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theoretical and practical considerations

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As anthropogenic stressors threaten the health of marine ecosystems, there is a need to better understand how the public processes and responds to information about ocean health. Recent studies of public perceptions about ocean issues report high concern but limited knowledge, prompting calls for information campaigns to mobilize public support for ocean restoration policy. Drawing on the literature from communication, psychology and related social science disciplines, we consider a set of social-cognitive challenges that researchers and advocates are likely to encounter when communicating with the public about ocean health and emerging marine diseases—namely, the *psychological distance* at which ocean issues are construed, the *unfamiliarity* of aquatic systems to many members of the public and the potential for marine health issues to be interpreted through *politicized* schemas that encourage motivated reasoning over the dispassionate consideration of scientific evidence. We offer theory-based strategies to help public outreach efforts address these challenges and present data from a recent experiment exploring the role of message framing (emphasizing the public health or environmental consequences of marine disease) in shaping public support for environmental policy.

1. Introduction

As anthropogenic pressures including climate change, pollution and overfishing affect marine ecosystems worldwide, corresponding changes in the chemical, physical and biological features of ocean ecosystems threaten the productivity of marine environments and the health of the species that inhabit them [1]. As discussed in detail elsewhere in this issue [2–4], research over the past few decades has documented the existence of infectious diseases afflicting a variety of ocean-dwelling species, including coral reefs [5–7], abalone [8,9], sea stars [10] and oysters [11], among others. Matters of ocean health are deeply intertwined with the health and well-being of human societies [12], given that oceans provide valuable ecosystem services—including carbon sequestration, coastal erosion protection and valuable animal protein for over a billion of the world's poorest people [13]—that depend on healthy and well-functioning marine ecosystems. Thus, achieving a sustainable future will depend, in part, on the ability of scientists and advocates to mobilize members of the general public to adopt behavioural changes and to support policy actions that mitigate broad-scale threats to marine ecosystems [14,15].

Communication will play a key role in public outreach efforts about ocean health; thus, these outreach efforts stand to benefit from social-scientific perspectives on how the public processes information about contemporary environmental issues. Social science research from the fields of communication and psychology seeks to understand the factors that shape how people process and are influenced by messages, examining elements such as audience (who is receiving the message), source (who creates and sends the message), channel (how the message is delivered) and content (what the message contains). To date, much of the work on ocean health has focused on how the public processes information about the consequences of climate change [16–18]. Limited work has considered the specific challenges that public officials,

scientists and advocates may face when communicating with members of the general public about ocean health issues, specifically.

This paper is intended as an initial step toward addressing the important and underexplored intersection of ocean health issues and social-cognitive aspects of communication. We first review the small but growing literature on public awareness and concern about ocean health issues linked to climate change which, from a communication campaigns perspective that focuses on how messaging efforts affect the attitudes and beliefs of audiences, provides baseline information that can enrich public outreach strategies [19]. In doing so, we adopt a broad definition of ocean health that encompasses the environmental quality and biological productivity of ocean ecosystems, including the health of marine species that inhabit them. We then introduce perspectives from communication and psychology, rooted in principles from the literature on social cognition, that offer insights into how the public processes and responds to information about ocean health and emerging marine diseases and that point to a set of communication challenges especially relevant to this domain. Throughout, we draw on recent behavioural science to suggest theory-based strategies for those tasked with communicating ocean health issues to the general public, and end by presenting data from a recent experiment exploring the role of news framing of marine disease issues on the public's support for environmental policy.

2. Public awareness and concern about ocean health

Recent years have seen a groundswell of attention to ocean health issues by leading national and international governing bodies, acknowledging the imperative nature of the threats and the importance of engaging the public in a collective effort to address them. For example, the US Department of State under Secretary John Kerry held its first 'Our Ocean' conference in 2014, which drew nearly 100 world leaders together to advance a dialogue on ocean sustainability in light of threats from pollution, acidification and fisheries [20]. At the international level, the United Nations (UN) initiated the World Ocean Assessment following the 2002 South African summit on sustainable development, which explicitly recognizes the importance of better understanding not only on the biophysical underpinnings of ocean health issues but also their economic and social dimensions. The UN describes it as a 'regular progress for global reporting of and assessment of the state of the marine environment, including socioeconomic aspects' (emphasis added) [21]. Indeed, numerous scholars have argued that public engagement is critical in building support for environmental policy [22] and for the foundational role of public opinion surveys that gauge levels of public awareness and concern about environmental issues [23].

