“It Feels Like Engaging With a Friend”: Using Interpersonal Communication Strategies to Encourage Science Conversations With Lay Audiences on Social Media

by

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Abstract

Citizens are increasingly being asked to participate in policy-making processes, and with the internet now a primary source of information, it is critical that policy-relevant research is communicated effectively online to equip lay people with the information they require to participate in decisions. Social media have the potential to facilitate two-way conversations needed for effective science communication; however, research communicators often struggle to reach lay audiences on these media. In this research project, the Twitter and Instagram activity of four individual scientists acting as recognized science communicators in North America and Europe is compared with the activity of three marine-focused non-governmental organizations (NGOs) (local, national, and international), paying particular attention to strategies that encourage audience engagement in two-way conversations. The study includes: 1) an analysis of public Twitter and Instagram data of each of the seven communicators to identify the social media strategies that are used and the resulting engagement in two-way conversations; 2) interviews with the individual and NGO communicators to determine their social media strategies; 3) a survey of audience members involved in two-way conversations to determine why they choose to participate in dialogues on social media, and 4) an audience "biography" analysis to determine whether communicators are engaging a non-scientific audience. The results of this study show that communication strategies have an important effect on social media engagement. More specifically, the evidence shows that a combination of interpersonal communication strategies, and how they are integrated throughout the social media activity of communicators via platform affordances, especially in Instagram, can have an important effect on the level of lay user engagement in two-way conversations over time. Further application of the interpersonal communication strategies could promote greater public engagement with science, including involvement with critical marine management issues that exist at the science-policy interface.

Keywords: science communication; dialogic communication; digital media; social media; Instagram; Twitter; organizational communication; interpersonal communication

List of Abbreviations

CARs: communicator-audience relationships

EIUI: Environmental Information: Use and Influence research program, School of Information Management, Dalhousie University

NGO: non-governmental organization

IND: individual communicator study participant

IGPs: Instagram posts

IGSs: Instagram stories

ORG: organization communicator study participant

SMI: social media influencer

SPI: science policy interface

TRPs: Twitter posts

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Chapter 1: Introduction

We rely on the ocean for a wide variety of services, ranging from food and recreation to climate regulation and the international transport of goods. However, our extensive presence in the marine environment has not been without consequence. Human activities—both past and present—are triggering a multitude of negative changes in the ocean: harmful fishing practices have driven fish stocks to critical condition, pollutants are entering the oceans in alarming quantities, resource extraction is expanding into new and uncharted territory, and anthropogenic carbon emissions are altering the physical and chemical state of the ocean to the detriment of many ecosystems (Cubasch et al., 2013; Jambeck et al., 2015; Moskvitch, 2014, Oceana, 2018). Many marine issues we currently face play out at the science-policy interface (SPI) where researchers and decision-making intersect. Various actors, barriers, and enablers operate at the SPI, affecting the flow of information from researchers to decision-makers (MacDonald, Soomai, De Santo, & Wells, 2016). One important group that interacts with a variety of stakeholders at the SPI is the general public. For the public to be an effective participant in decisions and solutions to address deteriorating ocean conditions, the public needs to become informed about relevant research. However, this is not a trivial task, as ocean literacy has proven to be a major challenge (Fauville, 2017).

1.1 Public Participation in Decision-Making

Public participation is a democratic mechanism that provides non-state actors the opportunity to become a prominent part of policy discussions and be included in decision-making (Bojovic, Bonzanigo, Giupponi, & Maziotis, 2015; Einsiedel, 2013; Kabiri, 2016). Public participation mechanisms grant members of the public greater access to decision-makers, allowing them to form trust relationships in the process (Beierle & Cayford, 2002; United Nations, 2007). Additionally, participatory approaches are more likely to engage citizens, increasing the probability they will become educated and informed on important policy issues (Beierle & Cayford, 2002; Bojovic et al., 2015; Burton & Mustelin, 2013; Cobb & Elder, 1983; Ferkany & Whyte, 2011).

Public participation in decision-making often leads to more effective decisions. The inclusion of broad knowledge, values, and experiences that diverse actors contribute to discussions increases the capacity of decision-makers to deal with issues that are social, environmental, and/or economic, as opposed to purely technical (Bahauddin, Rahman, & Hasnine, 2016; Collins & Ison, 2009; Ferkany & Whyte, 2011; Few, Brown, & Tompkins, 2007; Reed, 2008; Sarzynski, 2015). Furthermore, more inclusive policy decisions often better reflect local contexts in which they are situated, and encourage decision-makers to be transparent and accountable, resulting in more legitimate decisions as perceived by the public (Beierle & Cayford, 2002; Burton & Mustelin, 2013; Collins & Ison, 2009; Einsiedel, 2013; Ferkany & Whyte, 2011; Few et al., 2007; Reed, 2008; Stringer et al., 2006).

Recognition of the need for greater public participation in decision-making has been growing internationally since at least the 1990s. Principle 10 of the Rio Declaration on Environment and Development states that environmental issues are best handled with the participation of all concerned citizens, and outlines the importance of access to information and the opportunity to participate in decision-making (United Nations, 1992). The Aarhus Convention adopted in 1998 by the United Nations Economic Commission for Europe defines three major components of public participation: access to information, public-participation in decision-making, and access to justice in environmental matters (United Nations Economic Commission for Europe, 1998). Participation is also institutionalized for environmental decisions and economic development in expectations of the United States Agency for International Development (Sarzynski, 2015). Although not recognized by the International Court of Justice as a general principle of international law, public participation is reaffirmed in all major United Nations (UN) outcomes regarding sustainable development, along with many other general UN outcomes (Ebbesson, 2015; Jodoin, Duyck, & Lofts, 2015; United Nations, 2002).

Numerous non-treaty initiatives also emphasize the importance of participatory approaches to decision-making. The Open Government Partnership (OGP)—a global multilateral initiative that commits governments to promote transparency, empower citizens, and strengthen governance—requires nations to release two-year action plans that formalize their commitment to standards set by the OGP on open, accountable, and

transparent government, and has received commitments from nearly 80 countries (Government of Canada, 2018a; Government of Canada, 2018b; Open Government Partnership, n.d.). The International Association for Public Participation (IAP2)—which has seven international affiliates—seeks to promote and improve public participation for individuals, governments, institutions, and other public interest groups, advocating for inclusive public participation around the world (International Association for Public Participation, n.d.). Many countries also have nation-specific commitments to public participation in decision-making. For example, the Canadian government practices open dialogue, giving all Canadians the opportunity to provide input and drive government efforts on participation and information access (Government of Canada, 2018c). This includes practicing public participation principles such as: open, effective, and transparent government; going beyond consultation to collaboration where appropriate; clarity on how public input will be used in decisions and the scope of change possible on issues that are relevant; the inclusion of diverse perspectives that reflect Canadian diversity; the reduction of barriers to participation; and an adaptable process that measures the success of public participation processes (Government of Canada, 2017).

1.2 Communicating Information Online

As participatory approaches to decision-making have become more prominent internationally, an arguably greater regime shift has occurred in the way people access information. "New media" (i.e., the internet and associated tools/applications) are now the main information source for the public, including for scientific and policy information (National Science Board, 2012; Purcell, Brenner, & Rainie, 2012). As of 2018, an estimated four billion people use the internet, with over three billion being active on social media (We Are Social, 2018). The latest statistics show that billions of social media posts are created daily across Facebook, Twitter, Instagram, YouTube, and other social media platforms, and the numbers are increasing (Internet Live Stats, n.d.; We Are Social, 2018).

New media—including social media—provide communicators with a significant opportunity to share policy-relevant information with citizens, including citizens engaged in public participatory processes. Because of the massive public audience seeking

information online, information has widespread exposure potential through new media, allowing communicators to reach large public audiences that are diverse in terms of ethnicity, age group, and sectoral affiliation (Claussen et al., 2013; Pew Internet and American Life Project, 2012). Although important barriers still exist in terms of internet access, new media are generally user-friendly and widely available; simple and quick web searches can break down technical and financial barriers to information, and social media platforms are primarily free and accessible internationally (Peters, Dunwoody, Allgaier, Lo, & Brossard, 2014; Voytek, 2017). Therefore, new media facilitate information exchange frequently and instantaneously, often irrespective of spatial, temporal, financial, and functional differences between users (Berger and Milkman, 2012; Faulkes, 2014; Ferguson et al., 2014; Shiffman, 2012; Sublet, Spring, & Howard, 2011; Wilson, 2016; Winkless, 2013).

With Web 2.0 technologies that exist today, virtual communities can now be formed online to facilitate public engagement in science, and the public now has the opportunity to participate in science communication. Through new media, internet users are able to engage in personal exchanges and form social networks—online communities of people who (generally) hold shared values (Connor et al., 2016; Mello & Rodrigues, 2012; Peters et al., 2014; Sublet et al., 2011; Voytek, 2017; Wilson, 2016). Individuals within social networks can act as information leaders/champions, aiding in science dissemination and increasing its perceived importance (Choi, 2014; Connor et al., 2016; Peters et al., 2014).

1.3 Management Problem and Research Framework

The internet and associated social media tools provide a significant new interface for communicating policy-relevant information to a public that, based on international agreements, is expected to be increasingly included in decision-making processes as they become more participatory. However, recent findings suggest that research communicators often struggle to reach lay audiences online, especially citizens within new social networks exposed to information for the first time (Alperin, Gomez, & Haustein, 2018; Ke, Ahn, & Sugimoto, 2017). Such results have led to calls for more innovative/inventive strategies to engage the public with research, predominantly on

subjects linked to important public policy issues (e.g., Galetti & Costa-Pereira, 2017). Furthermore, social media communication strategies often vary among communicators, including between individuals and organizations, which may have implications for whether communication is effective (e.g., Kent, 2013; Kozinets, 2010).

This exploratory study investigates strategies to engage citizens with marine research and policy information on social media and addresses the following research question: do particular social media strategies encourage two-way conversations between science communicators and lay audiences online? To examine this question the social media activity of four scientists acting as recognized science communicators using individual Twitter and Instagram accounts to share research was compared with the social media activity of three environmental non-governmental organizations (NGOs) using organization accounts to share research and policy information on Twitter and Instagram. This study included: 1) an analysis of public Twitter and Instagram data of each of the seven account holders to identify social media strategies used by communicators and resulting follower engagement in two-way conversations; 2) interviews with the individual and NGO communicators to determine their social media strategies; 3) a survey of audience members involved in two-way conversations to determine why they participate in dialogues on social media; and 4) an audience "biography" analysis to determine whether communicators are engaging a non-scientific audience on social media (Figure 1). The goal of this research is to identify communication strategies that encourage two-way conversations between communicators and citizens on social media. If particular strategies are more engaging, they could be adopted or prioritized by marine communicators to improve how research and policy information is shared with citizens on social media, and ultimately better prepare citizens for participation in decision-making processes.

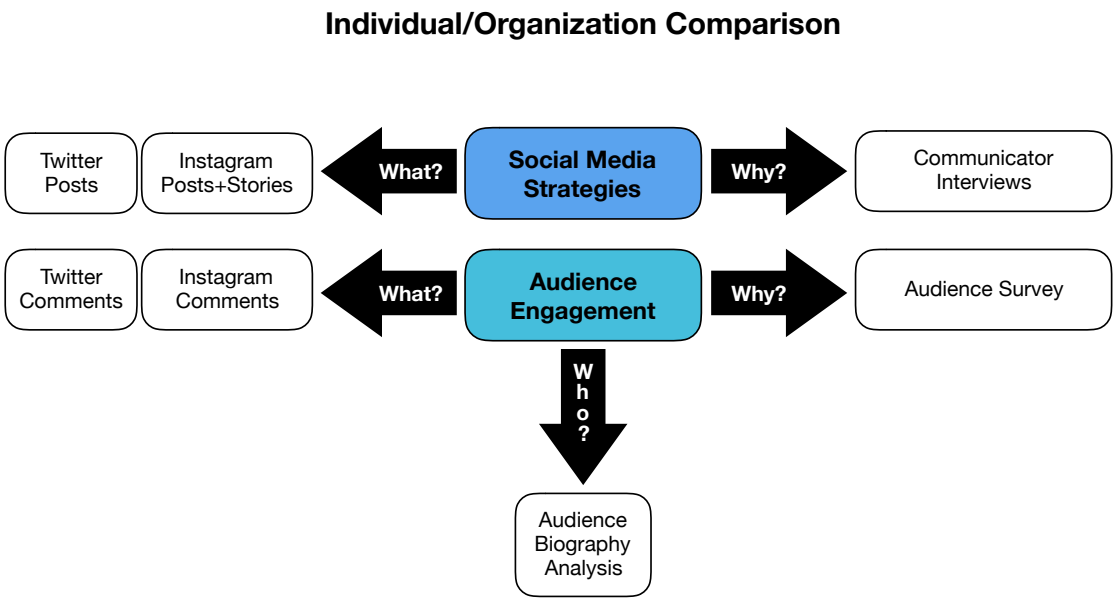

Figure 1. Research framework outlining the study design/methodology.

Chapter 2: Literature Review

2.1 Science Communication and Social Media

The ability to communicate science to a wide variety of audiences is important. First, scientific information is required by policy makers, and strong science communication can promote the use of research in environmental decisions, helping to close the science-policy gap (Kahan, 2010; MacDonald et al., 2016). Second, scientific information should be provided to the public. Not only is the majority of scientific research publicly funded, citizens also need scientific information to make informed input to decisions on subjects relating to public policy, technological advancement, and political preferences, among others (de Bruin & Bostrom, 2013; Fauville, Dupont, von Thun, & Lundin, 2015; Fischhoff, 2013; Mea, Newton, Uyarra, Alonso & Borja, 2016; Papworth et al., 2015; Treise & Weigold, 2002). Furthermore, poor science communication, specifically during extreme events, can be socially detrimental, leading to emotionally distressed citizens rather than an informed public (Reddy, 2011). Science communication is also increasingly seen as a responsibility of scientists, and is in some cases central to receiving funding (Brownell, Price, & Steinman, 2013; Mea et al., 2016; Uren & Dadzie, 2015).

Strategies for researchers to communicate their results have recently shifted to focus on using new media, including social media (Brossard, 2013). New media are significant for science communication because they grant communicators an interface for two-way dialogues with the public. Previously, the accepted model for communicating research was based on correcting a knowledge deficit to improve public understanding of science (Aitken, Cunningham-Burley, & Pagliari, 2016; Salmon, Priestley, & Goven, 2017; Wakeford, 2010). In this "first-order" way of thinking it was assumed that citizens lacked knowledge and acted as passive receivers of information; solely providing people with the necessary information would lead to greater understanding and awareness of public issues (Aitken et al., 2016; Irwin, 2008; Salmon et al., 2017; Wakeford, 2010). "Second-order" communication that is reflexive, deliberative, and depends on dialogic, two-way information exchange is now thought to be the best model for sharing information with the public (Irwin, 2008; Salmon et al., 2017; Wakeford, 2010). This

latter model promotes knowledge co-production between researchers and the public by allowing citizens to bring values to the conversation, and facilitates the formation of trust relationships between researchers and the public (Aitken et al., 2016; Corner, Markowitz, & Pidgeon, 2014; Dietz, 2013; Salmon et al., 2017; Soomai, MacDonald, & Wells, 2013; Wynne, 2006). Social media—including blogs, microblogs, social networks, podcasts, and curatorial tools—especially have the potential to facilitate deliberative communications, allowing the public to participate in research communication online by responding to information, sharing it with others, and/or directly producing communication content (Brossard, 2013; Valdez Soto et al., 2016).

2.2 Organizations as Science Communicators on Social Media

Social media has become increasingly significant to organizational practice (Bughin & Chui, n.d.). Non-governmental organizations (NGOs) in particular have been credited with pioneering the use of social networking tools, adopting them prior to government agencies and private companies (Nonprofit Tech for Good, 2018). As a result, social media—including Twitter and Instagram—are used by many NGOs internationally; according to a recent report, 77% of NGOs use Twitter, and 50% use Instagram (Nonprofit Tech for Good, 2018). Because the focus of this study is Twitter and Instagram, statistics for both platforms were considered. Furthermore, NGOs are highly active on Twitter and Instagram, with 79% posting on Twitter and 70% posting on Instagram at least once per week (Nonprofit Tech for Good, 2018). Additionally, NGOs of all sizes are reaching large audiences on Twitter and Instagram, with average follower numbers ranging from 4,000-40,000 users on Twitter, and 1,500-20,000 users on Instagram (depending on organization size) (Nonprofit Tech for Good, 2018). Organization audiences on social media can also grow much larger; for example, TED Talks has over 11.1 million Twitter followers (www.twitter.com/tedtalks), and National Geographic has nearly 100 million Instagram followers (www.instagram.com/natgeo).

Although NGOs cite numerous benefits associated with social media use—including fundraising, increased brand awareness, volunteer recruitment, improved event organization, and more effective communications—overall understanding of how organizations use social media and the impacts of their efforts are not well understood

(Lovejoy & Saxton, 2012; Nonprofit Tech for Good, 2018; Treem & Leonardi, 2013). Social media has been shown to provide organizations with an improved means of communicating with the public, allowing organizations to share information, participate in dialogues, and build relationships with their audiences (Lovejoy & Saxton, 2012; Waters, Burnett, Lamm, & Lucas, 2009). Dialogue can be beneficial for organizations to improve public perceptions and to form relationships through one-on-one interactions, building trust in the process (Kelleher, 2009; Yang & Kang, 2009; Yang, Kang, & Johnson, 2010). Social media also grant organizations with affordances that were not previously available to them, including greater visibility to their audiences, an increased opportunity to form personal connections with their audiences, and the ability to share curated content that is persistent online, all simultaneously (Treem & Leonardi, 2013).

Although the potential for social media to positively impact how organizations communicate is well documented, various studies show that organizations have largely failed to capitalize on the affordances granted by social media (Kent, 2013; Kent, Taylor, & White, 2003; Sweetser & Lariscy, 2008). Organizations have typically been found to focus on one-way communication models characteristic of a knowledge-deficit, using social media primarily as a broadcast tool, similar to the practices observed for some government agencies (Bortree & Seltzer, 2009; Lee & VanDyke, 2015; Rybalko & Seltzer, 2010). This attention to one-way transmission of information occurs in spite of the fact that social media can be leveraged to encourage dialogic communication between organizations and their audiences online (Bortree & Seltzer, 2009).

2.3 Scientists as Science Communicators on Social Media

Until recently, scientists were relatively slow in adopting social media (Barteau, Hoffman, Maynard, Miller, & Scavia, 2014; Priem & Costello, 2010). One of the reasons for slow acceptance is that science outreach is rarely incentivized for researchers; researchers interested in communications are therefore often required to pursue communication activities on a volunteer bases in addition to their professional duties, creating a time barrier (Collins, Shiffman, & Rock, 2016; McClain, 2017). Furthermore, scientists—especially those working in government—are sometimes discouraged from open communications (e.g., Boyd, 2018; Fox, 2018; Gaston, 2018). As a result, science

communication is typically not regarded as a valuable activity for researchers (Collins et al., 2016). In spite of existing disincentives, almost all individual scientists now use new media for communication (Peters, 2013). According to a recent study, it appears as though a majority of scientists use Twitter—although many are relatively new to the platform—and a smaller, but still substantial fraction use Instagram (Collins et al., 2016). Scientists also seem to be quite active on social media, with the majority spending time on social media platforms each day (Collins et al., 2016). With evidence that scientists are utilizing social media to share their research and do outreach, it is clear that social media have become an important tool for science communicators (López-Goñi & Sánchez-Angulo, 2018; Parsons, Shiffman, Darling, Spillman, & Wright, 2014; Thaler, Zelnio, Freitag, & MacPherson, 2012).

Numerous studies have demonstrated the strong communication potential that social media provide to science communicators (Bubela et al., 2009; McClain & Neeley, 2015; Van Eperen & Marincola, 2011; Wilcox, 2012). Social media afford scientists the ability to build their "personal brand" by communicating their research and other related subjects (Wolf, 2017). Additionally, social media provide a new avenue through which scientists can communicate to the public, which, although not new, is a more common and more requested pursuit for researchers today (Bik & Goldstein, 2013; Wilcox, 2012). Because scientists generally communicate with the public as individuals or small groups, social networking applications can facilitate conversations between scientists and members of the public (Davies, 2008; López-Goñi & Sánchez-Angulo, 2018). However, research shows that scientists utilizing social media are mainly reaching out to other scientists rather than communicating to citizens generally or other important stakeholders (Collins et al., 2016). In other words, scientists are mainly sharing research within their own fields, with outreach to the wider public remaining a lower priority (Collins et al., 2016). Many scientists also over-emphasize the importance of blogs as a tool for communicating with public audiences; blogs were previously thought to be useful for encouraging dialogues with citizens, but in practice have not been widely successful in reaching lay audiences (Collins et al., 2016; Ranger & Bultitude, 2016).

Social media influencers (SMIs)—a group of independent individuals who can influence the behaviour of social media users with whom they are socially connected—

have recently emerged as online communicators (Freberg, Graham, McGaughey, & Freberg, 2011). These influential communicators have changed the way marketers utilize word-of-mouth techniques by taking advantage of the significant reach, transparency, and accessibility afforded by social media (Kozinets, de Valck, Wojnicki, & Wilner, 2010). Social media influencer communication strategies employ active forms of marketing, where individuals both create and share messages with their followers to great effect; in fact, recent reports show that 90% of current social media marketing impact is linked to SMIs (eMarketer, 2017; Gretzel & Yoo, 2014). Social media influencers combine credibility, expertise, enthusiasm, communication skills, and a connected/centralized relationship with their audiences to exert influence (Bakshy, Hoffman, Mason, & Watts, 2011; Kozinets et al., 2010). They also focus on creating engaging content that is tailored to the interests of users in their network, utilizing emotions to connect with their audiences and encourage social media conversations (Bohan, 2016; Ge & Gretzel, 2018). With observations of science communicators struggling to reach lay audiences on social media, it has been suggested that researchers should coordinate their communication efforts with SMIs to more effectively share important information with the public (Galetti & Costa-Pereira, 2017; Ke et al., 2017). Another possibility is for science communicators to adopt a SMI-like approach to communication, utilizing emotions and audience connections for more effective communication.

2.4 Social Media Users

Recent reports demonstrate the ubiquity of social media and how users are distributed across different platforms; 98% of people online use social media, and social media takes up about 30% of daily internet time, with young people being particularly active (Global Web Index, 2018; Smith & Anderson, 2018; "What Americans do online," n.d.). The majority of internet users are also active on multiple social media platforms (Gruzd, Jacobson, Mai, & Dubois, 2018; Smith & Anderson, 2018). Facebook and YouTube have the highest proportion of active users, with Twitter and Instagram also drawing a large user-base, though not to the same extent (Gruzd et al., 2018; Smith & Anderson, 2018). Global social media adoption continues to grow annually, but adoption rates are not equal between platforms, with more users joining Twitter and Instagram

each year than Facebook (although platform age is important to consider, with Instagram being newer than the other two platforms) (Smith & Anderson, 2018; We Are Social, 2018). It is also important to note that social media adoption rates (and platforms used) are not equal internationally (We Are Social, 2018). Similarly, social media use—including the use of specific platforms—is not equal among demographic categories (e.g., age and socio-economic status) (Gruzd et al., 2018; Smith & Anderson, 2018).

People have been found to use social media for a large variety of reasons (Hoffman & Novak, 2009; Kuznetsov, 2006; Weiss, Lurie, & MacInnis, 2008; Zhao, Grasmuck, & Martin, 2008). These tend to fall into four "higher-order" categories: 1) to connect with other people through interactions/conversations, 2) to create and post content for others to see, 3) to consume information that others have posted online, and 4) to exercise control/curation for what is seen online (Hoffman & Novak, 2011). Because social media can facilitate social connections, they allow people to extend existing relationships by supplementing face-to-face interactions, or even form new relationships (Hoffman, 2012). Furthermore, participation in social networks has been shown to have a positive effect on well-being (although negative effects have been demonstrated as well) (e.g., Kim, LaRose, & Peng, 2009; Shaw & Gant, 2002). Ultimately, people are motivated to use social media differently depending on context; the choice and motivation to participate in activities such as connecting with others and creation/consumption are both thought to be situational (Hoffman, 2012).

2.5 Investigating the Effect of Social Media Strategies on Engagement

As noted above, a variety of previous studies show that both individuals and organizations have had limited success in translating the potential of social media to create two-way conversations with public audiences into practice. As a result, numerous researchers have explored whether relationships exist between social media posting behaviours and audience engagement (e.g., Balan, 2017; Bortree & Seltzer, 2009; Fauville et al., 2015; Ferchaud, Grzeslo, Orme, & LaGroue, 2018; Hwong, Oliver, Van Kranendonk, Sammut, & Seroussi, 2017; Lee & VanDyke, 2015; Zhang, Moe, & Schweidel, 2017). Research on this subject has been relatively exploratory, with studies covering a range of social media platforms and methods used to investigate strategy-

engagement relationships. At present, results indicate that social media strategies can play an important role in determining engagement for both individual and organization communicators on a variety of social media platforms; however, researchers have called for further exploration into this area to better understand why communicators have struggled to encourage dialogues on social media, to identify additional social media strategies that may encourage engagement, and to investigate whether strategy and engagement patterns hold across communication topics (Bortree & Seltzer, 2009; Lee & VanDyke, 2015; Zhang et al., 2017).

This study takes a novel approach to investigating potential social media strategies that encourage engagement by comparing the social media strategies and two-way conversation engagement levels of individual and organization communicators across two different social media platforms. This study also combines quantitative and qualitative methods to: identify emergent activity- and sentiment-related social media strategies and resulting engagement; gain insight into why particular social media strategies are employed by communicators, and the challenges communicators face in implementing particular strategies; and to better understand why audiences choose to participate in social media conversations with communicators. Strategy-engagement relationships are not investigated on a post-by-post basis, but rather in a holistic manner, looking for differences in overarching social media strategies and engagement levels between individual and organization communicators.

Chapter 3: Methods

This study used a mixed methods approach to investigate the social media strategies of individual and NGO communicators and the dialogic engagement they receive on their social media posts. These methods included the collection of quantitative social media post and comment data from Twitter and Instagram, interviews with the seven communicators being studied, a survey of social media users (i.e., communicator audience members engaged in two-way conversations on communicator posts during the study period), and qualitative analysis of social media user biographies. Due to the small sample size of interview and survey participants, all study participants in this study were treated anonymously.

