter directly affected by ocean acidification, but marine organisms can also experience physiological stress not directly related to calcification due to an increase in CO_2 (hypercapnia) and/or a decrease in pH (Dupont and Thorndyke, 2009). The life cycle stages are differently susceptible, though, but reproductive and early life-story stages are considered particularly vulnerable (Dupont and Thorndyke, 2009; Fitzer et al., 2012; Kurihara, 2008). As such, even if increased acidity may not directly kill non-calcifying organisms, many are likely to be harmed in ways that reduce their overall fitness and ability to survive. These impacts could include decreased growth rate, reduced reproduction, disrupted respiratory and nervous system function and increased susceptibility to predators and disease (Harrould-Kolieb and Savitz, 2009), all of which could produce ripple effects through food webs and ecosystems and in turn on human communities that depend on these resources for sustenance.

Greater availability of food or nutrients, reduced physiological costs of maintenance, or reduced competition/predation, may furthermore benefit some groups of organisms by enhancing their survival, growth and reproduction, making them the winners in the new environment (Doney et al., 2012). However, new conditions can also be stressful, making species experience suboptimal physiological performance, thus creating the losers of the new system (Doney et al., 2012). To carbon-limited autotrophs such as seagrasses and some phytoplankton, higher availability of CO_2 may enhance photosynthesis benefiting them and turning them into winners. Finally, some species might be winners in one stage of its life and losers in another, being vulnerable and resilient at the same time (e. g. some phytoplankton, fish and sea urchins). Therefore, long-term studies including all life stages of the target species, their interactions with other species and multiple generations are needed (Dupont and Pörtner, 2013; Dupont and Thorndyke, 2009; Kroeker et al., 2011; Pörtner et al., 2014).

Since ocean acidification represents a large and very rapid change in the chemistry of the ocean, with the potential to affect the biodiversity and function of a variety of marine ecosystems (Gattuso et al., 2015; Howes et al., 2015), it follows that human communities also should be affected since the functioning of marine ecosystem will be impaired. While there is mounting evidence of the impacts of climate change on marine species and ecosystems, research into the effects of acidification in ocean services is still limited (Falkenberg and Tubb, 2017; Narita and Rehdanz, 2017). This is alarming since, according to a recent report by the World Wildlife Fund (Hoegh-Guldberg, 2015), the world's oceans are worth $24 trillion to human communities. If the ocean was a country, it would be the seventh largest economy on Earth. The ocean furthermore directly, for only the fisheries and aquaculture sector, supports the livelihoods of 13% of the world's population and marine tourism alone is responsible for more than 200 million jobs worldwide (Ocean Health Index, 2018). It is estimated that by 2100, the impact of acidification on mollusc production in Europe alone will reach 1 billion US$ annually (Narita and Rehdanz, 2017), affecting these sectors. In the UK alone, it is estimated that in 2100 shellfish production losses due to Ocean Acidification will range from 14% to 28% of current values (Mangi et al., 2018).

Though impacts of acidification on marine finfish need more research, current evidences already suggests that embryos and larvae are more sensitive than juveniles and adults to elevated CO_2, and there could be sublethal effects such as impaired growth rates (Heuer and Grosell, 2014). Global total capture fishery production in 2014 was 93.4 million tonnes, of which 81.5 million tonnes from marine waters and 11.9 million tonnes from inland waters (FAO, 2016), but the current knowledge is still insufficient to quantify the impact of ocean acidification on fisheries. Models of the future impacts of ocean acidification and ocean warming and results suggest however that the decrease in primary production (10–30%) projected by the bio-geochemical models in UK fishing waters for example will translate into an overall fish and shellfish catch decrease of between 10 and 30% by 2020 (Fernandes et al., 2017). Furthermore, it is expected that some demersal fish and sharks that some human communities may depend on will be strongly affected by ocean acidification since they consume species known to be highly sensitive to changing pH like epibenthic invertebrates (crabs, shrimps, benthic grazers, benthic detritivores, bivalves) (Marshall et al., 2017).