Although research into public perceptions of ocean health issues to date is rather limited, the available evidence creates a portrait of a public that is concerned but uninformed about the specific threats that oceans face [24]. Analysing data from a US national probability sample, Steel *et al.* report that few respondents felt 'informed' (10.0%) or 'very well informed' (4.3%) about US ocean and coastal policy issues [15]. These

subjective knowledge assessments were reiterated in the public's poor performance on an objective knowledge assessment, a multiple-choice quiz on which average performance was below 50%—an accuracy rate that, for comparison purposes, is somewhat lower than that observed on objective knowledge measures of polar-region warming in representative surveys of the US public (approximately 60%) [25]. A more recent study involving over 10 000 respondents across 10 European nations [26] found that the public reported feeling moderately informed about anthropogenic impacts on marine environments (between 'slightly' and 'somewhat' informed, on average), and that subjective knowledge assessments about specific impacts (such as coastal erosion and overfishing) predicted one's level of concern about that impact. In particular, respondents expressed being highly concerned about 'pollution,' with one-third of respondents (33%) offering it in response to an open-ended question soliciting the 'three most important environmental matters' facing the ocean. By comparison, only 4% offered 'climate change' as a response, and ocean acidification—which many scientists see as a leading threat to marine species worldwide [5,27,28]—received the lowest knowledge self-ratings across all impacts surveyed. Moreover, when estimating the point in time at which climate change impacts would occur, just 16% of respondents judged ocean acidification's threat to fish and other marine species as 'already apparent' (compared with 54% for increases in extreme weather). In fact, more respondents (19%) selected 'don't know' or did not respond when asked if and when ocean acidification would threaten marine species; no other climate impact engendered as much uncertainty.

In related work Chilvers *et al.* analysed responses from a survey of $n = 1001$ UK residents [24], which similarly suggests that the public is less attuned than are scientists to the role of climate change and ocean acidification in ocean health matters. When prompted for 'the most important environmental issues' that come to mind when thinking about the ocean, 'pollution' was again offered by a sizable portion of respondents (21%), surpassed only by 'coastal erosion' (28%). By comparison, a much smaller portion mentioned 'climate change' (3.6%), and when asked to judge their level of knowledge about ocean acidification, just over 10% felt 'very well informed' or 'informed'—again, the smallest percentage observed across all impacts surveyed (lower even than reported knowledge about 'increased jellyfish blooms/swarms'). Perhaps not surprisingly, ocean acidification also ranked in the bottom half of impacts in terms of level of public concern and below coastal flooding and erosion. In explaining these patterns, the authors suggest that their 'data indicate that marine climate change impacts that are more immediate, visible, tangible and "available"...tend to be more salient for publics' [24, p. 173], a conclusion corroborated by their in-depth survey interviews in which respondents explicitly acknowledged the role of personal experiences (e.g. as residents of coastal areas impacted by flooding) in shaping awareness and concern about marine issues, a perception borne out by other recent studies [29,30].

Taken together, findings from the small but growing literature on public perceptions of ocean health issues offer a glimpse into some of the challenges that scientists may encounter when disseminating information about ocean health and emerging marine diseases. Echoing longstanding

themes in science communication [31–33], it appears not only that the public lacks basic knowledge about the anthropogenic pressures facing oceans but also that factors beyond the scientific evidence can significantly shape awareness and concern. Moreover, as is common with other emerging scientific issues characterized by various levels of complexity (e.g. nanotechnology, genetically modified organisms), we suggest that communicating about ocean health poses additional, related challenges that may operate to undermine support for ocean restoration efforts, even in the face of earnest attempts to promote increased awareness among the public [34,35].

Before turning to a discussion of these challenges, we present a relevant case study as an illustrative example. This case considers the recent rise in infection rates of *Vibrio* bacteria in oyster populations and related communication efforts to inform the public about the disease and its health consequences. Owing to the public's familiarity with oysters as seafood and the disease's consequences for both ocean and human health, the case of *Vibrio* is instructive for identifying key communication challenges surrounding emerging marine disease and strategies for overcoming them.