3.1 Account Identification

Seven social media communicators were selected for this study: four individual scientists acting as recognized science communicators and three environmental NGO communicators. The four individual communicators were selected from The SciCommunity – an Instagram community made up of science communicators using social media to make science, technology, engineering, arts, and mathematics more accessible (instagram.com/thescicommunity). All selected individuals use personal Twitter and Instagram accounts to communicate research multiple times per week throughout the year, and have at least 10,000 social media followers (Twitter and Instagram combined). Individuals from four different countries in North America and Europe were selected to highlight international perspectives, and all primarily use English to communicate on social media. The three environmental NGOs were selected based on their focus on sharing marine research and policy information on social media. Similar to the individual communicators, the NGOs use their organization Twitter and Instagram accounts to share information with their followers multiple times per week throughout the year. The local, national, and international NGOs were selected to explore the social media activity of organizations of different sizes communicating at different scales.

3.2 Social Media Data Collection and Coding

Publicly available Twitter and Instagram data were collected for four weeks from July 30 to August 26, 2018, including all Twitter posts (TRPs), Instagram posts (IGPs), and Instagram stories (IGSs) posted by the seven communicators. Twitter and Instagram were selected for this study as Twitter is traditionally seen a social media platform for science communication, whereas studies on Instagram as a medium for science communication are limited to date. All associated TRP and IGP comments were also collected. Twitter posts from each account were collected manually using the desktop version of Twitter (twitter.com). The posts were captured one week after they were posted to allow time for follower engagement (data capture took place once per day from August 6 to September 2, 2018). For each account, a screenshot of the TRPs was taken to record the date/time of posting, capture images, and preserve a "snapshot" of the content and engagement at the time of data capture. Next, all text from the original post and comment section of each post was copied and pasted into a rich text format (RTF) document. Each RTF file was saved and named according to the account it was posted from, the date it was captured on, and the number of posts from that day. In the case of multiple Twitter posts together (i.e., a thread), each post within the thread was captured together and treated as a single post, unless posts took place over multiple days. Instagram posts by each account were collected from the desktop version of Instagram (instagram.com) using the same process that was used to collect TRPs. Instagram stories posted on each account were also collected manually using the desktop version of Instagram. The stories were collected twice per day to ensure none were missed (as they expire 24 hours after being posted). All IGSs were collected using screen capture software to record the video and audio associated with each story post. Each set of stories captured during collection was saved as a video file named according to the account stories were posted to and date/time of capture. The stories were separated into threads based on the time between posting and topic continuity. Engagement data were not captured from IGSs as they are not public.

All Twitter and Instagram data were organized into spreadsheets and then imported into Rstudio version 1.1.456 for statistical analysis. For the TRPs, five separate

spreadsheet files were created: one each for original content, comments, handles, names, and reply type. Original content files contained two columns—one for post caption data, and another for hashtag data—with each row representing a unique post. The remaining four files were organized similarly, with each row containing data on either comments, handles, names, or reply types associated with a unique post. The same process was used for IGPs, but only files for original content, comments, and handles were created, as data for names and reply type are not recorded in Instagram posts. Every TRP, IGP, and IGS was coded for a number of content characteristics used in analysis (see Table 1 for codes and definitions). The codes were developed for this study based on topics listed as central to organizational goals on organization websites, as well as the Instagram biography

Table 1. Codes and definitions used to characterize Twitter post, Instagram post, and Instagram story content.

Code	**Code Definition**
Date	The date that the original content was posted
Media Type	The combination of text, image, and/or video included in the post
Audio Type	If the post included video, the combination of no audio, music, speaking, and/or background audio used in the post
Science	Presence/absence of science content in the post (keywords: science, data, research)
Policy	Presence/absence of policy content in the post (keywords: government, decision, policy, legislation)
Marine	Presence/absence of marine content in the post (if coded as "marine," also coded as "environment")
Environment	Presence/absence of any environmental content in the post
Action	Presence/absence of a call to action for the environment in the post
Advocacy	Presence/absence of advocacy in the post without explicit calls for action
Selfie	Presence/absence of a person associated with the account pictured in the post

description for The SciCommunity. Because the Instagram story data were only captured in audio/visual formats and not text, the IGSs were only subjected to content coding.

3.3 Text and Sentiment Analysis

Text and sentiment analysis were completed for all Twitter and Instagram post captions collected from all communicators, as well as all Twitter and Instagram comments on the communicator posts. The text analysis was completed using Linguistic Inquiry Word Count 2015 (LIWC2015) computer software. LIWC2015 was selected for text analysis due to its relative agreement with other sentiment analysis software (Gonçalves, Araújo, Benevenuto, & Cha, 2013). English and non-special character data from all text captions posted by a particular communicator during the study period were analyzed as a single dataset using LIWC2015, and the results were exported into Excel

Table 2. LWIC2015 code categories and their definitions (LIWC, n.d.). All scores are on a scale of 0-100.

Code	Code Definition
Analytic	Analytical thinking: higher scores indicate more formal and hierarchical thinking patterns, whereas lower scores indicate more narrative and personal thinking patterns
Clout	Clout: higher scores indicate higher leadership, social status, or confidence in speaking/writing
Authentic	Authenticity: higher scores indicate more personal, vulnerable, and humble sentiments
Tone	Emotional tone: scores above 50 indicate a more positive tone, and scores below 50 indicate a more negative tone
Personal pronouns	Percentage of words that are personal pronouns
Positive emotions	Percentage of words that are positive emotion words
Negative emotions	Percentages of words that are negative emotion words

for further analysis. Analysis was conducted separately for the Twitter and Instagram data, and repeated for all seven communicators. The same process was then used to analyze the comment data (i.e., all comments received by a single communicator were analyzed as a single dataset). Because usernames were present in the text captions and comments, and therefore also analyzed by LIWC, they may have affected LIWC scores. Therefore, instead of discussing absolute LIWC2015 scores from text analysis results, individual and NGO scores are discussed in relative terms, as both groups of communicators were analyzed under the same conditions. LIWC2015 code categories and their definitions are listed in Table 2.

3.4 Interview Data Collection and Analysis

The owners or representatives of all seven accounts identified were invited to participate in the study via email. Each communicator that was invited agreed to participate, and was subsequently assigned a random code based on communicator type (e.g., ORG1 or IND1). A semi-structured interview guide was developed to ensure the interviews focused on the research topic while still allowing for natural conversation and the flexibility to probe emergent themes (see Appendix A). The interview guide included four main sections to investigate how communicators view their own use of social media: general social media use, social media goals/objectives, social media posting strategies, and participation in social media conversations. Ethics approval to proceed with interviews was obtained from the Faculty of Management at Dalhousie University under the Faculty of Management Ethics Review Policy (see Appendix B). Following ethics approval, the study participants were invited to participate in semi-structured interviews via email.

The interviews were conducted by phone or via Skype and were each about one hour long. All interviews were audio recorded (upon consent by the interviewees) and transcribed verbatim into word processing software for analysis. The interview data were then copied into Excel and coded for content. The coding process was completed in three steps: an initial stage to generate codes that were as specific as possible for each interview response, and then two rounds of code collapsing based on patterns/themes

observed across the interviews. An independent check of the coding was completed by another researcher for reliability and consistency of the coding.

3.5 Survey Data Collection and Analysis

A survey was developed using Opinio software available at Dalhousie University to query engaged social media users on their participation in social media conversations. The survey was broken into four main sections: general social media use, motivation to follow the communicator with whom they were engaged, participation in social media conversations, and demographic questions (see Appendix C). Ethics approval to proceed with the survey was obtained from the Faculty of Management at Dalhousie University under the Faculty of Management Ethics Review Policy (see Appendix B). The survey participants were not asked identifying questions, and the Opinio software did not record the submission origin of participants; therefore, the survey participants remained anonymous.

The survey was open from September 10 to October 31, 2018, and targeted all social media followers who posted English comments in two-way conversations on Twitter or Instagram posts of each of the accounts during the study period, except for ORG3, which requested that its audience not be surveyed. Social media users were invited to participate in the online Opinio survey if they were involved in a conversation with a) one of the communicators being studied, or b) another user commenting on the same post (see Appendix D). A two-way conversation was defined as a comment that received at least one response, with both the commenter and respondent being invited to the survey. Social media accounts that were deleted or changed to a different "handle" by users before invitations were sent out, accounts that did not belong to individual people, and accounts that were obvious trolls/bots (based on their social media profile and/or comments) were excluded. The seven accounts being studied were also excluded from the survey. In total, 425 "conversationalists" were invited to participate in the survey.

Each user selected for the survey was invited to participate via the social media platform that they were in a conversation on (i.e., Twitter or Instagram) using a unique comment that tagged the individual in a Twitter or Instagram post and identified which of the six accounts they were being contacted about. Each comment asked users to follow a

link that directed them to a separate webpage containing the survey link. If users were in conversations on posts of more than one of the accounts being studied, random selection was used to decide which account the user was contacted about. Also, as one of the NGOs engaged a large number of users in conversations (n=1,810), a random number generator was used to select 115 participants to invite to the survey for this NGO (this number was selected based on the communicator who engaged the next highest number of conversationalists). Additionally, because this same NGO had an extra "pool" of conversationalists (as only 115 out of a possible 1,810 users were initially invited to the survey), and 64 users invited during the initial invitation process had private social media accounts, a second round of survey invitations were sent to 64 random users (with public accounts) from the remaining pool of NGO conversationalists. All survey participants were limited to completing the survey once. Finally, the survey data were analyzed quantitatively using the Opinio software's basic statistical analysis package, and the open-ended, free text responses were extracted to Excel and coded for content.

3.6 Audience Analysis

The social media "biography" of each user invited to complete the survey was analyzed to determine if individuals engaged in conversations self-identified as scientists on Twitter and Instagram. The followers were classified as scientists if their social media biography mentioned science or science disciplines (e.g., neuroscientist, biochemistry), or if their social media profile picture clearly depicted them as a scientist or doing science. These data were first entered into Excel and then imported into Rstudio version 1.1.456 for statistical analysis.

3.7 Data Results

The following chapter presents results for all data collected, including public social media data (quantitative), interview data (qualitative), survey data (quantitative and qualitative), and audience analysis data (quantitative). The first section provides an overview of overarching social media goals and challenges outlined by communicators during interviews. The remainder of the chapter is broken into sections that typically begin with a presentation of social media data related to a particular strategy or

engagement type, followed by interview and/or survey responses to enhance quantitative observations.

Chapter 4: Results

The results are presented in four sections in this chapter. The first section provides an overview of social media use by the NGO and individual communicators based on the interviews. The remainder of the chapter is organized in three sections: social media strategies, social media engagement, and audience analysis. Quantitative social media data and qualitative interview data are generally reported together, with the interview data used to supplement social media observations with communicator comments. In the engagement section, the quantitative and qualitative survey data are also treated together to complement quantitative social media data and interview comments.

4.1 General Social Media Use: Motivation and Challenges

4.1a NGO Social Media Goals and Challenges

Each person who represented the three NGOs spoke from slightly different organizational roles/perspectives. One interviewee leads the digital marketing team that coordinates social media activities, another is the social media manager responsible for the bulk of social media strategy development and posting, and the third occupies a position with a primary role other than social media but participates in and is well informed about the social media activities of the NGO. Each interviewee demonstrated a strong understanding of their organization's social media practices, including overall motivations to use social media, and some associated challenges. The interviewees' responses reflected their organization's social media practices as a whole, and are referred to accordingly in the rest of this report.

The three NGOs highlighted various motivations for using social media. Overall, the representatives of the larger NGOs were confident about expressing explicit objectives. For example, the communications staff member of one of the larger NGOs stated, "We have a number of set goals that we are constantly striving for on social media." Similarly, the representative of the second large NGO emphasized the importance of having a robust social media strategy. In contrast, the interviewee for the small NGO was less certain about overall social media goals, saying that they are still evolving: "I don't know that they necessarily exist in like a super structured way yet. It's

coming along." Regardless of the clarity provided by overarching social media objectives, the three interviewees mentioned multiple factors motivating their social media activity. Both ORG1 and ORG3 highlighted how social media aids in their fundraising efforts. First, it provides the NGOs an opportunity to demonstrate influence: "I know that it helps with funding proposals … Like when we can tell funders … that we have a reach of … [number of] people between our four or five social media accounts … [it] definitely helps with our organizational clout" (ORG1). Additionally, social media followers can spread fundraising messages posted by NGOs and increase the number who see the messages, which is significant "because shares are just as valuable as dollars" (ORG3). Social media also afford the NGOs the ability to disseminate their messages and increase brand awareness, as posts are immediate, shareable, and NGOs "have full control over [the] messaging" (ORG3). In fact, the larger NGOs emphasized how social media are essential for delivering information: "Social media of course we see as a key and absolutely necessary platform to … convey our message and … get our point of view across" (one large NGO); and "Because at the end of the day it's how people … consume information. It's where they go to learn about what's happening in the world" (second larger NGO). In this way, social media give the NGOs an opportunity to grow and develop their audiences. Finally, NGOs cited social media as a means of meeting demand and interacting with a large online audience: "We need to be where those people are, and the fact is, as we're seeing, people are on social media" (ORG2); "It touches people everywhere. Everyone has social media now … it's just another way for us to be able to connect with people … As long as there's an audience, there's an opportunity" (ORG3).

Each NGO also faces social media challenges. For example, ORG1 discussed the problem of coordinating social media activities between multiple staff members at the organization, with "everyone in the past having access to the account if they want." In contrast, ORG3 said that it can be difficult to share content about all of their work—which takes place in multiple regions—because social media activities are coordinated from a single location: "I'm only in [one location]. Now, I can show … things happening here. But actually most of our really cool work happens outside of [where I am], right?" ORG3 also highlighted challenges associated with staff turnover and position vacancies: "I'm barely … keeping the lights on. So we're not as active as we normally would be …

definitely not as strong as normal." ORG1 and ORG2 also outlined challenges associated with limited resource allocation for social media (including time, staff, and funding), which can bar organizations from reaching their full social media potential: "Being a non-profit organization, we, at the end of the day, don't really have the resources internally" (ORG2); "But I don't think to this point I've really had much of an opportunity to do that … but I'd like to do more of it if I had more time for it" (ORG1).

4.1b Individual Communicator Social Media Goals and Challenges

Although each individual communicator is a part of the same social media community, each provided a unique perspective based on their location and experiences. Two of the individuals are located in North America and two in Europe. Two of the individuals are female, and two are male, and all four primarily communicate in English on social media. As with the NGOs, the individual communicators spoke about their overall motivations for using social media and mentioned some associated challenges.

The individual communicators were mixed in identifying specific, overarching social media goals. Two individuals were somewhat hesitant when asked about specific objectives, with one saying that the goals are no more specific than science communication (IND1), and the other stating that "[I] did not have any … quantitative goals" (IND2). In contrast, one individual referenced a clear, overarching social media goal: "I want to make high quality evidence-based scientific information available to the masses. That is my objective" (IND3). Nonetheless, all four communicators outlined multiple factors motivating their social media efforts, most of which fit into three categories: improving the quality and/or availability of scientific information, offering a positive science communication perspective, and improving the way science is communicated online.

The individual communicators spoke about using social media to improve the quality and/or availability of scientific information in different ways. For example, IND3 tries to improve the depth of information available online: "Just to add a deeper layer, to add another opinion, to fill in any gaps that I see in reporting. Most of the time I'm just providing the information on a new medium." IND3 also spends time correcting mistakes or false information: "I want to bust myths and give an alternative to the pseudoscience

that proliferates on those specific social media platforms." Information accessibility for non-scientific audiences was a significant concern for individual communicators as well. For example:

> It's also about, like – most of the funding … here is funded by government or charities. So … that's obviously funded then by the taxpayer and the public. It's about me sharing what I'm doing with the people who are then funding me … and sharing what I'm doing with that money in a way that is more accessible. Because even though I might publish papers, the average person off the street is not going to read them. (IND4)

Another individual communicator stated that information accessibility is related to how it is presented, not just the medium used for delivery:

> I think that the findings of science should belong to everyone, but the way that science is often communicated makes it feel like … the scientists opened the window to their ivory tower and announced to the world, "Here's what we found," and they close it again and retreat … If someone wants to find the facts, they're there … I think people just don't feel like the facts belong to them. (IND1)

Accessibility was also discussed in terms of audiences that are typically marginalized in science communication:

> I think we need to think about the way social media still contributes to marginalization. It's not free from the social inequalities and challenges we face in the real world, they still apply in the virtual world. I think we need to think about that when we're thinking about best practices in science communication as well. (IND3)

Furthermore, one individual shares science on social media to satisfy "a really strong craving and demand for interesting science content that's not being supplied" (IND1).

Each individual discussed their intention to be a positive scientific influence on social media, for example, to "inspire positive behaviour" (IND2). One communicator strives to reach this goal by acting as a role model for aspiring scientists and breaking down stereotypes: "For me it's about being a … scientific role model that perhaps I didn't have when I was younger" (IND4). Three of the individual communicators shared their hope of fostering critical thinking in their audiences, as exemplified by IND3: "The biggest behaviour change I'd like to see my audience adopting is just to be evidence-based and critical in their interactions with the world. At all dimensions: social, health … personal, philosophical, spiritual, whatever." Two of the individuals also share science information in the hope of adding value to the lives of their audiences: "I just [want] to create valuable content that can have an impact on people's lives" (IND2); "I want to share that with people because I think it can positively influence their lives … I believe in the positive impact what I am doing can have" (IND3). Most of the individuals mentioned the importance of scientists publicizing scientific information alongside and in cooperation with communication professionals to provide multiple perspectives (IND1, IND2, IND3).

Individual science communicators are also attempting to improve the way science is presented on social media by going beyond fact-sharing (IND1). Individuals strive "to humanize science" (IND1), build trust with their followers (IND3, IND4), and create best practices for science communicators on social media (IND3). All of the individuals also use social media as a networking tool to connect with other scientists and communicators. In fact, three of the four individuals use social media to seek out information in addition to sending out information (IND1, IND2, IND4). Another reason individuals share science on social media is because they enjoy it: "But also because I love doing it. It's helped me grow as a person" (IND4); "I mean there's also of course the aspect that I just enjoy doing science communication" (IND2); and "It is very personally rewarding. I've always loved to teach. And being able to do it on a high throughput scale has been very fulfilling for me" (IND3). This in part is why individual communicators reported being less concerned with reaching a large audience on social media and content to connect with anyone who wants to listen: "If I had one follower or [thousands of] followers it doesn't matter for me. The way I would present my content to those persons or person

would be exactly the same" (IND2); "If no one were following me, I think I would be doing almost the same thing. Like it was never about that. … it's just what I'm interested in" (IND3). That said, the individuals stated that finding the time and energy to communicate consistently on social media can be a challenge. For example:

> It does get difficult sometimes, because you can easily get swept up by the numbers, and how many likes and how many comments you've got, and if there's a dip in engagement, and how many followers you've got, and why you've lost all these different followers. So sometimes that can sort of get on top of you. (IND4)

Similarly, IND2 noted: "creatively you burn out quickly. Also sometimes mentally as a person you can burn out because there's constantly that push in the back of your head that says you have to post something, you have to post, you have to engage" and IND3 stated: "Yeah it's often difficult. It's very difficult … it's difficult to maintain a stream of content even when you know, I also work … and have a social life." To cope with the demands of being a social media communicator, the individuals said it can help to take a break for a few days and come back fresh (IND2, IND4), or try to incorporate posting into their daily routine (IND3).

4.2 Social Media Strategies

4.2a Frequency of Social Media Posts

In total, 840 social media posts (522 Twitter posts (TRPs), 152 Instagram stories (IGSs), and 166 Instagram posts (IGPs)), were collected during the study period. Posting frequency varied among the seven communicators studied. Six of the seven communicators posted on social media between 3-25 times per week on average across all platform types (including TRPs, IGPs, and IGSs) (Figure 2). IND1 and IND2 posted less than the other communicators—at about 10 times per week on average across all platform types—and IND3, IND4, ORG1, and ORG3 posted more often, at around 20 times per week on average. ORG2 posted at a much higher frequency than the other communicators, at over 120 times per week on average across all platform types.

The communicators cited multiple factors that determine how often they post. Overall, the NGOs try to post regularly according to a pre-determined schedule (i.e., set number of posts for each day) (ORG1, ORG2, ORG3). Although these schedules tend to

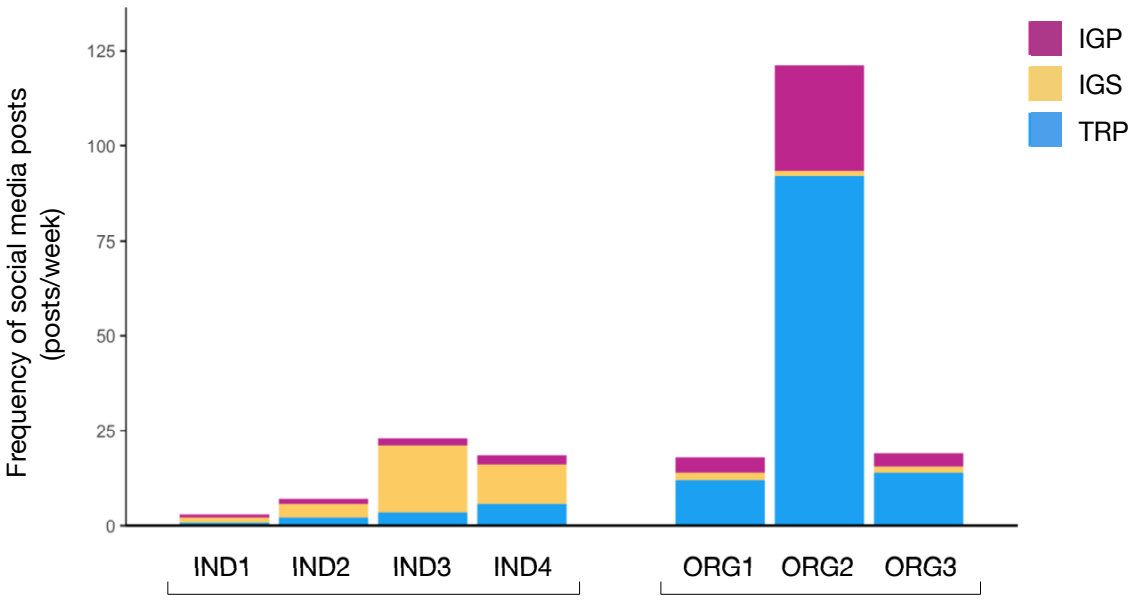

Figure 2. Average number of social media posts per week by individuals (IND) and NGOs (ORG), July 30-August 26, 2018. Colours indicate the platform distribution of communicator posts across Twitter posts (TRPs), Instagram stories (IGSs), and Instagram posts (IGPs).

be used as a guide rather than a strict set of rules (e.g., ORG1, ORG3), the representatives of the NGOs said that they post regularly to keep content appropriately spread out and avoid content overlap or discordance (ORG1). The NGOs also post regularly because it helps them achieve their social media goals (ORG2). Individual communicators are less concerned with maintaining a regular posting schedule, even if it leads to variable post frequencies (e.g., IND1). The individuals did not directly describe why they post this way, but their posting behaviour may relate to the effort it takes for individuals to maintain consistently high content outputs, which was discussed above. For example: "I've kind of come to the point where it's best for me just to post when I like, when [it] suits me best" (IND4).

Another important factor explaining communicator post frequency on social media is the extent to which communicators are able to plan their posts. The NGOs typically try to pre-plan their social media content as much as possible, for example, "we definitely do actually schedule our posts so that we're not … posting them live, typically at least, in an attempt to pre-plan content as best as possible" (ORG2). Pre-planned content for the NGOs is generally tied to particular occasions that occur across social media, such as a designated day meant to celebrate a specific animal (ORG2, ORG3). The NGOs feel that pre-planning their posts leads to better content performance on social media, as more time can be spent researching and curating the post message and/or visuals (ORG2, ORG3). However, all of the NGOs also emphasized the importance of being reactive on social media, even though it is not their preferred posting strategy. For example: "so [we're] doing as much planning as possible, but trying to leave in the flexibility to react when there is a more timely or necessary content need" (ORG2). Another NGO communicator stated: "that [schedule is] typically a maximum unless someone has an event that they're live tweeting from, then there's a bit more leeway" (ORG1). Similarly, the third NGO spoke about the need to be reactive, but also that there are risks to this posting strategy: "so I think both [planning and reacting] are key, it's important to have a balance … but at the same time being reactive can be dangerous too … So you do … always have to be careful" (ORG3). The spokespersons for the NGOs said that the need for flexibility in posting frequency relates to the type of work they do:

> In terms of building in the flexibility, it's necessary because we are a policy-oriented scientific-based organization, and we're working on active campaigns, so we need to be able to be the voice of their campaigns and support them to help achieve their objectives at the drop of a dime (ORG2);
>
> As much as we would like to be able to plan content in advance, so much of what we do is quite reactive because we are a science-based organization … and we're always getting in new results and data and stuff to communicate … So everyday is really different because you never know … what's going to happen. We are more reactive than we'd like to be, but I think that's just the nature of the work that we do. (ORG3)

Additionally, ORG3 said that reacting is a key part of being relevant on social media: "you need to be reactive—again if you're not reactive then you're not part of the conversation on social media … and then you're not relevant." Like the NGOs, one individual communicator said that a proportion of posts are planned around scheduled international events (IND3); however, the individual communicators are mainly reactive on social media, for a variety of reasons. The individuals want to communicate about events as they happen to be topical, and to make their social media content visible and exciting (IND3, IND4). Additionally, the individuals post about what captures their interest at the time, which can be more creative, allowing them to share when they feel inspiration (IND2, IND3). The individuals are also reactive so they can respond to audience questions (IND3).

The majority of the communicators post as often as they do based on optimization, updating the frequency and timing of their posts to maximize engagement. For example: "doing something like setting a particular volume and timing of content is simply because, 'Hey, this seems to be the most effective'" (ORG2). The communicators said that they gauge effectiveness based on social media analytics, which they use to evaluate the level of engagement they are receiving on posts, and also try to optimize their posting behaviours based on platform-specific algorithms (ORG1, ORG2, ORG3, IND1, IND2, IND4).

