Rules of Engagement:
How and why are ocean and aquatic researchers communicating with the public?

by

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Abstract

In marine-management contexts, public engagement is increasingly being incorporated into the decision-making process. As governments devolve more responsibility for the management of marine space and resources, it is more important than ever to establish effective communication between scientists and the public. However, the extent to which scientists embrace their role as communicators varies, as do the channels and methods of engagement they pursue. Scientists have historically relied on a "deficit model" of communication, which holds scientists and scientific information in a privileged position relative to the public. The public engagement with science field has repeatedly criticized this model, citing its repeated failures to improve science literacy or enhance support for science. Rather, they argue that scientists must engage with the public by becoming more open and responding to their interests and concerns. Through surveys and interviews, data was collected to help understand the factors that encourage or discourage ocean and aquatic researchers from engaging with the public. Findings suggest that participants had a very positive view of "engagement" as a whole but differed in their interpretation of what engaging with the public entailed. Many participants also reported frequent contact with the public and media but little formal communications training. Recommendations include increased communications training for scientists at the post-secondary level, as well as future case studies that examine interactions between scientists and the public in specific marine-management contexts, such as aquaculture siting.

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This work is dedicated to Irene Johnson, who—though she still might not have read it—would have been proud.

Table of Contents

1. INTRODUCTION

The oceans are currently undergoing massive changes as a result of anthropogenic effects, from overfishing to climate change (Jackson, 2008). In order to address some of these challenges and their consequences, particularly at a regional or local scale, there is a growing interest in getting the public more actively involved in marine management. From a theoretical perspective, public engagement is desirable because it appears to be more democratic than top-down decision-making (Lee, 2015); from a practical perspective, public engagement is believed to improve management outcomes by increasing governability, transparency, and adaptability (Reed, 2008; Chua et al., 2006). Under the Obama administration, for example, the United States' National Ocean Policy encouraged the formation of Regional Ocean Plans, incorporating a wide variety of stakeholders and public participation into the decision-making process (National Ocean Council, n.d.). In Canada, where the federal government has full legal control over the ocean and its resources, there is nevertheless a growing acknowledgement that public participation (especially by coastal communities) is both ethically and practically preferable to managing by fiat (Bennett, Kaplan-Hallam, Augustine et al., 2018). As governments begin to devolve more responsibility for the management of marine space and resources, and ocean and coastal spaces become increasingly contested, it is more important than ever to establish effective communication between scientists and the public.

However, research suggests that scientists' communications strategies do not align with best practices from the science-communication field, and that current communications practices may be doing harm to the relationship between scientists and the public (Dudo & Besley, 2016; Nyhan & Reifler, 2010). Scientists have historically relied on what has been called a "deficit

model" of communication, which holds scientists and scientific information in a privileged position relative to the public. Under this model, scientists generate and select the information that they believe is necessary for the public to know, and this information is processed (often through the media) in a way that the public can understand (Miller, 2001). Those who study public engagement with science have repeatedly criticized this model, citing its repeated failures to improve science literacy or enhance support for science (Sturgis & Allum, 2004; Nisbet & Scheufele, 2009). Rather, they argue that in an age of misinformation and amid increasing mistrust of experts, scientists must engage with the public by becoming more open and responding to the public's interests and concerns (Kofman, October 25, 2018). Yet communications professionals who have had experience training scientists report that most researchers are not trained to do so, and that many still operate under the assumptions of the deficit model (Besley & Tanner, 2011).

At the same time, the science-media interface, which has traditionally facilitated the flow of information between scientists and the public, has changed dramatically in the last few years. The internet and social media offer both opportunities and threats for scientists who are interested in taking their message directly to the public, circumventing gatekeepers, while also allowing the public to engage more directly with scientists (Nisbet & Scheufele, 2009). Meanwhile, traditional and local media outlets have experienced a decline of their available resources, limiting coverage of science and the expertise of the journalists involved; the *Globe and Mail*, for example, has only one dedicated science reporter (2018). Amid these changes, scientists have gradually begun to accept that communication is an expected part of their profession, becoming not just knowledge generators but translators and communicators (Peters, 2013). Yet for the most part, they are neither trained nor directly incentivized to develop good

communication practices, and it can be professionally and ethically complicated to be both a scientist and a science communicator (Pielke, 2007; Marvel, August 8, 2018).

In the context of marine management, there are pressing situations that increasingly require scientists to engage with both decision-makers and the public and ensure that knowledge is mobilized effectively. In Nova Scotia alone, the last two years have seen conflicts over aquaculture, tidal energy, and natural gas storage in which members of the public have pushed back against decisions made with scientific information, and in some cases called into question the soundness of the science itself (Grant, Filgueira & Barrell, 2016; Withers, October 20, 2016; Doucette, January 30, 2017). Given that scholarly criticism has failed to substantially alter scientists' communications practices, and considering the increasingly important role scientists play in transmitting knowledge, it is imperative to understand how ocean and aquatic scientists themselves perceive their role as science communicators, what their existing patterns of communication are with the media and public, and to what extent these align with the deficit model of communication.

1.1 RESEARCH QUESTIONS AND METHODS

This study investigated these questions through an online survey, supplemented with semi-structured interviews. The central research question of this project is: What are the factors that either encourage or discourage ocean and aquatic researchers to communicate their work with the public?

This question is supplemented by four additional sub-questions: a) are these factors similar to those identified in large-scale surveys of scientists in other countries?; b) are researchers comfortable "framing" their results to facilitate communication?; c) do researchers

regard scientific literacy as a precondition for meaningful engagement with scientists and managers?; and d) what are the preferred channels of engagement among researchers?

Participants were drawn from the Ocean Tracking Network (OTN), where the author completed his internship. OTN is a Dalhousie University-based organization that tracks aquatic animals around the world and stores related data for the purposes of informing management. OTN-affiliated researchers conduct research globally, and the organization has links with non-governmental organizations, industry, and government as well as academia. Participants therefore represent a broad cross-section of researchers involved in the application of science to marine-management questions. Further details about the design of this study are provided in the "Methodology" section.

2. BROAD CONTEXT

Science and technology play a crucial role in contemporary life, at the level of both the individual and society at large. From the quotidian act of using a smartphone to the seemingly esoteric world of particle physics, they affect the way we both interact with and understand the world (UNESCO, 1999). Scientists also help us make decisions by analyzing problems and making predictions, which in turn allow us to weigh alternative courses of action (Hendy, 2015). In democratic societies such as Canada, science plays a role in decision-making across a variety of policy areas, from resource management to health (Innovation, Science, and Economic Development Canada, November 2, 2017).

Although the public holds a generally positive view of science, it can also be a source of controversy. Climate change, genetic modification and nanotechnology, for example, have generated debate about science's authority, motives, and ethics (Jasanoff, 2014; Miller, 2001). Where conflicts have occurred, questions have emerged regarding the cause of those conflicts. Do conflicts arise because the public has an inadequate understanding of the science involved? Are scientists not communicating their work effectively enough within a highly competitive marketplace of ideas (Nisbet & Mooney, 2007)? Or is asking whether we can improve the public's receptiveness to scientific information the wrong question in the first place (Miller, 2001)?

The answer to these questions depends on whom one asks. In general, scientists understand their work to be a progressive and apolitical force for good that generates objective knowledge about the world (Alberts, 2008); thus, the issue from a scientist's perspective is typically that the public possesses a *deficit* of knowledge, which needs to be addressed through a

better understanding of scientific facts and methods. Conversely, those who critically study science regard it as a value-laden culture with its own set of norms that operates within, and is influenced by, a particular political and economic context (Salmon, Priestley & Goven, 2017). According to this view, scientific information is merely one of many kinds of knowledge within a broader set of discourses and is sometimes in contest with others. In Nunavut, for example, the territory's polar bear management plan—which is based largely on Inuit knowledge—argues that polar bear populations are not currently in decline due to climate change, and that there may in fact be too many bears, contravening the position of Environment Canada and many scientists (The Canadian Press, November 12, 2018).

This kind of conflict between scientists and resource users and/or local knowledge holders can be viewed through two different science-communication perspectives: the deficit model, and the dialogue model. Whereas the deficit model tends to regard the public as an audience, the dialogue model sees them as an interlocutor that must be engaged, for both theoretical and practical reasons.

2.1 THE DEFICIT MODEL

Scientists have generally understood conflicts between scientific authority and public understanding as an issue of "science literacy," an ill-defined term that arose in the 1950s and may describe both knowledge of scientific facts and methods and the cultural role of science (Miller, 1983; DeBoer, 2000). Further refinements to the idea established the concept of "civic science literacy," which is "the level of understanding of science and technology needed to function as a citizen in a modern industrial society" (Miller, 2010). A methodology was developed that is in use around the world to test scientific literacy: a combination of closed and

open-ended questions that endeavour to measure citizens' understanding of foundational scientific facts (e.g. the Earth's core is hot) and processes (e.g. whether or not astrology is a science) (Miller, 1998). The most recent survey of Canadians using this test found that our country had the highest science literacy rate in the world—42% of people met the threshold, defined as the level of understanding necessary to read and comprehend the science section of the *New York Times* (Canadian Council of Academies, 2013).

In an ocean context, there has been a growing movement among scientists and policy-makers to increase the public's "ocean literacy". This concept originated in the US in the early 2000s and has since been taken up by the UN as a part of Sustainable Development Goal 14: Conserve and Sustainably Use the Oceans, Seas and Marine Resources for Sustainable Development—its aim is to "improve public knowledge […] regarding our global ocean," which will raise public awareness and promote "more responsible and informed behaviour" (International Oceanographic Commission, July 11, 2018, para.2). The concept of ocean literacy is very similar to scientific literacy, focusing on basic scientific knowledge relating to the oceans that the public needs to know in order to be considered "literate" (e.g. Guest, Lotze & Wallace, 2015).