Moreover, the ocean provides values greater than those associated with fisheries, including recreational values and symbolic values of marine environments and organisms, and these non-fishery ocean activities will also be affected by ocean acidification. For example, it is estimated that the destruction of the coral reefs would represents a huge loss—as much as $375 billion annually—for the local economies along the globe (Costanza et al., 1997). Furthermore, globally, reefs avert substantial flood damages and thus provide significant annual expected benefits for flood protection. According to Beck et al. (2018) reefs reduce the annual expected damages from storms by more than $4 billion. Without reefs, annual damages would more than double (118%) and the flooding of land due to storm surges would increase by 69% affecting 81% more people annually.

3. Methods and theoretical framework

We know objectively that ocean acidification has been shown to be a critical environmental challenge for the marine sphere, with a real and estimated effect on human communities and in turn society as a whole. Policy makers are still regularly faced with making difficult management decisions while weighing social and ecological concerns against each other in a political setting, though (Bunnefeld et al., 2011; Liu et al., 2011; Tiller et al., 2014), making assessments on what issues will reach the top of the agenda. They therefore often look to identify trends, assess different possible or plausible futures, and evaluate the information to see what changes could be critical in the future in order to mitigate, or prepare to adapt, to environmental challenges. Even if one can never accurately foresee exact events in a case where human and social variables are involved, given the complexities of free will and coincidences, it is nevertheless possible to envision future landscapes (Botterhuis et al., 2010; Slaughter, 1994).

For a given social or environmental issue to be seriously handled by policy makers, the issue therefore has to capture their attention (Liu et al., 2011), and the process by which these attention getters are prioritized for action – bypassing that of other issues - by any state or individual policy maker is that of agenda setting (Jones and Baumgartner, 2005). In light of this, we first framed our search of plastics and ocean acidification media articles within the framework of newsworthiness and inclusion in media outlets, based on theories about the agenda setting of the media, and the newsworthiness of events that happen in a given location (Oliver and Myers, 1999). We used Oliver and Myers (1999) definition of "newsworthy", which determines that a news story is considered newsworthy when it is: *"… about the public sphere [and is] … communicating information relevant to public concern …"*. We also based our further investigation on the media articles being used as a tool to measure the public concern over a given environmental implication of a given issue, whether it is plastics or ocean acidification, consistent with media agenda setting theory, which considers media attention to environmental issues to have an impact on what communities expect (Brown and Deegan, 1998). Furthermore, the prominence of issues in the news is a principle basis for the public's understanding of what are the challenges facing them or their environments according to others (see for example Iyengar and Kinder (2010)). We will therefore work within the framework of the review made by Liu et al. (2011), focusing on their "*Attention-Grabbing factors*" in agenda setting, emphasizing 1) problem indicators, 2) focusing events, and 3) feedback, based primarily on works by Jones and Baumgartner (2005) and Kingdon (1995).

The 1) problem indicators can originate from personal experience, such as seeing plastics littering the beach or corals bleaching, or from second-hand data sources such as fish mortality rates, plastics production numbers, greenhouse gas emissions etc. These problem indicators, however, are not in and of themselves enough in many cases to reach the attention of the policymaker, and are therefore often amplified by 2) focusing or triggering events that enable the issue to be pushed *"… above the noise threshold of other issues."* (Liu et al., 2011). We will therefore also in our case assess if there were any shocks or focusing events in the case of plastics that may have enabled it to be moved to the front of the agenda setting line of global marine governance issues, that is, above that of ocean acidification. The last attention-grabbing factor is that of 3) feedback on topics, specifically from non-governmental entities such as public opinion polls and NGO pressures, as well as the scientific community in the forms of scholarly articles, books and data. We will also therefore look at our data in light of this to assess the agenda setting of ocean acidification in a global setting. We will do this following the contingency model of political agenda setting by the media developed by Walgrave and Van Aelst (2006), through assessing media input, political context and level of political adoption of the issues of ocean acidification as compared to marine plastics at a global governance level.

To enable us to do this, we first conducted a systematic literature search on topics related to ocean acidification, global governance and effects on ecosystem goods and services, as well as literature on the science of ocean acidification itself. We coupled this with the media analysis, where we used Retriever as a database for our search. We did this in order to explore the newsworthiness of ocean acidification to assess to what degree it is considered a social problem by the media and the public. This database allowed us to search for all newspaper articles that contained the term "Ocean Acidification" in the lifetime of the records available. In this manner, we were able to deduce to what degree the topic has had staying power in the media's attention over time. We chose all English sources from the internet, which in the case of ocean acidification returned 1095 sources from web. For the plastic string, it returned 3693 searches. For the purposes of this study, we chose to focus on the top 100 returns, and deleted those that were clearly scientific journals and as such, covered by the comparative search in Web of Science for research articles. We used the Boolean search modifier quotation marks («») for «ocean acidification». This was because we were searching for the phrase as a whole, and not have the search engine split the word. However, we are aware that we may have missed some scientific papers in our literature research that addressed this topic but did not specifically call it ocean acidification, but rather used "high CO2" or "low pH" in their titles and full text instead.