4.2b Platform Type

All seven communicators used all platform types during each week of the study period; however, the majority of social media posts by the individuals were IGSs, whereas the NGOs mainly posted TRPs (Figure 2). When speaking about how to decide when to use a particular platform for posting, the representatives of the NGOs were hesitant to designate a priority platform: "I wouldn't say we necessarily prioritize one platform over the other" (ORG2). One NGO interviewee said that platform prioritization exists only in the sense that the organization more commonly uses and relies on Twitter "because it's what [we've] been [using] most in the past" (ORG1). ORG1 answered similarly when asked if there was a preference for using one platform over another: "I don't know about preference … I don't know that there's necessarily a preference other than [Twitter has] typically been the most relied upon platform" (ORG1). In contrast, ORG2 clearly expressed that Instagram is the NGO's most preferred platform due to its performance and functionality: "in 2018, our preference, or our top performing platform I should say, has been Instagram … it's still at a point of very rapid growth and evolution in terms of the functions or things you can and can't do on the particular platform. So that's lent itself to being a top performer."

The individual communicators showed more certainty than NGOs when asked about their priority platform, with all four individuals saying that Instagram (including IGPs and IGSs) is their social media priority. Moreover, three of four individuals specifically indicated IGSs as a priority (IND1, IND3, IND4). The individuals prioritize Instagram over Twitter for a number of reasons. Instagram is a focus based on audience size: "I would say my main … following then is from Instagram" (IND4). Likewise, IND3 said: "I prioritize Instagram because … that's where my biggest audience is" (IND3). Furthermore, IND2 "prioritize[s] Instagram a bit more than Twitter, because … Twitter is a bit more spontaneous." One individual also feels as though they stand out from other communicators more on Instagram than on Twitter: "I think I'm more unique on Instagram as well, so I'm really committed to building that as my main platform" (IND3). In addition to prioritization, the individual communicators clearly prefer using Instagram over Twitter. A main reason for this preference is Instagram's functionality:

> I love how many dimensions there are to using it. You can do pictures, you can do posts, you can do videos and stories, you can live stream. It's so … versatile in how you can use it that it's been incredible as a creator … You can showcase your personality in so many different ways. (IND3)

Similarly, IND4 prefers Instagram because of its visual aspects, and IND1 because Instagram affords the ability to interact with other users. Another individual stated a preference for IGSs specifically, because the platform type allows the communicator to showcase creative skills developed during previous social media work:

> I transferred … from YouTube to Instagram. So I had basically no experience at all in how to edit photos – this is something that I had to learn [along] the way. But I [actually had] experience in editing videos … [which] let me distinguish myself from content creators on Instagram. (IND2)

The individual communicators also prefer Instagram over Twitter because it is "more creative" and less "preachy" (IND2, IND1).

In addition to platform priorities and preferences, the communicators decide which platform to use based on audience expectations in relation to specific communicator goals. In other words, the communicators operate under implicit "best practices" while communicating on each platform, as expressed by ORG2: "a lot of the decision-making really just boils down to … what's appropriate on Twitter or what is optimal on Twitter, and what is optimal and appropriate on Instagram … We want to try to essentially engage with people how they want to be engaged with on each unique platform." The individuals indicated that there are differences between the platforms as well: "both [platforms] have their goals and strengths and weaknesses … So they are complementary for me, rather than competitive" (IND2); and "[the platforms] all have their unique purpose" (IND3). Twitter is used by one NGO to post about recent news relevant to its work, and to send out press releases from the organization (ORG1). For IND2, Twitter is used mainly for professional activities and re-posting interesting

information, resulting in relatively spontaneous posting habits. Alternatively, multiple individuals and NGOs mentioned that they use Instagram (IGPs and IGSs) when they want to communicate on a more personal level: "I think [Instagram] is much more effective for science communication because, first of all the fact that it's visual means you can put a human side to everything" (IND1). One NGO communicator said, "through Instagram stories … we try to use that to connect more on a personal level" (ORG3). IND4 mentioned "Instagram stories is … a personable thing." Particular challenges can also affect how platforms are used, as demonstrated in a statement by ORG3: "I would love to post more on Instagram stories. It's so difficult to be like, 'Hey scientist, … can you send me cool photos?' I can't be there to do it … So that's definitely a huge challenge."

4.2c Media Type

All social media posts by all of the communicators included a text caption, regardless of platform (Figure 3a). Images were also used in the majority of social media posts, with images included in between 55-98% of communicator posts in the accounts of the seven participants (Figure 3b). Images were used relatively evenly across platform types, with a couple of exceptions: IND1 included images in a slightly lower proportion of TRPs than IGSs or IGPs, and IND3 included images in a slightly higher proportion of TRPs than IGSs or IGPs. Videos/GIFs were used by the communicators far less often than text or images, with between 2-36% of posts containing videos/GIFs (Figure 3c). Additionally, the communicators favoured IGPs and IGSs for posting videos/GIFs, with only two NGOs posting videos/GIFs on Twitter during the study period.

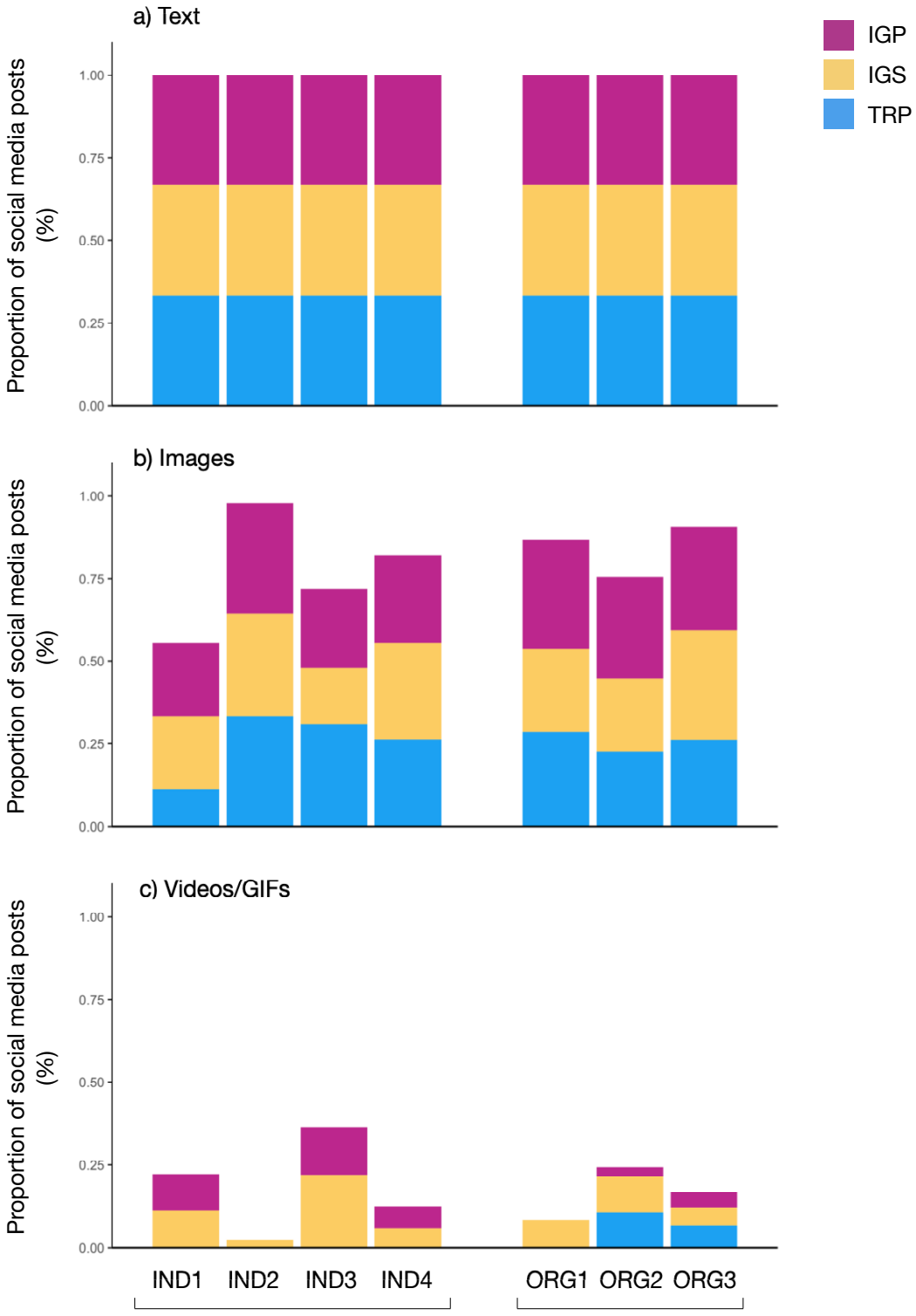

Figure 3. Proportion of social media posts by individuals and NGOs containing a) text, b) images, and c) videos/GIFs, July 30-August 26, 2018. Colours indicate the relative proportion of posts with text, images, or videos/GIFs across TRPs, IGSs, and IGPs.

Videos were not used in the same way by individuals and NGOs, as the two groups of communicators favoured different audio types. Individuals used selfie-style audio (where they spoke directly to the camera) in 38-67% of video posts, and background audio in 22-38% of video posts (Figure 4). In contrast, the NGOs used selfie-style audio in 5-7% of video posts, and background audio in 8-14% of video posts during the same period. The NGOs also posted videos with no audio more frequently than individuals: between 21-77% of videos posted during the study period by the NGOs contained no audio, but only one individual communicator posted videos without audio, at a frequency of 8%. Music was used variably in the video posts by all of the communicators, with between 9-57% of video posts containing music.

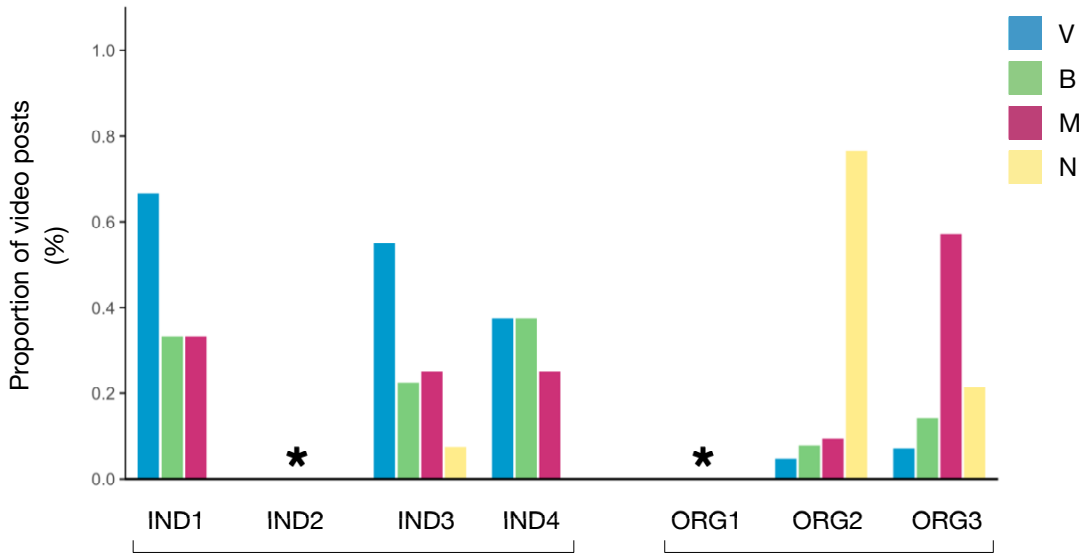

Figure 4. Proportion of video posts by individuals and NGOs that used selfie-style audio (V), background audio (B), music (M), and no audio (N), July 30-August 26, 2018. *Data were excluded for communicators that posted 2 videos or fewer during the study period (IND2 and ORG1).

The individual and NGO communicators referenced platform expectations and communication goals when speaking on how they decide which media type to use in social media posts. None of the interviewees explicitly talked about their reasoning for including text captions in all posts, but one individual mentioned spending time thinking

about “what the format and story behind the picture will be” for IGPs and IGSs, highlighting the rationale for captions (IND2). The communicators did talk about their use of text in social media posts in more detail, but they typically did so in connection to the content of posts, which is discussed in more detail in the following sections. In regard to image use, most communicators referenced Instagram (including IGPs and IGSs) as being a more visual platform than Twitter overall, both in terms of image quality and visibility (ORG1, ORG2, IND1, IND2, IND4). Alternatively, ORG2 said that Twitter seems to be a more effective platform than Instagram for sharing GIFs, and IND2 uses IGSs primarily for posting videos. As with text, the communicators generally discussed their use of audio on social media in relation to post content (specifically selfies), which is outlined in more detail below.

4.2d Selfies

Images were used differently by the individuals and the NGOs across platform types. Selfies were frequently included in posts by the individual communicators, with between 30-42% of all social media posts by the individuals containing selfies (Figure 5). The NGOs used selfies less frequently than individuals, with ORG1 and ORG3 including selfies in 14% and 15% of social media posts, respectively, and ORG2 never posting a selfie. Selfies were used more in IGPs and IGSs than TRPs by all communicators that posted selfies.

The interviewees from the two NGOs that posted selfies feel that selfies help present the organization as more human on social media (i.e., demonstrating that the organization is made up of people):

> It’s good for people to get to know who … the researchers or advocates are behind each of the stories and who’s working on them and why. I think [that’s] useful for people … that human aspect is important, and … giving people a chance to get to know who’s behind the controls is a good thing. (ORG1)

Similarly, the representative of another NGO stated: “I definitely see the importance of putting a face to our work … like, just showing a more … hands-on [perspective of] the

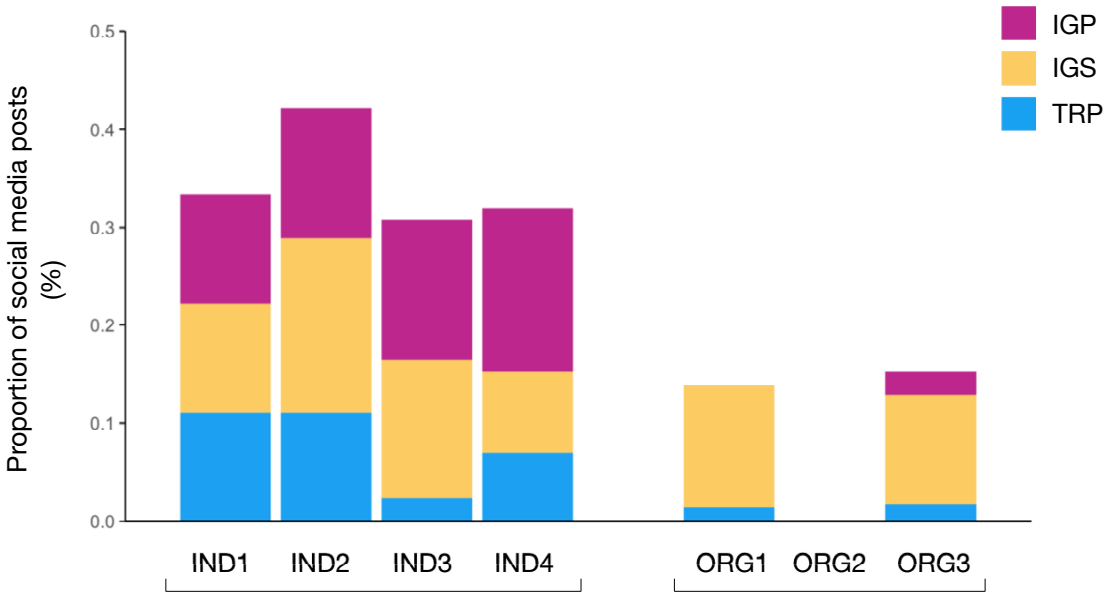

Figure 5. Proportion of social media posts by individuals and NGOs containing selfies, July 30-August 26, 2018. Colours indicate relative proportion of posts with selfies across TRPs, IGSs, and IGPs.

work that we're doing … when the opportunity arises. That's definitely a priority" (ORG3). However, both of the interviewees from the NGOs also stated that posting selfies is not easy for them, for example, because staff members are not always willing to be pictured in posts (ORG1). In fact, for ORG3, "putting a face to [their] work … is one of [their] biggest challenges." The individual communicators include selfies in their posts for two main reasons: to appear as more human on social media, and to provide more interactive and engaging content for their audience. For example, IND2 noted: "that's why I like to film in a selfie mode, because also it … puts a face on a scientist. People like to connect with other people." IND1 shared an analogous comment: "that's one hundred percent to be human … even if you post a photo with your science, or with your code, or whatever … I think even in my facial expressions I try to make it about inviting people in"; and so did IND 4: "yeah … so they have a face to put to the name, that sort of thing." IND3 talked about how selfie-style videos feel very authentic and conversational:

> I think video content, especially … a selfie-style video? I think that like feels pretty intimate actually. It feels like you're having a one-on-one conversation, and it really helps … to build relationships with the audience. Because it feels very personal to have someone speaking right to you via the phone in your hand. It also — just recording an off the cuff video just kind of … confers some level of honesty. Because it's you just free stream talking as if in conversation. And so I try not to overly produce anything. Because I want people to see … we're just talking, this is not so serious. We're just having conversations, let's delve in. (IND3)

Three of the four individuals also said that they feel selfie-style content is more likely to engage their audience. For example, IND1 said: "you're much more likely to want to know more about [science] when there's a person you recognize," and IND3 said that selfies can draw users in: "it can be a hook, because we know that the brain is drawn to faces. So it does make people stop scrolling." IND4 expressed uncertainty as to why selfies seem to get more engagement: "I've found that when I post a picture that has my face in it, I tend to get a lot more engagement on it … The reasons for that I'm not exactly sure about, but … from my experience I kind of feel that having a person in there makes people want to engage with my … posts more." Consistent with the results presented in previous sections, IND3 said that part of the reason for posting selfies is because it is a common practice on the platform: "the reason why I also include them is because that is kind of the medium of Instagram. That is just like, what you do."

4.2e Topic Analysis

The individuals and NGOs posted off-topic content on social media at different frequencies during the study period. Posts were considered off-topic for individuals if science content was not included, and were considered off-topic for NGOs if not linked to their primary organizational mission (e.g., if environment, marine, action, policy, or advocacy content were not included). Overall, the individuals posted off-topic content more frequently than NGOs, with the proportion of off-topic posts by individual communicators ranging from 16-44%, and the proportion of off-topic posts by the

organizations ranging from 0-17% (Figure 6). Additionally, IGSs included the highest proportion of off-topic posts for all communicators except IND1, who posted a similar proportion of off-topic content on IGSs and TRPs during the study period.

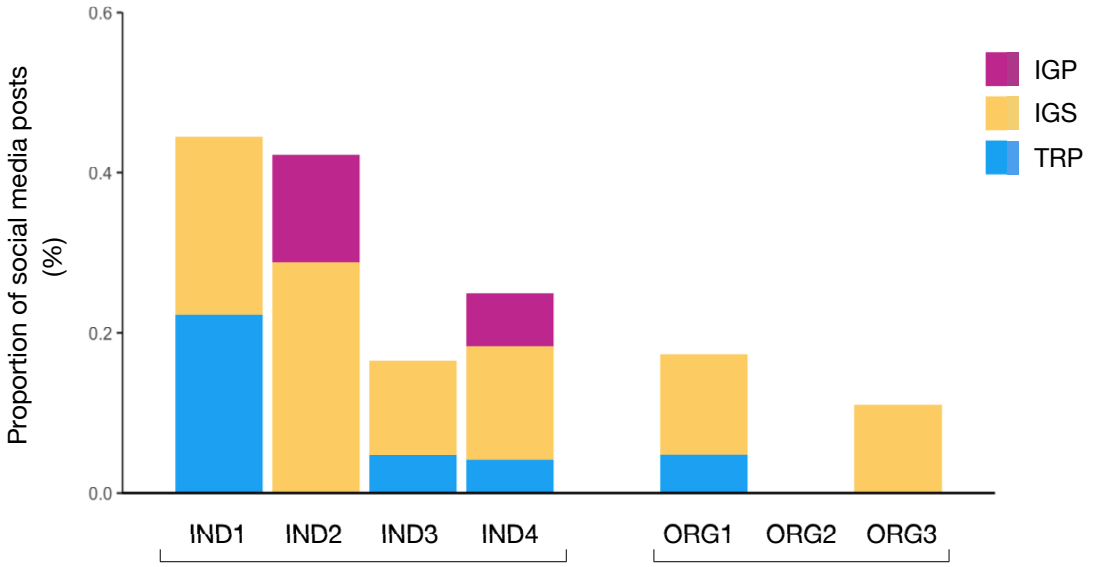

Figure 6. Proportion of off-topic posts by individuals and NGOs, July 30-August 26, 2018. Colours indicate the relative proportion of off-topic posts across TRPs, IGSs, and IGPs.

Like many of the previously mentioned posting strategies, the topics that communicators post about on social media are partially determined by which platform they are posting on, coupled with communicator goals. The interviewees from the three NGOs explicitly discussed the topics they share in relation to specific goals, such as promoting their organization, maintaining a consistent stream of content to provide their audience with a clear understanding of what to expect on social media, and communicating with a unified voice. For example, "[we're] trying to create a steady series of content that our audience, and those who are so inclined, can depend on. So there's that level of consistency" (ORG2). To ensure that social media posts are aligned with higher-level NGO goals, the NGOs employ content rules, such as topics to avoid (ORG1, ORG2, ORG3). Although the individuals spoke less explicitly about the topics they post about in terms of overarching social media goals, IND1 and IND2 both echoed a similar message to that of the NGOs, in that they try to relate most of their posts back to

a common topic. For example, IND2 stated, "yeah there has to be some kind of link. I think that's always very important … So you have to be consistent in that and not just start … randomly diverting, because then it gets chaotic and people don't know what kind of value they can get out of your content." In regard to platforms, Twitter is typically used by the communicators for posting news or content that is easily shareable via Twitter's "re-tweet" function (ORG1, ORG3, IND1, IND2). On the other hand, IGPs and IGSs tend to be used for more "general" content, including more personal topics (ORG1, IND1, IND2, IND4). For one NGO, IGPs are used to post content "that [they] hope is going to interest people personally, and attract them to the organization," but do not "know that there's necessarily … an explicitly personal tone to what [they're] doing" (ORG1). The individuals, on the other hand, expressed a clear intention to post personal content using IGSs, such as day-to-day activities that are not necessarily scientific (IND1, IND2, IND4). IND1 discussed how posting personal content on IGSs helps to portray scientists as human, i.e., regular people who have interests outside of science:

> I think that Instagram stories humanize [science] more than anything else. Just because they're quick, they don't have to be high quality … Sometimes [content is] not exciting enough to warrant a whole post on Instagram, but you know, people like seeing it on the stories. Because it's a way for them to check in with me, and like, what am I doing between posts.

IND2 also uses IGSs to post daily activities, but mixes in more curated content: "I also have my Instagram stories, which can either be a loose feed of what I'm doing through the day … but sometimes I also make more 'fancy' videos … which are edited with music and stuff … when I do something special." Most of the communicators also post about particular topics on particular platforms because of the audience that exists there (ORG1, ORG2, ORG3, IND2). This practice may involve posting about topics that concern a majority of the social media audience to be as inclusive as possible (e.g., IND1, IND3), or focusing more specifically on topics of concern for the account followers:

> At the end of the day it's all based on who your audience is, what they like, what makes them tick … You always start with your audience first … because if you ignore them and their needs, and don't craft messaging that will appeal to them, and content that will appeal to them … you'll lose them. (ORG3)

Consistent with the NGO's efforts to be reactive on social media, all of the organizations post on topics related to current events to keep their posts timely and relevant. For example, ORG3 pointed out that "[pre-planned content] doesn't feel alive. Like the content doesn't come to life, in a way … But when you have that mixed content, and of course mixed medias, it feels like a very vibrant online presence." The individuals likewise post social media content in a way that is consistent with their posting frequency. For example, IND2, IND3, and IND4 spoke about posts on topics that are personally inspiring or prompt curiosity. One individual posts in this manner to cultivate audience curiosity:

> I do that because that's what I love about science … For me this general curiosity and awe about the world is what drew me to science. And I think it's really important that, especially for biology related topics, we encourage that kind of awe and curiosity … I like to post about the basic science of things, because I think that's an area of science, particularly when it comes to biology, that's neglected. (IND3)

Another individual enjoys communicating based on inspiration and feels this approach is better for conveying genuine excitement to social media audiences:

> It gives kind of a personal aspect, because these are things that I grasp out of my life, and so I'm excited and enthusiastic about them. I hope that translates in my posts as well. Because if you're enthusiastic and you're really behind something, I still think people can feel that when they read your posts. (IND2)

All of the communicators are using social media to post about science and/or public policy information, and therefore all of them discussed an educational component to their social media content, which is delivered using a combination of text, images, and videos (ORG1, ORG3, IND1, IND3). For example, ORG2 noted that "yes … I would certainly say on social media specifically there is that … what you may call educational element." The NGOs pursue this educational objective to build capacity in their audience and encourage particular policy and/or environmental decisions, provide their audience with important background information related to their work, get their audience involved with the causes they are advocating for, and establish their organization as a leader on environmental issues (ORG1, ORG2, ORG3). However, the NGOs emphasized that the educational content they communicate must also be balanced with lighter content:

> I try to find at least one factoid or item that I suspect people won't have heard before, and then also try to include at least one sentence, or clause … that acts as more of an interactive message … I think it's a combination of maybe sneaking in a bit of information that people might learn from. Or a bit of information about why we need to either protect or conserve some of the species or ecosystems that we're presenting (ORG1);

> Our general audience isn't super interested in … getting too deep into the science. They just want … to know that we're helping [nature], from time to time they want to know how, and … then mostly they want to celebrate [nature] … So we try and create roughly one fun, positive, or informative post a day … but then a lot of it tends to be linking to articles that either are about our work, or align with our work in some way (ORG3);

> The content tends to be a bit of a pre-defined mix of general engagement pieces — so content that is related to our space but meant to be very easily accessible [for] someone who may not have a pre-existent passion for ocean conservation. And then a mix of higher tier content … that provides additional information

> about specific campaigns or work that [we are] doing in an engaging way. (ORG2)

Examples of lighter content the NGOs post about include environmental activities going on in particular communities, animals in their natural environment, and interesting ecosystems/environments (ORG1, ORG2, ORG3).

The individual communicators are also working to provide their audience with educational content on social media, with all of the individuals generally focused on sharing science topics. For the individuals, science posts are not limited to research findings, but also what science is, how science works, and ways science can be communicated (e.g., IND1, IND2). In addition to goals that they discussed earlier, two individuals share science content on social media because they feel they have a responsibility to exercise their social media influence to discuss important topics. For example, IND2 said, "also one thing that I think, once you have a certain following, there's kind of [an] intrinsic motivation to speak out [about] these things, because you can speak for those who can't, especially in things like mental health, diversity issues, and stuff like that." Similar to the NGOs, all four of the individuals also balance their educational content, but do so by including personal perspectives in their social media posts. This was expressed by IND4:

> I think ... sharing experiences that I've gone through, or perhaps others have gone through, [I] can maybe show younger [people] who are thinking about a career in science that they actually can do it, and there is an option for them, that they don't have to be put off by the stereotypes. But then also if they are further along the journey and they are experiencing problems, that they're not the only ones experiencing that, and there are other people that can help and advise and support as well.