3. Communicating about *Vibrio* in oysters

In November 2012, a panel of scientists convened by Governor Christine Gregorie of Washington in the US Pacific Northwest issued a set of recommendations to address growing concern over threats to the state's oyster industry resulting from rising ocean temperatures and acidity levels linked to anthropogenic carbon emissions. In particular, the panel noted that these changes threatened the viability of oyster larvae and created ideal conditions for the spread of certain diseases—notably *Vibrio* bacteria—that put the state's \$300 million annual oyster industry, and the health of individuals who consume oysters, at serious risk. *Vibrio* bacteria in humans cause a painful infection that proves fatal in over 50% of cases [36]. Among the report's stated goals was to inform stakeholders and the general public about the consequences of altered ocean chemistry and to increase public support for limiting atmospheric emissions of carbon dioxide, its chief cause.

Thus, although it is clear that public officials recognized the importance of communication and risk messaging surrounding the *Vibrio* outbreak, the complexities of the disease's causes and consequences make it less clear what form such messages should take. The different ways that news media covered *Vibrio* is suggestive. For example, some news headlines framed the issue primarily as a marine disease problem, emphasizing its impacts on the health of oysters ('Oysters dying as coast is hit hard') [37]; others, by contrast, highlighted consequences for human beings, including the economy ('Bacterial outbreak roils Mass. oyster industry') [38] and public health ('*Vibrio* risk prompts oyster recalls') [39]. Some, but not all, explicitly acknowledged the role of global warming and/or climate change in disease transmission and infection rates ('With global warming, expect more deadly *Vibrio* cases') [40], thereby prominently linking the specific issue of *Vibrio* to the more general and highly politicized issue of anthropogenic climatic change. Not only do these different emphases, known as 'frames' in communication and media studies [41],

raise questions about their differential effects on audiences, but they also hint at particular challenges that researchers and advocates face when communicating information about emerging marine diseases to the public.

Next, we draw on the literature from communication and psychology to highlight three such challenges—barriers that are rooted in everyday social and cognitive processes and that may interrupt the often-assumed but rarely realized linear pathway linking increased knowledge of environmental threats and enhanced support for mitigation and restoration efforts—namely, the potential for ocean health issues to be experienced as *psychologically distant*, *unfamiliar* and *politicized* in the minds of many citizens (see table 1 for a summary). We posit that each of these characteristics may partially explain the relative lack of coordinated and broad-scale policy action to address ocean health issues, to date.

4. Psychological distance

In seeking to understand why public opinion lags the urgency expressed by the scientific community on environmental issues, notably climate change, scholars point to the psychological distance at which environmental impacts are commonly construed. A core component of construal level theory [42], the concept of psychological distance is theorized to involve four dimensions—spatial, temporal, social and hypotheticality (or uncertainty)—such that an increase on any dimension promotes a psychological construal of an object or event that is more abstract and high-level, as opposed to more concrete and low-level. In the case of climate change, the public's tendency to imagine impacts that occur in faraway places (e.g. the North Pole), in the distant future (e.g. after their lifetime), and that affect dissimilar others (e.g. people from different cultures than one's own) is theoretically expected to promote mental images of impacts that are less vivid and, thus, less likely to motivate the general public to adopt behavioural changes and support policies to mitigate the threat [51,52].

Like impacts from climate change, emerging threats to ocean health may be construed as psychologically distant along multiple dimensions and thus may be less likely to spur behavioural change. First, although they cover over 70% of the Earth's surface, oceans are spatially distant for the large share of the world's population living in landlocked nations or interior regions of coastal nations [53]. Moreover, for those living closer to the oceans or in communities with deep economic and cultural ties to ocean services (e.g. fishing, tourism), the vast and 'invisible' depths of the sea may nevertheless encourage a more distal and abstract construal of the environmental threats occurring there. Thomas *et al.* [54] recently reported relevant findings in their interviews with people living in the Severn Estuary in Wales, UK. Even though scientists predict that this region will be negatively affected by sea-level rise due to climate change, participants reported not thinking about it much relative to other issues. In terms of temporal distance, research suggests that a majority of the public expects that negative anthropogenic impacts to ocean ecosystems and marine species will occur in the future rather than the present [24,54], a perception that contrasts starkly with the scientific literature documenting the contemporary threats to coral reefs and the rise of marine infectious diseases. In addition,

Table 1. Social-cognitive challenges to communicating about ocean health issues to the general public.