Since we also wanted to visualize the effects of a more "urgent" environmental challenge, namely marine plastics, we used the modifier asterix (*) as a root search which allows the engine to find all words that start with the word plastic*. We coupled this with the modifier OR and included (microplastic*) so that the final search string for the plastics media literature was (plastic* OR microplastic*). We then added the term AND to signify that we also wanted the results to be linked with marine or ocean terms, so (marine OR ocean*). The final term then was (plastic* OR microplastic*) AND (marine OR ocean*). This means the results could have both plastic or microplastic as well as marine or ocean, which is not a problem for this analysis. We then compared the media analysis with an analysis of published scientific articles on both plastics and ocean acidification since 1990. In the case of Web of Science, we additionally checked the article titles and eliminated those that were not linked to the subject. An example of this was that there were many results from journals of science of materials in the original results. We then used this information and assessed it in light of global governance initiatives towards ocean acidification and marine plastics within the framework of agenda setting theory.

A limitation of the method used in this article is that we have assumed that all the media sources we included will have the same perceived ability to have an impact of a given community, saliency, and that furthermore each article is equally weighted. The relative impact of neither the source or the article in question has been considered. Nor have we considered the placement of the articles in question, or the weight placed on photos used. Even given these limitations, though, we argue that this study contributes to the literature because it has demonstrated that states' emphasis on moving the agenda towards one environmental challenge rather than another is associated with the extent of media attention.

4. Results

4.1. Media and scholarly outputs

For plastics in the media, the results were a total of 61,431 articles from 1990 to 2017. For ocean acidification in the media, however, the search string returned a total of 7105 articles in the same period (Fig. 2) (Table 1). For journal articles, the numbers were much smaller and reverse in terms of dominance (Fig. 3) (Table 2). For plastics, for example, the total number from 1990 until 2017 was 1923 articles, whereas for ocean acidification 4951 articles.

The figures show a dramatic increase of plastics as a topic in the media starting in the early 2000s and this interest has increased consistently since – with the occasional dips. The same graph also shows ocean acidification in the media, which is substantially lower and barely mentioned at all at some years and has had a decline in media occurrences in the last three years. The trend is different when it comes to research articles, however, plastics having fewer academic articles than that of ocean acidification in the research literature over the years, as can be seen in Fig. 3. We see that this is the reverse of that of media in that ocean acidification is dominant over plastics in the scientific literature. What is interesting though is that even though the research community finds ocean acidification to be of a more pressing issue as determined by their research efforts on the topic that of plastics, this is not translated into the popular media or in turn the general population.

4.2. Global ocean governance: ocean acidification

In assessing to what degree the media emphasis has any implications for global governance of these issue areas, we first need to explore to what extent the international community has embraced them as issues of importance in their agenda. In fact, only a few years before the media started reporting on ocean acidification, in 2008, the Convention on Biological Diversity (CBD) (CBD, 1992) recognised it as a threat to an accelerated loss of marine biodiversity. These losses affect livelihoods and economies of communities that are dependent on marine life, including their genetic resources. In fact, ocean acidification impacts negatively on all three founding objectives of the CBD (i.e. the preservation of biological diversity, the sustainable use of such diversity and its components and fair and equitable use of genetic resources). However, the recognition of this goes only as far as the formulation of regional and global agreements is concerned, with no provision for any legal support, thus minimising the effectiveness of such pro-actions.