IND2 said it is important to acknowledge that the social nature of humans permeates into all human activities, including science:

> I want to share something with [my audience] that I think they will like or learn something from; that can be scientific content or personal experiences, stuff like that … There's also always a social … part in sciences as well. We are humans in every profession … and so we also have to deal with these things as science communicators. We have to talk about all aspects of science, not just purely the science facts.

All of the communicators emphasized that the manner in which they share information on social media—including educational content—is important. First, both the individual and NGO communicators were somewhat hesitant to refer to what they do on social media as "teaching," recognizing the need for two-way engagement with their audience, instead of just information transmission. For example, ORG1 pointed out: "I don't know if it's teaching … We don't want to be talk 'down-y.'" One individual emphasized a similar sentiment:

> I don't like to — yeah, teaching, but with an engagement model. Yeah, so not like … I forget what it's called when we think that we just need to tell people things—it's not a good science communication model—but an engagement model of helping people to engage with educational content. (IND3)

Both the NGOs and individuals also strive to portray themselves as human in their social media posts. The NGOs try to do this by attaching human characteristics to the animals that they post about, as expressed by ORG2: "so you know … perhaps … we're going to post a GIF of [an animal] that appears to be celebrating. Some instance of what you would identify as celebrating." A similar view was voiced by ORG1:

> Well just like … putting the creature in like a humanoid frame of mind I guess? … So imagining … yourself in the mind of the animal that's photographed, and then thinking, what are they doing right now that's eliciting this portrait? Or like … why are they doing that thing that they're doing in this photograph, and how might we look at that through a human lens? (ORG1)

The NGOs feel that sharing content in this way helps their audience to relate to the content more. The NGOs also try to make their posts more relatable through the use of metaphors, and by expressing human emotions in their posts:

> Or another thing that we use typically to describe like kelp forests or eelgrass beds is we compare … the base of biodiversity in those areas to a tropical rainforest on land, or something that you know people are a bit more familiar with than a lot of the ecosystems in the ocean. (ORG1)

The interviewee for ORG3 said that language and emotion play a big role in content relatability:

> Also with the language. We are a science-based organization … but sometimes it's ok to be like, "We're upset about this too." Like to let people know, "you're mad about this, and so are we." That really helps people feel more connected to us … just trying to be real, and not always be a "science-y" account. Because people can't relate to that. They can't relate to the facts, they relate to feelings and emotions. And so … if another [endangered animal] dies, it's important for us to [say], "Yeah, she had a name. And she had a family. And this sucks." People feel more connected when we can kind of change our language a little bit … around issues like that. I think that really helps. People feel more connected [when] we're not just pushing out content. (ORG3)

In addition to their focus on selfies discussed earlier, all four of the individual communicators try to portray themselves as human on social media by being warm, being friendly, and being themselves. For example, IND3 noted: "I do try to be the most honest version of myself that I can display." The individual communicators feel that posting personal content also conveys relatability, which "is important because it helps people to understand and also care about what you're communicating … The general public can

see that they can still partake in scientific conversations, even if they break the mold of what they're used to hearing a scientist is" (IND3).

Another aspect of communicating on social media that is a focus for the individuals and NGOs is building trust with their audiences. The NGOs develop and maintain trust on social media in a number of ways. ORG1 emphasized that all of their posts are based on scientific evidence: "I mean everything that we do at the organization is meant to come from a science-based, or an evidence-based standpoint." Furthermore, ORG2 spoke about taking the time to research content sufficiently, and being transparent by correcting mistakes should they happen. All individual communicators similarly build trust by ensuring their content is backed by scientific evidence. In addition, the individuals said that establishing trust involves communicating on social media in a relatable, human manner. For example, IND3 stated, "I think it's important we humanize scientists, because again, that helps to confer trust and relatability," and IND2 said, "I think this is more [natural], or [organic] with me … I just try to show who I am, and really try to tell stories and be consistent in who I am … If you really try to be personal and try to be yourself, I think that can make all the difference … in how you're perceived as a person." Similarly, IND4 said that "you want to be able to show that you're a person that they can trust and reach out to if they have any questions about it." One individual outlined the importance of trying to personally connect to the audience to build trust: "when you dare to be personal it creates connections with people … I think that's often something that we miss in science communication, is that often we just present facts … rather than try to build a community and trust within that community" (IND2).

The majority of communicators focus on making their social media content entertaining for their audiences by posting about fun topics or including humour. The NGOs try to make content fun because it is an accepted social media practice, and because they see stronger engagement on content that is more entertaining (ORG1, ORG3). The individuals stressed that making science content entertaining on social media is crucial, and often overlooked. Two individuals discussed this point in some depth, each referencing a well-known and successful science communicator:

Neil deGrasse Tyson does this as well. His tweets are really funny. But I think this is a pretty basic point that's lost on a lot of scientists going on social media, is that you have to make it entertaining. And humour is one of the basic forms of entertainment … So I think professional science communicators — some of them are really, really good at being entertaining. Which I think is a lesson that practicing scientists that use social media to communicate need to learn. Because I think if your content isn't entertaining on its own, you know, minus the science part of it, then people aren't going to want to … follow you or read your content. Like, it's kind of what I said, you know, Wikipedia's there. If someone wants to go and look something up, they can. The question is, can you … show people why it's interesting in the first place … I mean our papers are not entertaining, they're fact. And it's a struggle. I see these [scientists] who take these really stunning photos … and then their caption will be something like, "I stained this using this genetic marker and this antiviral body and this protein blah blah blah blah" and it's like … people saw the photo and were interested, and then they got to the caption and they stopped caring. First they have to understand it, and they also have to be entertained by it (IND1);

I think it's important to be fun because, thinking about science is fun, first of all. So I'm not injecting fun where it doesn't exist. Personally I have fun learning, reading, writing about science. So that's part of why I try to be fun … The other important thing is … if you think of Carl Sagan and how he popularized cosmology, it was just like from an awe and curiosity angle. And if you think of the way we talk about, especially biology in the popular media, it's always related to health. Who wants to come home at the end of the day, a long day, and learn about how they're going to die from cancer from everything that they touch in their life? Nobody! I don't want to learn that, that's scary. So we kind of turn people off from caring about these things deeply. Sure we'll get clicks but will they really care if they don't want to sit with it and it's scary? If it's fun, it's approachable. They feel like they can talk, they feel like they can learn … it makes it less intimidating when it's fun and not just always a scary angle. (IND3)

4.2f Text and Sentiment Analysis

The average caption length for Twitter posts was relatively similar for all seven of the communicators, ranging between 24-36 words per caption (Figure 7). However, the communicators used more than double the number of words in Instagram post captions on average, compared to Twitter captions (it is important to note that Twitter captions are limited to 280 characters, whereas Instagram captions can have up to 2,200 characters). Additionally, three of the four individual communicators used substantially more words in Instagram post captions than NGOs, with Instagram text captions posted by IND2, IND3, and IND4 containing an average of between 265-312 words, and the NGO text

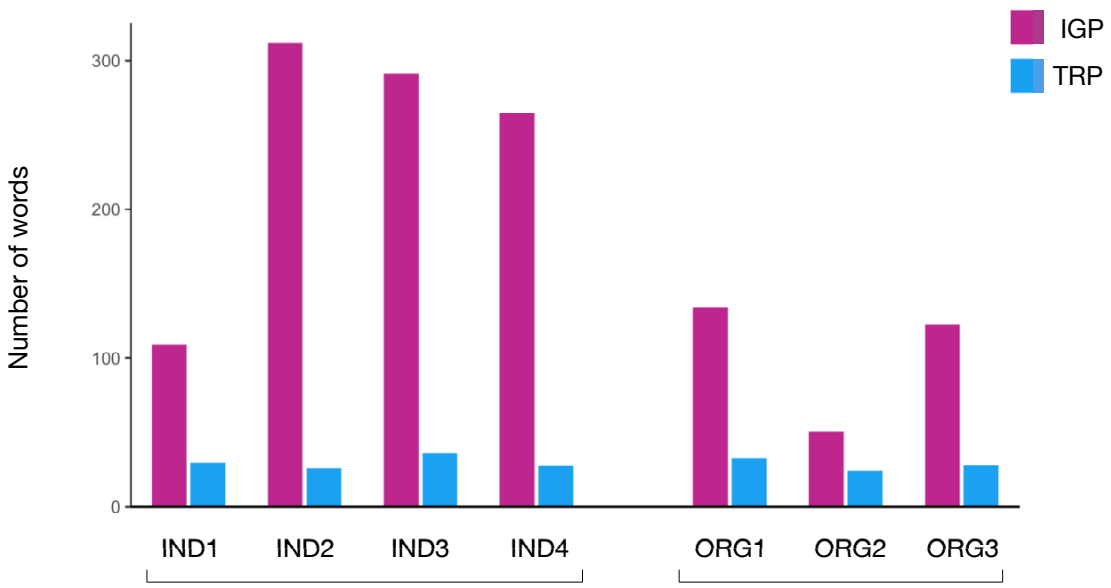

Figure 7. Average number of words per post caption for TRPs and IGPs by individuals and NGOs, July 30-August 26, 2018. Note: each emoji was counted as one word.

captions containing between 50-133 words on average. On average, IND1 used 109 words in Instagram captions.

The text sentiment also differed between the individual and NGO communicators (see Table 2 for sentiment codes and definitions). The text captions posted by the NGOs on both Twitter and Instagram scored higher in analytic (formal thinking) and clout

(leadership/confidence) categories than captions posted by the individual communicators (Table 3). In contrast, text captions posted by the individuals scored higher than those

Table 3. Text analysis results from LIWC2015 for Twitter and Instagram captions posted by communicators from July 30-August 26, 2018. Average NGO (ORG) scores and average individual (IND) scores were calculated for analytic, clout, authentic, and tone categories. See Table 2 for LIWC2015 codes and definitions.

		Analytic	Clout	Authentic	Tone
TRP captions	Average ORG score	93	80	26	53
	Average IND score	78	66	40	91
IGP captions	Average ORG score	91	76	20	50
	Average IND score	72	61	56	78

Table 4. Text analysis results from LIWC2015 for Twitter and Instagram captions posted by communicators from July 30-August 26, 2018. Average percentage of captions that were personal pronoun, positive emotion, and negative emotion words for individuals and NGOs. See Table 2 for LIWC2015 codes and definitions.

		Personal pronouns	Positive emotions	Negative emotions
TRP captions	Average ORG %	4.16	2.80	1.21
	Average IND %	6.15	4.71	0.36
IGP captions	Average ORG %	4.08	2.53	1.20
	Average IND %	7.78	3.66	0.75

posted by the NGOs in authentic (personal/vulnerable) and tone (positive vs. negative emotion) categories on both platforms. The individuals also used more personal pronoun and positive emotion words in their Twitter and Instagram post captions than did the NGOs, whereas the NGOs used more negative emotion words than the individuals across both platforms (Table 4).

4.2g Comment Response Rate

The individual and NGO communicators did not respond to the same proportion of audience comments on their social media posts. On average, the individuals responded to a much larger proportion of comments received on their posts than the NGOs, with the individuals responding to an average of between 15-34% of comments on each post, ORG2 and ORG3 responding to 0.3% and 8% of comments per post, respectively, and ORG1 not responding to any comments received on its social media posts (Figure 8).

All seven of the communicators emphasized that responding to audience comments on their posts is a high priority; this contradicted quantitative observations for

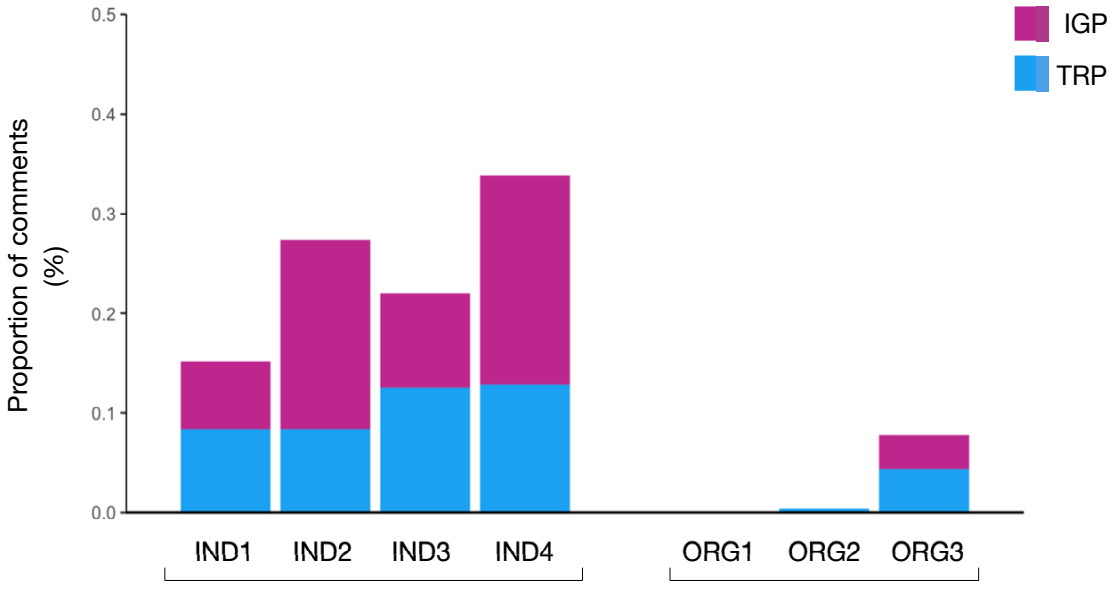

Figure 8. Average proportion of comments responded to per social media post by individuals and NGOs, July 30-August 26, 2018. Colours indicate the relative proportion of comments responded to on TRPs and IGPs.

some of the communicators, and will be discussed in more detail in the next chapter. For example, ORG1 stated: "if there's reaction to [a post] then we certainly do our best to address all the comments, or, if somebody [direct messages] us, get back to them quickly." Responding to comments remains a priority for one NGO in spite of a vacancy in a staff position usually tasked with this activity (ORG3). The individual communicators also prioritize responding to comments. For example, IND4 said: "whenever I post I try to respond to every comment that I get, any direct private messages that I get. I think … I reply to all of them." Furthermore, all of the communicators emphasized that responding to audience questions is a priority, as the following NGO statements highlight: "I think for the most part if there's a direct question for us, then yeah we'll definitely try to respond to it" (ORG1); "So, for instance, if we have someone who's commenting on a post and asking a question, we're going to make a concerted effort to answer that question or to respond to that individual and ensure that we're not, sort of leaving them in the dark" (ORG2). Two of the individual communicators also said that they focus on addressing audience questions, as described by IND4, "if someone approaches me I want to respond to their question, I want to help them," and IND1, "so comments I'll respond to pretty much every one. Like … if it's a question in a comment? Then I'll pretty much always respond." For IND3, responding to audience questions is time-intensive: "A lot of my time on social media is responding to people's questions, whether it's comments on my posts, in tweets, or in direct messages."

For some of the individuals and NGOs, the strategy behind responding to comments relates to their social media goals. Two of the NGOs said that it is important for them to take advantage of these opportunities to engage with their audiences (ORG1, ORG2). The individuals and NGOs also stated that responding to audience comments is necessary for two-way engagement (e.g., ORG1, IND3). One communicator said responding to comments offers the opportunity to provide more in-depth information than is possible in a single post caption, helps to inspire critical thinking social media audiences, and helps with audience growth (IND4).

The communicators also feel that they have a commitment to respond to audience comments and reciprocate the effort put in by audience members who choose to comment on posts. Two of the NGO representatives commented on this subject: "if anybody is

making enough of an effort to put a comment or ask a question, then that means that there's at least an initial interest there. And that becomes a much better opportunity to try to talk to someone" (ORG1); and likewise: "for me, if somebody makes an effort to reach out to us … it's important that we make an effort to respond … Whether it's a [direct message] or it's public, it's just important to engage with people everywhere … It's so important that you respond as often as possible" (ORG3). One of the individuals also discussed the commitment to their audience: "I want to [respond] because … everyone who replies has put the effort in to give me a boost of engagement, so I want to give them something back by replying to their question or thanking them for their comment" (IND4). For another individual, part of being a social media communicator is setting time aside to reply to user comments: "that's part of, for me, scheduling a post. Scheduling time to do a post. I include time to reply. Especially to the first few comments. That's part of the commitment to putting content out there in my opinion, is taking time to engage back" (IND3). Two individuals also said that they feel responding to comments is a common courtesy, and even a responsibility they hold as a social media communicator, for example, as expressed by IND2:

> I mean, for me that's basically … if you would have a following and they would reach out to you, and you would never respond, that's kind of like saying, "Ok, I just post these content. I just want to have as [many] likes as possible. You can post here … to push my engagement for Instagram, but after that I really do not care about what your opinion or your question is." So [it's] basically just common courtesy.

Likewise, IND1 pointed out: "that's very important, to [respond] … I think I have a responsibility to do that. If I'm putting myself out there on this platform as someone who is available to non-scientists, I think that if they ask a question, I need to respond."

Another frequently discussed factor motivating the individuals and NGOs to respond to audience comments is that dialogic interactions help communicators to establish a relationship with their audience. For example, ORG2 said that "it's difficult to build that relationship without having a conversation. So … enabling, sort of the

opportunity to interact one-on-one with the individual … [offers the opportunity] to be able to sort of take that next step in that relationship." For one of the NGOs, connecting with individual followers is a way to create brand recognition in its audience and establish a link between environmental issues and the NGO's work (ORG2). For another NGO, communicating with its audience allows the organization to better understand issues that are important to individual audience members:

> I think you can get a lot more detail about what the person you're talking to is interested in and what makes them tick, or why they came to your page … and it's much harder to do that with … one-way posting … It's of course much easier to connect with people who might be interested on plastics via conversation [when you know] exactly why they're interested in plastics in the ocean, and what's driving them to care about that [subject]. (ORG1)

The individual communicators expressed a similar sentiment. For example, IND3 stated:

> A lot of the time we're just building relationships, we're laughing. I'll post something funny, and someone will reply … Further, it's important for me to let people know that scientists do care about them … We care about individuals more than people realize … So it's important for me to address people's concerns, and talk with them, and share with them information that they're curious about.

One individual illustrated how talking with users has led to relationships through which advice can be exchanged:

> I get a lot of messages about how … the experiences that I've shared [have] helped someone in a similar situation and how me sharing has helped them get out of that problem. Or I quite often get asked advice for applying to graduate school and those sorts of things. So it's kind of nice to know that by finding me, people have found me relatable and they can reach out to me for advice and help too. (IND4)

One of the individual communicators also said that two-way interactions have led to numerous relationships: “I think I’ve built many relationships, I don’t know what the number is. But a lot” (IND3). IND4 expressed how they’ve formed relationships via digital interactions, even without face-to-face exchanges: “Yeah, [meeting up with an audience member for the first time] was great. It was weird in the fact that it wasn’t a complete stranger. So although it was the first time that you met them, you were talking to them like you had known them for ages.” One NGO representative reported a similar experience when asked about success in forming relationships with audience members, although expressed with some uncertainty:

> Yeah, I think so. I think we’re getting there. And I think it’s evidenced by the amount of people who engage with us. They feel like we’re not just a brand, they feel like, “Oh, we’re people.” I think people don’t comment and ask questions if you’re just pumping out content. (ORG3)

In contrast, ORG1 thought relationships had not been fully formed through social media: “I don’t feel like I have much of a personal relationship with the followers, no.”

Although all of the communicators prioritize responding to comments, most discussed how it can be a major challenge. As for any social media user, the communicators are exposed to receiving comments from “trolls,” which for the most part are not worth responding to (ORG2, ORG3, IND1, IND2, IND3). Additionally, due to the nature of their work, two of the NGOs are not always able to find the answers they need to respond to audience comments (ORG1, ORG2). For example, ORG3 stated: “I think the only time [comments] might be lost are when I personally don’t know the answer, so I look to somebody in conservation, and I’m waiting for a response to them. Sometimes I don’t get one. And so maybe the odd [comment] will fall through the cracks.” ORG2 expressed that, because not all comments require a response, focus is placed on instances “where [responses] can be of actual benefit.” Many of the communicators also mentioned the significant effort required to respond to comments,

and that they are limited by the time and/or resources to do so (ORG2, IND1, IND2, IND3). This was highlighted by ORG2:

> We do receive a number of comments and often times a number of questions, and being a non-profit organization, we, at the end of the day, don't really have the resources internally to be able to respond to each and every interaction that we may have on social.

4.3 Social Media Engagement

4.3a Comments on Posts and Social Media Conversations

In total, 13,151 comments were collected during the study period—2,024 Twitter comments, and 11,127 Instagram comments. Because this study focuses on two-way conversations and longer-term engagement patterns (as opposed to post-by-post statistics), non-dialogic engagement metrics—such as likes, hashtags, retweets, and views—are not included. The individual communicators and NGOs received different levels of engagement on their social media posts across IGPs and TRPs. On average, the individuals received more comments per post for both TRPs and IGPs than the NGOs (when normalized to number of followers) (Figure 9). Except for IND1, who had one TRP that received an anomalous number of comments, more comments were received on IGPs than TRPs. IND2, IND3, and IND4 received an average of 0.8-4.2 comments per TRP for every 10,000 followers, whereas the three NGOs received an average of 0.04-0.42 comments per TRP for every 10,000 followers. IND1 received an average of 60 comments per TRP for every 10,000 followers. In contrast, the four individual communicators received an average of between 19-42 comments per IGP for every 10,000 followers, and the NGO communicators an average of between 1-5 comments per IGP for every 10,000 followers.

The comment length for TRPs and IGPs was also different for the individuals and the NGOs. Overall, the individuals received slightly longer comments than the NGOs on both TRPs and IGPs (Figure 10). The average number of words per comment for individuals ranged from 10-26 on IGPs, and 9-26 on TRPs. For the NGOs, the average number of words per comment ranged from 4-7 on IGPs, and 2-15 on TRPs.

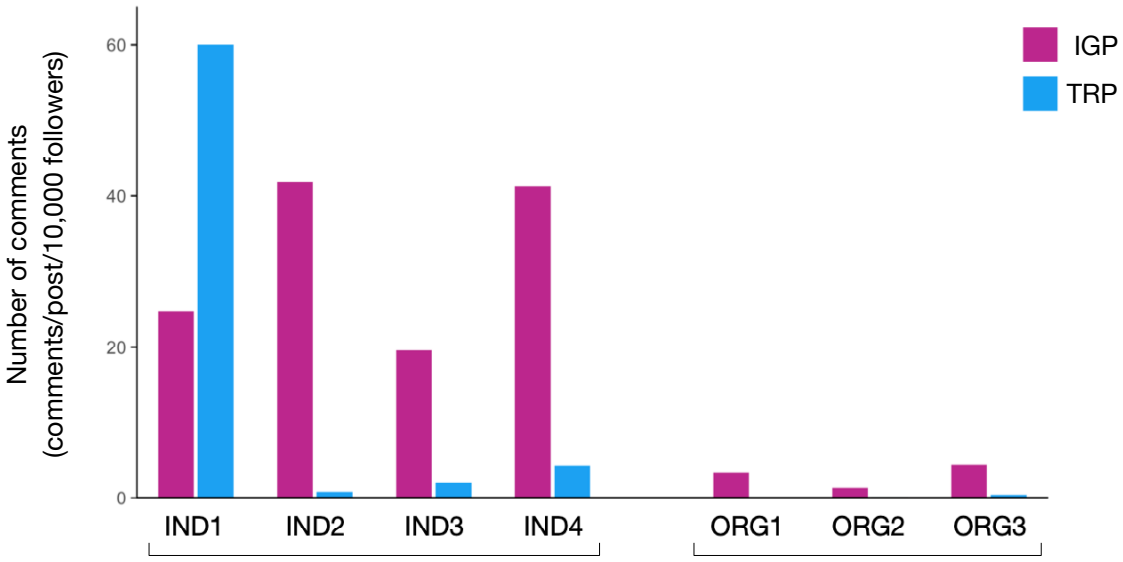

Figure 9. Average number of comments received by individuals and NGOs on each TRP and IGP, July 30-August 26, 2018. These data were normalized to 10,000 followers to aid in data visualization.

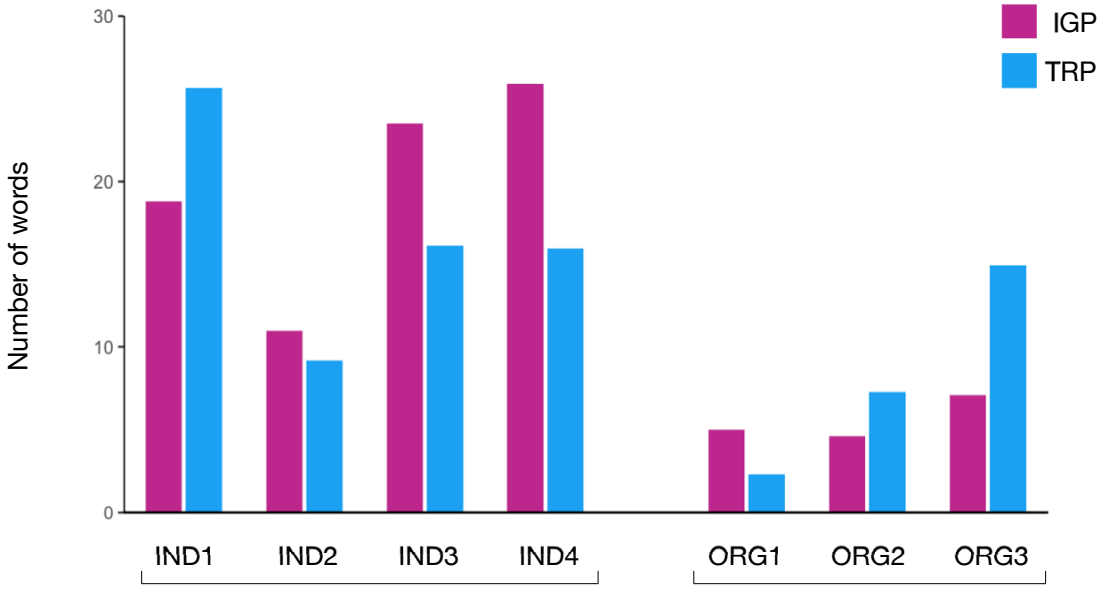

Figure 10. Average number of words per comment on TRPs and IGPs by individuals and NGOs, July 30-August 26, 2018. Note: each emoji was counted as one word.