The concern with the public's ability to absorb scientific information and attitudes is often framed in democratic terms: failing to do so inhibits people from participating meaningfully in democratic debates around issues that involve science. But to a certain extent, it is also based on "the well-intentioned belief that, if laypeople better understood technical complexities […] their viewpoints would be more like scientists', and controversy would subside" (Nisbet & Mooney, 2007, p.56). The "deficit model," as it has become known, focuses on how to take the knowledge produced by science and convey it in a digestible way for public

consumption: it is a one-way flow of information that is typically funnelled through traditional media (radio, newspapers, or television, for example) (Miller, 2001). It remains the predominant model of engagement for most scientists, despite the fact that its ability to change attitudes or enhance public understanding has been repeatedly called into question (e.g. Sturgis & Allum, 2004). In reaction to low levels of science literacy and resistance to scientific consensus, however, many science organizations have doubled down on the importance of facts and blamed either journalists' inability to articulate science correctly, and/or public ignorance (Nisbet & Scheufele, 2009). This dynamic has played out in the debate over tidal energy generation in the Bay of Fundy. Graham Daborn, a scientist who studies the effects of tidal turbines, published a lengthy opinion piece in the *Chronicle Herald*, rebutting "inaccurate and exaggerated claims" about the turbines' danger to fish (October 15, 2016). The article failed to allay the concerns of local fishermen, who continued to oppose the project; when they lost a court bid to prevent the installation of a test turbine, the fishermen's association released a statement saying that the court had "accepted industry-controlled junk science as truth" (CBC News, April 10, 2017). While universal approval for development is rarely possible, the continued and worsening dispute over what constitute salient facts in this case is troubling.

2.2 THE DIALOGUE MODEL

Social scientists and communications scholars argue that the deficit model of communication is neither desirable nor truly possible, for three related reasons.

First, science is not necessarily in a privileged position with respect to other forms of knowledge. For example, local and traditional knowledge systems exist that, while not "scientific," are nevertheless valid ways of knowing and describing the world (Cruikshank,

2006). However, while local and traditional knowledge has emerged as an important source of information for management—particularly in marine areas—it tends to be subsumed by science rather than treated as equal (Thornton & Scheer, 2012). Even in cases where a group does not possess a specialized body of knowledge, proponents of the dialogue model argue that there is value to be gained from genuine and equal interactions with the public; it gives a better understanding of their concerns and values, and (in theory) makes science more democratically accountable (Owens, 2000).

Second, as previously mentioned, the dialogue model argues that science always exists in a particular economic, political, and cultural context, and cannot be easily separated from these factors. Therefore, what appear to be objective solutions to particular problems are in fact often influenced by pre-existing values or political and economic priorities (Salmon, Priestley & Goven, 2017). Fisheries management, for example, was historically concerned with maximizing either the volume or value of the catch, which had both negative social and environmental consequences (Bromley, 2009). Proceeding from the assumption that there is "science" on the one hand and "society" on the other limits our ability to understand either (Jasanoff, 2014). Science should instead be understood as something embedded in society—it is in dialogue with public concerns whether it wants to be or not.

Third, from a practical perspective, the deficit model has largely been ineffective at meeting scientists' goals of improving science literacy or increasing support for science. Within the field of science communication, there is a consensus that scientific information needs to be "framed" for particular audiences in order to be effective (Nisbet & Scheufele, 2009). "Framing" entails explaining scientific facts in such a way that they resonate with an existing worldview, rather than just presenting the facts in isolation. For example, rather than simply explaining what

GMO research is, it could be articulated through its role in combatting poverty or ongoing efforts to "improve" crops for human use. Some of these principles are slowly filtering into the way scientists communicate, but in many cases older attitudes still prevail—and not just among older scientists (Peters, 2013). This is a concern for science advocates because, if scientists do not take advantage of the frameworks and narratives that the public uses to make sense of the world, more effective but less scrupulous communicators may manipulate science for their own ends, as with the climate-change "debate" (Nisbet & Mooney, 2007). It should be noted that, while framing is related to the dialogue model in that it situates science within society, it does not inherently result in more democratic outcomes: frames can be generated by the public, but they can also be produced by scientists and communications professionals (Nisbet & Scheufele, 2009). A "dialogue" approach typically recognizes that science communication is in fact a two-way process, and that engagement is necessary to produce both more democratic science policy and negotiate an agreed-upon body of knowledge (Maarten, Van Der Sanden & Meijman, 2008).

2.3 ATTITUDES TOWARDS COMMUNICATION WITHIN SCIENCE

Organizations such as the Royal Society in Britain and the American Association for the Advancement of Science (AAAS) have explicitly included increasing dialogue and public engagement among their goals (Kimbrel, June 1, 2018; Miller, 2001). However, the deficit model has proven resilient. Possible reasons include scientists' belief that rationality is the most important factor in decision-making, a lack of formal communications training, and negative perceptions of social science (Simmis, Madden, Cacciatore et. al, 2016). Regardless, it is apparent that the "deficit-to-dialogue" transition within science communication is more theory than practice (Trench, 2008). Indeed, as Salmon et. al. note, "there is little evidence […] that this reconceptualization of the "problem" of "deficit in understanding" as the need for "dialogue and

engagement" has taken hold outside of the [public engagement with science] literature" (2015, p.54). Among scientists who do choose to communicate, their motivations are various, although most of them are in line with deficit-model approaches. Previous surveys of scientists have indicated that they prioritize defending science or correcting misinformation above dialogue-oriented goals, such as tailoring messages or building trust (Dudo & Besley, 2016).

As communicators, therefore, many scientists still adhere to the deficit model. But there are other important factors that influence whether a scientist engages in the first place. Historically, scientists have not necessarily seen communication as a part of their work (Royal Society, 2006). This attitude has changed in recent years, and it is increasingly (though not universally) accepted among academics that researchers must not only publish articles, but also communicate their work to the public and mobilize the knowledge they produce to useful ends (Peters, 2013). In addition, there is external pressure in the case of publicly funded research, as governments increasingly target funding to develop the "knowledge-based economy" and deliver tangible benefits (Metcalfe & Fenwick, 2009). Accordingly, governments require researchers to demonstrate the impact of their work beyond academia (Bornmann, 2012). Furthermore, communicating with the public raises the status of institutions with which scientists are affiliated, which may in turn bring indirect benefits or rewards to researchers (Peters, 2013). Generally speaking, however, scientists themselves do not receive incentives or training for their role as communicators (Marvel, August 8, 2018).

Another challenge is that, within the scientific community, there is a popular perception that researchers who spend time communicating rather than researching may have their academic career suffer as a consequence (Martinez-Conde, 2016). While there is actually a positive correlation between academic output and frequency of public engagement, there remains a sense

among scientists that those who spend time in the public eye are neglecting their "true" work or are otherwise professionally inferior to those who do not communicate (Jensen et al., 2008; Russo, 2010). This issue has persisted into the age of social media: one researcher, for example, proposed the idea of a "Kardashian Index," or K-Index, which would compare a scientist's number of Twitter followers against their citations in order to discover which researchers' online celebrity outstripped their scientific bona fides (Hall, 2014).

There are conditions in which researchers consider communication with the public or media justified. These include the status of the institution that the researcher is affiliated with, their academic standing, and whether or not it was the researcher who decided to initiate contact (Rodder, 2012). As might be expected, scientists tend to have a more positive view of interactions involving respected, senior scientists talking about issues in which they are the acknowledged experts (Peters, 2013). This may affect the willingness of early-career researchers to communicate with the public, despite their enthusiasm or the high quality of their work (Martinez-Conde, 2016).

2.4 SCIENTIST VERSUS ADVOCATE

Scientists retain a large amount of trust and respect relative to other professions (National Science Board, 2008). This is at least in part due to the perception among the public, and among scientists themselves, that science is an objective process that generates value-neutral facts; consequently, scientists are wary of doing or saying things that might compromise that perceived objectivity (Hutchings & Stenseth, 2016). The result has historically been a professional dichotomy between the role of "scientist" on the one hand and of "advocate" on the other (Turnhout, Stuiver, Klostermann, Harms & Leeuwis, 2013). This distinction is important from a

communications perspective because it restricts the sphere of activities a scientist can or should engage in.

Further research has developed this framework into additional typologies. In Pielke's influential 2007 book, *The Honest Broker*, he identifies four main ways that scientists can engage with society. There are "pure scientists," whose work engages little or not at all with the broader world; "science arbiters," such as an advisory panel called upon to answer a specific question; "honest brokers," who use science to present policy alternatives; and "issue advocates," scientists who take a clear position in favour or against a certain policy (Pielke, 2007). Other researchers, building on Pielke, have recommended including "participatory knowledge producers" to denote those scientists who work closely with a given stakeholder group and co-produce knowledge with them (Turnhout, Stuiver, Klostermann, Harms & Leeuwis, 2013). Pielke himself adds the figure of the "stealth issue advocate"—those who have a position, but do not declare it (Pielke, 2007). In reaction to calls for an additional "science communicator" role, Pielke claims that this is "a fast track to stealth advocacy," particularly when commenting on issues that have been politicized (Pielke, January 19, 2015). This suggests that science communication is, fairly or not, always at risk of being perceived as a form of advocacy, and thus breaking an important cultural taboo within science.

Within fields where the knowledge generated can have a direct impact on management and policy, however, there is more debate around whether or not communication or advocacy should be an accepted or necessary part of scientific practice. It has been suggested, for example, that conservation biology is a "crisis discipline," as it is oriented toward dealing with the imminent loss of biodiversity (Soulé, 1985). Given this challenge, there is currently a controversy among ecologists about the extent to which they should engage in advocacy and use

rhetorical strategies such as catch phrases and appeals to emotion in order to further their efforts (Begon, 2017; Saul, Shackleton, & Yannelli, 2017). It has been further argued that, given the multiple threats currently facing the environment, environmental communications is *itself* a crisis discipline, and that communication is an ethical duty for those who are aware of the issues (Cox, 2007). There may therefore be more positive attitudes towards engagement among scientists who deal with environmental issues.

2.5 THE SCIENCE-MEDIA INTERFACE

Historically, scientists have predominantly relied on the traditional media to relay their messages and results. While the media has always covered science, it first became common to have specialized science reporters and writers in the 1960s, and many scientists had contact with journalists despite the perceived professional penalties for doing so (Dunwoody, 2014; Peters, 2013). At the same time, very few published papers made it into the news, and the vast majority of those that did related to health (Suleski & Ibaraki, 2010). The relationship between scientists and journalists has had other issues: for example, they have disagreed vehemently about whether journalists should have to run their stories by scientists before they are published (Smith, March 1, 2018). It is also not universal practice among journalists to read the paper about which he/she is writing (Randerson, March 28, 2012). Nevertheless, scientists generally have favourable opinions of their own interactions with journalists (Peters, 2013).