Following this, in 2012, the United Nations Conference on Sustainable Development adopted *The Future We Want*, a document containing a vision for a sustainable world, later adopted as UN General Assembly Resolution, where in fact ocean acidification concerns were reflected (UN General Assembly, 2012). During this same conference, the Ocean Acidification International Coordination Centre in Monaco (OA-ICC) was launched to promote, facilitate and communicate global activities on ocean acidification. It has tasked itself to encourage states to develop ways and means of adaptation, while using the precautionary and ecosystem-based approaches. Judging from its online presence and the communication of scientific findings in the field of ocean acidification, OA-ICC is actively fulfilling its mission to increase awareness of the urgency and relevance of the impacts of ocean acidification on marine life (International Atomic Energy Agency, 2012). In addition, the United Nations General Assembly has in fact re-iterated CBD's call on ocean acidification measures by expressing its concern over the projected negative effects of climate change and ocean acidification on marine resources (Shepard, 2013). It did so by arguing in favour of collaborative work to mitigate the ocean acidification problem as well as to enhance the resilience of marine ecosystems and communities that are dependent on it.

This should then arguably have been clearly expressed in the UNFCCC which is the most appropriate environmental regime to deal with the mitigation of ocean acidification by the reduction of carbon dioxide levels in the atmosphere. It also provides funding mechanisms and the right forum for responses to ocean acidification in favour of their integration with national adaptation plans (Harrould-Kolieb and Herr, 2012). However, proper concrete actions on how ocean acidification could be integrated within the UNFCCC are still lacking. The Paris Climate Agreement, adopted in 2015 as an agreement under the UNFCCC, does furthermore not include any reference to ocean acidification nor ocean warming. In fact, there is just one reference to the ocean, where parties noted "*… the importance of ensuring the integrity of all ecosystems, including oceans …*" (UNFCCC, 2015), though the role of sinks and reservoirs of the greenhouse gases has been largely recognised in the climate change regime, and both in the commitments of parties under the Paris Agreement (UNFCCC, 2015) and the UNFCCC (United Nations, 1997).

At the regional level, several regional seas agreements provide, in one way or another, relevant frameworks for ocean acidification when dealing with climate change's impacts in the global oceans. Most relevant frameworks include the London Convention (1972 and 1996), the Bonn Convention (1983) the Barcelona Convention (1980 and 1995), the Nairobi Convention (2010), HELCOM (1992 and 2014) and OSPAR (1992). For example, while it aims to conserve terrestrial, aquatic and avian migratory species throughout their range, the Bonn Convention actively calls for adaptation measures to ensure the