Furthermore, three out of the four individuals received longer comments on IGPs than TRPs, and two out of the three NGOs received longer comments on TRPs than IGPs. Regarding comment sentiment, the average LIWC2015 analytic scores for comments were relatively similar for the NGO and individual communicators, but with some slight differences (Table 5). On IGPs, the comments scored slightly lower in the analytic category for individuals than for the NGOs. Similarly, the comment clout scores were lower for individual posts than the NGO posts across both IGPs and TRPs. Comments on posts of individual communicators scored higher in the authentic category across both platforms on average. The comment tone scores were similar between individuals and NGOs, but somewhat higher for individual TRPs than NGO TRPs. The comments on both the individual and the NGO communicator posts generally had a similar percentage of personal pronouns, positive emotion words, and negative emotion words across TRPs and IGPs (Table 6).

A larger number of unique social media users (unique as to avoid double-counting) were engaged in conversations on IGPs than TRPs for all communicators (when controlling for number of followers), with the exception of IND1, who had a larger number of unique users engaged in conversations on TRPs than IGPs due to an anomalous TRP (Figure 11). IND2 and IND4 had a larger number of unique users engaged in conversations on IGPs than the other communicators, at 69 and 108 unique users over the month (normalized to 10,000 followers), respectively. The remaining communicators had between 14-30 unique users engaged in conversations on IGPs (normalized to 10,000 followers). There were between 1-6 unique users engaged in conversations over the month on TRPs (per 10,000 followers) for all communicators except IND1 and IND4, who engaged about 30 unique users in conversations over the month. When the number of unique users in conversations is restricted to those that were in conversations with communicators only (and not other users), engagement statistics for each individual communicator are quite similar (e.g., IND3 engagement is similar between Figure 11 and Figure 12), except for IND1 on TRPs. Alternatively, the NGO engagement levels clearly decrease (Figure 12). In other words, users in conversations on the posts of individual communicators mainly interacted with the communicators,

whereas users in conversations on the posts of NGO communicators mainly interacted with other users.

Table 5. Text analysis results from LIWC2015 for Twitter and Instagram comments on communicator posts, July 30-August 26, 2018. Average NGO (ORG) score and average individual (IND) score were calculated for analytic, clout, authentic, and tone categories. See Table 2 for LIWC2015 codes and definitions.

		Analytic	Clout	Authentic	Tone
TRP captions	Average ORG score	60	78	15	73
	Average IND score	57	65	36	88
IGP captions	Average ORG score	62	81	17	98
	Average IND score	53	59	40	95

Table 6. Text analysis results from LIWC2015 for Twitter and Instagram comments on communicator posts, July 30-August 26, 2018. Average percentage of comments that were personal pronoun, positive emotion, and negative emotion words for individuals and NGOs. See Table 2 for LIWC2015 codes and definitions.

		Personal pronouns	Positive emotions	Negative emotions
TRP captions	Average ORG %	7.86	4.76	1.88
	Average IND %	7.58	6.82	1.67
IGP captions	Average ORG %	8.97	7.81	1.35
	Average IND %	9.08	6.77	1.33

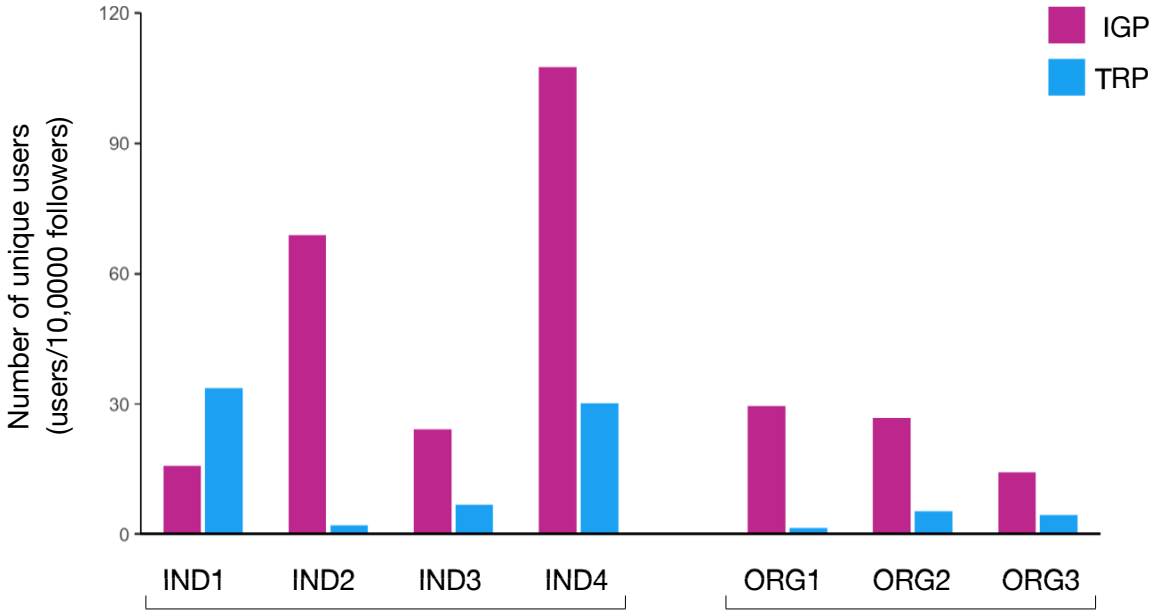

Figure 11. Total number of unique social media users involved in conversations with individuals and NGOs on TRPs and IGPs, July 30-August 26, 2018. These data were normalized to 10,000 followers to aid in data visualization.

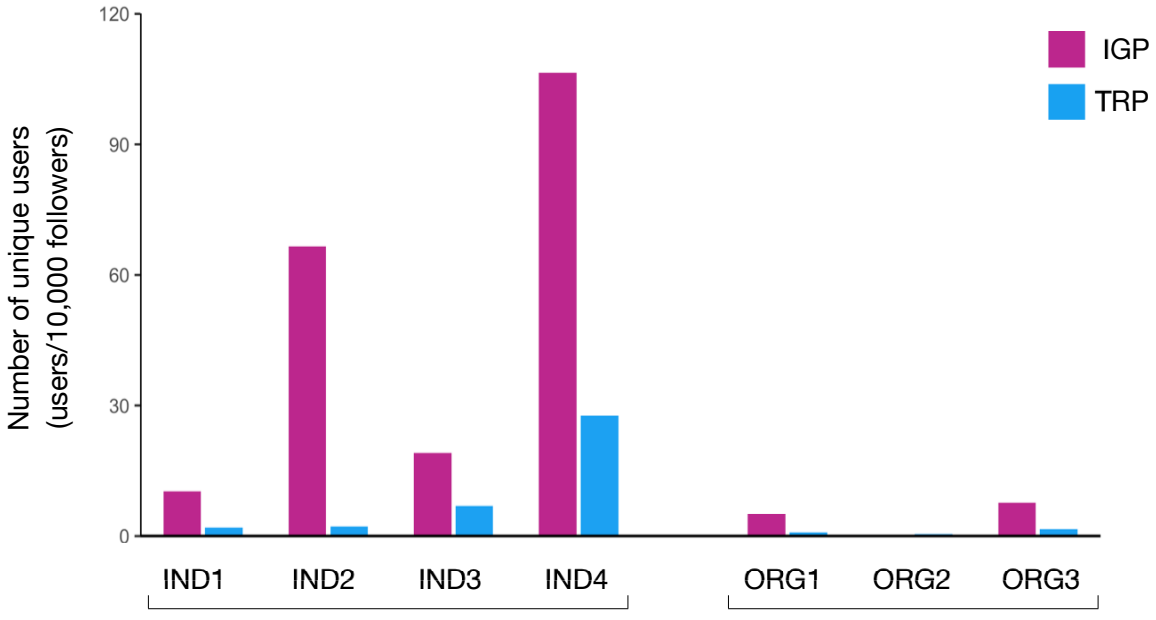

Figure 12. Total number of unique social media users involved in conversations with the communicator on TRPs and IGPs, July 30-August 26, 2018. These data were normalized to 10,000 followers to aid in data visualization.

4.3b The Use of Social Media by "Conversationalists"

Of the 425 social media "conversationalists" invited to complete the survey, 45 responded (for a response rate of 10.6%). Due to constraints that Instagram and Twitter placed on posting the invitation messages (i.e., the number of messages that could be posted from an account, and how users were notified of messages), users who were invited early in the dissemination process may have been more likely to receive the invitation message and respond. Although the relative proportion of respondents for each social media platform was similar to the relative proportion invited for each platform, those who responded due to engagement with individual communicators vs. NGO communicators was different (a higher relative proportion responded for individual communicators than NGO communicators compared to those invited). This difference in responses may be a reflection of those who chose to respond to the survey, but it may also reflect the limitation noted above. Therefore, the survey data are mainly reported in aggregate rather than separating the data received for the individual vs. NGO communicators.

Of the 45 survey respondents, 38 were engaged on posts of the individual communicators during the study period (five from Twitter and 33 from Instagram), and seven were engaged on posts of the NGO communicators (all from Instagram). The majority (62%) of respondents who identified their age were between 19-33 years old, with a smaller proportion (16%) aged 5-18 and aged 34-49 (Table 7). Only two of the survey participants were aged 50 or above. Most of the survey respondents who chose to reveal their gender identified as female (82%), with the remaining users identifying as male (Table 7). The respondents were also highly educated and science-associated overall: 83% of respondents had some level of post-secondary education, and 80% consider themselves part of the scientific community (Table 7). This demographic composition might account for how the survey participants characterized the social media activity of communicators, as discussed below.

The majority of social media "conversationalists" use Twitter (60%) and/or Instagram (98%) (Figure 13). However, four of the five users in conversations on TPRs also use Instagram, but only 22 of the 40 users in conversations on IGPs use Twitter. Furthermore, not all users prefer the same social media platform: for the users that chose

to rank Instagram among their preferred platforms, 66% ranked it as their number one choice, whereas only 21% of users who ranked Twitter among their preferred platforms put it as their first choice (Table 8). Additionally, 98% of the users who ranked Instagram

Table 7. Participant age, gender, level of education, and scientific community association.

Age (n=37)	Number of Participants
5-18	6
19-33	23
34-49	6
50-64	1
65+	1
Gender (n=34)	
Female	28
Male	6
Level of Education (n=36)	
Grade school or high school	6
Post-secondary and above	30
Member of the Scientific Community (n=45)	
Yes	36
No	9

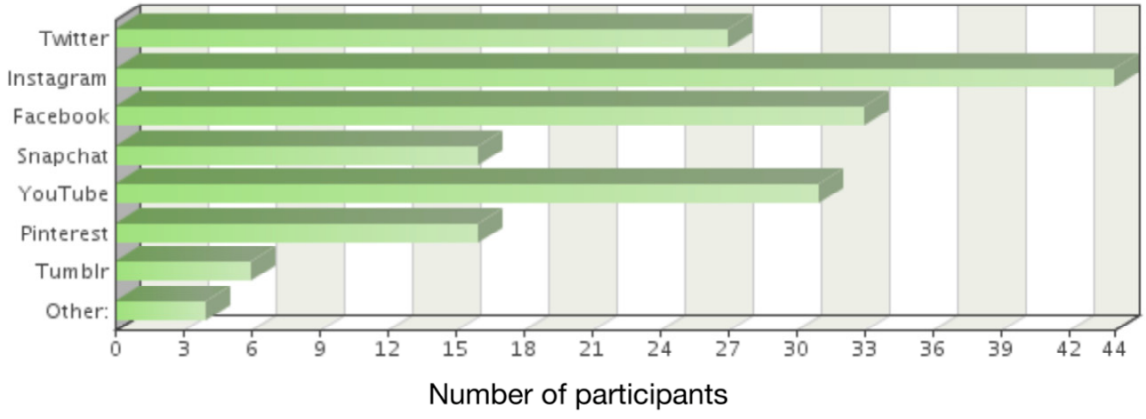

Figure 13. Social media platforms used by survey respondents (N=45).

Table 8. Survey participant platform preferences: ranks for Twitter and Instagram.

Platform Preference - Twitter (n=33)	Number of Participants
First choice	7
Second choice	8
Third choice	10
Platform Preference - Instagram (n=44)	
First choice	29
Second choice	11
Third choice	3

among their preferred platforms put it as their first, second, or third choice. For respondents who use more than one social media platform, 84% indicated that they use different platforms for different purposes (Figure 14). Finally, most of the respondents (91%) use social media in a personal capacity, and just over half (56%) use it in a professional capacity (Figure 15).

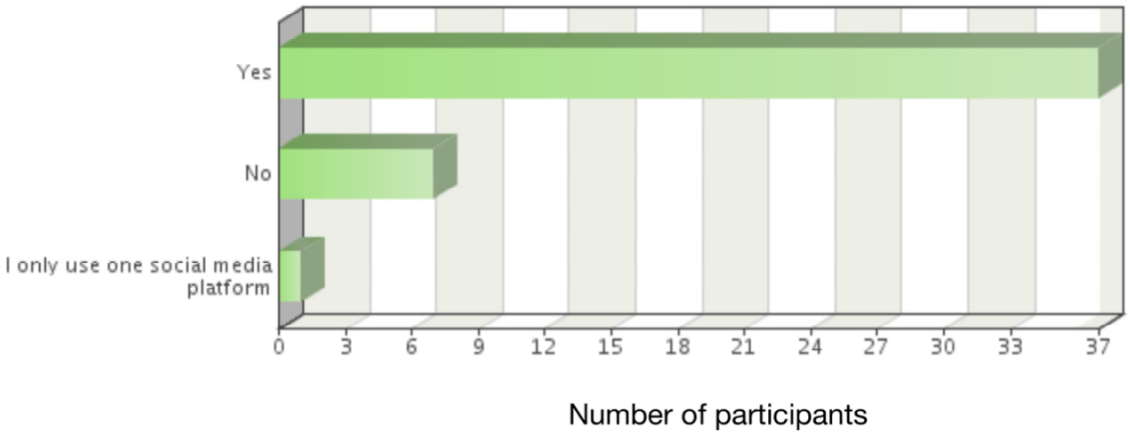

Figure 14. The number of participants who use different social media platforms in different ways (n=45).

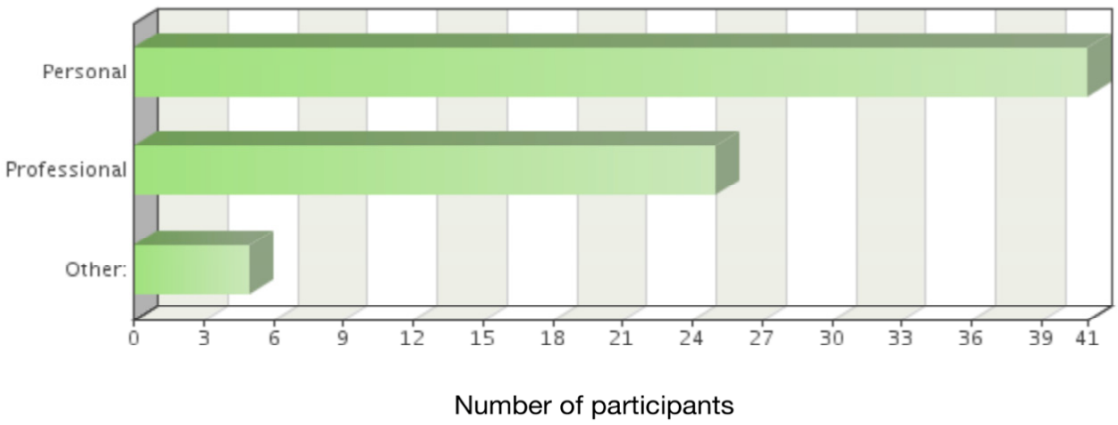

Figure 15. The reasons for which participants use social media (n=45).

Social media conversationalists interact with the communicators and communicator posts in different ways. Most of the users (97%) like to see IGPs from communicators, and a majority (57%) also like to see IGSs (Figure 16). In contrast, only 17% of users like to see TRPs from the communicators. Regardless of platform, 90% of the users like to see mixed media posts (i.e., posts that include some combination of text,

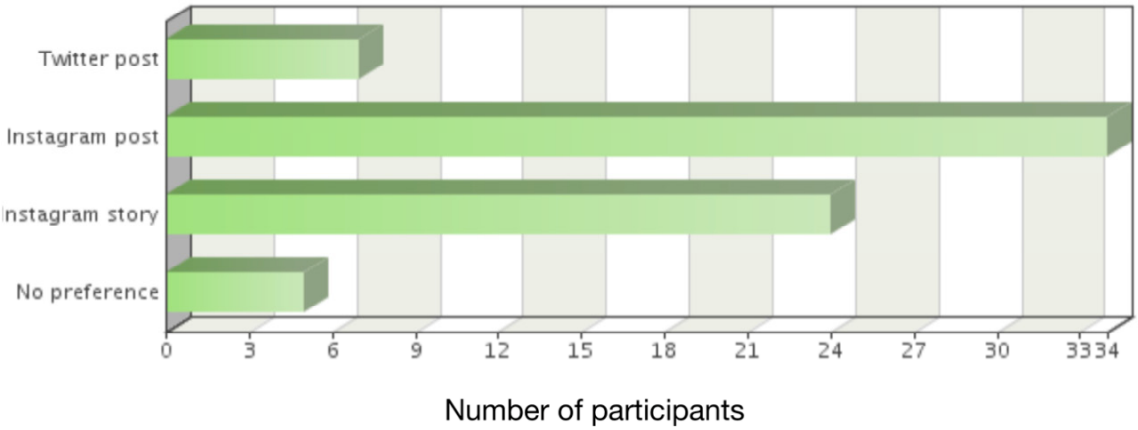

Figure 16. Type of social media posts that participants like to see from communicators (n=42).

images, and videos) from the communicators (Figure 17). The social media users also generally find interactions with posts of the communicators to be a positive experience; not only do 98% of users feel that the communicator posts are easy to understand, but 93% also feel that all or most communicator posts are trustworthy (Figure 18). Furthermore, 45% of social media users feel that they have developed a relationship with the communicator that they were in a conversation with during the study period (Figure 19).

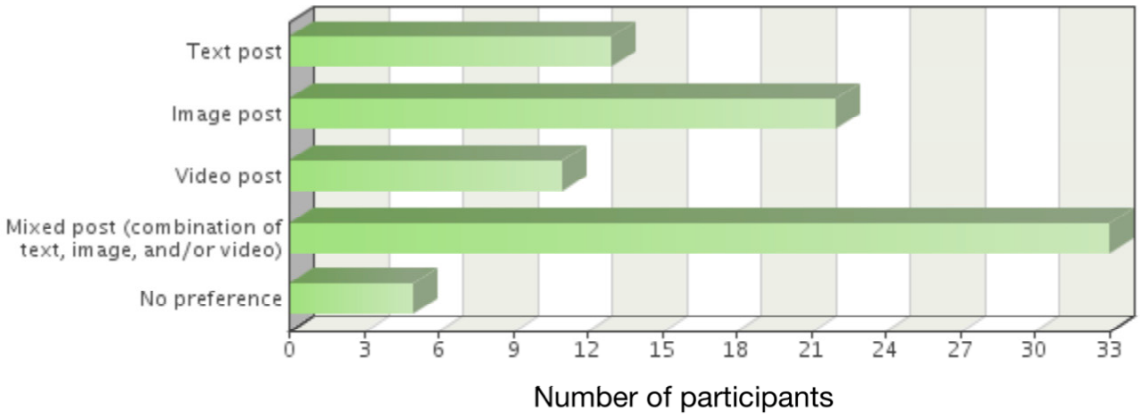

Figure 17. Type of social media posts that participants like to see from communicators (n=42).

Although all survey respondents were in conversations on posts by the communicators during the study period, they tend not to interact with communicator posts very often. In fact, only 13% interact once per week or more, with 39% interacting a few times per month, and 33% of users interacting once a month or less (Table 9). When they do interact, 94% of the respondents use comments to do so, and 26% use direct messages (some use both) (Figure 20). Consistent with the types of posts users like to see from the communicators, 90% of users are more likely to respond to IGPs, while 36% and 18% are more likely to respond to IGSs and TRPs, respectively (Figure 21). A large proportion (56%) of social media users are more likely to respond to social media posts communicated by the individuals than organizations, with 41% being equally likely

to respond to individuals and organizations, and only 3% more likely to respond to organizations than individuals (Figure 22).

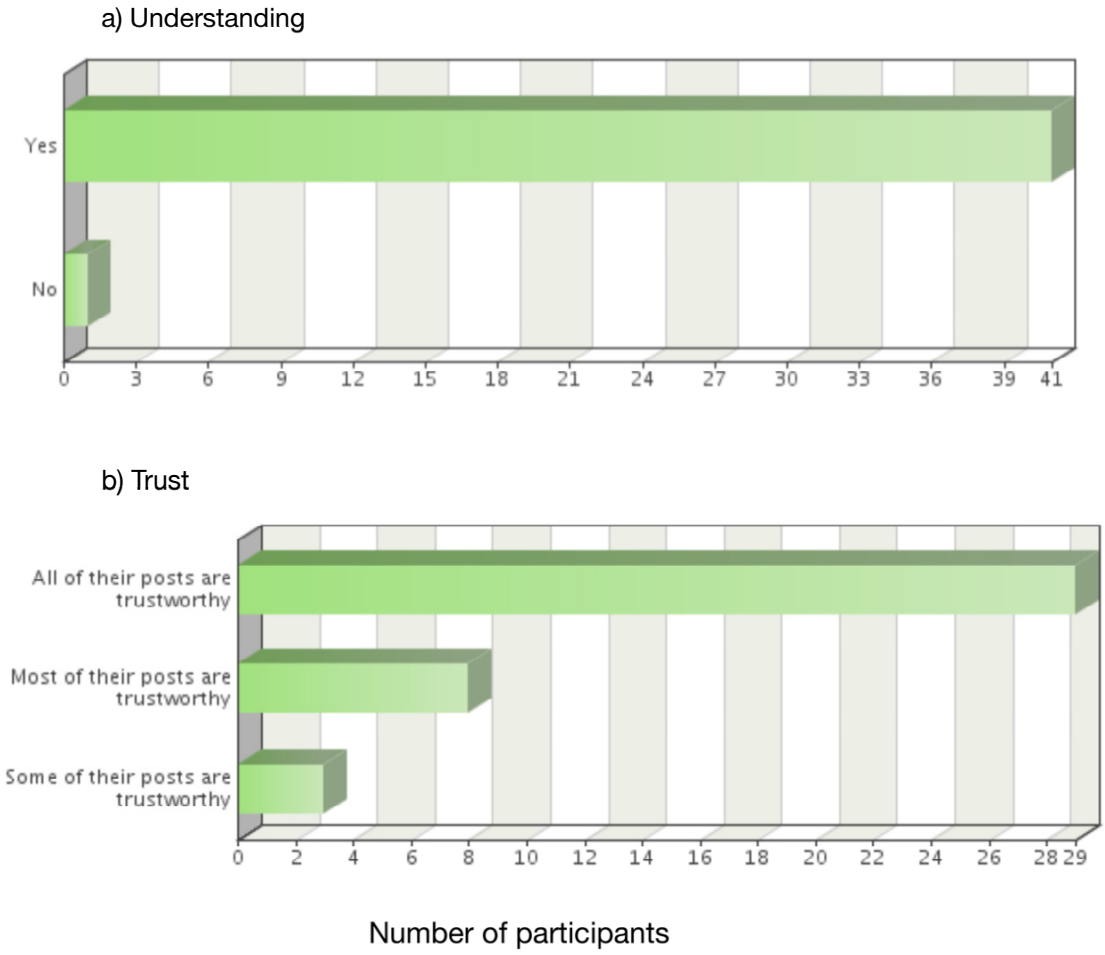

Figure 18. Participant responses to the questions: a) Do you find the communicator's posts easy to understand? (n=42) and b) Do you feel that the communicator's posts are trustworthy? (n=40) Note the different x-axis scale between panel a) and panel b).

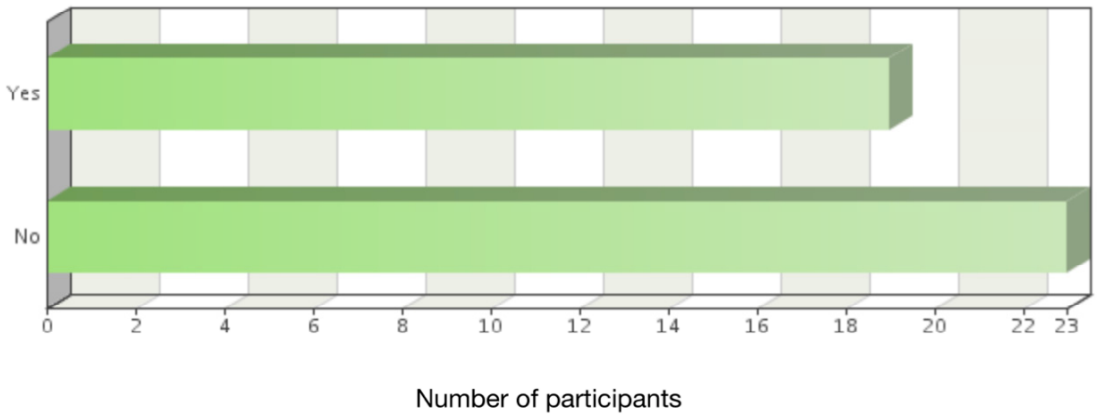

Figure 19. Number of participants who feel they have developed a relationship with the communicator (n=42).

Table 9. Frequency of participant engagement with the communicators.