Recently, the media landscape has begun to change dramatically. Firstly, the internet has changed how people communicate. Yet although the internet and social media offer more opportunities for dialogic engagement, many scientists have not taken advantage of these tools; furthermore, opinion regarding the use of new technologies does not seem to be split on the basis

of age (Peters, 2013; Peters, Dunwoody, Allgaier, Lo & Brossard, 2014). Communications experts have suggested that "participatory media" such as blogs, video sites, and social media could generate "bottom-up" frames for scientific discourse, helping democratize science by, for example, enabling citizens to form advocacy groups on particular issues (Nisbet & Scheufele, 2009). The current situation is more complicated, as these channels have been both monetized and weaponized through practices such as "astroturfing"—the creation of fake grassroots movements—to affect public discourse on issues such as climate change, or even to influence elections (Cho, Martens, Kim et al., 2011; Metaxas & Mustafaraj, 2012).

The rise of the internet has also coincided with major changes to the traditional media landscape. While the situation varies from country to country, it has been particularly serious for local news organizations and specialist reporters in North America (Gill, 2016). This situation has created both opportunities and risks for scientists. In terms of opportunities, scientists have, in theory, more control over how their work is represented, which is something they have historically wanted (Peters, Dunwoody, Allgaier, Lo & Brossard, 2014). At the same time, scientists do not necessarily have access to the kind of training or network of support that can help them become effective communicators (Fischhoff, 2013). The result is that scientists are often called upon to do a job they have not been trained for, which may have negative consequences in their communications goals. As the scientist and science communicator Kate Marvel writes, "McDonalds does not force their cooks to engage in Hamburger Communication; they hire highly paid PR professionals instead" (August 8, 2018). Thus, while the cultural and professional attitudes within science may be changing with regard to communication, the incentives and training have not kept pace, with potential consequences for both scientists and public discourse.

Beyond technological developments, a growing awareness of the importance of "engagement" has resulted in other fora for scientists to meet directly with the public and bypass media. Soapbox Science, for example, is a rapidly expanding organization that holds public events where female scientists give presentations in highly visible, accessible places such as London's Hyde Park or the Halifax Seaport Market, with the aim of both improving communication between scientists and the public and changing the public's perception of what a typical scientist looks like (Watton, Pettorelli & Sumner, 15 November, 2017). Institutions such as the Royal Society and AAAS have also dedicated resources to facilitating engagement between scientists and the public; in some cases, however, these efforts have been criticized for essentially replicating deficit-model approaches in the guise of dialogue (Wynne, 2006). And even with a commitment to two-way dialogue, many scientists still lack the skills and confidence to directly communicate with the public in this way (Stylinski et. al, 2018).

3. METHODOLOGY

To address the research questions in the context of the research in the Ocean Tracking Network (OTN), this project made use of a general literature review, an online survey, and follow-up semi-structured interviews. Mixed-methods research combines the strengths of quantitative and qualitative approaches to provide a fuller picture than either method in isolation (Guetterman, Babchuck, Smith et. al, 2017). The survey and interview questions were informed by feedback from the Marine Affairs ethics committee as well as from OTN senior management. The survey included multiple choice, ranking, and Likert-scale questions (available in full at Appendix A). There were also text boxes for some questions, to give participants the opportunity to elaborate on their answers. Many of the questions were based on previous surveys of scientists' attitudes towards the media (e.g. Peters, 2013) and their objectives regarding communications (e.g. Dudo & Besley, 2016).

The questions pertaining to both the quantitative and qualitative data were grouped into five major themes drawn from a review of the literature: scientists' perceptions of the public; their perceptions of the media; their communications objectives; their training and previous experiences; and their time management. Taken together, these themes were used to answer the research question.

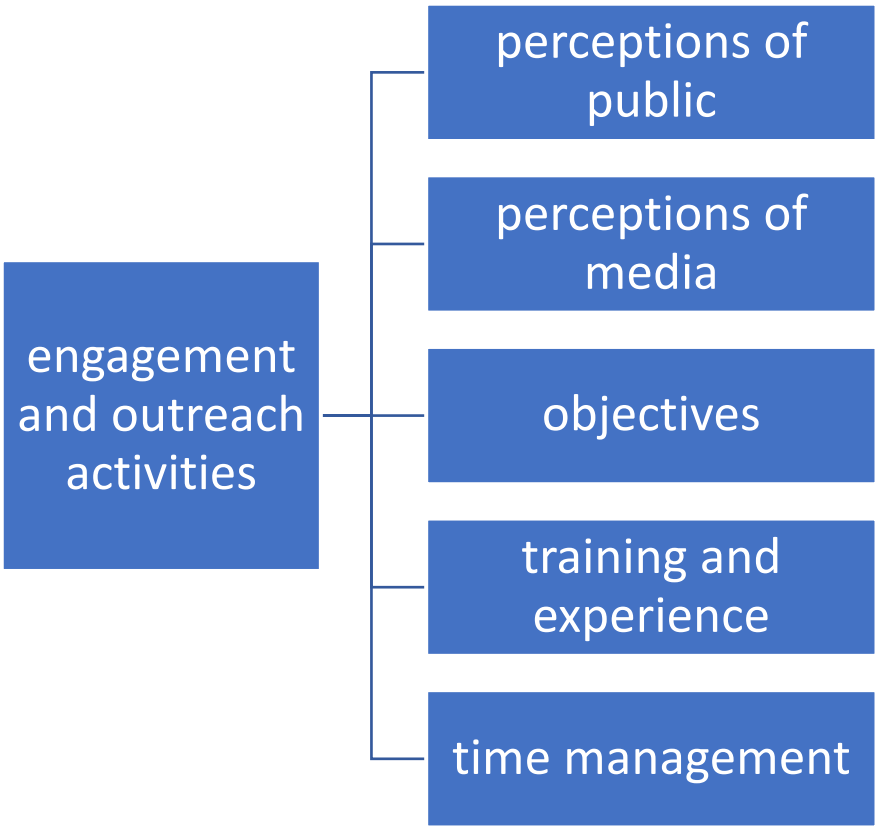


Figure 1. The five themes related to scientists' engagement and outreach.

The targeted population for this study was researchers affiliated with OTN, which is headquartered at Dalhousie University in Halifax, Nova Scotia. While based in Atlantic Canada, OTN works with a geographically diverse group of researchers across multiple disciplines, making them an ideal partner for the study. The study population was different relative to previous surveys of scientists in that this study targeted participants based on a shared research problem rather than a shared discipline. However, the work of OTN researchers aligns clearly with the study's research questions. First, OTN is involved in ocean conservation: its goal is to combine physical oceanographic data with information about the movements and survival of aquatic animals, and to make that information available in order to help inform management; knowledge mobilization is necessarily a key component of this objective. Second, OTN's

research is publicly funded. In 2007, OTN received $10 million from NSERC and $327,500 from SSHRC to fund research projects; one of the conditions for this funding was that they engage in "public outreach." Finally, part of the organization's strategic plan involves undertaking "outreach to and engagement of end users, and the public, nationally and internationally, on the outcomes of OTN enabled research and its implications" (OTN, 2012). The organization was therefore interested in seeking out the opinions and attitudes of those who produce that research when it comes to outreach and engagement activities, and to see how it can facilitate those processes in the future.

Participants were recruited using contact information provided by the OTN Data Centre. The Data Centre keeps information on all OTN-affiliated projects; principal investigators self-report information about the relevant members of their team for each project, including contact details (C. Bate, pers. comm., August 16 2018). In total, the Data Centre list included 392 researchers.

After receiving ethics approval from the Marine Affairs Program Ethics Review Standing Committee (Appendix B), an online survey was set up using Opinio, a survey platform licensed by Dalhousie University. E-mail invitations were sent through Opinio to the 392 researchers listed in the Data Centre contact sheet. Of the 392 researchers contacted, 51 were either out of the office over the survey period or had non-functioning email addresses. Two follow-up e-mails were sent through the Opinio account; additionally, the executive director and the scientific director of OTN sent e-mails to members of the list, requesting that they complete the survey. The survey opened on August 14, 2018 and closed on August 28th. In total, 82 people completed the survey, a response rate of 21%.

Five respondents were selected from this group for follow-up interviews. Respondents were selected to highlight different demographics and the diversity within the study group (Ragin, 1994). Two students, one mid-career researcher, and two senior researchers were chosen based on a combination of their responses, their demographic information, and their current and previous work. One respondent was employed by Fisheries and Oceans Canada; two worked at universities; one was conducting research in partnership with an environmental non-governmental organization, a university, and an industry stakeholder; and one worked for a First Nation group. Each was asked a series of semi-structured questions (Appendix C). These interviews were transcribed and entered into Microsoft Word, and then coded by the researcher according to the 5 existing themes following multiple read-throughs of the data.

4. RESULTS

This chapter will highlight some of the respondents' demographic information, and then describe the quantitative and qualitative results organized according to the five major themes derived from the literature. Graphs were generated using Opinio software.

4.1 DEMOGRAPHICS

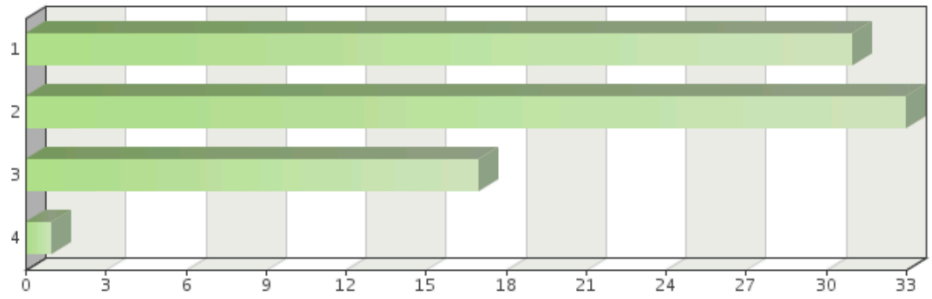
Of the respondents (n=82), 64 identified as male (78%), 16 as female (20%), and 2 chose not to reveal their gender (2%). 32 respondents identified themselves as senior researchers (34%), 27 as mid-career researchers (28%), 14 as junior researchers (15%), and 9 as students (9%). Respondents were also asked to self-report their specific field of study. 48 included the word "fish," "fisheries," or named a fish species in their responses. "Ecology" was also mentioned 35 times, suggesting a focus among respondents on holistic approaches to management problems. 10 respondents included "conservation" in the description of their work.