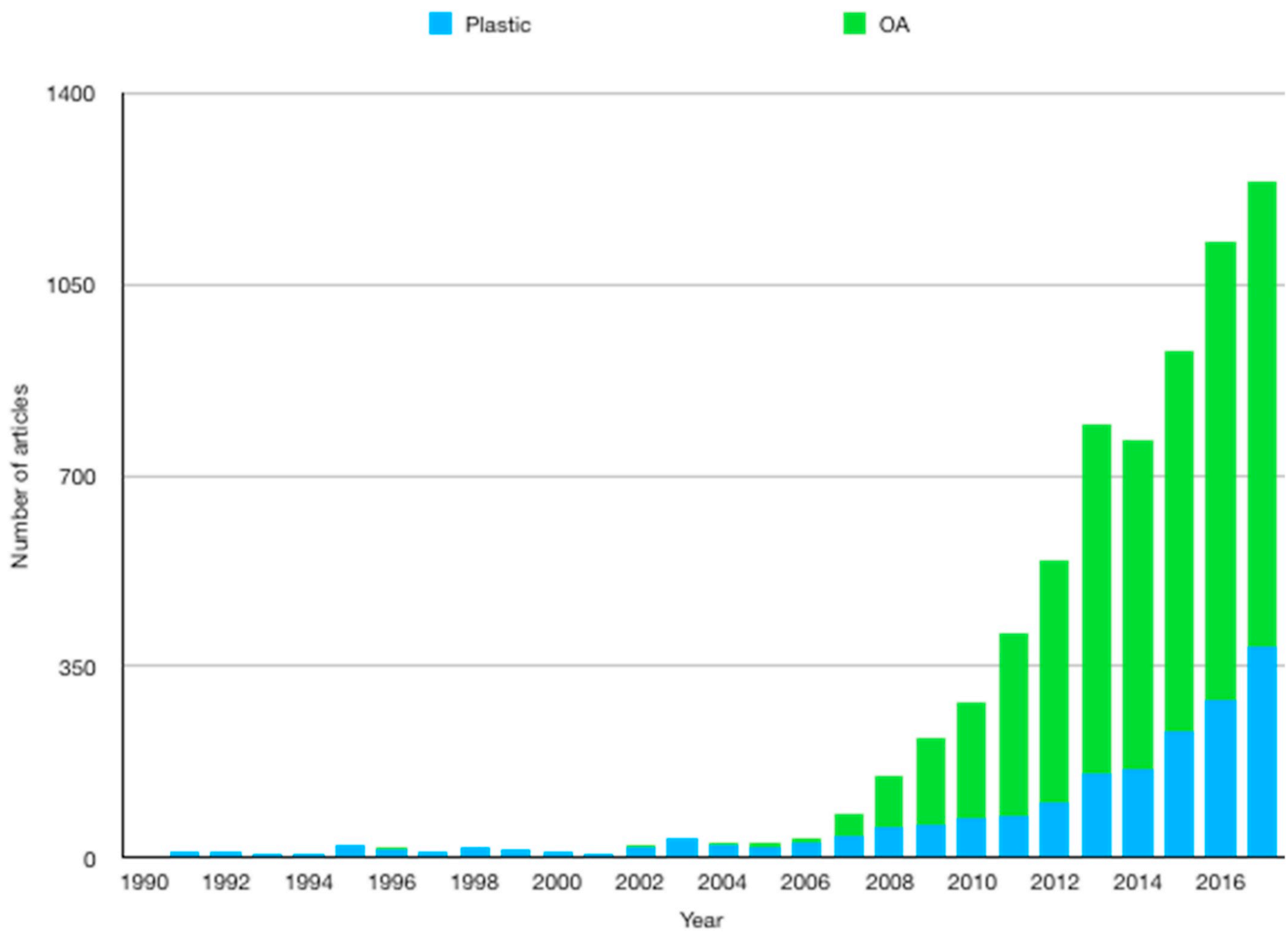

Fig. 2. Graph for research articles in Web of Science over time for plastics and ocean acidification. Note that for Web of Science, articles on ocean acidification are most numerous.

conservation of migratory species. Even though ocean acidification is not specifically referred to in the Convention, this phenomenon has since 2010 been part of the discussions at various technical workshops and climate change vulnerability papers and described as a potential and wide-ranging problem for all aquatic species (Herr et al., 2014).

Within the OSPAR context, ocean acidification was first discussed in 2006. A year later, parties to the Convention, hailing from 15 States bordering the western coasts and catchments of Europe together with the EU, expressed their concern on the 'implications for the marine environment of climate change and ocean acidification due to the elevated concentrations of CO_2 in the air'. This initiative turned the tide in a positive way and led to the publication of an elaborated report in 2010 on the assessment of climate change mitigation and adaptation (Baconnais-Rosez, 2010). Among other issues, the report requested all Parties to integrate climate change and ocean acidification into OSPAR's work areas, and in doing so, a joint OSPAR/ICES Ocean Acidification Study Group was established. In a way this can be seen as a working framework by which the potential impacts of ocean acidification can be ingrained in mitigation strategies and in the formulation of international objectives to limit future levels of atmospheric carbon dioxide.

The formulation of the UN Sustainable Development Goals (SDGs) (United Nations, 2015) have furthermore provided new momentum and hope to deal with sustainability in a medium to long term perspective. Although many of the SDGs are interconnected and relevant for ocean sustainability, SDG 14 entitled "*Life below water*" (United Nations, 2016a) is particularly devoted to ocean governance by conserving oceans, seas and marine resources and use them sustainably. A total of ten targets fall under this Goal, being one of them minimising ocean acidification, which is placed at the same relevance and priority level as mitigating global eutrophication and plastic pollution. Furthermore, the UNGA has adopted a number of resolutions related to the implementation of SDG 14, and ocean conservation and sustainability (United Nations, 2016b, 2017, 2018a,c). In particular, last year resolution on *"Oceans and the law of the sea"* (United Nations, 2018b) highlights the relevance of ocean acidification and emphasizes the urgent need to address the issue. The resolution reiterates that marine debris (in particular plastic), climate change, ocean acidification and loss of biodiversity are 'some of the greatest environmental concerns of our time'.

As such, it is clear that there have been a number of initiatives at the global level that are both direct and clearly aimed towards addressing the topic. However, these are no clear commitments with direct targets attached to them, and as mentioned, the UNFCCC is the arena where this would have been best addressed though that too lacked direct commitment to the topic of oceans in general, and less so to specific issues associated with it such as that of ocean acidification.