challenge	description	relevant empirical examples	potential communication strategies
psychological distance	ocean issues are likely to be psychologically distant in the minds of many, reducing the vividness of threats and potentially undermining support for restoration policy	events depicted at greater distance are construed more abstractly [42] images of climate change impacts commonly depict faraway places [43]	messaging that highlights the centrality of ocean health and services to society immersive technologies that make ocean spaces feel vivid and close (e.g. virtual reality)
unfamiliarity	compared with terrestrial environmental issues, those occurring in oceans may feel unfamiliar to large segments of the public, who may think about marine issues from a highly 'terra-centric' perspective	opinion surveys reveal limited knowledge of specific threats facing oceans [15] 'most salient' issues reflect a terra-centric bias (e.g. coastal erosion) [24]	interactive tools that aggregate and simplify data for the public (e.g. Ocean Health Index) [44] metaphors that ground marine systems in terrestrial concepts (e.g. coral reefs as <i>forests</i>)
politicization	like other contemporary environmental issues (notably climate change), ocean issues are at risk for being interpreted through partisan schemas rather than through more dispassionate reasoning	US political partisans show a reliable divide on the existence, causes, and mitigation of climate change [45] similar patterns have been observed for related environmental issues [46–48]	emphasizing the certainty of marine disease occurrence over the <i>uncertainty of mechanisms</i> framing ocean health issues in terms of 'public health' (versus 'environmental') consequences [49,50].

because many afflicted species differ markedly from human beings in outward appearance (e.g. molluscs such as oysters and abalone), the general public may be relatively unmoved by information that details the plight of such species, as compared with messaging that portrays humans or charismatic mega-fauna as the victims of environmental threats [55] in persuasive attempts to change attitudes and behaviours in more pro-environmental ways [56,57].

While the psychological distance of marine environments may impede attempts to build support for ocean restoration efforts, emerging perspectives point to strategic communication opportunities for overcoming this barrier. For instance, framing messages [41,58] so that they highlight the deep reliance of many human societies on marine ecosystems services, as well as degradation to ocean environments that can be clearly observed today (as opposed to future projections, which are temporally distant and inherently uncertain), may help attenuate psychological distance and increase concern among the general public. In the USA, for instance, 39% of the population resides in shoreline counties [59], and more than 40% of the world's population lives within 150 km of the ocean, many concentrated in coastal metropolises such as Shanghai, Tokyo and New York [60]. In addition, the opportunity to experience ocean environments up close, even temporarily, may boost the public's concern. In this vein, research has found that visits to an aquarium can promote attitudes that are more supportive of marine stewardship [61]. Moreover, advances in virtual reality technology provide unprecedented opportunities for sensory immersion into difficult-to-reach environments, including the deep ocean [62]. Although in its early days, such research offers intriguing possibilities for bridging

psychological distance by depicting faraway environmental threats in vivid detail which, in turn, may reduce psychological distance and thereby promote increased awareness, concern and support for restorative policies [63].

5. Unfamiliarity

Regardless of the psychological distance at which they are experienced, ocean health issues are also likely to feel unfamiliar to many members of the general public; although related, we distinguish psychological distance from unfamiliarity in that the former primarily pertains to the level of abstraction that characterizes how the public construes ocean issues, whereas the latter primarily pertains to how the public understands and interprets ocean issues. Because humans are a terrestrial species that evolved in response to challenges and opportunities on land, people may have difficulty understanding and interpreting processes that occur in ocean environments, given their unique physical and chemical features. Although scientists have documented threats to marine systems from increasing water temperatures and ocean acidification linked to climate change, public opinion data suggest that in addition to being less aware of climate impacts occurring in aquatic as compared with terrestrial environments, the public may view aquatic impacts from a highly terrestrial or 'terra-centric' perspective—interpreting such issues through knowledge structures that are more salient and familiar.

This terra-centric view of climate change impacts is apparent in research on climate change risk perception. Analysing data from a national probability sample of US adults, Leiserowitz [43] reported that the two most common thoughts or

mental images prompted by 'global warming' were of melting ice and rising temperatures (heat), associations that may seem more directly threatening to terrestrial species (such as polar bears and drought victims) than to marine species. Moreover, when estimating the likelihood of six global warming impacts (including decreased standards of living and increased rates of serious disease), the potential for worldwide water shortages received the highest likelihood ratings observed—a consequence that, from a lay perspective, may appear exclusively relevant to terrestrial environments. The prevalence of these 'hot and dry' associations with 'global warming' is further supported by studies based on priming methodology from the psychological literature, which report that people express greater concerns about the issue on hotter days [64] and even when tasting 'hot' cinnamon gum [65] (see Schuldt & Roh [66] for a detailed discussion). Taken together, such findings suggest that the public may predominantly construe climate-related impacts in relatively simplistic ways that feel more applicable to terrestrial as opposed to marine environments—despite the fact that the world's oceans represent the vast majority (over 90%) of the planet's habitable environments [67]. We speculate that this bias is rooted, in part, in our species' terrestrial nature and the diminished salience of marine issues in the everyday lives of the majority of the public.