4.2 TRAINING AND EXPERIENCE

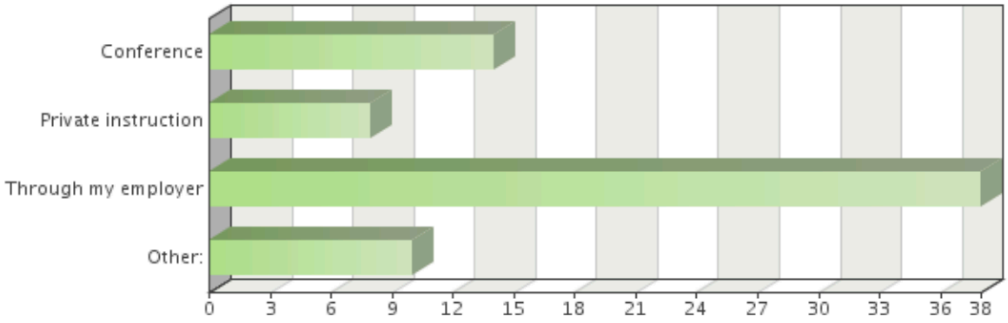
In the survey, respondents were asked about their previous training and experience in public engagement, and whether future training would make them more likely to engage.

About one third (33%) had no formal communications training, while the majority had a small or medium amount of training.

How much formal communications training have you had, with 1 being none and 5 being a college diploma or university degree in a communications-related discipline?



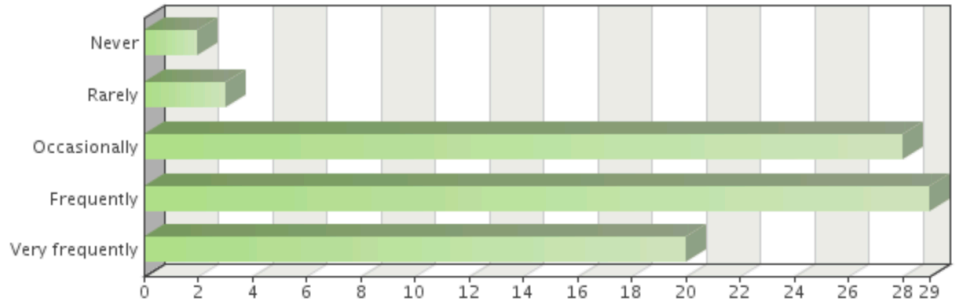
Of those who had some form of communications training (n=53), respondents were asked to indicate their sources, with the possibility selecting multiple sources. The most common source of training was through an employer, followed by conferences. A text box was available in the case of "other": the two most common responses were university courses and hands-on experience.



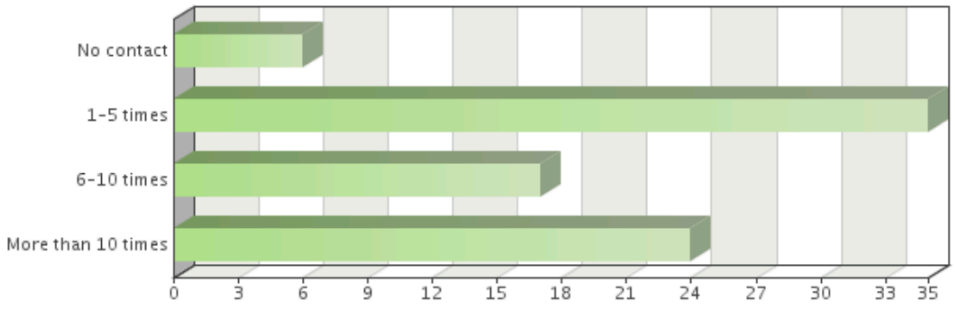
Despite having relatively little formal communications training, many respondents engaged frequently with both the public and the media.

94% reported engaging at least occasionally with the public, while the majority (60%) engaged either frequently or very frequently. For the purposes of this study, "engagement" included both in-person and digital interactions. There was not significant variation in engagement by career level, although no students reported engaging "very frequently."

How frequently do you engage with the public directly (in-person presentations, through social media, a personal blog etc.?)



Respondents were also asked how many times they had had professional contact with the general mass media (radio, television, newspapers, etc.) within the past 3 years; the 3-year period was chosen to facilitate comparison with a 2013 study done by Peters. The vast majority (93%) had at least 1 interaction with the media, while 50% had interacted with the media more than 6 times. A significant subset (29%) had more than 10 instances of professional contact. Of this subset, 83% were either mid-career or senior researchers.



Finally, respondents were asked whether increased training would make them more likely to engage with the public. Although a majority (53%) either agreed or strongly agreed, a third of respondents disagreed. Text responses from some researchers indicated that they felt they already had adequate training and engaged frequently. One respondent, seemingly anticipating this answer, called this attitude into question in the text response: "I think it's worth noting that many (most) of my colleagues think they are good communicators with non-scientists but aren't. This is a challenge that needs to be addressed."

Semi-structured interviews elaborated on the nature, availability, and desirability of training. First, the majority of training that scientists described receiving—and the kind they were interested in having more of—was focused on interacting with the media rather than directly with the public. The two senior researchers interviewed, both of whom had frequent contact with both the media and the public, reported that an important part of their training had consisted of understanding how journalists think and what their priorities are (as discussed later in 4.5).

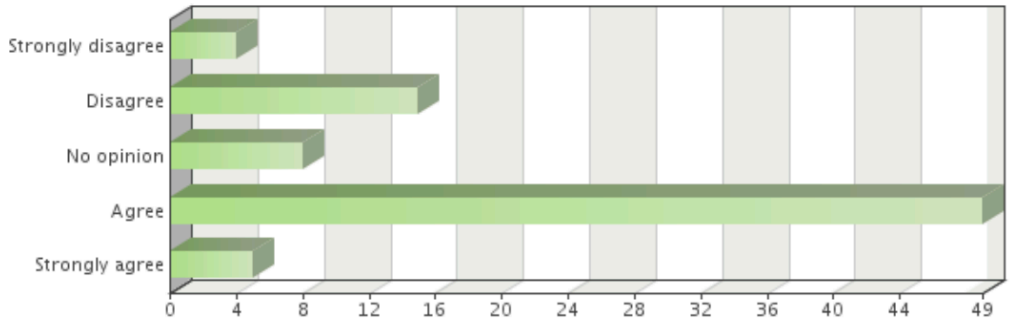
Respondents also spoke to the importance of "learning by doing." Each one mentioned that experience and practice had been beneficial, and in most cases constituted the bulk of their training. One student also drew attention to the informal training networks they had taken advantage of, contacting researchers in their field at their university who had media experience and asking for advice. A senior researcher spoke about how they are teaching the next generation of researchers, both through a class and by working directly with their students. This suggests that informal networks and training within disciplines may exert a formative influence on how researchers conceive of and execute their role as communicators.

The availability and variety of outside training depended on respondents' positions. A government senior researcher, for example, had access to a communications team. A senior researcher at a university had been singled out for special training by an outside organization; two students mentioned that training was available within their universities, but only one had taken advantage of it. A researcher who had studied management and worked with industry had had both media relations and cultural sensitivity training.

This training was also in some cases tied to a particular outcome: for example, in the case of government communications, a senior researcher reported that raising the profile of their institution was one of the motivations for encouraging public appearances. In the case of a researcher formerly involved with the oil and gas industry, cultural sensitivity training improved the likelihood of attaining social licence.

4.3 TIME MANAGEMENT

Scientists frequently cite the amount of time available as a barrier to communications activities (AAAS, 2018). Respondents were therefore asked whether they had enough time to both complete their academic and/or professional duties and engage with the public. Surprisingly, 67% either agreed or strongly agreed.



In text responses, five researchers wrote some variation on "I make time," suggesting that they prioritized outreach and engagement within an otherwise crowded schedule.

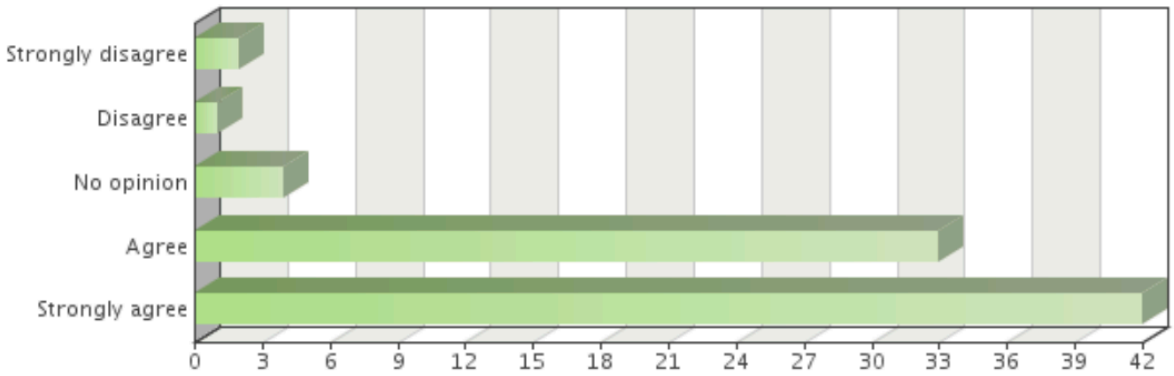
In interviews, respondents had diverse attitudes to making time for communications and outreach, although most considered it a necessary aspect of their work. One senior researcher said that media appearances were in fact "the best input/output ratio thing [they] do, period," as with relatively little work they were able to reach a large audience for their research and ideas. At the same time, this researcher disagreed with the idea that all scientists should do it; rather, he argued that communication requires love and passion. One student often volunteered to present his research and engage with the public when invited to do so by other individuals and organizations, but the student noted that he did not have the time to organize public events on their own.

