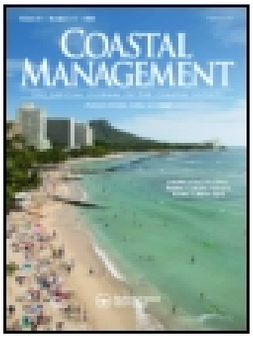

Coastal Management

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ucmg20

Designing and Delivering Webinars to Improve Science Communication and Engagement between Environmental Researchers and Natural Resource Practitioners

Emily N. Mazur, Shelby E. Walker, Cristen Don & Flaxen D. L. Conway

To cite this article: Emily N. Mazur, Shelby E. Walker, Cristen Don & Flaxen D. L. Conway (2021): Designing and Delivering Webinars to Improve Science Communication and Engagement between Environmental Researchers and Natural Resource Practitioners, Coastal Management, DOI: 10.1080/08920753.2021.1928458

To link to this article: https://doi.org/10.1080/08920753.2021.1928458

Published online: 23 May 2021.

COASTAL MANAGEMENT
https://doi.org/10.1080/08920753.2021.1928458

Designing and Delivering Webinars to Improve Science Communication and Engagement between Environmental Researchers and Natural Resource Practitioners

Emily N. Mazur[a], Shelby E. Walker[b], Cristen Don[c] and Flaxen D. L. Conway[d]

[a]College of Earth, Ocean, and Atmospheric Sciences, Marine Resource Management Program, Oregon State University, Corvallis, Oregon, USA; [b]Oregon Sea Grant, Oregon State University, Corvallis, Oregon, USA; [c]Oregon Department of Fish and Wildlife, Marine Resources Program, Newport, Oregon, USA; [d]College of Liberal Arts, Oregon State University, Corvallis, Oregon, USA

ABSTRACT

Research across natural resource management disciplines has identified an implementation gap between researchers and managers, where institutional norms and practices limit integration of novel data and observations into decision-making. This gap has largely been addressed using one-way science communication tools such as publications and conference presentations. While these tools can be designed and delivered effectively, mounting evidence suggests two-way communication builds more trust, enhances engagement, and may lead to more active use of scientific information in decision-making. The National Oceanic and Atmospheric Administration (NOAA) Western Regional Collaboration Team's West Watch webinar is a one-way communication tool that shares information about climate, weather, and ocean condition anomalies to an internal audience of NOAA experts and key partners. NOAA is interested in expanding this tool to improve information accessibility and use by communities of interest that NOAA serves. This research uses a mixed-methods approach to evaluate how West Watch could change to function as a two-way communication tool, facilitating bilateral information movement between research presenters and the audience. Research results, supported by literature, inform five best practices and recommendations for changes to West Watch, as well as the design and implementation of future science communication tools.

KEYWORDS
coastal;
decision-making;
engagement;
management;
natural resource managers;
science communication

Introduction

The National Academies of Sciences, Engineering, and Medicine define science communication as "the exchange of information and viewpoints about science to achieve a goal or outcome" (NASEM 2017). While science communication can have various initiators or audiences, this research explores communication between environmental researchers (information providers) and natural resource managers (information users/

CONTACT Emily N. Mazur emilynmazur@gmail.com College of Earth, Ocean, and Atmospheric Sciences, Marine Resource Management Program, Oregon State University, 23 Union St. #1, Charlestown, MA 02129, USA

audience). Most traditional science communication between researchers and managers has been transactional, or one-way, in nature; scientific information is transferred from the research to management sector to be put to some "use" (e.g., models, decision-making). In one-way communication systems, researchers "push" scientific expertise to managers through formal academic communication tools such as peer-review publications, reports, or conference presentations (Adams et al. 2017; Barbour 2007). Additionally, managers are responsible for "pulling" useful information from these tools to incorporate into their work (Adams et al. 2017; Kocher et al. 2012; Roux et al. 2006).

The transactional relationship of one-way communication has several unintended consequences. First, since researchers are the ones initiating one-way communication, they decide what information is important to include in their communication products (Barbour 2007). This approach leaves managers without a pathway to communicate their information needs to researchers, resulting in science that might not be applicable to decision-making. Second, because of the rigidity of the one-way communication structure, there is limited ability for information to be refined based on feedback from managers. However, for information to be useful to managers, it needs to be presented in unambiguous and non-complex ways and be consistent with the researcher's previous work and credibility (Roux et al. 2006). If the communicated information is too complex, managers may use a "simplification strategy" by which they disregard information that makes challenges more complex (Leskens et al. 2014; NASEM 2017). Finally, formal one-way communication tools are traditionally time-intensive because of data collection, analysis, and peer-review processes. This time-intensive process lacks flexibility to respond to rapidly evolving management needs (Roux et al. 2006).

In contrast to one-way communication, two-way communication between researchers and managers attempts to build common ground by having bidirectional information movement, allowing for iterative information refinement. By having managers contribute their practical knowledge and researchers contribute their scientific expertise, both parties become valid contributors to knowledge co-production (Fazey et al. 2014; Kocher et al. 2012). Two-way communication emphasizes the importance of relationship building and active interactions so both researchers and managers can build trust and understand the other's perspective (Cone et al. 2013; Hunter 2016; Kocher et al. 2012). By building trust and knowledge co-production, two-way communication attempts to facilitate science application by framing research questions around management questions and producing information in ways that can be incorporated into management decisions.

Benefits from relationship building and two-way communication have been documented in literature. Multiple studies demonstrated that scientific information transfer is most effective when there is a built relationship between researchers and managers (Barbour 2007; Roux et al. 2006; Ryan and Cerveny 2011). This transfer is effective because researchers and managers can understand each other's information needs and barriers to obtaining that information. Two-way communication vocalizes these needs so they can be better understood and addressed, potentially leading to better alignment of research questions and management challenges where both parties are contributing to knowledge production (Fowler and Hobbs 2009; Matso and Becker 2014). Finally,

improving two-way communication in funding-limited environments may increase collaboration that can reduce redundancy of available decision-making tools and leverage information across resource-limited organizations (Averyt et al. 2018).

While two-way communication can have these benefits, successful implementation varies based on communication goals, the researchers and managers involved and their respective home institutions, and the type of information being shared. For example, Averyt et al. (2018) evaluated two projects that implemented two-way communication and co-production to improve actionable science and drought preparedness. These cases were successful because the participating organizations had long-standing relationships and existing two-way communications, and they shared common principles to co-develop and co-produce the products, which provided value for all involved. In another study, Kocher et al. (2012) found that researchers and managers wanted more professional relationships, such as those developed through workshops and conferences, so that managers could have more active roles in research and communicate their ideas and scientists could have a larger audience to which they could communicate findings. However, these respondents felt there was not enough institutional support to invest in this kind of relationship-building. Finally, Roux et al. (2006) suggests that communities of practice may support the easiest form of knowledge co-production because these communities are based on similar values and interests and circumvent organizations' institutional barriers.