Frequency of Engagement (n=39)	Number of Participants
More than once per week	5
Once or twice per week	1
A few times per month	15
Once per month or less	13
Other	5

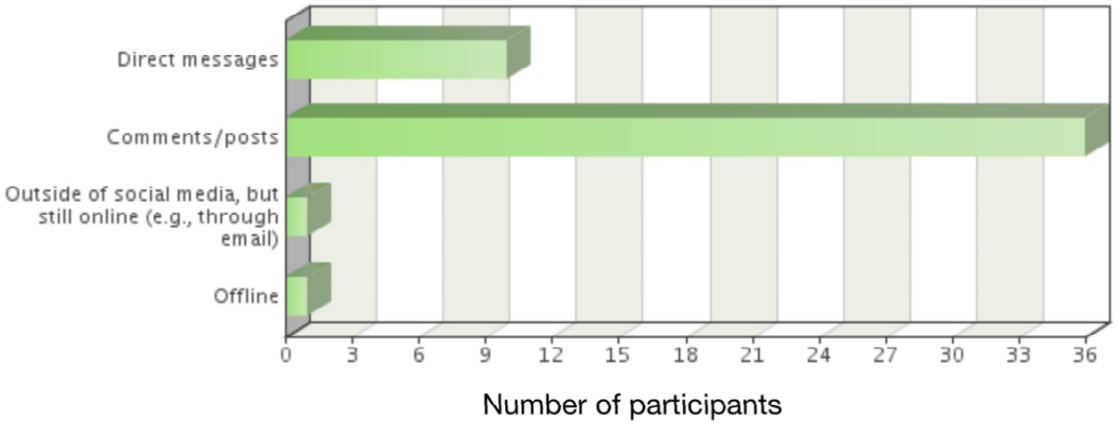

Figure 20. Response methods participants use to reply to communicator posts (n=38).

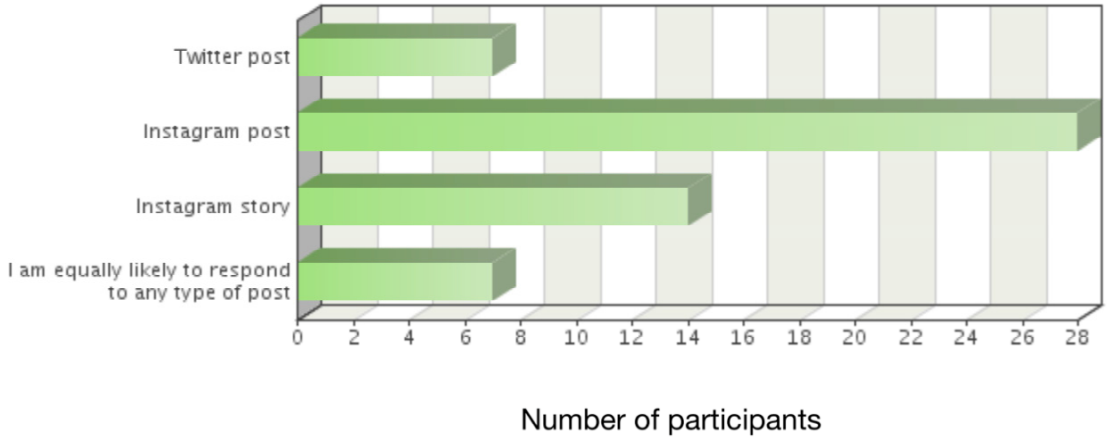

Figure 21. Post types that participants are most likely to respond to (n=39).

The majority of users (94%) feel that the communicators respond to their comments, 50% feel that direct messages generate responses, and only 6% of users feel that they do not receive responses from communicators (Table 10). Two-thirds of the users noted that social media interactions lead to two-way conversations. However, the conversations are mainly short; 27% of conversations with communicators only involve two posts in the conversation, and 68% of conversations include four to six posts in the

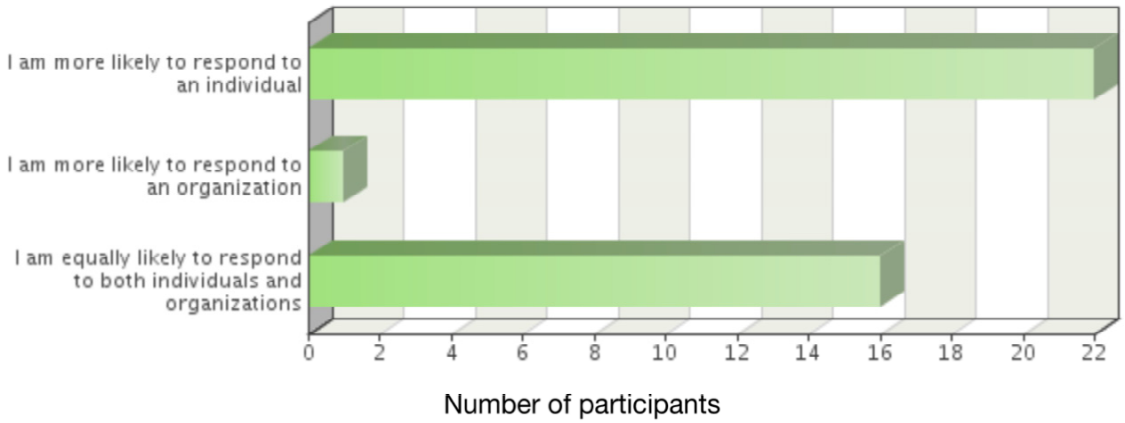

Figure 22. Number of participants who are more likely to respond to individuals vs. organizations, or equally likely to respond to both (n=39).

conversation (Table 10). Furthermore, although 34% of users feel that conversations are better for facilitating learning on social media, 50% feel that both single social media posts and conversations are equally helpful for learning (Table 10). Finally, 72% of social media users participate in conversations with other communicators on social media (Table 10).

A number of the survey respondents chose to supplement their quantitative responses to particular questions with qualitative submissions; these submissions provide insight into why users are commenting and engaged in conversations on posts of the communicators. Social media users that prefer Twitter tend to do so due to its short message length and focus on news/relevant information (Table 11). Users prefer Instagram mainly because of its visual nature, its communication affordances, and its ease of use/functionality (Table 11). Regardless of platform preference, the most cited reasons users are on Twitter relate to work, and to seek out news/information. In contrast, users are mainly on Instagram because of its visual nature, and for personal reasons such as self-expression, relationship-building, and connecting with friends/family (Table 12). Personal sentiments also emerged when the respondents wrote about their motivation for following the account they interacted with during the study; although users follow the

Table 10. Post types that participants receive responses to, typical conversation length, conversations and their usefulness for learning, and whether participants are in conversations with other communicators on social media.

Responses from Communicators (n=36)	**Number of Participants**
Respones to direct messages	18
Responses to comments	34
Responses to questions	20
No response	2
Conversation Length (n=22)	
One post each	6
Two or three posts each	15
Four posts each or more	1
Conversations and Learning (n=22)	
Conversations and single posts are equally helpful for learning	8
Conversations make learning easier	11
Conversations with Other Communicators (n=39)	
Yes	28
No	11

communicators to learn new information, many also do so because they find the communicators (or the communicators' content) relatable (Table 12).

One common theme throughout survey responses was that users feel personally connected with the communicators on social media, and as a result, are more likely to participate in conversations. In addition, users often cited Instagram specifically as a more personal platform. This was expressed by two users when explaining why they prefer to use Instagram, for example, "it seems personal and engaging (photos and captions) but without the threat of things getting out of hand or out of context like on Twitter." Another respondent wrote: "I prefer [Instagram] because it is a 'happy place'.

Table 11. Participant responses explaining their most preferred platform. "n" = number of people who provided a qualitative response regarding their most preferred platform.

Reasons Participants Prefer Twitter (n=7)	**Code Frequency**
Relevant news/information *"I use Twitter for advertising my research as well as keeping up-to-date with others' research and upcoming research/news in my field."*	3
Reasons Participants Prefer Instagram (n=27)	
Communication and outreach *"Instagram is most frequently used as it allows easy and efficient communication with people, businesses and organizations."*	10
Visual content *"I love that images are first and foremost with the caption then complementing this. This way of communicating speaks to me."*	9
Functionality/ease of use *"I like Instagram because it has a really clear and easy to handle design and because it is really intuitive to use … I also really appreciate the experimental stuff Instagram does, like adding Instagram Stories."*	5

People aren't complaining about everything, but rather showcasing the good things." Two of the survey respondents also noted that Instagram is quite conducive to communication: "I'm most active on Instagram and it's easy to make and respond to comments, posts, and stories"; and likewise: "I like explaining science in terms of infographics AND having a conversation. [Instagram] encourages both."

Similarly, when the survey respondents commented about their decisions to respond to individual vs. organization communicators, many did so in terms of personal

Table 12. Participant responses explaining their reasons for using Twitter, Instagram, and for responding to the communicator. "n" = number of people who provided a qualitative response regarding their preferences.

Reasons for Using Twitter (n=15)	**Number of Participants**
News/information *"I use Twitter to get news"*	8
Work	3
Reasons for Using Instagram (n=26)	
Personal *"Instagram helps me express myself."*	9
Multimedia information (text and visual) *"Instagram is photo and short caption/story based."*	5
Reasons for Following the Communicator (n=26)	
Relatability *"It is interesting to read [about a] person who is going through the same [things] in life."*	10
Learn new information *"They have engaging content that I enjoy, and I constantly learn new things from them about grad school. The insight is really interesting and important to me"*	8

connections, authenticity, and knowing who is behind the account (Table 13). Users mainly cited personal sentiments as their reason to respond to individuals rather than organizations, for example, “for me it is easier to contact a person instead of an organization with 'unknown faces' behind it.” Similarly, one user wrote: “responding to one person feels more comfortable to me,” and another user commented: “organizations can sometimes feel less personal.” One survey respondent also described a sense of comfort in responding to organizations that are comprised of known individuals, “I use social media for work so I know there are ‘individuals’ behind the organisation. So I think it’s equally important to respond to both. However if I didn’t know the organisation, then I would be less likely to reply than if it was an unknown individual.”

When queried about establishing relationships with communicators, 24 respondents chose to add qualitative explanations, and 13 of these users—both those that do and do not feel that they have formed relationships with the communicator—commented in terms of two-way conversations. One user does not feel that they have had

Table 13. Participant responses explaining their reasons for responding to communicators. “n” = number of people who provided a qualitative response regarding their preferences.

Why Participants Respond to Communicators (n=19)	Number of Participants
Personal connection *“I just feel that I engage better with a single person rather than an organization.”*	5
Know the person behind the account *“[I] prefer to know the person I’m engaging with.”*	4
Communicator is authentic *“An individual is more likely to respond authentically.”*	3

an opportunity to form a relationship, because no direct interactions have taken place: “I don't think [the communicator has] ever responded to anything I've said on their post, responded to one of my posts, or anything of the like. It's impossible to feel any link if it's not reciprocal.” In contrast, users that were able to form relationships emphasized dialogic interactions: “we have commented back and forth to each other as well as [direct messaged] in the past!” Two other users expressed similar comments: “we talk in private as well as I do with my friends”; and: “I often message [them] if I need to know anything about being in academia, because I am new to it and [they are] really helpful.” One user also stressed that the way posts are shared on social media is crucial, and can even result in a relationship-type connection in the absence of direct interactions:

> We don’t talk, but their welcoming demeanor and friendliness makes learning science personal. It feels like engaging with a friend. Their method of communication makes science a more fun and accessible conversation. You feel like you are involved, and you can always put forth your input without judgement—something that is super important because science can appear condescending to a lot of people. It’s constant learning and that’s all that matters.

The individual and NGO communicators also provided impressions of the engagement they receive on their social media posts. The representatives of the NGOs all said that they see more engagement from their audiences on Instagram than on Twitter, including both direct messages and comments. For example, ORG2 said that on “Instagram [they] certainly do see people comment more heavily than on [their] other social platforms.” ORG3 also noted a disparity in engagement between platforms: “no, [engagement is] totally different. People … [direct message] us way more, by a crazy margin on Instagram.” One NGO even feels that more engagement occurs on Instagram despite having a smaller audience on the platform:

> Typically I’m finding that there’s just a lot more engagement with the stuff that’s on Instagram, even though there … [are fewer] followers. Like we tend to have … just as many, if not more … actual interactions with the material that goes up on

> Instagram than we do on Twitter and Facebook, even though there are probably five times the followers on each of those other [platforms]. (ORG1)

In the case of ORG3, "every single Instagram story … [gets] tons of responses," and "brand to brand, Instagram's engagement is really growing." ORG3 suggested the following to explain Instagram engagement:

> On Instagram there seems to be … a strange community where people feel more – even though there's individual accounts that feel so private … people are so much more likely to … reach out via [direct message] and talk to a stranger … it's definitely a place where people feel more comfortable tagging their friends on posts, commenting on posts, and also [direct messaging]. We just get so many [direct messages] on Instagram … I think it's just that it's more accepted … everybody does it. It feels like a safe space.

The individual communicators also feel that they receive more engagement on Instagram than Twitter, and by a wide margin. IND4, for example, stated: "yeah, a lot more on Instagram, it's definitely more interactive on Instagram than it is on Twitter." IND3 also expressed a similar view: "way more on Instagram, by far." Two of the individual communicators spoke about why they think more engagement happens on Instagram. IND3 thought visibility was a factor: "I … just think visibility-wise, far more people see my Instagram posts, and in general Instagram posts have a larger half-life, longer half-life." IND1 provided a more detailed assessment on Instagram engagement:

> Definitely Instagram posts get most comments, and conversations, and thoughtful conversations. On Twitter it will just be more retweets … it's not so much asking questions. It happens, but it's much … [rarer] on Twitter. Whereas, on Instagram, people can have these long, thought out questions, or comments … I think just the platform encourages it. Twitter doesn't seem like a place to have a conversation. If you're having a conversation on Twitter I think it often just evolves into a screaming match. Just because it's so short. (IND1)

IND2 thinks that although "Twitter is more of a discussion platform than Instagram" currently, Instagram is "heading in the direction of having … impact as a science communication platform," and Instagram is still growing. In IND2's view, "we're kind of in the middle of the road, we're not at the end yet."

All of the communicators receive direct messages regularly, but typically in equal or fewer number than comments on posts. Fewer direct messages than comments are received by ORG2, whereas ORG1 receives a similar number of direct messages and comments. Users typically send NGOs direct messages in response to IGSs. As ORG1 stated: "we get quite a few direct messages on the stories, which is interesting and something I've been recognizing lately is that that seems to be a thing." The NGO audiences also frequently initiate conversations using direct messages (ORG1, ORG3). For example:

> In terms of [direct messages], we get [them] everyday … But again, often times I would say the bulk of our [direct messages] are people, sharing a picture or an article with us, being like, "Oh my gosh, this is terrible, how can you help? What are you guys doing about this?" … So mostly it's people trying to make us aware of an issue that they feel like we're not paying attention to. (ORG3)

The individual communicators said that although they receive direct messages regularly, the frequency varies depending on how active the communicators are and what is being posted on social media (IND1, IND2, IND3, IND4). Additionally, multiple individuals stated that direct messages can be lower quality than comments, as they do not always relate to what communicators share on social media (IND1, IND2).

The NGO communicators said that most of the comments they receive on social media tend to be in response to emotional content. For example, ORG2 noted: "certainly I mean this will often deal with a post related to a campaign or issue that our users will find particularly interesting, concerning, [or when] you have something that's going to

stoke some form of emotional response." The representative of one NGO also noted emotional engagement from users:

> I think the thing that tends to engage people the most is … if there's something that's an active and hot [topic], and we're lending a voice to that issue, then those tend to be the ones that pick up most of the conversation … it's mostly the stuff that's active, and people want to express opinions about … That's most of what we tend to get from what I've seen. (ORG1)

For another NGO, seeing an emotional response from their audience means audience members are engaged with a particular issue:

> Let's say a species has … been added to the endangered list — I'm just using … a random example. People are outraged … "what do you mean this animal's endangered now?" … I find that the conversation only really happens around something very terrible … But, when something really terrible happens … people [say], "Why is this happening?" Or, "What can we do?" And that's great conversation. We love when people ask, "What can I do to help?" (ORG3)

The individual communicators also tend to see more engagement on emotional posts, but unlike NGOs, the sentiment is typically more positive and often relates to a personal experience. For example, IND2 commented on a recent interaction:

> I posted a couple of days ago … a picture for my birthday and I got a lot of comments on that. But also if I share a personal story about a certain topic then … I sometimes see more interaction as people say like, "Ok, I've been in this same situation, you're completely right," or "I feel motivated because of this story." (IND2)

One individual outlined the personal and emotional engagement of users in more detail:

> For example … my most successful posts [are] always hitting an anniversary, like a milestone on Instagram, a birthday, but … those are congratulatory engagements. The ones where I … shared presenting my poster at a conference … because it was personal, but then I also gave them some scientific information about what the poster was about, what a poster even is … that got a ton of engagements, because people were so fascinated. So I think that people are very fascinated with people online. I don't think I'm particularly interesting, I just think in general we're very fascinated by people. So when you have that personal angle, and you reveal something about yourself, and then I'm also giving education broadly about science, people seem to love it, and I love that too so I get it … it's not me, I'm pretty boring … we [just] love to people watch. (IND3)

IND3 also pointed out that the informal nature of Instagram invites conversation.

During the interviews, the NGO communicators said that conversations with their audiences on social media tend to be relatively short (ORG1, ORG2). The individual communicators said that the conversations they participate in are also generally short, but that the exchanges are often constructive, and can sometimes grow into longer, more thoughtful discussions. IND1 described this experience as follows: "I think that they're typically shorter … But sometimes, depending on the post, someone will say, 'Huh, interesting, this makes me think "x," "y," and "z."' And then I'll respond to that and then they can generate conversation." IND4 also spoke on the brevity of conversations:

> Most of the time they're not very long. They'll reply to my post, I'll obviously do the thank you, reply to anything that they've asked me, and then add a question at the end, which I usually get an answer to. So it's probably normally like the three or four, sort of thread length. But you do sometimes get more of a debate going, but that's [rarer] I would say. (IND4)

One individual communicator noted that although typical conversations on social media posts might be short, the conversations extend far beyond single posts:

> Oh my gosh, they're ongoing. They're very ongoing. There are many examples of people messaging me to ask for advice … and [they] almost always they follow up. So I had one woman applying to a … program, and we actually even met in person because she happened to be visiting, and we exchanged some advice and conversation. And a year later she followed up and let me know she got into the program … and we had been chatting in the interim, but not so much. But many times people will follow up and let me know how it went, and say thank you, and say, "Oh I also learned this, you can tell people that next time" … So now we've turned a one-time interaction into a long-term resource, which I think is cool. (IND3)

Because sparking conversations on social media is a priority for both the NGOs and individuals, the communicators have adopted numerous strategies to encourage conversations on their posts. First, a representative of one NGO stated that applying an overall social media strategy that encourages conversations is important, as getting audience members to participate in conversations is often a challenge (ORG3). All of the communicators also agreed that it is important to post interesting content that is fun and entertaining for their audiences. Third, most of the communicators often include a call to action in their posts, or end their posts by posing a question to the audience. Finally, as discussed several times above, the individual communicators focus on presenting personal content that invites audience engagement, which was highlighted by IND2:

> I think [it's] very important as a science communicator, that you're accessible to people. Both accessible and approachable. Because you can be accessible, but if you're not approachable, you kind of have a problem … So therefore I try to really do everything from a personal perspective and organically, rather than focus on this type might work, or that type might not work. Every post might be valuable to at least one follower … so why not post it?

4.4 Audience Analysis

Of the 425 conversationalists invited to complete the survey (i.e., the social media users engaged in conversations on posts of the communicators during the study period), 32% self-identified as scientists in their social media biographies. Between 42-100% of social media users who participated in conversations on posts of individual communicators self-identify as scientists on social media (Figure 23); in contrast, only 0-22% of conversationalists engaged with NGO communicators self-identify as scientists in their social media biographies. Furthermore, between 19-57% more conversationalists on Twitter self-identify as scientists than on Instagram (excluding users engaged on posts of IND1).

All of the communicators spoke about their social media audiences and who they try to reach with their communication activities. The communicators described their Twitter audiences as generally comprised of users who are more familiar with or educated on the information the communicators share, such as decision-makers, academics, and politicians (ORG1, ORG2, ORG3, IND2, IND4). In contrast, all of the

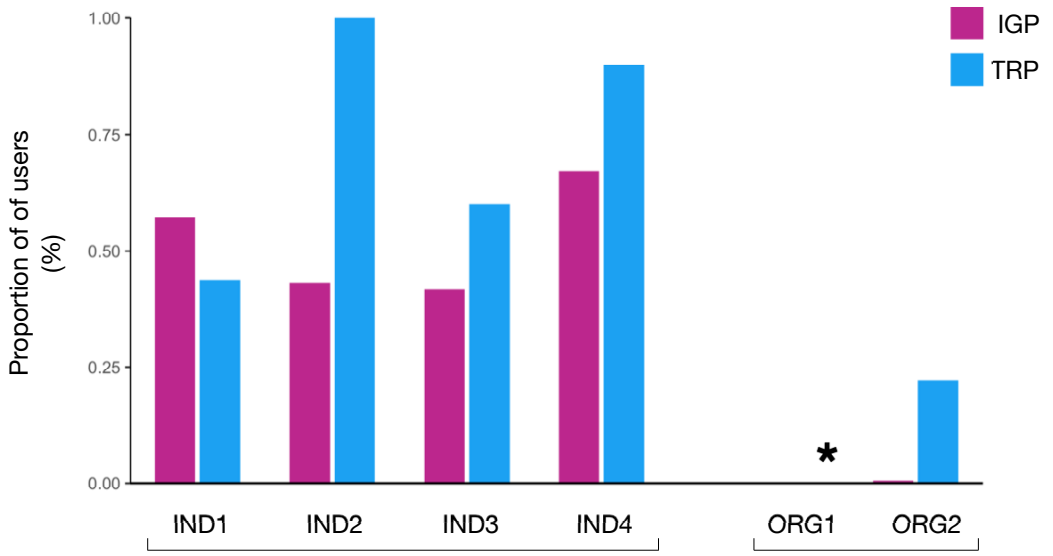

Figure 23. Proportion of users invited to the survey that self-identify as scientists in their social media profiles for individuals and NGOs across TRPs and IGPs. *No Twitter users were invited to the survey for ORG1. ORG3 requested its audience not be surveyed, and therefore ORG3 was excluded from the audience analysis.

communicators stated that Instagram tends to attract a larger lay audience than Twitter. Additionally, the communicators said that Instagram users are generally younger and largely female (IND1, IND4, ORG3). The communicators feel that the difference in Twitter and Instagram audiences is a result of demographic differences between the two platforms.

The target social media audiences for the NGOs are diverse. One NGO interviewee stated that the audiences they try to reach are platform-specific, with their Instagram feed "definitely targeting a much more general audience" (ORG1). Furthermore, ORG1 explained that with Twitter, where multiple accounts are used, the priority audience is different for each account. Audiences that communicators are trying to reach can be quite specific, as ORG2 said that they "really [vary] depending on the post," with some posts aimed at particular users, and others intended for a majority of followers (ORG2). Nonetheless, all of the NGOs use social media to expand their audiences and bring new members into the organization. Overall, the individual communicators hope to be inclusive in their social media efforts, not necessarily limiting their communications to specific groups. For example, IND2 claimed: "I communicate for everyone who is interested." However, the individual communicators do tend to give attention to reaching non-scientific/public audiences and/or those who are not typically the focus of science communication. As IND4 noted: "yeah, it's something I'm looking to branch into more [is] trying to reach a non-scientist audience." The other individual communicators are similarly motivated. "Yes … I really hope that I also target these people," IND2 stated, "because this is also kind of one of the reasons why you do science communication is to inform everyone. If you would only inform the scientist … what would be the point?" IND3 exclaimed: "I'm passionate about reaching people who might be excluded from STEM conversations."

4.5 Dataset Integration

This chapter has presented results from four different datasets: quantitative social media data regarding the seven communicators' social media activity and dialogic engagement; qualitative interview data related to social media motivations, strategies, and challenges for the seven communicators; quantitative and qualitative data contributed by

conversationalists regarding their participation in conversations; and quantitative audience analysis data based on social media "biographies" of conversationalists. The Discussion chapter, which follows, integrates these datasets in order to provide a holistic understanding of the relationship between the social media strategies employed by communicators and audience engagement.

Chapter 5: Discussion

This chapter integrates consideration of the study results by making three main comparisons: 1) the social media strategies of the seven communicators compared to the quantitative social media observations, 2) the social media strategy-engagement relationships observed in this study and how they compare to previous research, and 3) consistencies between the strategies employed by communicators and the factors motivating conversationalists (i.e., users who were engaged in conversations on posts by the individual or NGO communicators) to participate in social media conversations. Through these comparisons it is possible to assess the translation of social media strategies into the practices of the communicators, explore whether the results of this study are in agreement with previous findings, and determine whether the strategies used by communicators are successfully encouraging dialogic interactions with social media audiences. The following sections illustrate connections between communicator social media strategies and two-way engagement with lay audiences, highlighting the prominent role of interpersonal communication strategies in promoting online dialogues.

5.1 Communicating Science Effectively on Social Media

The individual and NGO communicators share numerous goals that motivate their social media use. All of the communicators strive to be prominent voices on social media, and hope to use their influence to build capacity, engender critical thinking, and inspire positive behaviour changes (see sections 4.1b and 4.2e). Both the individual and NGO communicators also have a clear-cut objective to encourage two-way conversations and establish relationships with their audience (section 4.2g). Furthermore, the communicators are focused on reaching social media users outside of the scientific community, and those for whom science information is traditionally inaccessible (sections 4.1a and 4.1b). Therefore, because some communication goals are shared between the individual and NGO communicators in this study, but each communicator group faces unique constraints on social media, a comparison of social media strategies and engagement between the two groups is important.

All of the NGO communicators expressed the view that social media are a key tool for fundraising, outreach, and building continuous, controlled brand awareness online (section 4.1b) – similar to what has been reported for NGOs internationally (Cox & Pezzullo, 2016; Nonprofit Tech for Good, 2018). The NGOs are also aware of the demonstrated demand for scientific information and other news on social media (section 4.1a; e.g., Cox & Pezzullo, 2016; Hitlin & Olmstead, 2018; Weiss et al., 2008), and are working to capitalize on their top performing platforms to educate and mobilize their audience (section 4.2e). During interviews the NGO representatives demonstrated that their organizations recognize the need for effective communication on social media, as the interviewees generally provided thoughtful and clearly intentioned responses regarding the social media efforts of their organizations (particularly for the larger NGOs). Because the NGOs see their participation in social media activities as an organizational necessity to demonstrate environmental leadership on issues of concern for citizens and gain citizen support to complete their work, and because the NGOs are evidence-based organizations working to positively impact critical marine policy issues through advocacy (e.g., through calls to action), it is crucial that they are able to communicate research effectively using social media.