For others, outreach formed part of their roles or responsibilities. This was especially the case for scientists employed by the government or industry. In the text responses to the survey, one researcher mentioned that meeting with stakeholders was an expected part of their work on behalf of the state (in the USA) that employed them; follow-up interviews also suggested that Canadian government researchers are expected to present their work to stakeholders, in addition to a subtler pressure to conduct media interviews where possible. While academic researchers for the most part did not speak about communications as an intrinsic part of their work, two researchers mentioned that they were working on participatory research projects. These necessarily involved regular contact with the public.

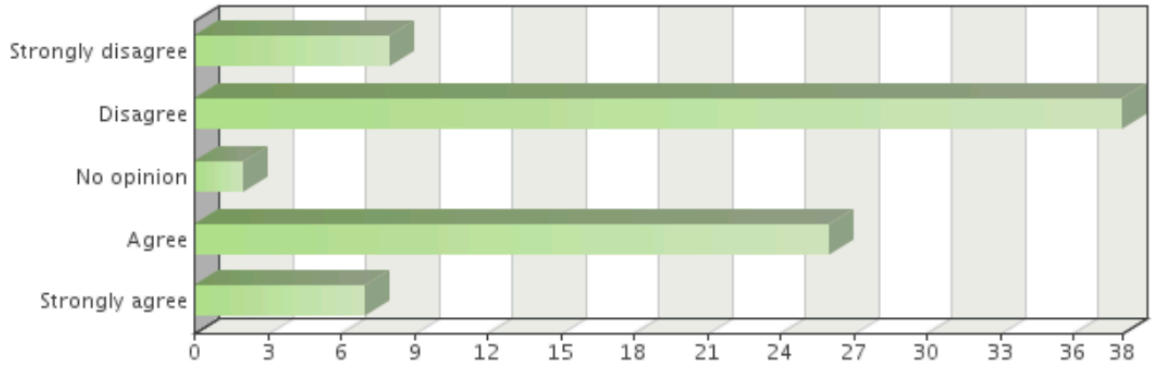
4.4 RELATIONSHIP BETWEEN SCIENCE AND THE PUBLIC

While the deficit model suggests that scientists take a dim view of the public's scientific understanding, questions were asked to further elucidate researchers' opinions on the public's roles and abilities in relation to science.

Respondents were asked directly whether they agreed with the proposition that "It is important that scientists engage in dialogue with the public, not just provide information." The overwhelming majority (91%) either agreed or strongly agreed; over half strongly agreed, suggesting that scientists are unambiguously in favour of greater dialogue.

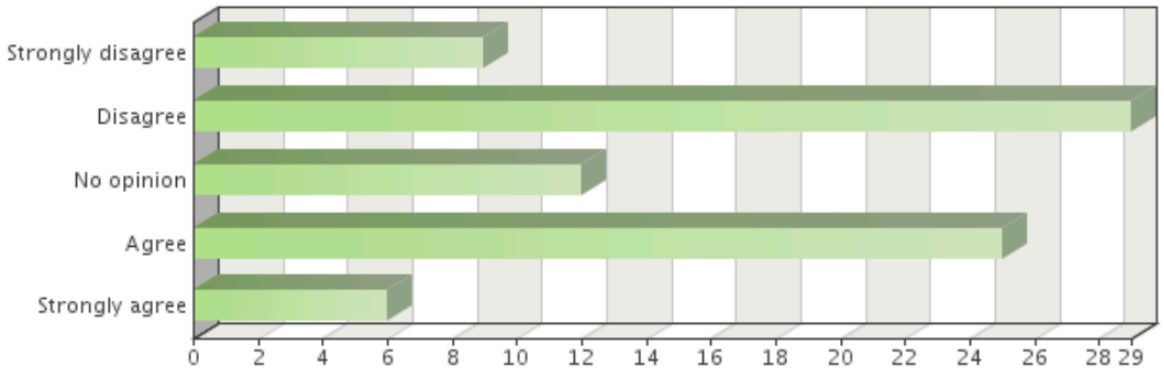


However, responses to other questions indicate that the picture is more nuanced. Respondents indicated that, in general, they disagreed with the proposition that "the public does not know enough about science to engage meaningfully with scientists," with 57% either disagreeing or strongly disagreeing. Yet a substantial number also agreed or strongly agreed, with only 2 respondents having no opinion.

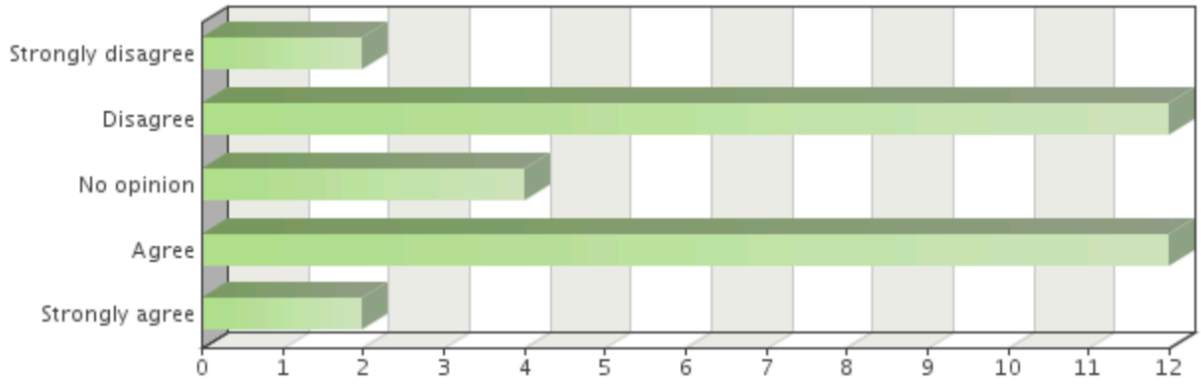


14 of those surveyed also included text responses. Half of these responses described successful communication with the public as being part of a scientist's job or responsibility. Those who agreed with the proposition cited "scientific illiteracy" and the public's desire for "black and white" information in the face of scientific complexity.

Another question asked for respondents' agreement with the following statement: "If a member of the public does not understand the relevant science, they should not participate in management decisions." Just under half (47%) either disagreed or strongly disagreed, while 38% agreed or strongly agreed. The rest had no opinion.



Again, there seemed to be a difference of opinion among respondents, but the source of the split does not appear to be generational: among senior researchers, the split was exactly even.



Text responses were various. Of the 14 responses, 5 mentioned the importance of information or knowledge that the public might possess that would be relevant to the management process. Other responses suggested the public had a responsibility to educate themselves in advance, or that science education should be provided before the public participates in a given management topic.

Respondents were also asked about their use of and experiences with online engagement tools, specifically social media (Facebook, Twitter, LinkedIn, Instagram) and personal blogs. Facebook had the highest number of users (48% of respondents reported using it to engage with the public), while LinkedIn had the fewest (12%). 39% had used Twitter, 20% had used Instagram, and 14% had used a personal blog.

Of these channels, no one reported mostly negative or very negative interactions. However, Facebook had the highest proportion of mixed experiences (35%), followed by

LinkedIn (33%) and Twitter (27%). On the other hand, users of personal blogs claimed to have had only mostly positive or very positive interactions.

In interviews, all respondents noted that there tended to be existing public interest in their work, and in ocean/aquatic science more generally. In some cases, there appeared to be a spatial dimension to the interest: for example, one researcher doing field work in an urban area frequently received questions from the public while she was doing research, and another suggested interest in ocean issues was related to proximity to the coast. All researchers also mentioned how different species and topics can affect public interest and attitudes. In particular, they expressed concern that the public's interest was unevenly distributed. One researcher mentioned that people were fascinated by her work with charismatic megafauna, but "equally important projects […] don't have that kind of opportunity, because they can't get the public engaged in the same way." Another researcher experienced challenges of this kind in her conservation work: when she mentioned what her research was about, people asked, "why would you want to save that fish? It's a garbage fish."

Additionally, researchers discussed how interactions between scientists and the public could lead to conflict or politicization. Two researchers expressed that they were fortunate to be studying topics and issues that had not become a source of polarization. "There's a lot of issues—immigration, or even climate change—that are much more politically charged. Oceans, I feel people of all kind of stripes can get behind," said one senior researcher. Another wondered whether their experiences engaging with the public would have been as positive had they studied something more controversial. However, of the researchers who had experienced tense situations, there was agreement that engagement and transparency were, if anything, even more vital. Referring to repairing the distrust between fishermen, Indigenous communities, and

scientists, one researcher argued that “engaging them is the only way [to rebuild trust]. I know it's hard for scientists to do that, and take the lumps with it, but I think it is important and I think it builds trust.”

Three researchers expressed some willingness to incorporate public information and feedback directly into their research. The researcher who had done work in Indigenous communities, for example, mentioned that “things go a long way when you do make some concessions” in response to concern about potential impacts of research, such as seismic testing. Two other researchers described how the public may have information that improves the quality of the research, and how it can also improve the outcome by addressing the public’s real-life concerns: “You need people to just talk to you, because that's where you get a sense of what matters and how things sort of go, and it can address a lot of mistaken impressions that I might have on a certain issue or topic, or just give you a new way of looking at things.” The remaining researchers did not directly address public input, focusing instead on how they could communicate their results to the public.

This led to some discussion about who constitutes the “public” that is being “engaged”. One researcher found that, while he had had positive experiences interacting with a well-informed public, the majority of his audience was people who were already interested in the issues: in this case, conservationists, recreational fishers, and fellow biologists. In terms of the engagement itself, researchers described a wide variety of activities that constituted “engagement,” ranging from answering questions from curious passers-by, to lectures at schools, to presentations at stakeholder meetings.

Of the three researchers who spoke directly about social media, all three had questions about its value. One felt that it was not an effective tool for communicating research: “the style of message that works on social media […] doesn’t actually get a lot of information across.” The second wondered whether, due to the nature of social media, posts reached beyond people who were already interested in the subject: “I have the network to receive that information. I'm not sure if I was outside of that network how easy it would be to just find these local organizations that are working towards ocean protection.” The third compared social media unfavourably to traditional media. Unlike in traditional media, “You're just broadcasting, without any checks and balances or anyone to question you.” The researcher felt that, by talking “into the void” in an “off-the-cuff” manner, “it can amplify conflicts [and] create misunderstandings.”