With both one- and two-way communication, researchers need to be presenting the right content using an effective process to achieve identified communication goals. Content must be applicable to managers and presented in useful formats. However, managers often find a mismatch between the information they need and information that is provided by researchers (Fowler and Hobbs 2009; Kocher et al. 2012; Leskens et al. 2014). This mismatch may stem from inadequacies with model outputs, unclear scientific uncertainties, or lack of timeliness in providing research results (Leskens et al. 2014). For example, managers often need information at different spatial scales or geographic locations than those at which research was conducted (Barbour 2007; Roux et al. 2006). These challenges are exacerbated in today's "information overload era" (Barbour 2007; Cullen et al. 2001; Kocher et al. 2012; Roux et al. 2006) where managers have difficulty sorting through information to find what is useful. Often managers are left searching for needed information and tools without knowing where to find them (Hunter 2016) or having time to find them (Roux et al. 2006).

With information mismatch and overload, researchers providing more and better information is not sufficient for it to be used in decision-making. Researchers need to be able to communicate the verification, strengths, and weaknesses in methodologies and results (Leskens et al. 2014). Additionally, the National Oceanic and Atmospheric Administration (NOAA) (2016) found that effective communication needs to have clear, developed messages that speak to managers' interests.

Effective science communication also involves building successful processes for delivering scientific information. Fazey et al. (2014) found that science communication tools should be designed for multiple end users, be explicit about how information exchange is conceptualized, be explicit about assumptions for how the process is expected to deliver its outcomes, and be designed with evaluative benchmarks

throughout the process. Most importantly, information transfer and implementation has been found to be most effective when there are built relationships and common ground between researchers and managers (Kocher et al. 2012; Ryan and Cerveny 2011).

Science communication research has developed many best practices for designing and delivering one- and two-way science communication tools; however, researchers follow these best practices to varying degrees depending on the circumstances surrounding the communication activity. Institutional barriers such as funding, personnel turnover, time availability, and policy priorities have all been identified in the literature as continual challenges to science communication (Averyt et al. 2018; Cullen et al. 2001; Kocher et al. 2012). Research culture may disincentivize communication; this can include perceptions regarding researchers' roles in science communication, a desire to reduce risk associated with providing data for real-world application (Barbour 2007; Kuonen 2018), and academic structures that reward outputs (e.g., publications) rather than outcomes (e.g., information utility). Finally, natural resource agencies may lack evaluative processes and scientific evidence of tangible outcomes or outputs (Cullen et al. 2001; Heintze and Bretschneider 2000; Hunter 2016).

In this article, we explore two-way science communication in the context of a NOAA-funded and -produced webinar called West Watch. Currently, West Watch is a one-way communication tool that confers information regarding climate, weather, and ocean condition anomalies to an internal audience of NOAA experts and key partners. However, NOAA is interested in expanding this tool to improve West Watch information accessibility and use by local communities (e.g., industries, residents, tourists) that NOAA serves. NOAA hypothesized that non-NOAA partners (e.g., state, local, or tribal resource managers; industry; non-governmental organizations) could serve as translators of the webinar's technical information to their communities or stakeholders of interest. In return, NOAA theorized these partners could gather community observations regarding environmental anomalies and report observations back during West Watch webinars, creating a two-way communication system to connect scientific expertise with on-the-ground observation.

The goal of this research is to assess the efficacy of West Watch and identify how these webinars can be transformed from a one- to two-way communication tool that engages natural resource managers, science practitioners, and other professionals who could connect NOAA to local communities of place and of interest (e.g., commercial fishing and/or aquaculture, recreation communities). Results can be used to inform changes to the West Watch webinars, as well as the design and implementation of future science communication tools.

Methods

Case study

Held every two months, West Watch webinars are a one-way communication tool used to deliver environmental condition information to an audience of NOAA experts and key partners (Figure 1). A typical webinar is an hour long, covering five distinct information sections: regional climate condition update, El Niño Southern Oscillation (ENSO) status update, a guest speaker presentation, near shore ocean conditions update

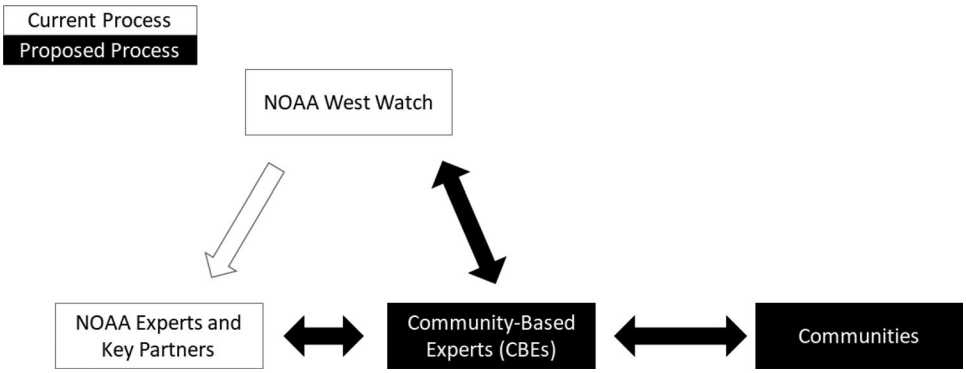

Figure 1. Current one-way communication mechanism (white fill) between West Watch and NOAA experts where the webinar transfers information to a current audience of NOAA experts and key partners. Proposed two-way communication system (black fill) includes CBEs who translates the webinar's information to their communities and gather community observations to report during West Watch webinars.

(provided by the three West Coast Regional Integrated Ocean Observing Systems [IOOS]), and environmental impacts report/discussion.

West Watch is funded and produced by the NOAA Western Regional Collaboration Team (NOAA West), which represents NOAA's interests in 11 western states (Washington, Oregon, California, Idaho, Montana, Nevada, Wyoming, Utah, Arizona, Colorado, and New Mexico), and is comprised of individuals from across NOAA's six line offices. NOAA West works collaboratively to address regional challenges by leveraging expertise from across these offices and NOAA headquarters to improve mission capabilities.

This collaboration mission was tested in late 2015 when rapidly evolving anomalous environmental conditions (e.g., El Niño, the Blob marine heatwave) created a need to share information quickly across all line offices. At this time, NOAA West started offering monthly West Watch webinars to NOAA experts and key partners to track these anomalous conditions and improve information transfer within the agency to aid decision-making. Since its inception, West Watch has had two goals: (1) communicating changing environmental conditions to NOAA experts and key partners, and (2) communicating the impacts those changing conditions have on NOAA's communities of interest.