The individual communicators are also aware of the demand for science information on social media, but are looking to capitalize on social media influence and reach affordances (i.e., potential number of readers/viewers) to redefine the meaning of science communication in terms of best practice (section 4.1b). For the individuals—who are not constrained by organizational rules—this means counteracting science stereotypes; building awareness of the methodological, political, environmental, and social systems in which science is situated; making science accessible to diverse audiences; and focusing on personal engagement strategies, such as portraying scientists as people with whom relationships can be formed, rather than strictly institutional knowledge-holders (section 4.1b). Because the individual communicators are asserting themselves as models for this new definition of science communication, the techniques that they utilize for science communication on social media are significant. If effective, the individuals will move closer to their goal of developing new best practices in science communication; if ineffective, the individual communicator efforts may be cited as

another missed opportunity to utilize social media as a tool for dialogic science communication (e.g., Bortree & Seltzer, 2009).

5.2 Activity-Related Social Media Strategies

A set of the social media strategies employed by the communicators were not content-related, but instead linked to posting frequency, platform use, and/or media use. Strategies of this variety are hereafter referred to as "activity-related" social media strategies, and are discussed below.

5.2a Post Frequency

The NGO communicators utilize activity-related social media strategies to maintain posting behaviours that are consistent with implicitly accepted social media practices (i.e., universally understood social media conventions), as well as more explicit organization goals. The NGOs strive to post on social media at regularly scheduled intervals, while remaining flexible to react when necessary. This approach allows the NGOs to share high quality information that is well-researched and backed by evidence, while still giving the organizations an opportunity to share topical content and insert themselves into the social media "conversation" around breaking news or unexpected events related to their work (e.g., an interesting animal encounter) (section 4.2a). In practice, ORG1 and ORG3 post on social media at rates similar to those reported by other NGOs (section 4.2a; Nonprofit Tech for Good, 2018). ORG2, however, posts on Twitter and Instagram at much higher rates than are typical for NGOs because it "seems to be the most effective" in terms of encouraging engagement (Nonprofit Tech for Good, 2018; section 4.2a, page 28).

The individual communicators post in a less scheduled manner than the NGOs, mainly posting when they feel inspired to (section 4.2a). IND3 and IND4 post at similar rates to ORG1 and ORG3, but IND1 and IND2 post half as often (or less) (Figure 2). For the individuals, posting frequency is not as important as post quality. The individual communicators typically post based on more mentally "dynamic" factors (e.g., creativity, curiosity, inspiration, interest), and consequently do not feel motivated to post at high frequencies, a strategy which the individuals find to be overexerting or time consuming

(sections 4.1b and 4.2a). Although the individual communicators did not discuss whether posting at high frequencies is an effective engagement strategy (other than ensuring the time between posts is not excessive, e.g., weeks), the individuals did mention that the excitement/passion they are able to convey when posting based on inspiration can be quite engaging for the audience (section 4.2e).

Previous research has shown that posting frequency has a positive effect on post likes, specifically for organizations (e.g., Balan, 2017). Nonetheless, the results of this study do not support a positive link between posting frequency and number of comments or conversationalists. When controlling for follower count, ORG2—which posts far more frequently than the other communicators—receives fewer comments than the other communicators, and is in conversations with fewer unique users than the other communicators (Figure 2; Figure 9; Figure 12). Similarly, IND1 and IND2 post less frequently than the other communicators, but do not receive lower engagement in terms of user comments or unique conversationalists (Figure 2; Figure 9; Figure 12). Therefore, post frequency does not appear to affect comment or conversation engagement levels (hereafter referred to collectively as "engagement") for the seven science communicators in this study. Because all of the communicators are posting on social media frequently (i.e., multiple times per week), they may all be above the particular threshold where post frequency becomes less important in determining engagement. Moreover, sharing relevant and timely content on social media has been shown to encourage discussions (Bortree & Seltzer, 2009), and all of the communicators expressed the importance of posting timely and relevant content. Therefore, post frequency in combination with post timeliness might be a more important strategy to motivate social media engagement with science information rather than frequency alone.

5.2b Platform Conventions

All seven of the communicators have an informed understanding of implicitly accepted practices on social media, both as a whole, and for each platform (section 4.2b). Accepted social media conventions for both Twitter and Instagram play an important role in dictating the social media strategies apply by the communicators (section 4.2b). In other words, all of the communicators recognize that to be an effective science

communicator on social media, one must adhere to the common platform practices that have emerged on each platform over time. Many of the accepted platform practices outlined by the individual and NGO communicators during the interviews were echoed in the platform expectations expressed by the survey participants. For example, both the communicators and the conversationalists noted that Twitter tends to attract a more educated and/or issue-cognizant audience seeking out news-centric posts, and that Instagram draws a larger general/lay audience seeking out more personal multimedia posts (see sections 4.2b, 4.3b, and 4.4). The observed social media behaviour of both the individual and NGO communicators is consistent with accepted platform practices that were highlighted during the interviews. For example, the communicators primarily share informal content (such as selfies or off-topic posts) on Instagram rather than Twitter, consistent with conversationalist expectations (Figure 5 and Figure 6; Table 12). Similarly, the communicators include substantial text captions with images on Instagram posts (IGPs)—a platform convention related to Instagram's "multimedia" nature (Figure 5 to Figure 7; section 4.3b; Table 12). The observed link between communicators and conversationalists understanding of platform "norms" illustrates the necessity for science communicators to become familiar with the accepted practices for platforms on which they are communicating. This adherence to platform conventions will ensure science communicator posts remain consistent with social media user expectations.

5.2c Platform Priorities

As expressed during the interviews, some of the communicators have platform priorities, while others do not (section 4.2b). The communicators who indicated a priority platform cited a mix of content output (i.e., posting) and content input (i.e., engagement) affordances that motivate communicator efforts toward a particular platform. Therefore, social media strategies that encourage engagement are not the sole focus for science communicators. The NGO and individual communicators do not prioritize the same platforms in their social media activity, both in the case of intended strategies, and strategies that are translated into posting practices. ORG2 prefers Instagram over Twitter, as Instagram is more aligned with the organization's overall goals (section 4.2b). ORG1 and ORG3 does not have clear platform preferences (section 4.2b). Nevertheless, based

on the social media observations (in this case, post frequency), all NGOs prioritize posting on Twitter over Instagram (posts and stories) (Figure 2). For ORG2, this practice is not consistent with its preferred platform as noted during the interview (section 4.2b). The individual communicators all prefer Instagram—especially IGSs—and prioritize IGSs in practice (section 4.2b; Figure 2). Although platform prioritization was not explicitly discussed by the communicators in terms of platform affordances as related to communication goals, this theme emerged during the data integration. For example, the dominant use of Twitter over Instagram (especially over Instagram stories (IGSs)) by the NGOs does not correspond with central NGO communication goals in relation to Instagram affordances (e.g., the sharing of personal content, section 4.2e). In contrast, the strategy to prioritize Instagram by individual communicators is not only consistent with their platform preferences, but also with affordances in relation to their communication goals. This theme is discussed in more detail in a later section, as it typically relates to post content, but is still highly relevant for effective science communication.

There does not appear to be a connection between platform priority in practice (i.e., the platform posted to most frequently) and engagement for the NGOs, as all of the NGOs receive more engagement on IGPs than Twitter posts (TRPs) (Figure 9, Figure 11 to 12). This outcome indicates a potential mismatch between NGO practice of prioritizing TRPs, and engagement opportunity (which, based on social media observations, appears to be greater on Instagram). The higher levels of engagement observed on Instagram relative to Twitter for most communicators may be explained by the fact that social media users prefer Instagram over Twitter for interacting with other users (see section 4.3b). Although this result might be expected from the survey, as the majority of survey respondents were invited based on their participation in conversations on Instagram, Instagram users in general—especially younger audiences—are highly active, and may be more predisposed to engage with social media posts than Twitter users (section 4.3b; Gruzd et al., 2018; Smith & Anderson, 2018). These results suggest that Instagram is a more effective platform for engaging in science conversations, and could be selected by science communicators as the platform to encourage science engagement on social media.

5.2d Media Types

All of the communicators post text, images, and videos on social media in accordance with accepted social media practices discussed above (section 4.2c). The individuals and the NGOs include text in all posts, images in most posts, and videos in a smaller fraction of posts (Figure 3). Although there are no major differences in the frequency with which the two groups of communicators use different media types, individuals do post longer text captions than NGOs on Instagram. In addition, the individual communicators do not use Twitter to post videos, whereas two of the three NGOs do (Figure 3). The individuals did not discuss their reasoning for omitting videos from TRPs, but based on the above discussion, it is likely motivated by one of two strategies (or both strategies in combination). The individuals may not post videos on TRPs simply because Instagram is their priority. Alternatively, perhaps the individual communicators are adapting their posting behaviour to evolving platform conventions, and the NGOs have been slower to adjust to such changes. Moreover, as discussed in the next sections, the type of videos posted by the two groups of communicators differ, and thus the strategy of individual communicators to exclude videos from TRPs might again relate to platform affordances. Regardless, it is clearly essential to utilize mixed media across all platforms when communicating science, as mixed media posts appear to be heavily favoured by social media users (particularly Instagram users) (Figure 17; Table 12).

Text-heavy posts have been shown to receive lower engagement than image or video posts, but the individual communicators—who post longer text captions than the NGOs on Instagram—still receive more engagement than the NGOs on Instagram (Fauville et al., 2015; Hitlin & Olmstead, 2018). However, consistent with previous research, all communicators post the majority of their videos and receive most of their engagement on Instagram (Fauville et al., 2015; Hitlin & Olmstead, 2018). Based on these results, and the discussion below, the way in which media are communicated in social media posts may play a greater role in determining engagement with science communicators than simply the presence/absence of particular media types.

5.3 Interpersonal Social Media Strategies

All seven of the communicators aim to integrate interpersonal strategies into their social media activities. First, the communicators recognize the need to make their science and policy content fun, entertaining, and interactive for their audiences (section 4.2e). Second, the individuals and the NGOs are aware of the pitfalls of the deficit-model of communication where audience members are treated as passive receivers of information, and therefore the communicators strive for two-way interactive learning (section 4.2e). Third, authenticity and trust are key concerns for communicators on social media (section 4.2e). Fourth, each communicator attempts to incorporate a human element into their social media activity, working to connect with their audience on a personal level and ultimately form communicator-audience relationships (CARs) (sections 4.2e and 4.2g). Because interpersonal strategies were present throughout the quantitative and qualitative data, the next sections present a comparison of the intended vs. implemented interpersonal strategies first, and discussion of the results in relation to the literature in a later section.

5.3a Non-Dialogic Strategies

A number of the interpersonal communication strategies employed by the communicators are non-conversational, with no direct interactions taking place between the communicators and audience members. Multiple communicators stated that humanizing social media content is an important strategy to establish personal connections with audiences (section 4.2e). All of the communicators defined humanization in slightly different terms (and utilized slightly different methods to humanize content), but portraying a recognizable face in communication content emerged as a theme. For representatives from ORG1 and ORG3, part of methods used to humanize their organizations involved displaying images of scientists or other staff members in social media posts (section 4.2d). For the NGOs, this portrayal of a person in posts allows audience members to become familiar with people working in the organization (section 4.2d). The interviewees representing ORG1 and ORG3 also stated that posting selfies and humanizing their organizations is one of their biggest social media challenges (section 4.2d). Unlike the other NGOs, ORG2 does not aim to use selfies as a social media

strategy. In practice, ORG1 and ORG3 include selfies in a small fraction of their posts, whereas ORG2 does not post any selfies on social media (Figure 5). For the individuals, selfies are a key means of humanizing scientists and displaying a face with which users can become comfortable (section 4.2d). The individual communicators use selfies to convey authenticity and encourage/invite their audience to engage with them (section 4.2d). These strategies are represented in the social media activity of individual communicators, who utilize selfies far more frequently than the NGOs (Figure 5). Additionally, selfie-style videos are an important component of selfies for the individuals, who speak directly to their camera to convey a sense of speaking directly to their audience. The individuals feel that these videos are especially effective for communicating on a personal level and establishing CARs (section 4.2c). Selfie-style videos are obviously being implemented as a social media strategy by the individual communicators, as a substantial proportion of their video posts include selfie-style audio (Figure 4). In contrast, the NGO communicators rarely use selfie-style audio in their video posts, generally opting for no audio or music-based audio (Figure 4).

Another set of non-conversational interpersonal communication strategies used by the communicators is linked to the social media topics that they post about. Although audience education on social media is an important NGO goal, the NGOs are concerned with the manner in which education is completed (section 4.2e). Namely, the NGOs work to communicate using a two-way model, rather than a top-down approach where information only flows from a communicator to an audience (section 4.2e). The NGOs also try to balance "heavier" educational/scientific content with "lighter" topics—such as interesting animals—and utilize metaphors to make science content more accessible for their audiences (section 4.2e). Similarly, the NGOs aim to make their social media content fun and interactive by sharing compelling information and mixing in humour (section 4.2e). Humanizing their social media topics is another sentiment-related strategy for NGO communicators. In this case, the NGOs define humanization in terms of using framing to portray animals through a human lens, and expressing human emotions in their posts (section 4.2e). In addition, the NGOs hope to build trust with their audience by ensuring all of their posts are backed by scientific evidence (section 4.2e).

Similar to the NGOs, the individual communicators exercise two-way communication practices to avoid talking down to their audience, and to balance the educational component of their social media activity with lighter content such as humour and entertainment (section 4.2e). In contrast to the NGOs, the individual communicators mainly balance their content by sharing personal social media topics, such as daily activities that might be unrelated to science (section 4.2e). The individuals also focus on putting human emotions in their post topics, and try to authentically display scientists as warm, kind people, instead of strictly as knowledge experts (section 4.2e). In addition to ensuring their posts are all evidence-based (a strategy noted by the NGOs above), the individual communicators work to establish personal connections with their audience in order to build trust (section 4.2e). As observed in the social media data, the individual communicators more clearly exhibit human, emotional, and personal sentiments in their social media posts than the NGOs. The individuals share a larger proportion of off-topic posts than NGOs, many of which are everyday activities (Figure 6; section 4.2e). Additionally, text captions posted by the individual communicators are more narrative/personal (lower analytic score), less leadership-based (lower clout score), and more authentic (higher authentic score) than those posted by the NGOs (Table 3). The individual communicators also use more personal pronouns, and express a more positive overall tone in their social media posts than the NGO communicators (Tables 3 and 4).

5.3b Dialogic Strategies

All seven of the communicators also implement interpersonal communication strategies via two-way conversations with their audiences. Both the individual and NGO communicators prioritize responding to audience comments on their posts, especially when users ask questions (section 4.2g). The communicators also put calls to action and/or questions in their social media posts, and try to make their posts intriguing, all in an effort to encourage audience members to participate in social media conversations (section 4.2g). In addition, all seven of the communicators view two-way dialogues as an opportunity to establish personal connections with their audiences and form communicator-audience relationships (CARs) (section 4.2g). In practice, the individual communicators respond to a substantially larger proportion of audience comments than

the NGOs. Although ORG3 responds to more comments than the other NGOs, it still does so far less frequently than all individuals (Figure 8). It is important to note that the study period for this research coincided with an organizational vacancy for ORG3, as mentioned above (section 4.1a). For this reason, the representative for ORG3 said that their organization's response rate to comments during this period was uncharacteristically low. This situation may mean that ORG3 typically responds to comments at a rate closer to that of the individual communicators (Figure 8). This situation also indicates that ORG3 may either prioritize responding to comments more than the other NGOs, or may receive a larger number of comments that are worth responding to (if the data from the collection month were uncharacteristically low).

The individuals receive more engagement than NGOs overall (controlling for follower count), including more comments on posts, longer comments on posts, and a larger number of users in direct conversations with communicators on posts (Figure 9; Figure 11 to 12). The communicator interviews show that direct messages are received at similar or lower rates than comments (section 4.3b); therefore, although direct messages were not measured for communicators in this study, they would likely show similar results. In addition to the difference in comment frequency on communicator posts, text analysis of the audience comments implies users include more narrative sentiments and fewer leadership-based words when engaged in conversations with the individual communicators as compared to the NGO communicators (Table 5). Furthermore, audience comments on posts of the individuals tend to be more authentic than on posts of the NGOs (Table 5).

5.4 Interpersonal Communication Strategies and Social Media Engagement

A variety of interpersonal communication strategies have been demonstrated to affect social media engagement, and many of these strategies are used by both the individual and NGO communicators. For example, both the individuals and NGOs actively invite users to participate in conversations on their posts, which is important because such strategies can encourage engagement, and omitting them would be a missed opportunity (Bortree & Seltzer, 2009; Hitlin & Olmstead, 2018). However, a comparison of the individual and NGO communicators shows that individuals are more

comprehensively implementing interpersonal communication strategies into their social media practices.

The individuals post selfies and selfie-style videos more frequently than the NGOs (Figure 4). This difference is noteworthy in terms of engagement, as social media users are more willing to comment on posts by communicators whom they know, and are therefore more likely to initiate dialogues with communicators who are familiar to them (Table 13; Fauville et al., 2015; Kent, 2013; Lee & VanDyke, 2015). Furthermore, previous research shows that speaking directly to social media audiences through the camera—as is common practice for the individuals in selfie-style videos—can personally connect communicators with audience members and help to establish CARs, even in the absence of direct communicator-user interactions (Cummins & Cui, 2014; Ferchaud et al 2018; Labrecque, 2014). The results of this study support the link between selfie-style posts, two-way conversations, and CARs, as the individual communicators receive more engagement than NGOs overall, and have successfully formed CARs, even in the absence of direct interaction (Figure 9; Figure 11 to 12; section 4.3b). Therefore, the frequent use of selfie-style image and video posts appears to be an effective strategy to establish CARs and stimulate science discussions on social media, which science communicators could implement to encourage more effective science communication. For organizations, selfies could include both the communicator specifically, as well as other researchers working at the NGO.

The expression of interpersonal sentiments in post content is also important for social media engagement. Recent research suggests that content characteristics affect engagement, including the extent to which communicated content matches what users are sharing on social media (Hwong et al., 2017; Zhang et al., 2017). In other words, when users see social media activity similar in nature to their own, they are better able to connect with the content on a personal level. This outcome indicates that the use of metaphors by communicators (mentioned specifically by NGOs) may encourage greater engagement on posts by putting science information in more relatable terms for users (section 4.2e). Nonetheless, the individuals still receive greater engagement than NGOs overall, which may be because the individual communicators choose to focus on posting personally-relatable content. When individual communicators post off-topic content such

as day-to-day activities (Figure 6; section 4.2e), they are creating relatable, shared stories that are thought to be key for audience engagement (Fauville et al., 2015). In fact, posts with a personal sentiment or message (including those without any science content) can surpass scientific posts in terms of engagement, even on science-focused accounts (e.g., Hitlin & Olmstead, 2018). Moreover, the less leadership-based, more narrative, and more personal pronoun-rich text captions posted by individuals (as compared to the NGOs) likely better reflect those posted by lay audiences on social media, and might allow non-scientific users to more closely connect with content communicated by individuals (Tables 3 and 4; Tables 11 and 12). Text captions posted by the individuals are also more authentic than those posted by NGOs (Table 3), and authenticity has been shown to help to build trust between communicators and their audience (Rubin & Rubin, 1985). This link may in part explain the high level of trust individual communicators have established on social media (Figure 18b). Furthermore, social media content containing particular emotions is also more likely to promote engagement. Communicators are thus able to use emotions to connect with their audience and encourage conversations (Berger & Milkman, 2012; Ge & Gretzel, 2018). However, the nature of such emotions plays a role, with positive sentiments being important to foster trust and engagement between users and communicators (Lee & VanDyke, 2015). Therefore, the use of more positive sentiments by the individual communicators on social media as compared with the NGOs may be promoting higher levels of engagement (Tables 3 and 4). In summary, the results of this study suggest that the use of personal, relatable, narrative, authentic, and positive sentiments in social media content can lead to greater social media engagement with science communicators, and ultimately, more effective science communication.

Previous social media studies suggest that using two-way conversations to form CARs is important for social media engagement. Two-way conversations can lead to personal connections between users and organizations, and cultivate positive organization-public relationships, and this is crucial because organizations typically struggle to retain engaged users on social media (Briones, Kuch, Liu, & Jin, 2011; Cox & Pezzullo, 2016; Kent & Taylor, 1998). However, the means through which relationships are formed between organizations and users on social media goes beyond direct interactions, as research shows that a significant number of social media users are

influenced by the interactions they see online. In other words, when organizations communicate with one social media user they are indirectly affecting relationship perceptions for any other users who observe the interaction, even when no direct communication takes place (Lee & Seltzer, 2018). Therefore, because the NGOs are currently less successful than individuals in encouraging two-conversations on social media (Figure 9; Figures 11 and 12), the NGO communicators may be more limited in their ability to form CARs than individual communicators. This result is supported by this study: two-way conversations between individuals and audience members have resulted in the establishment of CARs (sections 4.2g and 4.3), whereas the NGOs have have been less successful in forming CARs (section 4.2g). Furthermore, because CARs can lead to greater engagement (as discussed above), two-way conversations and CARs appear to be mutually reinforcing. Consequently, using two-way social media interactions to form CARs is likely an important strategy to create sustained social media engagement between science communicators and their audiences. Another important point expressed by one of the individual communicators is that conversations are not limited to individual posts. Instead, the establishment of CARs allows for conversations to extend far beyond a discrete instance, and into a larger, ongoing conversation (section 4.2g). Therefore, science communicators can work to establish CARs in the effort to facilitate long-term, ongoing conversations about science.

Because organizations operate differently than individuals in terms of communicating information, a shift to more interpersonal communication strategies might require organizations to re-evaluate how they handle public communication moving forward. The NGOs studied made it clear that their goals are consistent with the interpersonal strategies discussed above, but there is an obvious tension in having an individual represent an organization on social media. For example, an individual speaking for an NGO may affect the perceived authority of information, and through two-way conversations, organizations risk losing control over their messages. With the rise of social media as a new tool for communication, it is important that organizations learn how to adapt their communication strategies to capitalize on the opportunities, but ensure these strategies are not incompatible with overall communication goals.

5.5 Non-scientific Audience Engagement

Both the individuals and the NGOs are specifically targeting non-scientific audiences with their social media activity in some capacity (although the communicators do not limit their audiences to non-scientific users alone) (section 4.4). The communicators generally use Instagram to reach non-scientific audiences, as they feel the platform has a larger population of lay users in comparison to Twitter (section 4.4). In reality, statistics show that the educational distribution of users on Twitter and Instagram is relatively similar (Gruzd et al., 2018; Smith & Anderson, 2018). This apparent mismatch may be due to the topics being shared by communicators on social media and the resulting audiences that they have built. To date, scientists have typically been heavier users of Twitter than Instagram, and because the communicators are sharing science-based content, they may attract more scientists via Twitter than Instagram (Collins et al., 2016). Furthermore, education level does not necessarily equate to science literacy. There is a possibility that Twitter users interacting with science content tend to be more scientifically literate than Instagram users interacting with the same content. In terms of this study, all of the communicators except IND1 appear to be engaging a larger proportion of scientific users in conversations on Twitter than on Instagram (Figure 23). Furthermore, a much higher proportion of non-scientific users are in conversations on posts by the NGOs than by the individual communicators (Figure 23). Once again, this result is likely a consequence of the slight differences in target audiences, topics, and social media goals among the communicators. Nonetheless, the individual communicators still seem to be engaging a substantial non-scientific audience on social media, particularly on Instagram (Figure 23). Therefore, focusing on Instagram as a platform to target lay audiences for science conversations may be an important science communication strategy.

5.6 Interpersonal Communications Afforded Through Instagram

One final point in need of emphasis is the extent to which Instagram appears to foster social media engagement. Not only was engagement higher on Instagram than Twitter for nearly all of the communicators (including the NGOs that do not prioritize the platform), it was also favoured by the communicators and users for conversation-related

uses overall, particularly based on their understanding of accepted social media practices (Figure 9; Figures 11 and 12; section 4.2g). Based on the above results, it appears as though the visual, informal, multi-functional, cordial, and multimedia-focused nature of Instagram (both posts and stories) lends itself to being a more conversational platform than Twitter. Furthermore, it seems that science communicators have the ability to capitalize on affordances granted by Instagram to encourage two-way conversations better through the use of particular social media strategies.

Chapter 6: Conclusions and Recommendations

The need to shift from a deficit to dialogue model for effective science communication is now widely accepted (Irwin, 2008; Salmon et al., 2017; Wakeford, 2010). Despite this knowledge, and the multitude of communication affordances granted by social media, there has not been a major advancement in terms of dialogic science communication online (Kent, 2013; Kent, Taylor, & White, 2003; Lovejoy & Saxton, 2012; Sweetser & Lariscy, 2008). Online communication with the public is especially critical currently, as communicators are increasingly forced to contend with prevalent misinformation and disinformation online (e.g., Del Vicario et al., 2016; Freedom House, 2017).

6.1 Study Conclusions

Recent work has illustrated that simply having a social media presence is not sufficient for successful communication; rather, it is important to consider how social media tools can be used to encourage two-way conversations (Bortree & Seltzer, 2009). The goal of this research was to investigate whether particular social media strategies encourage two-way conversations between science communicators and lay audiences online. A mixed method approach was used to compare the social media strategies and engagement of individual and marine-focused NGO science communicators. Quantitative social media observations were analyzed along with qualitative interview and survey data to understand better why particular strategies are being implemented by the communicators (or not), and why audiences choose to participate in social media conversations.

Both the individual and NGO communicator groups studied share similar goals and conveyed strong awareness of communication strategies known to be more effective for science communication (such as the need for dialogues). Nonetheless, the communicators are not implementing social media strategies equally, nor do they receive the same levels of engagement from users. Activity-related strategies—such as frequency of posting (overall and on each platform) and media types used—vary between the communicator groups, but do not appear to have a strong influence on engagement. For

example, although all of the NGOs post at higher frequencies on Twitter than Instagram (nearly 3.5 times higher for one NGO in particular), they still receive more engagement on Instagram than Twitter (Figure 3; Figure 9; Figures 11 and 12). The main difference between the communicator groups is their overall implementation of interpersonal communication strategies, both dialogic and non-dialogic. The individual communicators focus heavily on conveying conversational, personal, authentic, positive, and human sentiments throughout their social media activity to make content relatable and establish communicator-audience relationships (CARs). In practice, the individuals achieve this by posting more selfies (photos and videos), posting more off-topic content, responding to more comments, and using more positive, authentic, and narrative language than the NGOs (Figures 3 to 6; Figure 8; Tables 3 to 4). The individual communicators also prioritize Instagram over Twitter overall, and particularly Instagram stories (Figure 2). This focus by individual communicators on interpersonal communication strategies is effective for promoting online dialogues, as interpersonal strategies play a prominent role in determining whether audiences choose to participate in two-way conversations (section 4.3b). Therefore, the evidence shows that a combination of interpersonal communication strategies, and how they are integrated throughout the social media activity of science communicators via platform affordances, especially in Instagram, have an important effect on the level of audience engagement in two-way conversations over time.