4.5 RELATIONSHIP BETWEEN SCIENCE AND JOURNALISTS

Researchers were asked questions to gauge their personal and collective attitudes towards journalists. One series of questions concentrated on respondents’ experiences in a variety of media settings: radio interviews, newspaper interviews, magazine interviews, television interviews, and interviews for an online-only platform such as a blog or podcast.

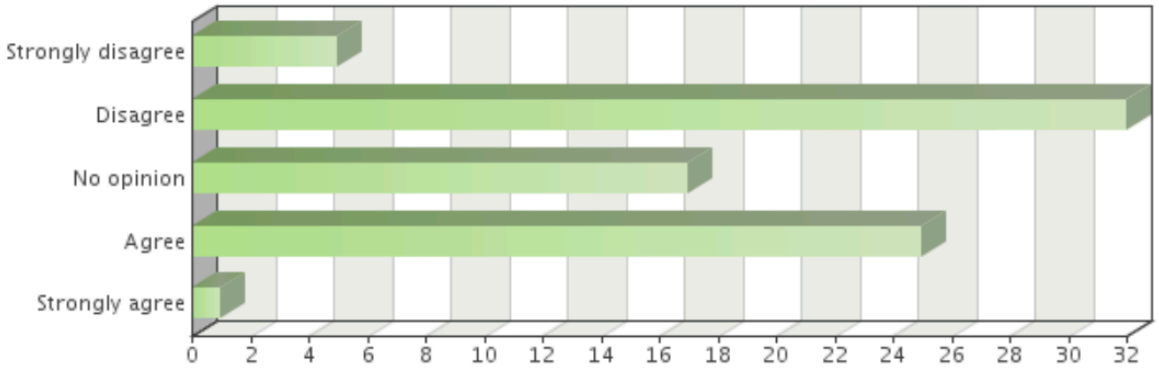
81% of respondents had experience with newspaper interviews. 21% of them described their experience as mixed while the rest described it as mostly positive or very positive, with the exception of one person who listed the experience as mostly negative. 71% of respondents had experience with radio interviews; the vast majority of these were either mostly positive or very positive.

Fewer respondents had experience with magazine or television interviews: 54% and 51%, respectively. In both cases, respondents largely indicated having either mostly positive or very

positive interactions, though slightly more had mixed experiences with television interviews than with magazines (16% versus 9%).

Finally, 50% of respondents had done an interview for an online-only platform, such as a blog or podcast. Again, a small minority (7%) had mixed experiences, while the rest were mostly or very positive.

Despite the fact that the majority of respondents had positive experiences with the media, they were less sure about journalists' and communication specialists' science-communication skills relative to scientists. In response to the statement "Journalists and communications professionals do a better job communicating science than scientists themselves could do," just under half (46%) disagreed or strongly disagreed. A significant number (21%) had no opinion, while the remainder (33%) either agreed or, in one case, strongly agreed.



Although this question received the highest number of "no opinion" responses, it also received the highest number of text responses (21). 5 responses helped answer this apparent contradiction: they drew attention to the fact that both journalists and scientists have strengths and weaknesses. For example, one respondent wrote: "Scientists get the information right more often, but aren't as able to communicate with the public effectively. Journalists sensationalize

and get facts wrong." 5 responses also referenced the fact that journalists often lack a scientific background or training.

In interviews, researchers repeatedly cited a lack of scientific nuance or small errors in some forms of journalism, tracing it to a variety of sources. Some understood this to be the nature of journalism more generally: the constraints of the medium require brevity, and information has to be packaged in a way that draws people in. Others noted, as the survey respondents did, that many journalists do not necessarily understand the relevant science.

However, the interviewees argued that scientists had a responsibility to communicate effectively, as well. The two senior researchers, who both had media training, spoke to the importance of understanding what journalists do in this respect. "As a scientist, you have no idea how media actually functions," said one researcher. Having the process clarified helps scientists understand "why it's so immediate, and why so much pressure gets put on [researchers to answer] very quickly." According to the second senior researcher, "journalists and scientists have a lot in common, you know—we're inquiry-based, analytical, critical thinking, trying to get at the truth. So there's a lot of common ground, once you get over the difference in language and packaging."

At the same time, the relationship was sometimes spoken of in adversarial terms, particularly with regard to the lack of control scientists possess in the interaction. For example, one of the senior researchers pointed out that journalists will not always take away the "key message" that the scientist is trying to convey: "Unless you can make your main point the "soundbite" of the article, it can be tricky to get your main message across, because that's typically what you've given the most explanation to and the least kind of "sound bite" answer

to." The researcher's response to this problem was to keep circling back to the key message, "so that there's no possibility of them not putting it in." One student researcher spoke about her desire for more practice doing interviews, because "a good journalist will ask the challenging questions and […] will try to get all angles of the topic, and so I wouldn't want to be left without anything to say."

Researchers also expressed some frustration with the kinds of stories that journalists pursued. For example, science more generally and oceans in particular get treated as a "niche" subject. When journalists do decide to produce an article, one researcher felt they typically desire one of two things: new discoveries, as opposed to "results" and their attendant caveats, or a story about the "process" of science. Speaking about a recent media appearance brought on by the tagging of an animal, she said, "Everyone's really excited about it. But they're excited about it because of the fact that we saw an animal, and we did something with that animal, and we released the animal. They're not excited about the science we're going to get from it." The result, according to the researcher, is public misconceptions about the extent to which new findings constitute fact and what it is that scientists are actually doing.

A final issue that was not brought up directly by the scientists, but which emerged over the discussion, was how journalists find and make contact with scientists in the first place. For example, one of the student researchers expressed interest in reaching out to media organizations, but he did not have communications support or existing contacts to draw on. Conversely, both senior researchers described fielding multiple media requests in a given week. Although researchers said that for the most part there was no longer stigma attached to being in the public eye regardless of whether you were still a student, it appears that not being sufficiently established can still harm your chances of interacting with the media.

4.6 SCIENTISTS' COMMUNICATIONS OBJECTIVES

Scientists were asked to rank 5 communications objectives, adapted from a survey by Dudo & Besley (2016) of AAAS scientists and their objectives in online engagement. These were: correcting misinformation and fighting against deliberate misinformation campaigns; getting the public excited about science; increasing public knowledge and understanding of science; building trust between scientists and the public by listening and being open; and tailoring scientific messages to connect to peoples' lives and values. The latter two are aligned with "dialogue" objectives, while correcting misinformation and increasing public knowledge are deficit-based. Getting the public excited about science is neutral.

Unfortunately, due to an issue with the survey, many respondents did not input their answer to this question correctly. However, of the 45 respondents who completed the question successfully, increasing public knowledge and building trust were tied for #1 (both received 29%). The next most commonly chosen objective was correcting misinformation (20%), followed by tailoring messages (16%) and getting the public excited (7%).

The second-ranked objectives were spread relatively evenly. Public understanding received 27%, while correcting misinformation was next (22%) followed closely by building trust (20%). Getting the public excited (16%) and tailoring messages came last (13%).

Another interesting result was what objectives were considered *least* important. 33% of respondents ranked correcting misinformation as their least important objective, while 29% chose tailoring messages.

The overall results from the objectives section of the survey indicate agreement on the importance of increasing public understanding and building trust, but division as to whether researchers should correct misinformation or tailor information to suit their audiences.

In interviews, scientists were asked if they were comfortable "framing" their results to suit particular audiences. Only one researcher was familiar with and correctly described the concept. However, once it was explained, all of them claimed to do some form of it. In particular, each researcher spoke of the importance of adapting language to suit the person or group of people they were talking to. While this is important, it arguably does not constitute "framing" as such, but merely making the information understandable for a lay audience. Some also expressed reservations about framing, especially to the extent that it might stretch the boundaries of what was borne out by the results. Two spoke about how data can easily be misinterpreted, either intentionally or unintentionally, to suit a particular narrative.

At the same time, researchers agreed that framing was extremely important in order to connect with the public. One of the senior researchers with extensive media experience described it as "the most important skill." As one student put it, "to show people how [the research] is important to their life or how it does apply to them, I think is incredibly valuable. And I think often not doing that means that research doesn't get to where it needs to go or doesn't hit home with the people that it needs to hit home with."

5. DISCUSSION

5.1 TRAINING AND EXPERIENCE

Most respondents had little or no formal communications training, but still engaged with the public and media relatively frequently. While training has become increasingly available and sought after through science-communication companies such as COMPASS (Schubert, January 25, 2018), the results suggest that many scientists still "learn by doing," emphasizing the heuristic nature of most scientists' communication practices. Qualitative results also indicate the importance of informal networks and mentorship within institutions and disciplines, as younger researchers seek advice from more experienced colleagues. This generational transfer of knowledge, techniques, and biases may be a contributing factor to the observed persistence of "deficit model" ideas (Simis et. al, 2016). The function and importance of these networks is deserving of future study: how do they arise, solidify, and influence communication practices within universities and other institutions outside of the sphere of formal education? A social network analysis of a particular case study or set of cases could help provide answers to this question (Borgatti et al., 2009).

Given the increasing importance of science communication, some researchers have argued that communications training should be a mandatory component of undergraduate and graduate science degrees (Brownell, Price and Steinman, 2013). Neither of the students interviewed had voluntarily done any science-communication courses despite them being available, suggesting that this strategy might be effective. Indeed, given that the majority of respondents indicated that increased training would make them more likely to engage in

outreach, mandatory training in postsecondary institutions would be a straightforward way to increase the frequency of contact between scientists and the public in the longer term.