4.3. Global ocean governance: marine plastics

Though no comprehensive global governance mechanisms is in place to deal with plastics, many countries have still started the process of plastics reduction through a number of different regulatory measures (Haward, 2018). In the US, for example, the emphasis first centered on

Table 1
Web of Science journal occurrences over time as per the specific Boolean search string (See Fig. 2).

Year	Plastic	Ocean Acidification
1990	2	1
1991	14	0
1992	14	0
1993	8	2
1994	9	2
1995	23	2
1996	15	6
1997	14	0
1998	20	0
1999	17	0
2000	14	1
2001	6	1
2002	21	3
2003	35	1
2004	24	4
2005	22	8
2006	30	8
2007	42	39
2008	56	93
2009	61	160
2010	73	213
2011	77	333
2012	102	443
2013	153	641
2014	163	603
2015	232	698
2016	288	841
2017	388	848

Table 2
Media occurrences over time as per the specific Boolean search string (See Fig. 3).

Year	Ocean Acidification	Plastic
1990	0	0
1991	0	0
1992	0	0
1993	0	0
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	1
2004	0	629
2005	5	968
2006	2	245
2007	79	2752
2008	235	2899
2009	390	2588
2010	259	1819
2011	311	3164
2012	912	6468
2013	1001	8263
2014	1456	7544
2015	1149	7652
2016	815	7305
2017	491	9134

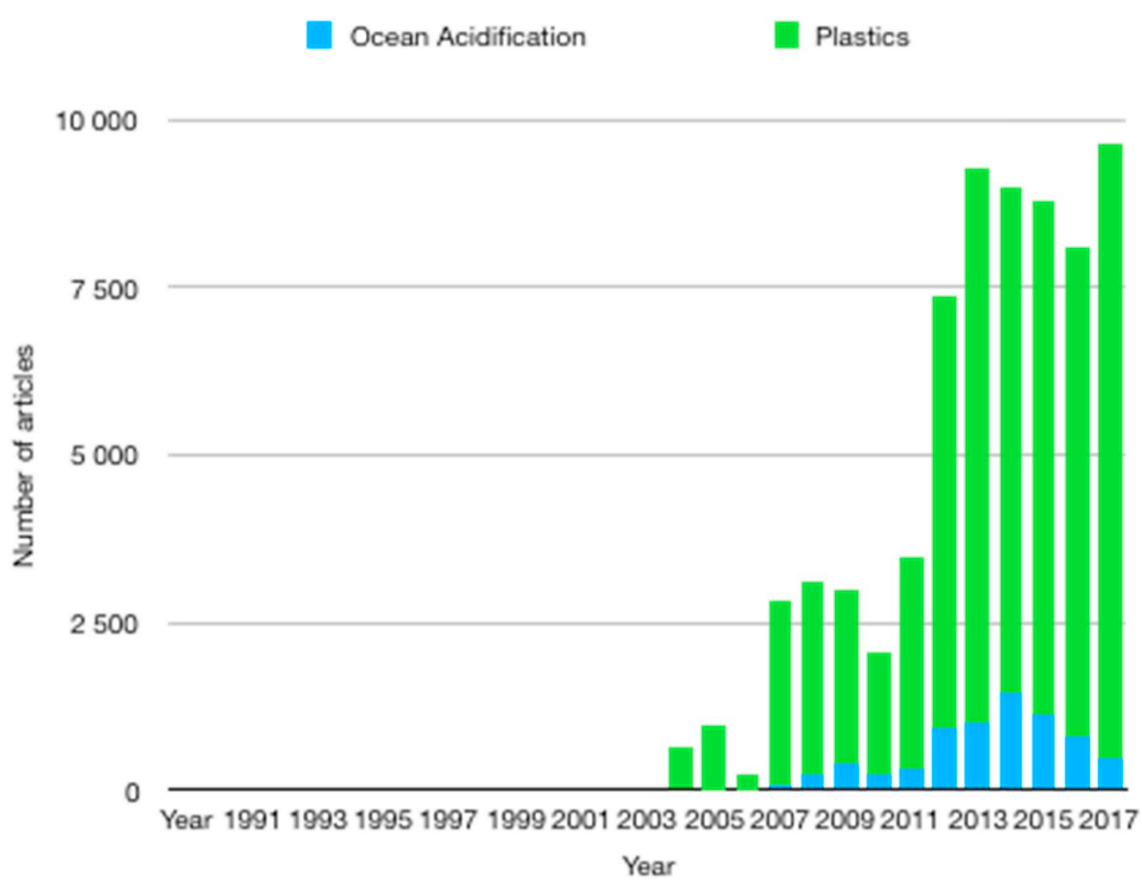

Fig. 3. Graph for media occurrences over time for plastics and ocean acidification. Note that for media, articles on plastics are most numerous.