A set of findings from this study stand out as particularly significant for both science communication on social media, and science communication more broadly. The use of interpersonal communication strategies on social media to encourage conversations can result in the formation of CARs. Once formed, these relationships between communicators and audience members can sustain ongoing conversations. Such conversations are not limited to individual social media posts, but take place on a continuous stream of social media activity that occurs over time. The results of this study also demonstrate that CARs and two-way conversations are mutually reinforcing; once established through dialogues, CARs further promote conversations between communicators and audiences (Figure 24). Moreover, CARs can be formed in the absence of face-to-face interactions, and even without any direct online interactions, highlighting the effectiveness of interpersonal communication strategies when applied to

social media. Another important finding of this work is that the individual communicators are engaging a diverse (both scientific and non-scientific) audience on their posts. This result suggests that interpersonal social media strategies are applicable to a broad range of audiences. Similarly, because interpersonal strategies mainly relate to *how* content is communicated rather than *what* is shared, these strategies can be adopted for a diverse range of subjects, as well as by a variety of communicator types ranging from individuals to organizations and government agencies. Finally, although interpersonal communication strategies are effective online due to social media affordances, these strategies are not limited to the digital environment, but can be implemented throughout a broad spectrum of science communication activities. For example, to address increasing conflicts over marine/coastal space, marine communicators could utilize interpersonal communication strategies to establish relationships with relevant stakeholder groups. This could lead to stronger understanding of stakeholder concerns, and ultimately greater cooperation toward the adoption of best practices in management (such as marine spatial planning and adaptive management) (Klain & Chan, 2012; Weinstein et al., 2007).

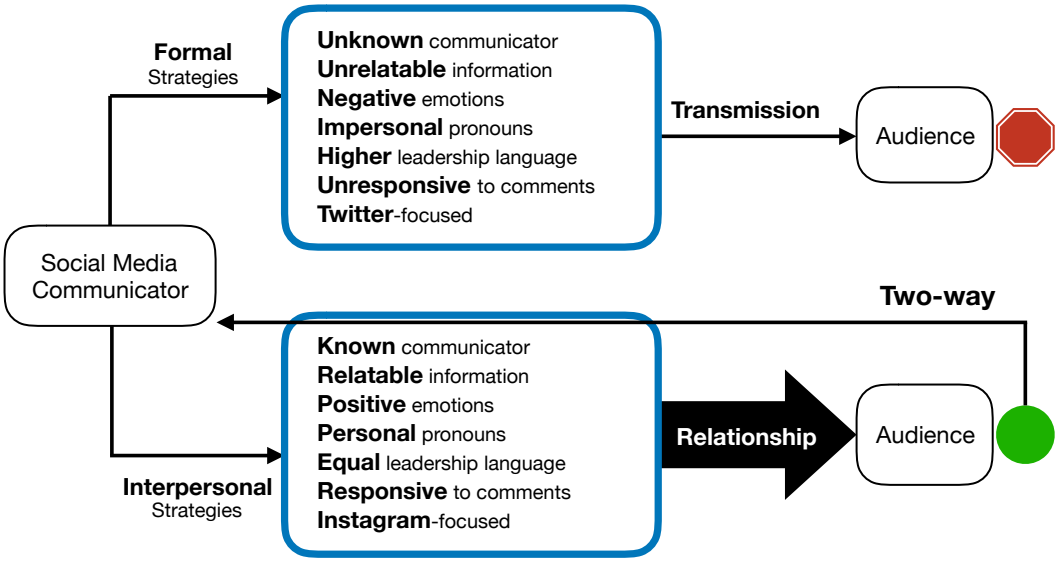

Figure 24. Representation of formal vs. interpersonal communication strategies on social media. Formal strategies are not sufficient to establish a relationship between audience and communicator, resulting in a transmission pathway. Interpersonal strategies act as enablers to information flow, resulting in communicator-audience relationships, which promote two-way dialogues sustained over time.

6.2 Communication Recommendations

The results of this study suggest that the NGO communicators are not reaching their full potential to encourage science dialogues on social media. Based on these findings, it is recommended that marine science communicators—including individual communicators, marine NGOs, and other marine organizational/agency communicators—integrate the following interpersonal communication strategies throughout their social media activities, where possible:

1) Post selfies regularly to make communicators more known/familiar to social media audiences. This approach includes using Instagram stories to address audiences directly through video posts. Organizations may particularly benefit from this strategy, as organizations typically employ numerous staff members with whom audiences could become more familiar over time.
2) Share Instagram stories that provide an informal, inside look at daily activities of communicators to help make social media content more relatable to audiences. For example, individual communicators could use Instagram stories to post about everyday activities, and organizations to post content about day-to-day operations of staff members working at the organization.
3) Incorporate interpersonal sentiments into posts where possible, including more positive emotion words, more personal pronouns, fewer leadership-based words, and more narrative words. Greater emphasis on interpersonal sentiment will help to create shared stories that audience members can personally connect with on social media.
4) Expand efforts to convey trust via social media through the sharing of evidence-based content combined with authentic messaging.
5) Strive to balance serious social media content with fun, entertaining, and/or interactive content to keep users engaged.
6) Give more attention to responding to comments and encouraging two-way conversations to form communicator-audience relationships. Communicators with large audiences have the opportunity to use this strategy to great effect by indirectly influencing relationship perceptions even for those who only observe direct

interactions (Lee & Seltzer, 2018). Additionally, because two-way conversations and relationships appear to be mutually reinforcing, communicators may experience more sustained engagement once relationships are established.

7) Focus on Instagram as a platform to encourage two-way science conversations on social media, as it affords the above strategies more readily than Twitter.

The interviews with the NGO communicators show that many of the strategies recommended above are already consistent with social media goals for the organizations. However, it is important to recognize that organizations do not function in the same way as individuals, and the different mandates may limit the ability of communicators working within organizations to employ the above strategies. In such cases, it is recommended that communicators adapt the above strategies into their social media activities in a manner consistent with organization-specific goals. Furthermore, organizations face particular challenges and risks when using social media, which are not eliminated with the implementation of interpersonal strategies. Therefore, organizations may be required to develop organization-specific guidelines when adopting interpersonal strategies to ensure communications remain consistent with higher-level goals.

6.3 Study Limitations and Next Steps

While some limitations were encountered in conducting this study, they could be addressed in future research. The participants from each communicator group in this research share slightly different information on social media. Future work could compare individuals and organizations that are both posting marine science content to examine whether content differences between the communicator groups have any impact on engagement observations. Future studies could also increase the number of research participants (both communicators and audience members) to investigate whether interpersonal communication strategies are effective across a broader group of communicators. Social media observations took place over a one-month period, and although this study took a holistic approach to evaluate longer-term strategies and engagement rather than on a post-by-post basis, a longer period of study would result in larger quantitative datasets with greater statistical power. This research also focused on

engagement in terms of comments and conversations. In the future, studies could integrate different measurements for engagement—including the total number of conversations—to determine whether interpersonal strategies affect different types of engagement equally. Additionally, extending the period of study beyond one month could uncover longer-term patterns, such as how social media behaviours may be changing over time, both in terms of functionality and the way in which users employ social media tools (for example, a new feature called Instagram TV was instituted while this research was in progress). Social media tools are evolving rapidly, which could affect communication and information sharing behaviour.

This study focused on Twitter and Instagram; therefore, studies could be repeated for other popular platforms such as YouTube and Facebook to see whether interpersonal communication strategies are equally as effective across platform types. In addition, this study omitted sentiment analysis of video posts. Because the majority of communicator videos are shared on Instagram stories, and communicators are already demonstrating the use of interpersonal strategies through Instagram stories, it is expected that an analysis of video sentiment would likely reinforce the above findings. Further, conversation quality and message framing were not measured in this study. Although words per comment could be used to gain an indication of conversation quality, this indicator does not capture the extent to which conversations are scientifically meaningful and learning-oriented, or how messages were framed. Further investigation into social media as a tool to facilitate a participatory model of communication could provide better understanding of conversation quality. Evidence from the survey suggests that communicators are positively influencing audience behaviour. For example, 44% of the survey participants (n=41) feel inspired by communicator posts to make behaviour changes in regard to the natural environment, with six respondents specifically noting a reduction in plastic use. Therefore, a focus on conversation quality in future research may provide new insights about communication strategies. Future work might investigate how conversation effectiveness could be measured for communicator and user interactions and also consider communicator-audience networks, as well as the role of "lurkers" within communication networks. Such work could provide deeper understanding of the extent to

which communicators are reaching non-scientific audiences, and how communicator-audience networks are structured and operate.

6.4 Embracing the "Social" Part of Social Media

It is widely recognized that the ocean provides humans with a wide array of services. Nonetheless, humans have a connection to the ocean that goes beyond one of extractive use. For many, this connection is quite personal, and embodies sentiments typically used to describe relationships (Klain & Chan, 2012; Klain, Olmsted, Chan, & Satterfield, 2017; Ryder-Burbidge, 2017). Juxtaposed to this sense of connection is an apparent disconnect between human reliance on the ocean and ocean literacy in the public (e.g., Schoedinger, Cava, Strang, & Tuddenham, 2005). An integral part of transitioning to a human-ocean relationship that is, to use biological terms, more mutualistic than parasitic, is engendering public engagement with marine science as related to human impacts on the marine environment, and building capacity for public participation in marine management.

Like the ocean, social media connect people around the globe. Social media also provide a means of science communication with great potential to facilitate two-way science dialogues and increase public capacity to participate in ocean decision-making. However, until now, science communication on social media has generally excluded personal sentiments, especially in cases of organizational and government communications. This research demonstrates that interpersonal communication is key to promote science dialogues on social media. To foster public engagement with marine science, communicators need to embrace the interpersonal affordances of social media and form connections and relationships with public audiences online. After all, as noted by one of the communicators: "it's 'social' media … The word 'social' … says it all" (IND2).

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Appendix A: Interview Instrument

Science dialogues on social media: Using Twitter and Instagram
to communicate science to a non-scientific audience

[Note: Prior to beginning the interview, participants will read the consent form and be given time to ask questions about the project and the interview process. Only once participants have asked all their questions and signed the consent form will the interview begin.]

In a few sentences, could you tell me what a typical day on social media is like for you?

Do you use social media platforms other than Twitter and Instagram?
-Do you prefer a particular platform?
    -Why?
-Do you prioritize your use of one over the other?
    -Why?
-Do you use each platform in the same way?

For the rest of our discussion, please focus on your use of Twitter and Instagram

Thinking about Twitter and Instagram, why do you use social media?
    -Do you have specific goals or objectives? What do you try to achieve with social media activity?
        -Are you trying to teach your audience about science?
        -Are you trying to teach your audience about public policy matters?
        -Are you trying to inspire action and/or behaviour changes in your audience?
    -Who is your target audience?
        -Do you aim to reach a particular type of audience or a mixed audience?
        -Is a non-scientific audience (i.e., the public) included/prioritized?
        -Are you doing analytics and is this informing your approaches?

In your use of social media, are you guided by particular strategies?

-How do you decide what to post?

-Do you post different content on Twitter vs Instagram?

-Do you only post science content?

-Do you try to personally connect with your audience through your posts?

-How and why?

-Do you work under guidelines/restrictions that determine how you use the social media account? **[For individual communicators, this question will read: "Have you established guidelines or restrictions that guide your use of your Twitter and Instagram accounts?"]**

-Are you maintaining a consistent character/personality/style on your account?

-Do you feel you have a relationship with your followers? Is this something you are trying to establish?

-Do you try to make your posts genuine/authentic for your audience?

-Do you feel they perceive you this way? Do they trust you?

For the next section we will focus on conversations that take place on Twitter and Instagram.

Do you choose to engage in conversations with members of your audience on social media?

-Do you try to involve your audience in conversations?

-How do you choose who/what to respond to?

-In conversations you had in the last week, what topics did you discuss?

-Is this typical?

-How many exchanges are in typical conversations?

-Do people ask you questions?

-Do you ever initiate conversations?

-Do particular types of posts lead to most conversations?

-Are conversations more likely to happen on Twitter vs Instagram?

-How do you normally respond to members of your audience (e.g., through direct message, offline, or separate posts)?

-How do you decide which response method you will use?

-Do you feel that it is important for you to respond to your audience?

-Do you feel that an audience member's understanding of a science topic has improved based on a conversation rather than a single post?

-Do your online interactions ever lead to offline conversations/interactions?

-Have you ever encountered trolls?

-If not, are trolls a concern?

-If yes, how do you deal with/control them?

Do you see your primary role as a researcher or communicator? **[For an organization, this question will read: "Is communicating on social media your primary role for the organization?"]**

-How does social media fit into your professional/research role?

-What motivates you to continue using social media?

-Do you have formal communications training?

-If yes, do you have formal social media training?

In light of the questions that I have asked, do you have anything further that you would like to add about your use of Twitter and Instagram or observations about your audiences' activities in response to your posts?

I have now concluded my questions. Thank you for your participation in this interview.

Appendix B: Ethics Approval from the Dalhousie Faculty of Management

DALHOUSIE UNIVERSITY
Inspiring Minds
Faculty of Management

Faculty of Management Graduate Student Ethics Approval for a Course-based Project

August 13, 2018

Curtis Martin,

I am pleased to inform you that I have reviewed your project "**Science dialogues on social media: Using Twitter and Instagram to communicate science to a non-scientific audience**" **(file no. 081318),** for the course MARA5002 (Graduate Project) under the supervision of Dr. Bertrum MacDonald, and have found the proposed research involving human participants to be in accordance with the *Faculty of Management Ethics Review Policy for Course-based Projects* and the *Tri- Council Policy Statement on Ethical Conduct for Research Involving Humans (TCPS2).* This project has received ethics approval.

This approval will be in effect until and not exceeding December 24, 2018 (fourteen days from the final date of classes for the 2018 Dalhousie Fall Semester). It is your responsibility to immediately report any adverse events involving participants to both your instructor and to the Research Ethics Officer. Please note that any significant changes to the research methodology, consent form or recruitment materials must be resubmitted to Research Ethics Officer for review and approval prior to their use.

Congratulations on your successful Faculty of Management Graduate Student Ethics Approval for your Course-based Project. I wish you all the best as you begin this next phase of your research. Should you have any questions regarding ethical issues at any point during your project, please do not hesitate to contact me.

Sincerely,

Ashley Cummiskey (Doyle)
Faculty of Management Research Ethics Officer
Dalhousie University
PO Box 15000, Halifax, NS B3H 4R2
a.doyle@dal.ca

Appendix C: Survey Instrument

[Note: Branching will apply to the response to the first question in Section 2 of the survey. The remaining questions presented to participants will be based on whether the participants converse on Twitter or Instagram posts of an organization, or the participants converse on posts of an individual communicator.]

Science dialogues on social media: Using Twitter and Instagram to communicate science

This survey is being conducted as part of a research study to understand how social media can be used to communicate science and public policy information to diverse audiences. You have been contacted because you are engaged in conversations on posts of the social media account specified in the invitation that provided the link to this online survey. This project is led by Curtis Martin, a graduate student with the Marine Affairs Program (MAP) at Dalhousie University, Halifax, Nova Scotia, and supervised by Dr. Bertrum MacDonald of the Environmental Use and Information (EIUI) research program based in Dalhousie University's Faculty of Management. Your participation is voluntary and you may withdraw from the survey at any time prior to completion. No personally identifying information will be collected, and all responses will be treated as confidential.

Only members of the research team at Dalhousie University will have access to the completed survey data. Only aggregate data will be reported in publications arising from this research. The survey should take no longer than 30 minutes to complete and involves four brief sections. The first section asks about your social media use. The second section asks about your activity as a social media audience member, and the third section about your engagement in conversations on social media. The fourth section includes some

demographic questions. If at any time you feel you can't answer a particular question, or if a question makes you uncomfortable, just skip to the next question.

For any questions, concerns, or more information about the study, please contact Curtis (curtis.martin@dal.ca; 778-679-3400) or Dr. MacDonald (bertrum.macdonald@dal.ca; 902-494-2472). If you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, you may contact Ashley Doyle, Faculty of Management Research Ethics Officer at Dalhousie University, for assistance (a.doyle@dal.ca).

□ I have read the explanation about this study. I understand what I am being asked to do and my questions about the study have been answered. I know that participating is my choice and that I can leave this survey at any time prior to completion. I understand that by completing this survey, informed consent is assumed. **[Note: this text will be bolded]**

□ I agree to the use of direct quotations from my survey responses in reports and publications arising from this research. I understand that these quotations cannot be attributed to me and will be treated anonymously.

Thanks for your time! Let's get started. **[Note: If a participant does not check both of the above boxes, they will not be able to continue with the survey, and will instead be directed to a screen thanking them for considering the survey].**

Section 1: SOCIAL MEDIA USE

1. Which social media platforms do you use? (Check all that apply.)
    - □ Twitter
    - □ Instagram
    - □ Facebook
    - □ Snapchat

- □ YouTube
- □ Pinterest
- □ Tumblr
- □ Other: _____

2. Rank the following social media platforms that you use in order of your preference of use (with 1 being most preferred).

Twitter ___
Instagram ___
Facebook ___
Snapchat ___
YouTube ___
Pinterest ___
Tumblr ___
Other: _____

2.1 Please explain your number one choice.

_____

3. If you use multiple social media platforms, do you use them in different ways from each other? (Check one.)

☐ Yes
☐ No
☐ I only use one social media platform

3.1 Please explain.

_____

4. For which reason do you use social media? (Check all that apply.)

☐ Personally
☐ Professionally

☐ Other:

_____

4.1 Please explain.

_____

5. Do you consider yourself part of the scientific community? (Check one.)

☐ Yes

☐ No

6. Do you consider yourself part of the science communication community? (Check one.)

☐ Yes

☐ No

Section 2: AUDIENCE MEMBER

For this section, please think about the Twitter or Instagram account you follow noted in the invitation to complete the survey.

7. Please select which type of account it was:

- ☐ The Instagram account of an organization **[If this option is selected, the remaining survey questions will have wording consistent with an organization Instagram account where necessary]**
- ☐ The Twitter account of an organization **[If this option is selected, the remaining survey questions will have wording consistent with an organization Twitter account where necessary]**
- ☐ The Instagram account of a person **[If this option is selected, the remaining survey questions will have wording consistent with a personal Instagram account where necessary]**
- ☐ The Twitter account of a person **[If this option is selected, the remaining survey questions will have wording consistent with a personal Twitter account where necessary]**

8. Please explain why you follow the Twitter **[or Instagram]** account.

_____

9. What type of posts do you prefer to see from the account? (Check all that apply.)

- □ Twitter post
- □ Instagram post
- □ Instagram story

9.1 Please explain.

_____

10. What type of content do you prefer to see from the account? (Check all that apply.)

- □ Text post
- □ Image post
- □ Video post
- □ Mixed post (combination of text, image, and/or video)

10.1 Please explain.

_____

11. Do you feel like you have developed a relationship with the person **[or organization]**? (Check one.)

☐ Yes

☐ No

11.1 Please explain.

_____

12. Do you feel that their posts connect with you on a personal level? (Check one.)

☐ Yes

☐ No

☐ It depends

12.1 Please explain.

_____

13. Do you feel that their posts are trustworthy? (Check one.)

☐ All of their posts are trustworthy

☐ Most of their posts are trustworthy

☐ Some of their posts are trustworthy

13.1 Please explain.

_____

14. Do you follow the Twitter **[or Instagram]** account to learn about science? (Check one.)

☐ Yes

☐ No

14.1 Please explain.

_____

15. Do you follow the Twitter **[or Instagram]** account to learn about public policy matters? (Check one.)

☐ Yes

☐ No

15.1 Please explain.

_____

16. Do you seek out science and/or public policy information elsewhere (including outside of social media)? (Check one.)

☐ I seek out science information elsewhere **[If this answer is selected, will branch to question 16.1]**

☐ I seek out public policy information elsewhere **[If this answer is selected, will branch to question 16.1]**

☐ I don't seek out science or public policy information elsewhere

16.1 Please explain.

_____

17. Do you find the information that the person **[or organization]** shares is typically easy to understand? (Check one.)

☐ Yes

☐ No

18. Do their posts ever inspire you to change your behaviour with regard to the natural environment? (Check one.)

☐ Yes **[If this answer is selected, will branch to question 18.1]**

☐ No

18.1 Please provide an example.

_____

Section 3: CONVERSATIONS ON SOCIAL MEDIA

For this section, please think about the Twitter or Instagram account you follow noted in the invitation to complete the survey.

19. How often do you send direct messages to, leave comments for, or ask questions of the person **[or organization]** on Twitter **[or Instagram]**? (Check the most applicable.)

- □ A few times per month
- □ One to two times per week
- □ Three to five times per week
- □ One or two times per day
- □ Three or more times per day
- □ Other: _____

19.1 How do you decide what to respond to? (Check all that apply.)

- □ I respond if I am interested in the topic
- □ I respond when messages are sent directly to me
- □ I respond to congratulate the person on exciting news
- □ I respond to show that I am engaged in what they are posting
- □ Other:

_____

19.2 How do you typically respond? (Check all that apply.)

- □ Direct messages
- □ Comments/posts
- □ Outside of social media, but still online (e.g., through email)
- □ Offline

20. Does the person **[or organization]** ever respond to your direct messages, comments, or questions on social media? (Check all that apply.)

- □ Respond to direct messages **[If this answer is selected, questions 20.1 will be available to answer]**
- □ Respond to comments **[If this answer is selected, questions 20.1 will be available to answer]**
- □ Respond to questions **[If this answer is selected, questions 20.1 will be available to answer]**
- □ The person **[or organization]** has never responded to my direct messages, comments, or questions

20.1 When the person **[or organization]** responds, does this ever lead to a back-and-forth social media conversation? (Check all that apply.)

- □ Yes **[If this answer is selected, questions 20.2-20.4 will be available to answer]**
- □ No

20.2 How many times do you each post in a typical social media conversation? (Check one.)

- □ Once
- □ Two to three times
- □ Four or more times
- □ Other: _____

20.3 Do you find it easier to learn about topics that are new to you in conversations rather than single posts? (Check one.)

☐ Yes

☐ No

☐ Both are equally helpful

20.4 Please explain.

_____

21. Which type of post are you more likely to respond to with either a direct message, comment, or question? (Check all that apply).

- □ Twitter post
- □ Instagram post
- □ Instagram story

21.1 Please explain.

_____

22. Which type of post are you more likely to respond to with either a direct message, comment, or question? (Check all that apply).

□ Text post

□ Image post

□ Video post

□ Mixed post (combination of text, image, and/or video)

22.1 Please explain.

_____

23. Are you more likely to respond (with either a direct message, comment, or question) to posts by an individual than an organization? (Check one.)

☐ Yes

☐ No

☐ I am equally likely to respond to both individuals and organizations

23.1 Please explain.

_____

For the next group of questions, think about a conversation you had in the last month with the account holder on Twitter **[or Instagram]** (where the account holder responded at least once to your message, comment, or question).

☐ Check here if you have not had any conversations with the account holder in the last month. **[If the above box is selected then the survey will skip to Section 4]**

24. Was the conversation on a science topic, public policy matter, or something else? (Check all that apply.)

☐ Science topic

☐ Public policy matter

☐ Other

24.1 Please explain the topic as specifically as possible.

24.2 Did you gain a better understanding of the topic because of the conversation? (Check one.)

☐ Understanding increased

☐ Understanding remained the same

☐ Not applicable

25. How did you feel when they responded to your message or comment? (Check all that apply.)

- ☐ I felt like I wanted to have more conversations in the future
- ☐ I felt like they cared about what I had to say
- ☐ I felt like they were a person rather than only an online avatar
- ☐ Other:

---

26. Do you have conversations with other science communicators on social media? (Check one.)

☐ Yes **[If this answer is selected, will branch to question 26.1]**

☐ No

26.1 Why?

Section 4: DEMOGRAPHICS

27. Please select your age range: (Check one.)

- ☐ 5-18
- ☐ 19-33
- ☐ 34-49

☐ 50-64

☐ 65+

28. Please describe your gender:

_____

29. What is the highest level of school you have completed? (Check one.)

☐ No schooling completed

☐ Some grade school

☐ High school

☐ Post-secondary (community college or university)

☐ Master's degree

☐ Doctorate degree

☐ Other:

_____

Thanks for completing this survey. We are happy to share the results with you. A summary report of the findings will be posted to the EIUI website (www.eiui.ca) at the completion of the study in December 2018. If you wish to receive a copy of the final report, please contact Curtis (curtis.martin@dal.ca; 778-679-3400) or Dr. MacDonald (bertrum.macdonald@dal.ca; 902-494-2472) after December 31, 2018.

Appendix D: Invitation Script Sent to Potential Survey Participants via Social Media

Dear **["name" of Twitter/Instagram Participant],**

Why do you engage in conversations on social media?

You are invited to take part in the survey, "Understanding Audience Engagement on Social Media."

My name is Curtis Martin. I am a graduate student with the Marine Affairs Program at Dalhousie University in Halifax, Nova Scotia, Canada. I am conducting a survey to understand how audience members of **[individual or organization name]** on Twitter/Instagram interact with their posts.

Do you engage in conversations with **[individual or organization name]** on social media? Do you feel a connection to **[individual or organization name]** based on their posts? Do you also use social media to communicate science/policy information?

Data collected in this survey will be used to understand social media strategies that make science and policy information more engaging for diverse audiences, and how communicators can improve the way they share information on social media. With your help, I'd like to provide science and policy communicators with information that will help them to share posts on Twitter and Instagram in a way that is more engaging for their audience.

You can complete the survey by clicking this link **[the URL for the Opinio survey will be embedded here].**

Please complete this survey, which should take no more than 8-10 minutes of your time, by **[closing date]**, 2018 after which survey submissions will no longer be accepted. All responses to the survey will be anonymous as no identifying information will be collected.

We are happy to share our results with you at the completion of this study in December 2018. If you wish to receive a copy of the summary report, please contact us via email any time after December 31, 2018.

Thank you very much for your time!

Kind Regards,

Curtis Martin
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