Once the anomalous conditions ended in mid-2016, NOAA West surveyed West Watch's attendees to determine how to proceed with the webinars. Responses indicated that, first, attendees agreed that the El Niño and climate summaries were the most important information segments, and the open discussion was the least important. Second, respondents mentioned that having such a large NOAA West geographic distribution created difficulties for determining an appropriate spatial scale for information. Other challenges included an ineffective open discussion format and lack of available resources for sustaining the webinars. Finally, respondents indicated that West Watch should include more partners and external audiences but suggested that potential attendees would need to have some background of climate science to understand the content.

NOAA West continued the webinars in early 2017, using the survey results to guide the restart. West Watch webinars transitioned to a bimonthly format and functioned as a communication tool for climate and marine conditions in the NOAA West region. Although the 2016 survey results suggested expanding the audience, minimal effort was made to reach external groups, so audience growth only occurred by word-of-mouth. The webinar continued as a one-way communication system where the coordinators and research presenters provided information to current attendees (NOAA experts and key partners).

However, NOAA West was interested in determining how West Watch could be adapted to facilitate increased engagement with non-NOAA partners who could serve as information liaisons between NOAA and communities of place and interest. By increasing engagement, NOAA West hoped to start conversations with non-NOAA partners rather than deliver information with minimal feedback. In mid-2017, a group of NOAA West members proposed a second evaluation of West Watch webinars. The proposed evaluation sought to confirm the assumed usefulness of the communication tool, while also exploring ways to expand the webinar to non-NOAA audiences.

NOAA West members proposed including "community-based experts" (CBEs; e.g., state, local, or tribal resource managers, industry, non-governmental organizations, other science practitioners) in West Watch webinars. The members hypothesized these CBEs could translate the webinar's technical information to their communities or stakeholders of interest. In return, the CBEs could gather community observations regarding environmental anomalies and report them back during West Watch webinars, creating a two-way communication system to connect scientific expertise with on-the-ground observation (Figure 1). By including CBEs, who serve as both translators of scientific information and community representatives, NOAA West hoped to improve its communication of scientific information to its constituents while also using community observations to improve their research. As such, this research served as the proposed evaluation and was designed to illuminate how West Watch could be adapted to be an effective two-way communication tool.

Study design

To evaluate this communication tool and process, we used a mixed-methods approach with three populations of research participants. By using both qualitative and quantitative data, we created a picture of changes that occurred with West Watch, and how and why those changes took place (Rubin and Rubin 2005). Quantitative data provide an explicit measure of outcomes, while qualitative data provide the context needed to get a deeper look into intangible aspects (e.g., institutional barriers) of the issue at play (Fazey et al. 2014). All three study populations provided qualitative data while one study population (current attendees) provided quantitative data. In addition, the research team observed West Watch webinars to document interactions among webinar participants; this observational data helped contextualized interview information (Auerbach and Silverstein 2003).

Study populations and data collection

Coordinators

The term "coordinator" refers to individuals who at some point served as a developer, presenter, or decision-maker for West Watch. Decision-makers were those who did not participate in the development and running of West Watch webinars but participate in NOAA West decisions. These individuals serve as "encultured" or "key" informants, providing insight into the institutional culture surrounding NOAA and West Watch webinars (Rubin and Rubin 2005).

Ten coordinator interviews were completed over the 14-month course of this research. Interviewees were asked a series of seven semi-structured questions regarding West Watch's goals, participants, and effectiveness, and how CBEs could be incorporated into West Watch. Coordinators were interviewed either on the phone or in-person at a location of the interviewee's choosing, and interviews took approximately 1.5 hours to complete. All interviews were audio recorded. Of the ten coordinators who were interviewed, five were involved in daily operations of West Watch (e.g., leading the webinar, presenting) at the start of this research in 2017, while the other five did not have an active role.

Community-based experts

CBEs refers to individuals who worked in Oregon environmental disciplines in capacities such as resource management (tribal, state, local), non-governmental organizations, industry, and other science professions (Table 1). CBEs were selected with the help of Oregon Sea Grant (OSG). As an organization with Extension capacity, OSG has existing relationships with coastal and marine stakeholders and served as a key informant (Rubin and Rubin 2005) to help identify CBEs who fit within the research goals. Participating CBEs were asked to recommend additional participants in a modified snowball sampling technique (Auerbach and Silverstein 2003).

CBE data collection occurred over 14 months which included seven bimonthly webinars. Prior to a webinar, CBEs were solicited by email to watch the upcoming webinar and participate in a follow-up, semi-structured interview (Auerbach and Silverstein 2003). Interview questions were designed to elicit how CBEs use science in their work, how they translate science for their stakeholders, and their perspectives regarding the content and format of West Watch webinars. CBEs were added to the webinar's email distribution list when requested, but only participated in the research

Table 1. Number of solicited, participated, and interviewed CBEs from each organizational category.

Organization	Number solicited	Number participated in webinar	Number interviewed
State manager/scientist (e.g., fisheries, land-use, marine policy)	12	7	4
Non-governmental organization	6	3	3
Local manager/scientist	4	0	0
Tribal manager/scientist	4	1	1
Federal manager/scientist	4	1	0
Extension agents	3	0	0
Fisherman	2	0	0

after the first webinar viewing. Of the 35 solicited CBEs, 12 watched a webinar and eight participated in a post-webinar interview (Table 1). Four CBEs who watched a webinar did not respond to a request for a post-webinar interview.

Current attendees

NOAA West maintains an email list of current webinar attendees, who are assumed to be NOAA personnel and key partners. We surveyed this population using this email distribution list. Individuals that participated in coordinator interviews did not receive a survey. There are likely individuals who tune into the webinar but are not on the NOAA-provided email distribution list; this coverage error was considered in generalizations and recommendations made from the survey data (Dillman 2011).

The questionnaire was created and distributed with Qualtrics online software, following the tailored design method of Dillman (2011). Questions were a mix of scale, multiple choice, and open-ended responses to illicit perspectives regarding the effectiveness of the webinar's content and process.