Another reason to conduct this training as part of scientists' university education is that many respondents reported having received training through their employer. However, as qualitative results illustrated, employers' communication goals do not necessarily align with the more idealistic goals of public engagement, such as more democratic decision-making; employers and individual scientists may be more interested in enhancing the reputations of their institutions or increasing social licence for their work. Furthermore, the training tends to concentrate on skills such as dealing with the media. Both these trends are also reflected in the literature (Miller & Fahy, 2009; Palmer & Schibeci, 2014). University-based science communication education, on the other hand, has the potential to go beyond facilitating communication between experts and the public by encouraging dialogue between disciplines and cultivating a more "reflexive" attitude within science (Trench, 2012). Such a program could foster not only the techniques required to communicate effectively with the public, but also a different perspective on why "effective communication" is desirable, and what that looks like in practice. A dialogue-based approach requires critical reflection on the goals and methods of science; it is not meant simply to make deficit-based approaches more convincing. It is therefore recommended that both the practice and *theory* of science communication be incorporated into post-secondary science education, following best practices derived from the inclusion of other humanities-adjacent courses such as ethics (Antes et al., 2009).

5.2 RELATIONSHIP BETWEEN SCIENTISTS AND THE PUBLIC

Previous research suggests that perceptions of the public's attitude and level of understanding are connected to scientists' willingness to engage and the strategies they use (Besley, Oh & Nisbet, 2013). Additionally, researchers have found that the majority of scientists see the public as homogenous, irrational, uninterested, and lacking education, which in turn leads scientists to adopt a deficit-model approach that concentrates on basic facts and presenting research in an accessible way (Cook, Pieri and Robbins, 2004; Burningham et al., 2007; Nisbet & Scheufele, 2009).

This study both confirms and challenges some aspects of this picture as it relates to ocean and aquatic researchers. Qualitative results found that scientists believed the public had a high level of interest in their work. The survey also indicated almost universal support for "engagement" versus simply providing information. However, there was disagreement about whether the public understood enough about scientists to engage meaningfully with scientists, or whether a scientifically uninformed public should participate in management decisions.

One explanation might be the fuzziness of the term "engagement" itself: in interviews, researchers described a variety of activities as engagement, not all of which involved substantial dialogue. As with the majority of papers involving surveys of scientists' attitudes towards public engagement, this study did not clarify what constituted "engagement" with the public (Besley, Dudo and Storksdieck, 2013). However, others have argued that the concept of "public engagement with science" is a deliberately vague buzzword whose success depends on its ability to obfuscate the actual issues involved, rendering the idea acceptable to a broad range of groups who might otherwise not be able to achieve consensus (Vincent, 2014). Thus, while everyone surveyed could agree that "engagement" was positive, they may have had different ideas about

what exactly that entailed. For some, perhaps it meant doing more presentations that were open to the public. Other engagement activities might include writing accessible summaries of research for a lay audience (Kuehne & Oldon, 2015), or even working directly with members of the public on research projects (Turnhout et al., 2013). Clearly, some activities require more effort and upset the status quo of the science-public relationship much more than others.

As with "engagement," clarifying who exactly the public *is* in a given situation could benefit this study and similar research. As mentioned in the results, one researcher noted that many people attending his public engagement sessions already had an existing interest or expertise in the topic; other researchers noted that people who were geographically close to the study area were more likely to express interest in their work. While most research related to public engagement treats the "public" as homogenous, scholars such as Jasanoff have argued that research should look more closely at the "mini-publics" that constitute themselves around "issues of concern," developing expertise to engage with, participate in, and contest scientific knowledge (Jasanoff, 2014). Accordingly, further research should look at what happens when these situations arise in marine management contexts: in Port Mouton Bay, Nova Scotia, for example, local fishermen have long been concerned about the effects of finfish aquaculture pens on their lobster catches. In addition to relaying these concerns to the provincial government, fishermen have partnered with scientists to study the effects of these aquaculture sites, participating in both the design and implementation of the research (Milewski et al., 2018). Examining this or similar projects could help elucidate how and when these "mini-publics" arise, and how best to facilitate engagement with them.

Finally, both the quantitative and qualitative results indicated low levels of social-media use relative to traditional media engagement. This is in line with previous research, which found

scientists were most willing to engage in face-to-face interactions, followed by media appearances, and were least willing to engage through online platforms (Besley, Dudo & Storksdieck, 2013). Qualitative data traced this reasoning to concerns that social media was not an effective tool for communication, either because it was not suited to conveying scientific results, did not reach a "general public" beyond those already interested, and/or had the potential to lead to misunderstandings due to its informal nature.

Low social media use may also be connected to a broader cultural pessimism about its utility to improve civic discourse. A decade ago, science-communication scholars expressed optimism about the possibility of social media to improve dialogue between scientists and the public (Nisbet & Scheufele, 2009). Research has since demonstrated that online engagement is driven most successfully by posts that generate strong negative emotions such as anger, and it has also become clear that social media has contributed to political polarization and the spread misinformation (Fan, Zhao, Chen & Xu, 2014; Sunstein, 2017). Matthew Nisbet, a co-author of the optimistic 2009 study who is described by Harvard University as "among the most influential communications scholars of his generation," recently deleted his Twitter account (Harvard University, n.d.).

5.3 SCIENCE AND THE MEDIA

The relationship between science and traditional media as described by the quantitative results is broadly consistent with previous surveys, with a few exceptions.

The sample in this study self-reported more frequent contact with journalists than those in previous surveys: only 6% reported having no contact over the last three years, compared with 20-40% in a 2011 survey of German researchers drawn from 16 fields and a separate 2011

survey of Taiwanese life scientists (Peters, 2013). The results do not indicate a clear reason for this discrepancy in frequency, although many respondents did report either having or making time for public engagement, which was also unexpected. It is possible that, either by virtue of their disciplines or changing expectations, ocean and aquatic researchers communicate more frequently with the media.

Similar to previous research, scientists who have engaged with the media generally reported positive experiences, with some concern about the broader failures of journalists to correctly transmit complex scientific information due to lack of training or other constraints (Brumfiel, 2009; Peters, 2013).

Qualitative data elaborated on this idea, emphasizing a kind of mutual responsibility: while it is important that journalists try to understand scientists, scientists also need to make sure they are communicating their work clearly to journalists. Two respondents who had received training spoke about how beneficial it was to understand the basics of journalism as a culture and practice; knowing this, they felt, a lot of misunderstandings could be avoided. It was not clear whether they felt the same about science: while interviewees and survey respondents mentioned the value of having journalists with scientific training or education, the data suggests they were more concerned with journalists' ability to understand scientific information rather than the culture of science. Nevertheless, it is reasonable to assume that, just as scientists benefit from a deeper understanding of journalism, journalists would also derive gains from understanding scientific culture and practice. It is therefore recommended both scientists and journalists take practical steps to better understand one another's crafts, while recognizing that the field of science *journalism* should remain distinct from science *communication* in its critical attitude toward its subject (Hayden & Hayden, 2018).

Finally, this study examined whether stigma still existed against researchers who communicate frequently, and whether this attitude affected younger scientists in particular. The results suggest that this stigma has substantially weakened within the scientific community. However, the results also indicated that it is important to study the other side—namely, who are journalists reaching out to in the first place? In interviews, the two senior researchers reported fielding multiple calls per week, while one of the students faced challenges reaching a wider audience. Within science journalism, there are signs that journalists are thinking more critically about this power: who they contact affects not only the public's perception about what a "scientist" looks like, but also in some cases the careers of scientists who benefit from the exposure (Yong, February 6, 2018). While understanding the pathways that lead from the generation of scientific information to the media is challenging (Hansen & Dickenson, 1992), it is important to elucidate the role journalists play in this process and the practices that lionize a small group of researchers while ignoring others.

5.4 COMMUNICATIONS OBJECTIVES

Compared to a previous survey of scientists' priorities for online engagement (Dudo & Besley, 2016), respondents in this study were less likely to prioritize "defending science," and more likely to prioritize dialogue-based objectives such as building trust and framing messages. This suggests the ocean and aquatic researchers surveyed are more aligned with dialogue-based approaches to engagement than their peers as a whole.

While there appeared to be agreement among respondents on the importance of building trust and increasing public understanding, there was disagreement on the value of correcting misinformation and tailoring messages, implying that these two objectives are more contentious.

Although the reasons are not clear based on the results, one study has found that tailoring messages is perceived by scientists to be unethical compared to other objectives (Besley, Dudo, & Storksdieck, 2015). Qualitative data suggests this concern may be shared by some respondents, who mentioned the need to separate "advocacy" from "communication," and discussed how results can be twisted to suit theories or to make a point.

This relates to the importance of understanding framing. The communications literature has enshrined "framing" as the paradigm for understanding how the public makes sense of scientific information (Nisbet, 2009). Yet previous research suggests that scientists often misunderstand framing, and rate it low as a communications-training objective (Besley, Dudo, & Storksdieck, 2015). Qualitative results from this study found that most scientists misunderstood framing as a concept, likening it to presenting information in a way that can be understood by laypeople. At the same time, everyone believed that framing was important. This suggests that there may be interest among scientists in learning more about framing, as well as a need. The current siloed state of affairs is detrimental to both sides: on the one hand, scientists and science communicators persist in using ineffective strategies; on the other, those who study and research public engagement struggle to have their ideas put into practice (Salmon, Priestley & Goven, 2017). Indeed, there is a great irony in the fact that those who claim to be scholars of engagement have been so singularly unsuccessful in reaching and changing the opinions of the researchers they study. It has been suggested that engaging in the co-production of knowledge could be helpful in overcoming this barrier (Salmon, Priestley & Goven, 2017). By working *with* scientists rather than merely criticizing them, engagement scholars could demonstrate the tangible value of their work and help craft shared solutions to science-communication challenges.

6. CONCLUSION

The factors affecting whether and how ocean and aquatic scientists communicate with the public are complex and multi-faceted. This study used an online survey and semi-structured interviews to examine five major themes as they relate to the outreach and engagement activities of Ocean Tracking Network-affiliated researchers. It found that many scientists are engaging with both the public and the media quite frequently, despite a lack of formal training. Results showed a high support for "engagement" with the public in theory, while in practice there remains division on the question of whether the public can or should participate in the spheres of science and management until or unless they receive more scientific training. Scientists still report frequent contact with the traditional media, suggesting that this remains an important vector for the distribution of scientific knowledge. In general, ocean and aquatic researchers seem somewhat more inclined to "dialogue" rather than "deficit" approaches as compared to their peers, and also more likely to engage in general.

