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Identifying and harmonizing the priorities of stakeholders in the Chesapeake Bay environmental monitoring community

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ABSTRACT

Research collaborations between volunteer monitoring groups and environmental scientists and managers are instrumental for understanding and managing complex socioecological systems. In the Chesapeake region, the Chesapeake Monitoring Cooperative (CMC) helps coordinate volunteer monitoring efforts throughout the watershed, and facilitates collaboration between environmental stakeholders. However, stakeholders perceive their environment and their own role in different ways, and these perceptions affect how they prioritize problems and respective solutions. We conducted a survey to explore the extent to which cultural knowledge about environmental monitoring was shared across the CMC community, pinpoint key similarities and differences in how stakeholder groups prioritized various environmental monitoring goals, and understand stakeholders' perspectives of the CMC's resources. We learned that stakeholders drew from a shared system of cultural knowledge surrounding environmental monitoring and prioritized goals related to collecting actionable data and improving environmental conditions. There were also compelling differences in how stakeholder groups prioritized increasing knowledge and building a sense of community. Furthermore, stakeholders especially valued CMC resources associated with increasing the quality, quantity, and accessibility of volunteer-collected data. Based on our results, we developed recommendations to inform the design and coordination of other collaborative environmental monitoring programs. We argue that cultural consensus can provide a foundation for collaboration, and stakeholders' highest-priority monitoring goals can inform organizational priorities and strategic outreach. Furthermore, efforts to build social capital and understand stakeholders' changing priorities over time will be important for ensuring the continued success of the research partnership.

1. Introduction

As the environment responds to increasing threats due to climate change and other anthropogenic pressures, it is extremely important to understand how environmental health is changing over time. Data from environmental monitoring programs can help scientists, managers, policy makers, and other stakeholders understand environmental changes and trends, identify areas of greatest concern, and prioritize restoration and conservation action (Sparrow et al., 2020; Lovett et al., 2007; Brydges, 2004). Chesapeake Bay is threatened by nutrient and sediment pollution from development and agricultural practices, overfishing, and climate change, and data and coordinated monitoring are needed to inform management decisions (Bilkovic et al., 2019; CBP, 2009; Boesch and Greer, 2003). Policy makers and environmental managers have known for decades that effective management of the Bay requires a sustained monitoring program and coordination among stakeholders (Gillelan et al., 1983).

The U.S. Environmental Protection Agency's Chesapeake Bay

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Program directs the restoration of the Bay and is widely-regarded as one of the most notable scientific management efforts in the world (Boesch and Goldman, 2009). The Bay Program initiated their monitoring program in 1984 after the prior year's inaugural Chesapeake Bay Agreement outlined the need for a comprehensive, cooperative, and coordinated approach towards Bay management and restoration (Hennessey, 1994). The monitoring program includes data collected by federal, state, and local governments, academic institutions, and non-governmental organizations. These groups contribute physical, chemical, and biological data that address the specific management goals and environmental outcomes outlined in the Chesapeake Bay Watershed Agreement (Matuszeski, 1995). The Bay Program's monitoring effort is robust and extensive; nevertheless, many spatial and temporal data gaps exist (STAC, 2005). These data gaps can impede scientific understanding of baseline and trend information and lead to lag times in management response (STAC, 2009).

The Chesapeake Bay watershed is also home to many volunteer-based monitoring programs that collect robust chemical, physical, and biological data in order to answer specific questions about health of local streams, watersheds, or broader ecosystems (Rubin et al., 2017). There are multiple definitions for volunteer environmental monitoring (*e.g.*, Stepenuck and Genskow, 2018; Pfeffer and Wagenet, 2007; Kerr et al., 1994), but in the present study the term refers to monitoring that involves individuals or groups that have not traditionally been included in the Chesapeake Bay Program's monitoring program, such as individual volunteers, non-profit organizations, watershed organizations, local governments, and conservation districts. Previous research has shown that volunteer-collected data has the potential to fill existing data gaps and inform timely management solutions in estuarine and freshwater systems (Stepenuck and Genskow, 2018; Fisher, 1993; Hiller, 1991).