To help combat the unfamiliar nature of marine environments when communicating about ocean health, we highlight two promising research trends. Taking advantage of opportunities afforded by the emergence of 'big data' analytics, the first are efforts to aggregate massive amounts of information relevant to ocean health and to distill it into a single familiar form that diverse audiences can readily understand. For instance, the Ocean Health Index [44] currently provides a summary score representing the overall health of over 200 coastal regions and open-ocean areas using a 0–100 numerical scale, along with corresponding colours displayed on an interactive map to symbolize overall health quality. The communication value of 100-point numerical scales (where 100 symbolizes the highest quality) and culturally held colour associations (e.g. where red and green symbolize negative and positive events, respectively) can be observed in a variety of other domains, from the popular 100-point rating scales used by leading wine critics [68] to 'traffic light' labels on packaged food products that readily convey nutritional and health information to consumers [69]. Theoretically, efforts like these allow their intended audience to engage in heuristic judgement and decision making (e.g. '85 is a decent score,' 'green means good') when confronted with the latest scientific information about the health of the world's oceans, thus substantially simplifying what would otherwise be a complex and nearly impossible task for the average citizen (see Sloman [70] for a discussion of heuristic reasoning).

A second promising means for overcoming the unfamiliarity of ocean environments comes from research on metaphors. Metaphors infuse everyday communication and thought, grounding abstract principles in concrete physical experiences and thus providing a psychological scaffold for making sense of complicated ideas [71]. Recent research suggests that metaphors can powerfully influence cognition in previously underappreciated ways, increasing the accessibility of metaphor-related thoughts and eliciting metaphor-congruent behaviours [72], as when research

participants are more likely to solve a challenging puzzle when exposed to a light bulb that suddenly flickers on [73]. Just as the light bulb metaphor grounds our understanding of having ideas in a common physical event, metaphors that use terrestrial concepts to communicate and help simplify complex and unfamiliar ocean health issues may help improve public awareness and understanding of the threats that marine species currently face. For instance, employing a forest metaphor ('Coral reefs are the *forests* of the ocean') to convey the multitude of life-sustaining services that coral reefs provide as well as the rich biodiversity that they support [74] would leverage existing mental schemas for terrestrial environmental issues (e.g. the 'Save the Rainforest' campaign of the 1990s [75]); similarly, a lung metaphor ('Coral reefs are the *lungs* of the ocean') could exploit basic knowledge of bodily systems to convey the essential filtering functions of reef species and the intimate interconnectivity of marine ecosystems [76]. Although further research is required to test the effectiveness of these specific metaphors, in general, metaphors offer a promising and underexplored avenue for advancing communication research and enhancing outreach efforts surrounding ocean health.

Although visual data-aggregation tools and metaphors may aid public understanding of complex and unfamiliar dynamics relevant to ocean health, communication tools such as these are unlikely to increase the salience of ocean health issues in the public's consciousness, *per se*. However, as national and international organizations increase their focus on the plight of the world's oceans and the role of anthropogenic stressors in their degradation, we anticipate a corresponding rise of these issues on the public agenda and a resulting need for messaging strategies that help overcome limited knowledge and feelings of unfamiliarity.

6. Politicization

Over the past two decades, climate change has emerged as a highly contentious political issue, especially in the USA [77], where opinion polling documents wide partisan disagreement over its existence, causes and how to address it [45]. Amid this persistent polarization, related environmental issues are at risk for being perceived and interpreted through similar 'politicized' mental schemas, in which citizens draw on their closely held values and positions of party leaders or other partisan elites, for example, rather than expressing independent opinions formed through a more dispassionate consideration of scientific evidence [78–80]. Beyond climate change, politicization has been observed in recent discourse surrounding a number of contemporary scientific and environmental issues, including debates about hydraulic fracturing, biofuels and nanotechnology, to name a few [46–48].