Based on the results of this study, some recommendations can be made for interventions and for future research that will improve the practice and theory of science communication between ocean and aquatic researchers and the public. First, more training for both scientists and journalists would be valuable. While some researchers emphasized their interest in learning particular skills, and suggested that journalists learn more about science, a better understanding of how each other's disciplines function is equally important. For example, the debate over whether or not scientists should be allowed to look over a journalist's work before it is published is essentially a cultural one: for scientists, the accuracy of the information is paramount; for journalists, the most important factor is editorial independence (Smith, March 1, 2018).

Understanding these differences can help prevent miscommunication and improve the flow of information from scientists to the media, and thence to the public.

Second, this study and much of the previous literature tends to assume that more (and more effective) engagement is better: "the *how* trumps the *why*" (Stilgoe, Lock & Wilson, 2014, p.5). However, this research has demonstrated not only that there are diverse activities which scientists believe constitute "engagement," but that their reasons for doing these activities are not necessarily the same as those of communications scholars, who (when they do consider the outcomes) tend to justify it through the creation of more democratic science policy (ibid.). For example, a "win" from their perspective might be the creation of a working group to better understand conflicts between scientists and member of the public, whereas a scientist might prefer if they could communicate their results in such a way that they were more likely to be accepted and the potential for conflict reduced. A previous study found that "engagement" is often justified for normative and instrumental reasons (it is the right thing to do/it will help achieve goals) rather than substantive ones (it will lead to a better outcome) (Barnett et al., 2012). There is therefore a tension within the public engagement with science field between the theory, which tends to support democratic science policy, and the practice, which focuses on effective communication techniques. While most training focuses on the latter, it is important that they be taught together. This could take place in a university context as part of scientists' basic education, similar to ethics classes.

Finally, there needs to be more research on how ocean and aquatic researchers engage with the public in practice, which can more clearly reveal the heterogeneous nature of both "engagement" and the "public." As previously mentioned, while most of the literature around public engagement with science from the perspective of scientists posits an imagined "public"

with which they engage, the public is in fact composed of multiple "publics" of varying interests and capacities (Jasanoff, 2014). This could be an opportunity for fruitful collaboration between ocean and aquatic researchers and science communication scholars: using an "action research" framework (Berg, 2004), the two disciplines could work together not only to elucidate who these publics are and how they are formed, but how science can best engage with them to promote informed, democratic policy outcomes.

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APPENDIX A

SURVEY QUESTIONS

Please indicate your gender.

Male Female Transgender Other _____ Prefer not to say

Please state your field of study.

Which of the following best describes you?

Student Junior researcher Mid-career researcher Senior researcher

How much communications training have you had, with 1 being none and 5 being a professional certification?

1 2 3 4 5

How frequently do you engage with the public directly (in-person presentations, through social media, a personal blog etc.?)

Never Rarely Occasionally Frequently Very frequently

In the past 3 years, have you had professional contact with journalists from the general mass media (radio, television, newspapers, etc.) face-to-face, by phone, or by mail/e-mail?

No contact 1-5 times 6-10 times More than 10

Please indicate how your interactions were for any channels of engagement that apply.

Radio interview

Very negative Mostly negative Mixed Mostly positive Very positive

Newspaper interview

Very negative Mostly negative Mixed Mostly positive Very positive

Magazine interview

Very negative Mostly negative Mixed Mostly positive Very positive

Television interview

Very negative Mostly negative Mixed Mostly positive Very positive

Interview for an online-only platform (blog, podcast, etc.)

Very negative Mostly negative Mixed Mostly positive Very positive

Twitter

Very negative Mostly negative Mixed Mostly positive Very positive

Facebook

Very negative Mostly negative Mixed Mostly positive Very positive

LinkedIn

Very negative Mostly negative Mixed Mostly positive Very positive

Instagram

Very negative Mostly negative Mixed Mostly positive Very positive

Personal blog

Very negative Mostly negative Mixed Mostly positive Very positive

Please evaluate the following statements:

Engaging with the public is beneficial for a scientist's career.

Strongly disagree Disagree No opinion Agree Strongly agree

Scientists have an ethical obligation to engage with the public.

Strongly disagree Disagree No opinion Agree Strongly agree

Engaging with the public is an expected part of a scientist's job.

Strongly disagree Disagree No opinion Agree Strongly agree

I have enough time to both complete my academic duties and engage with public.

Strongly disagree Disagree No opinion Agree Strongly agree

In general, the public does not know enough about science to engage meaningfully with scientists.

Strongly disagree Disagree No opinion Agree Strongly agree

Journalists and communications professionals do a better job communicating science than scientists themselves could do.

Strongly disagree Disagree No opinion Agree Strongly agree

Increased media training would make me more likely to engage with the public.

Strongly disagree Disagree No opinion Agree Strongly agree

It would be best if the public deferred to scientists when it comes to decision-making that involves scientific information.

Strongly disagree Disagree No opinion Agree Strongly agree

It is important that scientists engage in dialogue with the public, not just provide information.

Strongly disagree Disagree No opinion Agree Strongly agree

Please rate the following science-communication objectives, with "1" indicating which you regard as most important and "5" indicating which is least important. Use each number only once.

Correcting misinformation and fighting against deliberate disinformation campaigns.

Getting the public excited about science.

Increasing public knowledge and understanding of science.

Building trust between scientists and the public by listening and being open.

Tailoring scientific messages to connect to peoples' lives and values.

APPENDIX B

Marine Affairs Program

DALHOUSIE UNIVERSITY

Marine Affairs Program Ethics Review Standing Committee

Letter of Approval

July 23, 2018

Dear Alexander,

MAPERSC #: MAP2018-09

Project Title: Scientists and public engagement: Which way forward?

Effective date: July 23, 2018

Expiry date: July 23, 2019

The Marine Affairs Program Ethics Review Standing Committee has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on Ethical Conduct for Research Involving Humans. This approval will be in effect until the date indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Sincerely,

Claudio Aporta, Chair

Post MAPERSC Approval: On-going Responsibilities of Researchers

After receiving ethical approval for the conduct of research involving humans, there are several ongoing responsibilities that researchers must meet to remain in compliance with University and Tri-Council policies.

1. Additional Research Ethics approval

Prior to conducting any research, researchers must ensure that all required research ethics approvals are secured (in addition to this one). This includes, but is not limited to, securing appropriate research ethics approvals from: other institutions with whom the PI is affiliated; the research institutions of research team members; the institution at which participants may be recruited or from which data may be collected.

2. Reporting adverse events

Any significant adverse events experienced by research participants must be reported in writing to Marine Affairs Program Ethics Review Standing Committee within 24 hours of their occurrence. Examples of what might be considered "significant" include: an emotional breakdown of a participant during an interview, a negative physical reaction by a participant (e.g. fainting, nausea, unexpected pain, allergic reaction), report by a participant of some sort of negative repercussion from their participation (e.g. reaction of spouse or employer) or complaint by a participant with respect to their participation. The above list is indicative but not all-inclusive. The written report must include details of the adverse event and actions taken by the researcher in response to the incident.

3. Seeking approval for protocol / consent form changes

Prior to implementing any changes to your research plan, whether to the protocol or consent form, researchers must submit a description of the proposed changes to the Marine Affairs Program Ethics Review Standing Committee for review and approval.

4. Submitting final reports

When the researcher is confident that no further data collection or participant contact will be required, a Final Report (template attached) must be submitted to Marine Affairs Program Ethics Review Standing Committee. After review and approval of the Final Report, the ethics file will be closed.

5. Retaining records in a secure manner

According to the application, researchers must ensure that both during and after the research project, data is securely retained and/or disposed of in such a manner as to comply with confidentiality provisions specified in the protocol and consent forms. This may involve destruction of the data, or continued arrangements for secure storage. Casual storage of old data is not acceptable.

It is the Principal Investigator's responsibility to keep a copy of the MAPERSC approval letters. This can be important to demonstrate that research was undertaken with Board approval.

Please note that the Marine Affairs Program Ethics Review Standing Committee will securely store your project file for 5 years after the study closure date at which point the file records may be permanently destroyed.

6. Current contact information and university affiliation

The Principal Investigator must inform the Marine Affairs Program Ethics Review Standing Committee of any changes to contact information for the PI (and supervisor, if appropriate), especially the electronic mail address, for the duration of the MAPERSC approval. The PI must inform Marine Affairs Program

Ethics Review Standing Committee if there is a termination or interruption of his or her affiliation with Dalhousie University.

7. Legal Counsel

The Principal Investigator agrees to comply with all legislative and regulatory requirements that apply to the project. The Principal Investigator agrees to notify the University Legal Counsel office in the event that he or she receives a notice of non-compliance, complaint or other proceeding relating to such requirements.

8. Supervision of students

Faculty must ensure that students conducting research under their supervision are aware of their responsibilities as described above, and have adequate support to conduct their research in a safe and ethical manner.

APPENDIX C

INTERVIEW SCRIPT

Ensure that participant has sent signed consent form prior to phone interview.

Hi there! How are you doing today? **Wait for response.** Thanks for taking the time to talk with me. Before we get started, did you have any questions or need clarifications regarding the consent form I sent you? **Field questions, if any, regarding consent form.** As I mentioned in the e-mail, my name's Alex, and I'm researching the attitudes, opinions, and experiences of OTN researchers when it comes to public engagement. If you want or need to stop the interview at any time, that's totally fine. I think that's everything—if you're okay to begin, I just have a few questions I'd like to start with, and then we can open up the conversation a little bit.

1. Can you tell me more about your work? What kinds of projects are you working on right now?
2. Have you ever talked about your work with the public? What were those experiences like?
3. Did you receive support from the Ocean Tracking Network or your university in terms of media training or preparation?
4. Do you think the public knows enough about science?
5. There's a lot of emphasis these days on the need for scientists to engage with the public. Do you think that public engagement is useful? Why/why not?
6. Have you had any contact with journalists recently? What was that like? **If no, skip to question 7.**
7. Do you think journalists do a good job communicating science? Would you change anything about the way they do things?
8. How do you feel about scientists who are in the public eye a lot? Is there any stigma attached to it?
9. Communications people talk a lot about "framing" science so that a message connects with its target audience. Do you think that's important, and is it something you'd be comfortable doing as a scientist?