Despite this clear potential of volunteer-collected data, a lack of coordination and continuity between monitoring programs in the Chesapeake Bay region has contributed to data comparability issues throughout the watershed. Organizations within the Chesapeake Bay watershed have invested in water quality monitoring for diverse reasons and at a variety of scales, based on community interests and needs (Rubin et al., 2017). Furthermore, these programs have traditionally operated independently of one another using different equipment and techniques based on each group's specific motivations for collecting data and their access to resources. When data comparability is lacking, it is difficult and time-intensive to use the data beyond the intended local-scale use or integrate the data with more traditional datasets to fill existing data gaps. This is especially true when those datasets stretch across a geographically expansive, multi-jurisdictional and ecologically-heterogeneous area like the Chesapeake Bay watershed. Nevertheless, data comparability plays a critical role in bridging the gap between fulfilling individual data collection motivations and addressing data needs assessed at a broader scale (Conrad and Daoust, 2008; Rebele, 1997). In 2015, the Chesapeake Bay Program initiated a program to increase data comparability and usability throughout the region (CBP, 2018). This program, known as the Chesapeake Monitoring Cooperative (CMC), is a multi-state initiative that supports volunteer-based monitoring groups in order to integrate volunteer-collected data with formal datasets that are traditionally used in policy and decision making processes.

The complexity of relationships within the volunteer monitoring community and between the volunteer community and local, state, and federal agencies is a challenge the CMC needs to overcome. Different stakeholders perceive their environment and their own role in different ways, and these perceptions affect how they prioritize problems and respective solutions (Verbrugge et al., 2017). In the Chesapeake region, the diversity of monitoring priorities, coupled with the lack of cohesion between monitoring efforts, has led to a widely-held perception that every group has fundamentally different monitoring goals and intended data uses. This perceived misalignment of interests between stakeholder groups is a historic and pervasive problem that hinders compromise and growth at all levels.Therefore, in addition to being tasked with integrating volunteer data within the watershed into traditional datastreams, the CMC also faces the challenge of reconciling a wide diversity of monitoring priorities, balancing multi-scalar stakeholder needs, and ultimately fostering a more collaborative mentality among members of the Chesapeake environmental monitoring community by finding the common ground between stakeholder groups.

Many researchers have investigated volunteers' motivations and goals for participating in environmental monitoring programs (*e.g.* Robinson et al., 2020; Wright et al., 2015; Alender, 2016); however, motivations and goals are often context-dependent and vary by stakeholder group (Verbrugge et al., 2017). Furthermore, studies exploring other stakeholders' priorities surrounding these collaborative scientific efforts are much more uncommon especially ones that investigate the perspectives of data consumers (*e.g.* Cooper et al., 2017). In their review of published papers that focus on stakeholder motivations for participating in community-based monitoring projects, Wehn and Almomani (2019) found that 36 of the 42 papers analyzed focussed on citizen participation, while only 10 papers investigated the motivations of other stakeholders, such as scientists and decision makers. Many existing studies do recognize that it is important to understand stakeholder perceptions and motivations in order to successfully recruit and engage participants and accomplish programmatic objectives (Wright et al., 2015; de Groot et al., 2014; Luyet et al., 2012). A detailed understanding of stakeholders' monitoring goals also allows volunteer programs to more effectively serve members by emphasizing shared priorities and strategically aligning programmatic resources. Furthermore, inclusion of diverse stakeholder knowledge and values in decision-making processes is also important for developing trust (Jones et al., 2014), fostering community empowerment (Thornton and Scheer, 2012), and increasing socioecological system resilience (Berkes, 2007).

Although many studies have acknowledged the importance of stakeholder views and perspectives, they have not taken a formal approach to the study of knowledge, beliefs, and values. Additionally, in the context of volunteer monitoring and citizen science, a gap exists for studies that attempt to systematically compare stakeholder values and perspectives across different stakeholder groups, and then contextualize those findings within the broader context of cognitive and cultural and environmental knowledge. Culture is important; it does influence understanding and behavior; however, far too often it is not defined and systematically studied. For the CMC, a more nuanced understanding of stakeholders' cultural knowledge surrounding environmental monitoring could unlock enormous potential for increased collaboration and data use within the Chesapeake environmental monitoring community.

In the present study, we explored the extent to which cultural knowledge about environmental monitoring is shared across the CMC community. We surveyed scientists, managers, volunteers, coordinators, and service providers within the CMC network to identify key similarities and differences in how stakeholder groups prioritize various monitoring goals. We also investigated stakeholders' perspectives on the value of various CMC resources. Finally, we provided four recommendations that can improve future CMC efforts. Beyond helping the CMC, our methodology and resulting recommendations could be applied to inform the design and coordination of other regional-scale or even national-scale environmental monitoring programs that include volunteer-collected data alongside traditional datasets.