To recruit research participation, those listed on the email distribution list were sent an email requesting them to complete an online questionnaire. Of the 111 emailed attendees, 43 completed the questionnaire (39 percent response rate). Within the 43 completed questionnaires, 38 individuals (88 percent) provided answers to open-ended questions. Figure 2 provides the job categorization for the West Watch email distribution list and survey respondents. This figure suggests that the survey respondent

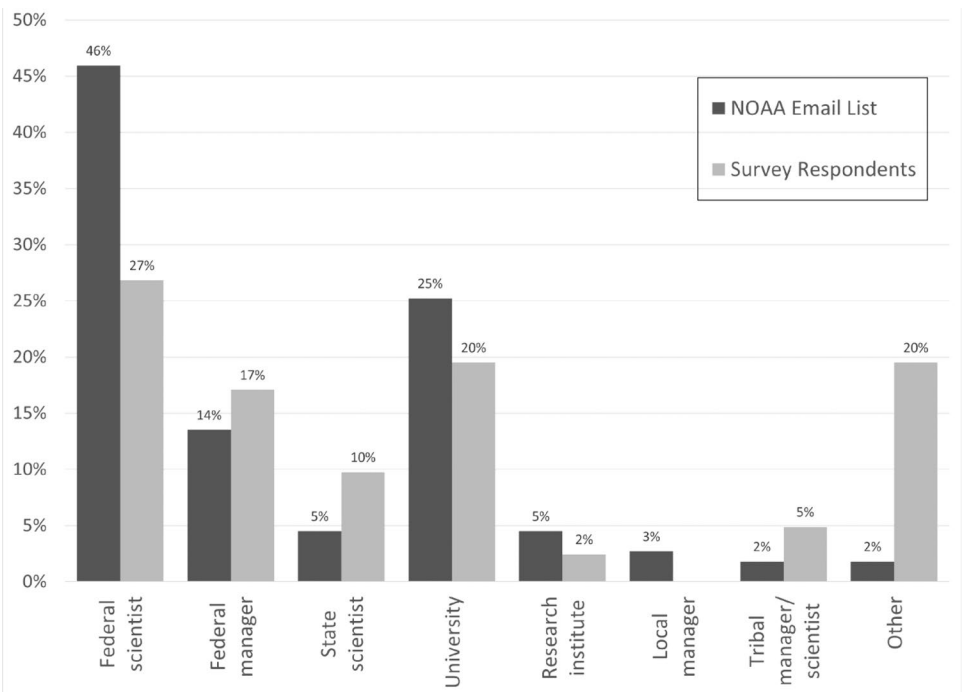

Figure 2. Distribution of job categories for the NOAA West Watch email distribution list and current attendee survey respondents.

job categories may not be representative of the email distribution list; the survey respondents had a much lower percentage of "federal scientists" and a larger percentage of "other" job types. However, there is currently no mechanism to identify who participates in the webinars, so we assume the survey respondents are more representative of the actual webinar attendees than the email distribution list.

Data analysis

Interview data

Interview data were transcribed from audio recording into Microsoft Word and edited to clean read transcripts (Kvale 2007). Transcripts were coded in MaxQDA 18 using the grounded theory approach, where themes were built through an iterative coding process (Auerbach and Silverstein 2003). Other researchers coded a subset of transcripts and reviewed common codes to identify missing themes to practice inter-coder reliability, a process that increases validity and reliability of qualitative data analysis (Auerbach and Silverstein 2003).

Survey data

Questionnaire responses were compiled in Qualtrics, and all survey data were exported to Microsoft Excel for analysis in IBM Statistical Package for the Social Sciences. Open-ended responses were transferred to a Microsoft Word document and coded in MaxQDA 18 using the same coding process as interview data.

Findings

From a quantitative perspective, the data collected from current attendees (Mazur 2019) indicates that West Watch appears to be functioning effectively and presenting appropriate content. Effectiveness is determined by meeting West Watch's documented goals of: (1) communicating changing environmental conditions to NOAA experts and key partners, and (2) communicating the impacts those changing conditions have on communities of interest. However, qualitative results from all three research groups provide more nuance on the perceived effectiveness of both the process and content.

West Watch currently has an effective process for one-way communication; it transfers information from the research-based presenters to current attendees. For example, current attendees responded that the presented climate, ENSO, and IOOS nearshore conditions updates (which consists of real-time conditions and modeled outlooks) provides regional context to their local conditions and observations. While content appears to be appropriate for both the current audience and CBEs, all three groups had suggestions for improving how this technical information is presented.

However, West Watch does not function effectively as a two-way communication tool. Although information is moving from the webinar to the current attendees, there is limited engagement that results in information moving from current attendees back to the webinar coordinators. The researchers observed only a few webinars which included designated discussion time; similarly, there were few discussion prompts or questions given to facilitate conversation.

Across all three research groups, five themes emerged relating to improving West Watch in both a one- and two-way capacity. We consider each theme in the context of relevant literature and develop best practices for each to guide the future design and delivery of West Watch and other science communication tools (Figure 3). While these themes and best practices are presented independently, they can interact and inform each other and be iteratively refined. Continually improving science communication activities may result in more effective movement of information between researchers and natural resource managers, ultimately aiding decision-making and better aligning research and management questions.

Theme 1: Goals and outcomes of the communication activity

West Watch coordinators agreed that the webinar's primary goals were to: (1) communicate changing environmental conditions to NOAA experts and key partners, and (2) communicate the impacts those changing conditions have on communities of interest. By sharing tools and information regarding large-scale environmental anomalies, the coordinators described potential outcomes as increased internal agency collaboration and broad regional awareness:

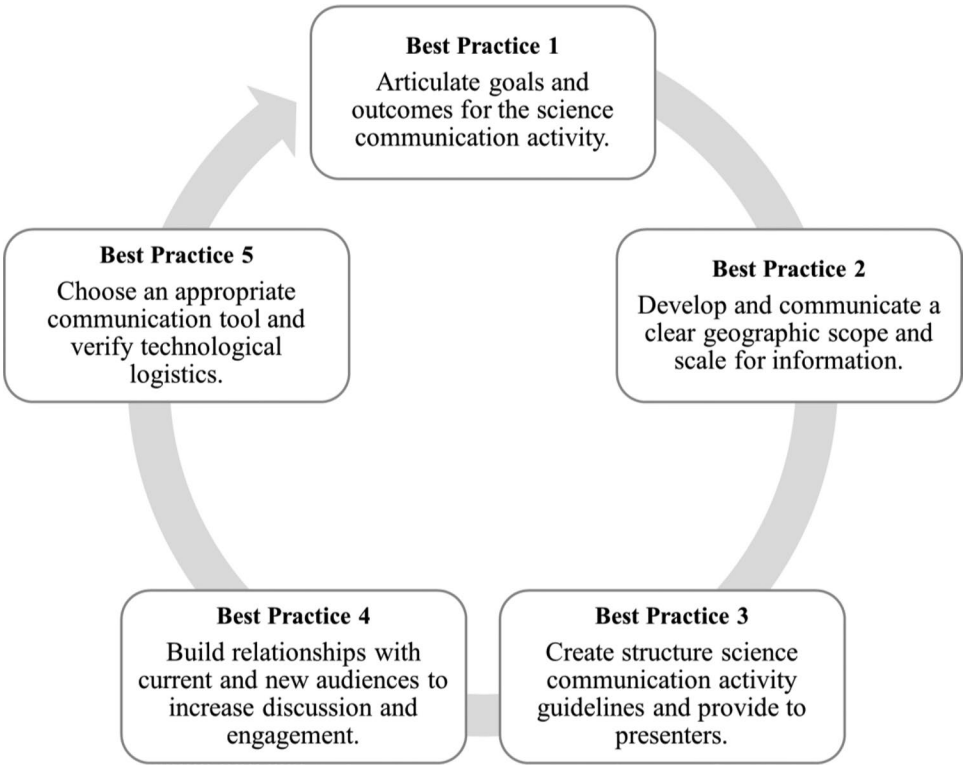

Figure 3. Five best practices for science communication development and delivery informed by case study results and relevant literature. Best practices can interact, and decisions made at each step may be iteratively refined based on feedback from the target audience.

> It may be a little bit harder to quantify or really talk about the benefits because it is a little bit more amorphous in that it's just learning and connections and that broader regional awareness.

These goals are being met based on feedback from current attendees and CBEs. When asked why they tune into West Watch, 74 percent of survey respondents (current attendees) said their primary reason for watching was to increase their awareness of environmental conditions. This contextual awareness was echoed in qualitative responses (47%, $n = 18$ of 38) from the survey about why the information in West Watch benefits them:

> [West Watch] provides coast-wide (and often basin-scale) context of weather patterns and conditions that helps me to better understand regional/local conditions and observations.

Similarly, a majority of CBEs described how the information in West Watch gave context to local environmental conditions that affect their work. They appreciated how the information drew connections between global and local conditions, marine and terrestrial conditions, and current and predicted future conditions.

West Watch's current goals and outcomes are appropriate for the originally intended one-way communication function. However, these goals and outcomes do not reflect NOAA West's interest in increasing engagement and discussion and transitioning to a two-way communication system. Additionally, the coordinators discussed their intention to increase discussion and engagement on the webinar; however, no processes were in place (e.g., discussion questions or prompts) to achieve this plan.

Best practice #1: Articulate goals and outcomes for the science communication activity

When designing science communication tools, Fazey et al. (2014) concludes that tools should be explicit about how information exchange is conceptualized, explicit about assumptions for how the process is expected to deliver its outcomes, and designed with evaluative benchmarks throughout the process. Communication goals should be clear, feasible, and developed in coordination with audiences. The goals should then be summarized into clear messages that are communicated to audiences (NOAA 2016). They may include language describing how the science communication activity is expected to meet the audience's information needs (NASEM 2017). The goals should reflect whether the activity will be one-way or two-way in nature. As described above, West Watch's current goals reflect one-way communication; they should include a goal for eliciting community-based observations of environmental anomalies.

Clearly stated and feasible outcomes should be stated and provide guidance for how the tool will be evaluated and considered effective. For example, the number of individuals or organizations reached might inform how effective an activity is communicating with target audiences. Outcomes can also illuminate assumptions about how the information will be useful to the audience. An implementation timeline for the activity, as well as establishment of evaluation checkpoints, will help monitor success.

Having more tangible outcomes and outputs may also help West Watch coordinators demonstrate the impact of this work and justify spending on the project (Cullen et al. 2001; Heintze and Bretschneider 2000; Hunter 2016).

Theme 2: Geographic scope and scale for information

The second theme that emerged related to an appropriate and useful geographic scope and scale for information. Since West Watch is meant to cover environmental condition anomalies from all 11 states represented by NOAA West, the coordinators described a challenge in catering to all information needs during the one-hour webinar. Furthermore, the coordinators disagreed whether the webinar should include more marine or terrestrial information.

Current attendees appear to be satisfied with the information's current geographic scope. When asked their level of agreement with three statements related to the information's scope ([1] information is spatially relevant; [2] information is not too marine focused; [3] information is not too terrestrial focused), respondents significantly agreed with all three statements (one-way *t*-test; p<.001; *p*=.003; *p*=.002; Table 2). However, open-ended survey responses provide a little more nuance to these results. For example, a minority of respondents requested more terrestrial information or information from sub-regional locations (e.g., Puget Sound).

This challenge of geographic scope and scale was also discussed in CBE interviews. A quarter of the CBE interviewees described that it was unclear if the geographic scope included only the NOAA West region or broader areas:

> It wasn't exactly clear to me during this what the overall extent was. There was some information coming from Alaska, including Hawaii, up and down our coastline, so was that the region?

Like the current attendees, there were also a minority of CBEs who needed information on a finer scale than was offered in the webinar:

> A lot of it, if it's not California specific, is looking at giant areas…. We're very much focused just on Tillamook County in Oregon, so this is much higher level than what we could potentially utilize.

Best practice #2: Develop and communicate a clear geographic scope and scale for information

Once overarching goals are defined, coordinators should delineate a clear scope and scale for webinar information with the help of webinar attendees; West Watch

Table 2. One-way *t*-test of mean agreement with questions regarding content's geographic scope[1].

Variable	Mean (*M*)[2]	Std. dev. (*SD*)[2]	*t*-value	*p*-value	Cohen's *d* effect size
Information is geographically relevant	6.31	0.98	14.74	< .001	2.36
Information is not too marine focused	4.95	1.87	3.22	.003	0.51
Information is not too terrestrial focused	4.83	1.57	3.33	.002	0.53

[1]Tested if indices were significantly different from 4 "neither agree nor disagree".

[2]Variables measured on 7-point scales of 1 "strongly disagree" to 7 "strongly agree".

coordinators should pay particular attention to the geographic scope and scale, and should consider assumptions as to why chosen bounds are thought to be useful and communicate these assumptions to attendees. This clarity will likely help improve the success of delivering West Watch's developed message (NOAA 2016).

When considering the appropriate geographic scale, the webinar coordinators will need to determine the appropriate balance between wide regional relevance and sub-regional application. A broader spatial distribution may appeal to a more diverse audience, but CBEs and current attendees indicated they need more fine-scale information for managerial use and decision-making. These results are consistent with previous literature that found that managers often need information on different spatial scales or from different geographic locations than where research was conducted (Barbour 2007; Roux et al. 2006). Guest speaker presentations could remedy the spatial distribution challenge; typical webinar information may be more broad-scale, while guest speakers can fill in sub-regional information needs indicated by current attendees.

With a clear geographic scope, current attendees can adjust their expectations about what information they will receive in the webinars. Additionally, presenters may be more cognizant about biases toward certain geographic locations.