Bolsen & Druckman [81] have recently outlined three core characteristics of politicization: that it occurs when (i) some *scientific finding* that (inherently) involves (ii) a degree of *uncertainty* is (iii) questioned by an actor who *accentuates* that uncertainty, often in the pursuit of some agenda other than scientific discovery. As with all emerging scientific findings, those linking ocean health issues to anthropogenic climate change are characterized by varying levels of uncertainty (e.g. the extent of disease spread, transmission pathways, etc.); individuals and groups inclined to reject the severity of these issues based on pre-existing values or

worldviews may seize on the uncertainty of the underlying mechanisms as opposed to the substantial scientific evidence that oceans are facing unprecedented anthropogenic threats. Although data on the extent to which ocean issues are currently politicized are lacking, the inherent uncertainty of the science, combined with the possibility of ocean health being construed as just another ‘environmental’ issue, raises the possibility that audience segments on either side of the political spectrum might engage in biased cognitive processing when faced with information about ocean health and emerging marine diseases.

A growing literature in communication on motivated reasoning about environmental issues suggests that the public may process information about ocean health in a less than even-handed manner. Reviewing studies of climate change beliefs in the USA, McCright [82] found that self-reported issue knowledge correlated positively with issue concern among Democrats; by contrast, the association between knowledge and concern was frequently weaker and sometimes *negative* among Republicans (see also Hamilton for a discussion of the moderating role of political orientation in climate change beliefs [83]). In an experiment testing partisans’ reactions to messages about climate change victims, Hart & Nisbet [84] found that the same message increased support for climate mitigation among liberals but *decreased* support among conservatives. Further demonstrating differential processing of climate-related information across partisans, Schuldt & Roh [66] found that reminders of unseasonable weather (e.g. record-breaking snowfall in the Northeastern USA) reduced conservatives’ (but not liberals’) belief in the existence of global warming. More generally, such findings highlight the possibility for unintended consequences, or ‘boomerang’ effects, in environmental communication [85]. Although partisanship represents one mechanism through which messages may exert unintended effects, there are additional possible pathways that are more specific to the issue of ocean health that future research should explore—including effects of communicating about the risks faced by less-charismatic species (e.g. molluscs); about impacts that may be emotionally unsettling for some (e.g. depictions of the gruesome symptoms of contracting *Vibrio* infection from eating contaminated oysters); and about consequences that might appear unproblematic, or even beautiful, to the untrained eye (e.g. coral bleaching).

Although social scientists have yet to uncover a reliable remedy for decreasing political polarization on environmental issues, recent work offers promising possibilities. Some scholars have suggested that re-framing many ‘environmental’ issues (such as climate change) as ‘public health’ issues may help to bypass and mitigate anti-environmental thinking, thus reducing issue polarization and ultimately laying a foundation for a broader consensus regarding mitigation and adaptation [49]. In this vein, Myers and colleagues [50] found that public health framing of climate change messages led to an increase in positive emotions predictive of more pro-environmental policy preferences (e.g. taxing carbon). With regard to ocean health and emerging marine diseases, downplaying or avoiding overemphasizing linkages to highly politicized topics like climate change in favour of other, less political factors (e.g. ocean acidification) may similarly reduce polarization. To date, however, research exploring the impacts of message framing in this context has been limited.

Informed by the literature on framing effects and the diverse headlines covering outbreaks of *Vibrio* discussed above, we recently conducted an experiment to assess the public’s response to varying news frames of this issue and to test how political orientation interacts with exposure to the frames. Below, we briefly summarize the study and some of its findings, which offer initial insights into the ways that message framing may shape public support for remedying ocean health issues that may be psychologically distant, unfamiliar and politicized in the minds of many citizens.

7. Framing *Vibrio* disease: an experimental study

To explore how framing the issue of *Vibrio* in news coverage influences public support for environmental policies, we conducted an experiment involving more than 500 respondents who were passengers aboard a ferry in the San Juan Islands, WA, USA. Depending on the experimental condition, respondents first read a short article about *Vibrio* in the Pacific Northwest that framed the issue primarily in terms of its health consequences for either marine species (i.e. the oysters themselves) or the health of the general public (e.g. from eating contaminated oysters). Next, they answered questions that gauged their perceptions of ocean health issues, which included items that measured support for regulating fossil fuel emissions, a chief cause of ocean health degradation. Drawing from past national opinion polls [86], we assessed support for regulating fossil fuel emissions by creating an index of responses to the following three items ($\alpha = 0.87$): *The United States should reduce greenhouse gas emissions*; *The United States should regulate carbon dioxide as a pollutant*; *The United States should encourage industry to shift away from using fossil fuels* (1 = Strongly oppose to 6 = Strongly support). To afford a comparative baseline, another group of respondents in a control condition simply completed the measures without any exposure to a message.