2. Conceptual approach and methods

2.1. Cognitive cultural approach

Despite the known importance of including local perspectives and values in environmental decision-making and problem-solving processes, participatory efforts often fail to meaningfully engage and empower stakeholder communities (Miller Hesed et al., 2021). One significant obstacle for participatory efforts, including volunteer monitoring programs, is a lack of understanding of stakeholders' diverse forms of cultural knowledge (Miller Hesed et al., 2021). Culture is widely recognized as a core element of how people value, interact with, and actively manage the environment (Paolisso, 2015). Cultural knowledge can be described as systems of values and beliefs that influence decision-making and behavior and help support group identity. In the context of environmental issues, cultural knowledge is created by shared experiences, as well as implicit and explicit understandings of nature and the natural environment (Miller Hesed and Paolisso, 2015). It is important to understand cultural knowledge because individuals and stakeholder groups draw from their cultural knowledge to understand and assign meaning to environmental issues (Miller Hesed and Paolisso, 2015), which affects their motivations and priorities. Understanding how cultural knowledge varies within and across stakeholder groups can inform strategic participatory efforts.

This study employs a cognitive cultural approach to looking at patterns in cultural knowledge and behavior. Specifically, we use a cognitive approach called cultural consensus to measure the distribution of cultural knowledge and values within the CMC stakeholder community. Cultural consensus is a formal conceptual and methodological approach from the field of cognitive environmental anthropology that uses a series of related questions to identify the cultural beliefs of a group and then statistically quantify the degree to which individuals share those beliefs (Weller, 2007; Romney et al., 1986). Cultural consensus analysis can be used to identify patterns in the distribution of cultural knowledge and quantify the degree of consensus within and between stakeholder groups (Paolisso, 2015; Dengah, 2013). This approach is particularly well-suited for interdisciplinary and transdisciplinary studies involving multiple stakeholders because it bridges statistics and qualitative social sciences (Miller Hesed et al., 2021). This approach has been used to study cultural dynamics of various socioecological issues, including fisheries (Johnson and Griffith, 2010), climate change (Kempton et al., 1996), and climate adaptation planning (Miller Hesed et al., 2021). Cultural models are similar to mental models (Craik, 1952; Jones et al., 2011), but with a greater emphasis on the shared, social production of individual knowledge structures and schemas. In this study, the cultural consensus approach is used to study the cultural knowledge of CMC stakeholders surrounding the topic of environmental monitoring. This cultural knowledge represents stakeholders' goals, priorities, and motivations for participating in environmental monitoring.

2.2. Study area

Chesapeake Bay, located in the Mid-Atlantic region of the United States, is the nation's largest estuary. The Bay's drainage basin covers 166,000 km^2 in six states and the District of Columbia (Gillelan et al., 1983), and is home to more than 18 million people (Bilkovic et al., 2019). Chesapeake Bay is also shallow, includes a dendritic tributary system, and has a relatively small volume in relation to its watershed size (Linker et al., 2012). This elevated land-to-water ratio and high level of interconnectedness between people and the water mean that the Bay is especially susceptible to anthropogenic effects that stem from human activities in the watershed (Boesch and Goldman, 2009). Active management is therefore crucial in order to ensure that Chesapeake Bay's long-term health is prioritized so that the Bay can continue to support ecosystems, communities, and economies throughout the watershed.

2.3. Study population

The CMC started in 2015 as a partnership between the Chesapeake Bay Program and the Alliance for the Chesapeake Bay, the Izaak Walton League of America, the Alliance for Aquatic Resource Monitoring (ALLARM), and the University of Maryland Center for Environmental Science. The initiative was originally called "Integration of Citizen-based Monitoring and Nontraditional Monitoring Partners into the Chesapeake Bay Program Partnership". With the philosophy that "all data of known quality are useful," the primary directive of the CMC was to increase the cohesion between volunteer, state, and federal monitoring programs and make volunteer-collected data more accessible for various intended uses (Rubin et al., 2017).

The first few years of the partnership were spent laying the foundation of a cohesive monitoring program by developing resources for volunteer monitoring organizations to help ensure the quality, comparability, and usability of environmental data collected throughout the Chesapeake Bay watershed. The resources included standardized monitoring methods, training protocols, a tiered framework, and a centralized and publicly-accessible database— the Chesapeake Data Explorer. The tiered framework classifies data into three tiers and provides the key structure needed to easily compare data that were collected using an assortment of methods. The Chesapeake Data Explorer provides easy access to data collected throughout the watershed and allows users to quickly filter the data based on the intended data use.