Theme 3: Design and structure of the communication activity and tool

A third theme that emerged related to the design and implementation of the communication activity and webinar tool, particularly the format in which technical content is presented. The coordinators agreed that presenters are given maximum flexibility and minimal oversight in presentation development. The coordinators defer to the expertise of these researchers to share what they think is most pertinent information. With the coordinators who had been involved with West Watch daily since the beginning of this research (50%, $n = 5$; hereafter "active coordinators"), there was consensus that presenters are told to provide technical information that is understandable to a broad audience:

> We know that the people are going to generally have some science background, but they're going to be different fields and different levels of how they use their science in their day-to-day work. We try to keep it for a pretty broad audience.

Current attendees confirmed that the technical information is broadly understood. Five survey questions were combined in a mean index to measure overall agreement with the information's understandability (Mazur 2019). A one-way *t*-test found that respondents significantly agreed that information was understandable ($p<.001$) with a large Cohen's *d* effect size ($d = 2.29$; Cohen 1988). However, open-ended responses provided additional detail. Of the qualitative responses that related to information understandability (66%, $n = 25$ of 38), 26 percent ($n = 9$ of 25) were satisfied with the current technical level while 64 percent of respondents ($n = 16$ of 25) suggested improving both the content (44%, $n = 11$ of 25) and format (20%, $n = 5$ of 25) to help them better understand the information. Suggestions from these current attendees for improving content included using less technical jargon and having better explanations of main

takeaways. All comments related to information format suggested improving slide organization to help make information more understandable and easier to read.

Similarly, a majority of CBEs were satisfied with the technical content but had suggestions for improving presentations, as represented by one CBE:

> People walking through their graphs is helpful. Not everyone is coming from the same background science, and we have different graphs that may be very familiar to an oceanographer but isn't necessarily to an ecologist or a freshwater biologist…. We also have some different terminologies across disciplines. So, as a science communicator be aware that jargon within your discipline may not translate across to other scientists.

Best practice #3: Create structured science communication activity guidelines and provide to presenters

While the coordinators do not need to change the technical content presented during West Watch, they should create standardized presentation format guidelines for all information segments. Current attendees and CBEs recommended that these guidelines include clear expectations on appropriate use of technical jargon, slide format, and the importance of clear takeaway messages. Content challenges appear to have resulted from a lack of standard presentation elements that stems from vague goals and outcomes. Presentation guidelines should improve information delivery by creating more cohesive information segments and clarifying assumptions regarding the audience's technical backgrounds.

Science curriculum and professional development program design literature emphasize the importance of developing structured plans to achieve learning goals and outcomes (Wiggins and McTighe 2005). Similarly, since science communication attempts to educate and inform, communication program and activity design should start with clear goals and outcomes, followed by planning for content that fills audiences' information needs (Fowler and Hobbs 2009; Kocher et al. 2012; Leskens et al. 2014). Program design should be iterative and adaptable (NASEM 2017), and audiences should have both formal (e.g., surveys, evaluations) and informal (e.g., conversations, emails) opportunities to provide feedback on how to refine information delivery.

Theme 4: Engagement and discussion

Results related to engagement and discussion with current attendees and potential new audiences (represented by CBEs) can be used to assess and inform West Watch as a two-way communication tool. Over the 14-month, seven-webinar research study period, the researchers observed minimal discussion during the webinars. Often, the webinars ran out of time for discussion and engagement. The webinar coordinators also did not articulate what mechanism they desired for contributing (e.g., chat box, audio). Finally, there was minimal discussion facilitation from the webinar coordinators.

The active coordinators agreed that engagement with current audiences is minimal. As a result, these coordinators do not have a good understanding of who participates in the webinars:

> We don't have a lot of understanding of why people are [participating]. As the audience has changed and grown a little more amorphous and more external to NOAA, it's more difficult to know what these folks are getting out of the webinar.

Likely, the lack of consensus regarding content effectiveness emerges from not having a clear understanding of the audience. Instead, these coordinators assume West Watch is successful because the webinars consistently have 30 to 40 attendees.

To understand how successful West Watch is at engaging with its audience, it is important to determine how the current attendees are using the communication tool. When asked how frequently they tune into West Watch, 90 percent of survey respondents are tuning in "a couple of times" or for "every second/third" webinar. Because the webinar coordinators are unable to track who is consistently tuning in, they may not be able to rely on the same methods of engagement every webinar. Additionally, presenters cannot assume that attendees can interpret figures or graphics that were presented in prior webinars.

West Watch is connecting to current attendees largely through word-of-mouth advertisement. Most survey respondents replied that they first heard about West Watch through the coordinators or their place of work, which may be inefficient advertisement methods to reach a more diverse group of interested individuals.

Despite the lack of engagement with current audiences, active coordinators see value in increasing engagement with both current and new audiences:

> If you can find a way to expand the audience and expand the engagement, then questions always help increase knowledge about issues; whether it's questions for the scientist that they never thought of before, different ways of thinking about a problem, or a connection with some other project that they didn't know about.

Of the potential new audiences, represented by interviewed CBEs, engagement and discussion themes emerged in half of the interviews. While these CBEs were open to discussion, they agreed that the webinar needed additional dedicated discussion time, better facilitation, and clearer engagement expectations:

> I feel like it is more difficult on a webinar to have the two-way communication versus an in-person presentation; but a webinar is best to get the information out to a broader audience. I think just allotting more time would help increase discussion.

One potential area for improving discussion and engagement is the reporting of environmental impacts to communities of interest. Currently, these impacts are collected from media reports, rather than direct communication with scientists, managers, or communities. Across all research groups, a minority of respondents suggested better solicitation of these environmental impacts from the webinar's audience. The active coordinators suggested using different solicitation methods, since the current methods are not resulting in desired discussion:

> We ask at the end of the call, but that's obviously not enough. So that could be followed up maybe once a month with an email reminding [attendees] about the call and also

asking them to please provide any impacts that they think would be useful to share with the group.

Current attendees also reported wanting more time than is currently spent on the environmental impacts report and discussion section (Table 3), as verified by a one-way *t*-test (p=.002), with a Cohen's *d* effect size between medium and large (d=.59; Cohen 1988).

Best practice 4: Build relationships with both current and new audiences to increase discussion and engagement

Having strong relationships between researchers and managers has proven effective for science communication and information transfer (Barbour 2007; Fazey et al. 2014; Leskens et al. 2014; Matso and Becker 2014; Roux et al. 2006; Ryan and Cerveny 2011). However, West Watch lacks a strong relationship with its current attendees. All research groups recommended creating dedicated discussion time, communicating expectations for how discussion is to occur (e.g., discussion topics, over chat versus verbal), and following up with attendees between webinar sessions. For example, as part of this case study, NOAA West hypothesized that CBEs could gather community observations regarding environmental anomalies (e.g., a landslide after heavy rains that impacted a coastal community) and report them back during West Watch webinars. The coordinators could improve discussion around this topic by clearly communicating the intent of this topic, asking attendees to document these types of observations between webinars, and providing their own examples to actively start discussions. Recent webinar technology advances such as polling questions, breakout groups, chat boxes, and surveys also increase opportunities to engage attendees.