microplastics in consumer products such as scrub creams, leading to the 2015 introduction of The Microbead-Free Water Act of 2015, signed into law by President Barack Obama. This act puts a " … ban [on] rinse-off cosmetics that contain intentionally-added plastic microbeads beginning on January 1, 2018, and to ban manufacturing of these cosmetics beginning on July 1, 2017. These bans are delayed by one year for cosmetics that are over-the-counter drugs." (114th Congress, 2015).

A similar national ban on microbeads in cosmetics came into force in the UK on 1st January 2018. Other examples include the Bali government, which has made a commitment to ban plastic bags by 2018, and Ghana, which plans to eliminate marine plastics from its coasts by 2025 (Earth Negotiations Bulletin, 2017). At the European level, the European Union Marine Strategy Framework Directive (EU MSFD) specifically defines microplastics as litter, thereby committing all member states to establish and implement mitigation measures to reduce this source of litter by 2020. In January 2018, the EU furthermore published its plastics strategy which aim is to transform the way products are designed, produced, used, and recycled in the EU so that the 30% recycling rate can be increased dramatically (European Commission, 2018). Both France and Italy, for example, already have bans on plastics bags, as does the African countries of Rwanda and Kenya, with some nations taking their plastic bag bans further than others, with public shaming, fines and jail time as possible preventive measures against its use (Freytas-Tamura, 2017a, b).

Even at a global level, there has been movement towards working together to solve the challenge of marine plastics, though this is still at the voluntary level for nation states. On February 23rd 2017, the UN Environment (UNEP) launched a campaign to eliminate microplastics in cosmetics single-use plastics in general by 2022, while at the same time launching the hashtag #CleanSeas (UNEP, 2017b), and at the close of the UN Environment Assembly in Nairobi in December of 2017, 13 non-binding resolutions were passed on pollution (UNEP, 2017c), and one of these specifically centre on microplastics in the marine environment, signed by all 193 nations present at the meeting. This is a step towards global management agreement on the challenge of plastics pollution (Ndiso, 2017; UNEP, 2017a). This is especially true when coupled with the Sustainable Development Goal 14 on life under water as this SDG specifically mentions the reduction of marine pollution by 2025 as one of its targets (United Nations, 2016a). Nevertheless, the governance initiatives are still largely fragmented, with parallel runs taking place even at the UN level, and the collaborations of efforts between nations on the topic are few. However, in the autumn of 2018, the UN convened a high level panel on plastics where the focus changed towards a more progressive stance on the topic from global leaders and launched UNEP's Global Plastics Platform. At the same time, a number of countries have made steps to reduce their plastics footprint, such as India proclaiming it will ban all single-use plastic by 2022; Botswana, Chile and Peru will ban plastic bag in 2019 and Nigeria revealed plans to establish recycling plants across the country as well as Brazil announcing a national plan on plastics (Leone, 2018).

5. Perspectives and conclusions

Different regions of oceans and seas are naturally more susceptible to an increase in acidification due to other factors such as upwelling, river and glacial discharges, sea ice loss and urbanization (Heldt et al., 2018). Despite growing evidence about damage to marine organisms, food webs and biodiversity, however, the effects of ocean acidification on oceans has been largely underappreciated by policy makers and other shakers and moves in the global governance arena. Hull (2016) concluded that the proposed legal and policy responses to ocean acidification in the United States for example have been largely inadequate and mostly oriented toward data production. He therefore recommended to use existing Clean Water Act and establish more protective marine water quality standards for pH. This is despite the fact that the West Coast of North America is among the most susceptible coastal zones to ocean acidification, and that West Coast ecosystems are already facing extensive impacts such as high mortality rates during early life stages in oyster hatcheries (California Ocean Protection Council, 2018). In fact, hatcheries encountered acute loss of oyster seed stock due to ocean acidification, and oyster production in the Pacific Northwest declined 22% between 2005 and 2009 (Chan, 2016).