To examine the effect of message framing on support for regulating fossil fuel emissions, we tested an analysis of variance (ANOVA) model in which experimental treatment (public health frame, oyster health frame, control), political affiliation (i.e. Democrat, Republican, Independent, Other; the latter two categories were combined for this analysis) and their interaction term were entered as the independent factors. This analysis allowed us to examine whether any effect of framing might vary across political groups, given the politicized nature of environmental issues and fossil fuel regulation in the USA and recent work reporting politics-contingent framing effects for environmental issues [87]. Indeed, results revealed a significant interaction between experimental treatment and political affiliation on policy support. Specifically, whereas policy support among Democrats and Independents was unaffected by the experimental treatment (Democrats: $M_{\text{public health}} = 5.51$, $M_{\text{oyster health}} = 5.55$, $M_{\text{control}} = 5.58$; Independents: $M_{\text{public health}} = 4.98$, $M_{\text{oyster health}} = 5.10$, $M_{\text{control}} = 4.88$; $F_s < 1$, n.s.), Republicans who read the article emphasizing consequences of *Vibrio* for public health ($M = 4.62$, s.d. = 0.94) expressed significantly greater policy support than those in the oyster health ($M = 3.88$, s.d. = 1.42) or control conditions ($M = 3.97$, s.d. = 1.30) (contrast $F_s > 5.50$, $p_s < 0.05$) (interaction $F(4,534) = 2.54$, $p < 0.05$) (see McComas *et al.* [88] for additional details and results).

These findings complement past work suggesting that framing environmental issues in terms of their public health implications may evoke more receptive reactions among those who typically express less concern for the environment [49] (here, Republicans) and provide initial support that framing emerging marine diseases in ways that make salient their impacts on human health and social systems may shift public support for policies aimed at restoring ocean health, carrying implications for the social-cognitive barriers discussed above. However, the public health framing of environmental issues is not without its downsides; for example, emphasizing the risk to human health from consuming oysters may negatively impact commercial fisheries by reducing demand for raw seafood—an important economic consideration. Nevertheless, by promoting a sense of shared fate between the health of oceans and humans, communicators may decrease psychological distance and, perhaps, reduce feelings of unfamiliarity that may stifle issue understanding and engagement. These findings also suggest that reactions to messaging about emerging marine diseases may be partly shaped by political orientation, and that this politicization may interact with message framing in nuanced ways, a topic that is ripe for further inquiry.

8. Conclusion

As marine species face unprecedented threats from anthropogenic climate change and its effects (e.g. sea-level rise and ocean acidification), engaging the public to promote greater issue awareness, knowledge and, ultimately, support for remediation efforts is a necessary and important challenge. From a communication perspective, however, outreach to promote marine conservation might not unfold in the linear manner that is often assumed; instead, various everyday psychological processes may intervene in ways that undermine the increased

public support for ocean restoration efforts that information campaigns seek.

Research in communication and related disciplines investigating how the public processes environmental messaging suggests a number of challenges for informing and persuading the public on ocean health issues. Although the present paper highlighted three challenges in particular—the *psychological distance* of oceans, the *unfamiliarity* of aquatic environments and the *politicization* of leading environmental issues (e.g. climate change) in the minds of the public—we do not intend this to be taken as an exhaustive set nor as necessarily the most important challenges that communicators face. Rather, recent social-scientific perspectives suggest that each of these factors may have consequences for how the public processes and responds to messages about contemporary ocean health issues that may help explain, in part, the relative lack of urgency shown by citizens and governments around the world to enact ocean restoration efforts. Moreover, we suggested that framing ocean health matters in terms of their consequences for public health (as opposed to as purely ‘environmental’ issues) might help researchers and advocates overcome these challenges and ultimately increase public support for pro-environmental policy. We see such strategies as fruitful avenues for future research in environmental communication, and, more generally, echo the calls made elsewhere for more research into the factors shaping public opinion on ocean health and emerging marine diseases.

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