Coordinator interviews suggested that audience growth was not a priority since advertisement typically occurs through word-of-mouth. West Watch should emphasize relationship-building with new attendees by diversifying advertisement methods such as list servs and newsletters that could help West Watch reach and build relationships across broad disciplines and organizations. Additionally, tools such as automated webinar sign-ups, websites, and publicly available recorded webinars can be promoted to new audiences.

Table 3. One-way *t*-test for desired change in amount of time spent on each information section[1].

Section	Mean (*M*)[2]	Std. dev. (*SD*)[2]	*t*-value	*p*-value	Cohen's *d* effect size
Regional Climate Update	2.29	.46	3.71	< .001	.63
ENSO Status Update	2.00	.43	0	1	
Guest Speaker	1.84	.63	−1.41	.169	
IOOS (Nearshore Ocean Condition Update)	1.85	.66	−1.30	.201	
Environmental Impact Report/ discussion	2.42	.71	3.44	.002	.59

[1]Topics measured on three-point scales from 1 "spend less time than currently" to 3 "spend more time than currently." One-way t-test that the sample mean differed from 2 "same amount of time as now."

Theme 5: Communication tool and technology logistics

Webinars are increasingly used by federal agencies to quickly communicate to broad audiences. However, as with all technology use, webinars are subject to technology and human error, and there is a lack of literature pertaining to webinar best practices in an agency setting. While the technological logistics theme was a minority across the research groups, there were suggestions from all for improved delivery of West Watch webinars.

All research groups discussed the benefits of recording West Watch webinars. Three-quarters of current attendees answered they would likely watch recordings if they were offered. Additionally, a minority of respondents across all research groups described that a recording is an effective mechanism for sharing the webinar with potential new audiences.

Best practice #5: Choose an appropriate communication tool and verify technological logistics

When using technology to facilitate science communication, an appropriate tool needs to be chosen to support the communication goals. West Watch webinars were an effective tool for quickly disseminating information to broad audiences, but may not be appropriate for hosting engagement and discussion. Webinar features such as chat boxes, polling questions, or dedicated discussion can improve audience engagement. While speculative, results from this study suggest that the format of a communication tool (e.g., using a webinar) is not as critical to its success as the content and built relationships, but having minimal technological errors while delivering the communication tool may help create buy-in and credibility with the audience. A minority opinion within the CBEs expressed frustration when the webinar technology did not run as planned (e.g., issues with audio, interruptions from other attendees).

Barriers to improving science communication

Institutional barriers such as funding, personnel turnover, time, and policy priorities have been identified in the literature as continual challenges to communication (Averyt et al. 2018; Cullen et al. 2001; Kocher et al. 2012). These challenges were also described throughout this research as reasons why West Watch was limited in its current format.

"Mission risk" or "agency risk" was the most common institutional challenge mentioned by West Watch coordinators, especially in relation to an expanded audience. Mission risk was previously described as being related to providing data to high-stakes end users, providing inaccurate or incomplete data, applying model data to real-world application, or data misuse and misinterpretation (Barbour 2007; Kuonen 2018). The webinar coordinators are increasingly risk-adverse as the webinar audience diversifies and increases because of uncertainty related to not knowing who is on the call and the potential for audiences to misuse or misinterpret information.

However, there are ways to mitigate this perceived risk. First, clearly defined communication goals should identify the target audience and set expectations regarding

who may be among audience attendees. Second, webinar tools can track subscribers and attendee use of the system, so coordinators can use this technology to have a better understanding of how audiences are interacting with webinar material. Third, West Watch should communicate the verification, strengths, and weaknesses in the presented model, methods, or results (Leskens et al. 2014). Finally, most information presented during West Watch is publicly available through government reports; guest speakers can be asked to limit presenting preliminary or novel data.

Another commonly mentioned institutional barrier is the lack of consistent funding for sustained webinars. While agency projects compete for funding, research has shown that information does not reach decision-makers if there are not enough allocated resources (Matso and Becker 2014). Results from Borberg et al. (2013) are consistent with this study, where broader audiences and stakeholders are not engaged because of resource deficiency and lack of demonstrated engagement from leadership. While it will take resources to improve West Watch and expand the audience, demonstrating the broad value of this communication activity may help procure funding.

Conclusion

This research sought to assess the efficacy of West Watch and to identify how the webinars could transform from a one- to two-way communication tool that engages natural resource managers, practitioners, and professionals. West Watch and similar communication tools have the potential to increase regional communication of anomalous environmental conditions, which could improve response to community impacts resulting from these events. While this research yielded some potential best practices for improving this system, future utility ultimately lies with cooperation from both science communication activity and program coordinators and their audiences. Additionally, institutional barriers such as funding and mission risk will need to be addressed if these programs and activities are to have long-term impacts.

Improving West Watch and increasing broad communication in other forms has clear advantages to NOAA and other science communication organizations. This research demonstrates that not only can these tools support broad dissemination of important science, but having feedback from information users could help providers improve communication about, and possibly production of, their work. Additionally, quantifying broad dissemination can help NOAA demonstrate the value of publicly funded research and tools that are increasingly important in funding-limited environments (Bell, Shaw, and Boaz 2011; NOAA 2016). Finally, although the communication tool (webinars) may present inherent challenges to facilitating discussion with audiences, there is potential for this mechanism to improve when engagement is made a priority and expectations are clearly communicated.

Benefits to target audiences go beyond just saving time or having information aggregated in one location. In this information-overload era, it can be challenging and daunting for managers to find information they need and synthesize it for decision-making. Communication tools like West Watch could expose managers to information they may not have previously found and/or in an easy-to-use, one-stop-shop format (Hunter 2016; Kocher et al. 2012). Additionally, information users could communicate their information needs that could then be addressed by individuals

coordinating the tool. Finally, natural resource managers and other practitioners are often intimately involved with their communities. Involving these CBEs gives constituents a voice in the scientific process and potentially in environmental policy on a regional level.

While there are benefits of two-way communication, future research should explore how researchers and managers can be incentivized to implement two-way communication systems. Potentially, making these benefits and incentives less abstract and more visible may help increase the occurrence and effectiveness of two-way communication.