Evidence shows that these known dramatic effects of ocean acidification still do not give it enough saliency in the media, nor do scientific facts and publications though these numbers are growing. In a recent polling study of over 10,000 European citizens from 10 countries on the impacts of climate change indicates that respondents were least aware of ocean acidification (Buckley et al., 2017). Considering policy actions, respondents ranked the highest controls of emissions of chemicals into the sea though they also highlighted importance of climate change mitigation. This is important because, in the case of issue voting, for example, we know that evidence has shown that voters weigh their opinions of different issue areas relative to the salience that is associated with it, where saliency can be measured by media attention (Druckman, 2004; Iyengar and McGrady, 2007; Miller and Krosnick, 2000). This ties into the framework of the study, whereby we looked at the media attention to plastics and ocean acidification under the lens of problem indicators, triggering events and feedback. We argued that the problem indicators could originate from personal experience, such as seeing plastics littering the beach or corals bleaching, or from second-hand data sources such as fish mortality rates, plastics production numbers, greenhouse gas emissions etc. These problem indicators, however, we argued, would not in and of themselves be enough to reach the attention of the policymaker in most cases. They would also be amplified by triggering events that would enable a given issue to be pushed to the top of the agenda. We can see in the dataset on media occurrences of plastics, for example, that the saliency doubled from 2011 to 2012. A valuable exercise for further research would be to analyze the events of 2012 and assess what the given triggering effect may have been. Finally, we argued that feedback from non-governmental entities such as public opinion polls and NGO pressures, as well as the scientific community in the forms of scholarly articles, books and data, would be important to push the topic to the top of the global agenda. In the case of plastics, this may be so, as we can see an increasing amount of scholarly journal articles on the topic. However, the same can be said about ocean acidification though according to the data, but it has not had the same effect on its saliency.

What then can explain the higher saliency of plastics over ocean acidification? McAfee et al. (2019) suggests in an article on optimism and conservation engagement in the public that conservation would be more effective if there is a balanced communication that includes both negativity and fear as well as positivity and hope about the topic. This would allow the public to build a sense of being efficient in their environmental goals, both privately and collectively, and lead them to want to set and achieve possible goals (Bandura, 2000; Besta et al., 2016). They argue that this feeling of efficacy is motivating for individuals, both in terms of acting on optimistic and pessimistic news items (Hart and Feldman, 2014), as humans are naturally more engaged when they have the perception of actually making a positive difference (Geiger et al., 2017). The opposite also holds true, that if people are pessimistic about their environmental future, they are also less likely to invest their time in making an effort to curb damages (Clayton and Myers, 2015).

What we can draw from this is that if the only dissemination about ocean acidification is cloaked in pessimism, the public may risk being fatigued and feeling hopeless and in turn diminish their desire to collaborate to be part of the change (McAfee et al., 2019; Serani, 2008). The opposite also holds true, in that if they feel that they are making a difference, they are likely to engage. This could also be part of the explanation for why plastics management is gaining ground with the public and ocean acidification challenges are not. Plastics is conceived as a manageable issue. People feel like they are making a difference by participating in beach clean-ups, by purchasing bracelets that fund ocean cleanup, by no longer purchasing bottled water, and cutting down on plastics consumption in general. With ocean acidification, though, there are no direct way to communicate this perception of making a difference, and as such, the public are inundated with news and science about dangers and fears and lose the feeling of motivational efficacy that could ensure their engagement, which in turn could push it higher on the global governance agenda. This could explain why feedback from non-governmental entities such as public opinion polls and NGO pressures, and the scientific community in the forms of scholarly articles, books and data, has been unable to push the topic to the top of the global agenda. As McAfee et al. (2019) states:*"Whilst we often need a dose of reality to shock us into awareness of a problem, it cannot be denied that success stories can inspire people and bridge the gap between problem and solution."*

The results of this study provide a resource for further exploring for understanding of what drives particular states to voluntarily push a given environmental issue over another in a global setting and to what degree a more optimistic angle to scientific publications and media outputs about ocean acidification may engage the public, and in turn move the issue up on the agenda to reach the importance it should have, even in the Plasticene.

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Appendix A. Supplementary data

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