Acknowledgements

The authors would like to acknowledge the research participants who gave their time to make this research possible.

Declaration of interest statement

No potential conflict of interest was reported by the authors.

Funding details

This work was supported by Oregon Sea Grant under Grant [NA18OAR4170072] and the National Oceanic and Atmospheric Administration's Western Regional Collaboration Team.

ORCID

Emily N. Mazur https://orcid.org/0000-0001-8997-6971

References

Adams, T. T., B. W. Butler, S. Brown, V. Wright, and A. Black. 2017. Bridging the divide between fire safety research and fighting fire safely: How do we convey research innovation to contribute more effectively to wildland firefighter safety?*International Journal of Wildland Fire* 26 (2):107–12. doi: 10.1071/WF16147.

Auerbach, C. F., and L. B. Silverstein. 2003. *Qualitative studies in psychology. Qualitative data: An introduction to coding and analysis*. New York, NY: New York University Press.

Averyt, K., J. D. Derner, L. Dilling, R. Guerrero, L. Joyce, S. McNeeley, E. McNie, J. Morisette, D. Ojima, R. O'Malley, et al. 2018. Regional climate response collaboratives: Multi-institutional support for climate resilience. *Bulletin of the American Meteorological Society* 99 (5):891–8. doi: 10.1175/BAMS-D-17-0183.1.

Barbour, J. 2007. Accelerating adoption of fire science and related research. U.S. Joint Fire Science Program Final Report 05-S-07, Boise, ID. Accessed March 23, 2019. http://digitalcommons.unl.edu/jfspresearch/97

Bell, S., B. Shaw, and A. Boaz. 2011. Real-world approaches to assessing the impact of environmental research on policy. *Research Evaluation* 20 (3):227–37. doi: 10.3152/095820211X13118583635792.

Borberg, J., S. B. Brandt, J. E. Stein, and T. Vann. 2013. *Knowledge, capacity, and needs for effective stakeholder engagement in marine planning: Key findings from a west coast assessment. ORESU-S-13-002*. Corvallis, OR: Sea Grant California.

Cohen, J. 1988. *Statistical power analysis for the behavioral sciences*. 2nd ed. Hillsdale, NJ: Lawrence Earlbaum Associates.

Cone, J., S. Rowe, J. Borberg, E. Stancioff, B. Doore, and K. Grant. 2013. Reframing engagement methods for climate change adaptation. *Coastal Management* 41 (4):345–60. doi: 10.1080/08920753.2013.803926.

Cullen, P., P. Cottingham, J. Doolan, B. Edgar, C. Ellis, M. Fisher, D. Flett, D. Johnson, L. Sealie, S. Stocklmayer, et al. 2001. *Knowledge seeking strategies of natural resource professionals. Technical Report 2/2001*. Canberra: CRC for Freshwater Ecology, Bungendore, NSW.

Dillman, D. A. 2011. *Mail and Internet surveys: The tailored design method – 2007 update with new Internet, visual, and mixed-mode guide*. Hoboken, NJ, USA: Wiley Publishers.

Fazey, I., L. Bunse, J. Msika, M. Pinke, K. Preedy, A. C. Evely, E. Lambert, E. Hastings, S. Morris, and M. S. Reed. 2014. Evaluating knowledge exchange in interdisciplinary and multi-stakeholder research. *Global Environmental Change* 25:204–20. doi: 10.1016/j.gloenvcha.2013.12.012.

Fowler, C. W., and L. Hobbs. 2009. Are we asking the right questions in science and management? NOAA Technical Memorandum NMFS-AFSC-202.

Heintze, T., and S. Bretschneider. 2000. Information technology and restructuring in public organizations: Does adoption of information technology affect organizational structures, communications, and decision making?*Journal of Public Administration Research and Theory* 10 (4):801–30. doi: 10.1093/oxfordjournals.jpart.a024292.

Hunter, M. E. 2016. Outcomes of fire research: Is science used?*International Journal of Wildland Fire* 25 (5):495–504. doi: 10.1071/WF15202.

Kocher, S. D., E. Toman, S. F. Trainor, V. Wright, J. S. Briggs, C. P. Goebel, E. M. MontBlanc, A. Oxarart, D. L. Pepin, T. A. Steelman, et al. 2012. How can we span the boundaries between wildland fire science and management in the United States?*Journal of Forestry* 110 (8):421–8. doi: 10.5849/jof.11-085.

Kuonen, J. A. 2018. Ocean views: Characterizing risk perception, uncertainty, and decision-making within the ocean condition forecast system. Master's thes., Oregon State University.

Kvale, S. 2007. Transcribing interviews. In *Doing interviews*, ed. U. Flick, 93–100. London, England: SAGE Publications, Ltd.

Leskens, J. G., M. Brugnach, A. Y. Hoekstra, and W. Schuurmans. 2014. Why are decisions in flood disaster management so poorly supported by information from flood models?*Environmental Modelling & Software* 53:53–61. doi: 10.1016/j.envsoft.2013.11.003.

Matso, K. E., and M. L. Becker. 2014. What can funders do to better link science with decisions? Case studies of coastal communities and climate change. *Environmental Management* 54 (6):1356–71. doi: 10.1007/s00267-014-0347-2.

Mazur, E. N. 2019. Designing and delivering effective two-way science communication tools: A case study of NOAA West Watch webinars. Master's thes., Oregon State University.

NASEM (National Academies of Sciences, Engineering, and Medicine). 2017. *Communicating science effectively: A research agenda*. Washington, DC: The National Academies Press.

NOAA (National Oceanic and Atmospheric Administration). 2016. Risk communication and behavior: Best practices and research findings. Accessed February 10, 2019. https://www.performance.noaa.gov/wp-content/uploads/Risk-Communication-and-Behavior-Best-Practices-and-Research-Findings-July-2016.pdf

Roux, D. J., K. H. Rogers, H. C. Biggs, P. J. Ashton, and A. Sergeant. 2006. Bridging the science-management divide moving from unidirectional knowledge transfer to knowledge interfacing and sharing. *Ecology and Society* 11 (1):4. [online]. doi: 10.5751/ES-01643-110104.

Rubin, H. J., and I. S. Rubin. 2005. *Qualitative interviewing. The art of hearing data*. 2nd ed.Thousand Oaks, CA: SAGE Publications, Inc.

Ryan, C. M., and L. K. Cerveny. 2011. Wildland fire science for management: Federal fire manager information needs, sources, and uses. *Western Journal of Applied Forestry* 26 (3):126–32. doi: 10.1093/wjaf/26.3.126.

Wiggins, G. P., and J. McTighe. 2005. *Understanding by design (Expanded 2nd edition.)*. Alexandria, VA: Association for Supervision and Curriculum Development.