Since its start, the CMC has worked with over 80 organizations, including approximately 2000 volunteers, to integrate data into the Chesapeake Data Explorer. As of January 2021, the Chesapeake Data Explorer had over 365,000 data points and included data from all seven Bay jurisdictions. These data have already been incorporated into the Chesapeake Bay Program's 2020 assessment, the Maryland Department of the Environment's 2020–2022 Integrated Report, the Virginia Department of Environmental Quality's 2022 Integrated Report, and various smaller-scale assessments such as tributary report cards.

2.4. Survey design

We conducted a pilot study in 2016 to begin learning about the monitoring goals and motivations of CMC stakeholders. The pilot study involved informal discussions and participant observation with volunteers, an exploratory questionnaire sent to volunteer coordinators that asked "Why do you monitor?", and informal interviews with several scientists and managers. With the knowledge gained from the pilot research activities, we designed a targeted web-administered survey, which we distributed from November 25, 2019 – February 13, 2020 to stakeholders within the CMC network who played a role in contributing data to the CMC or using volunteer-collected data.

The survey asked respondents to consider their personal and professional motivations for participating in environmental monitoring. We provided a randomized list of 44 distinct monitoring goals and asked survey participants to use a 7-point Likert scale to indicate to what degree they personally prioritized each of the goals (Appendices A and B). The Likert scale ranged from 1 "not a priority for me," to 4 "medium priority for me," to 7 "top priority for me," with the intermediary numbers unlabeled but provided as additional options. The list of 44 goals were categorized into five distinct themes in order to help us develop a balanced survey and enable multi-scalar analyses (by individual goal and by broader thematic category). The individual monitoring goals and the goal categories were directly informed by qualitative coding of free-response data collected using the pilot study questionnaire. The goal categories were known to the research team but were not revealed to participants during the study.

The five goal categories that were included were 1) Data, 2) Environment, 3) Management, 4) Knowledge, and 5) Community. The Data category included goals relating to establishing baseline water quality data, collecting longitudinal data to monitor trends over time, and providing scientists and agencies with credible data. The Environment category contained goals pertaining to identifying impaired waters, improving watershed health, and addressing a concern for habitat or waterway condition. Goals within the Management category were relevant to monitoring restoration and conservation progress, conducting impact assessments, influencing environmental policy or advocating for compliance, and determining risk to public health and human recreation. The Knowledge category included monitoring goals relating to learning about the local environment and educating others on environmental issues. Finally, the Community category encompassed goals pertaining to providing opportunities for community engagement and promoting stewardship and protection of local waterways. We acknowledge that these categories do not represent mutually-exclusive or unrelated concepts; indeed, one could argue that some of the monitoring goals could potentially relate to multiple categories. Still, the categories represent distinct themes that arose during our pilot research, and the goals were categorized into the single category that we believed best captured the core essence of each individual goal.

Additionally, a second set of questions asked participants to share their thoughts on how effective the Chesapeake Monitoring Cooperative has been in helping them achieve their primary environmental monitoring goals. Respondents were given a comprehensive list of CMC resources and services and asked to choose up to five that have been the most effective in helping them accomplish their monitoring goals.

Finally, respondents were asked to self-categorize themselves as members of one of five stakeholder groups: professional scientists, environmental managers, volunteer monitors or citizen scientists, waterkeepers or volunteer coordinators, and service providers. Respondents were also given the option to indicate that they did not identify as a member of any one of the five listed stakeholder groups and provide a description of their role. Responses from these individuals who described themselves as “other” types of stakeholders were included in our aggregate analyses of CMC stakeholders as a whole, but were not considered in analyses of individual stakeholder groups. We did not provide definitions of the five stakeholder groupings on the survey itself, so as to allow respondents to interpret the categorizations for themselves; however, we now define these stakeholder groups for the purpose of this manuscript.

Professional scientists were defined as people who were paid to conduct scientific research for the primary purpose of producing new scientific knowledge. Like in other studies concerning volunteer monitoring stakeholder groups, this group included experts in diverse environmentally-focused fields such as ecology and chemistry, who were working at applied research institutes and universities (*e.g.*, Wehn and Almomani, 2019). In the present study, scientists’ participation primarily involved using the aggregated volunteer-collected data to conduct analyses for their own research or educational purposes beyond the CMC’s primary intended uses for state and federal environmental decision making. Environmental managers were individuals who used existing scientific knowledge to inform or execute decisions that promoted sustainable use of natural resources, such as generating environmental reports, leading restoration initiatives, and promoting standardization of monitoring protocols. Volunteer monitors and citizen scientists were combined into a single category for this study, which we refer to as volunteers throughout this manuscript. Volunteers were people who elected to participate in environmental monitoring activities, in their role as unpaid members of a local environmental organization. Volunteer involvement often involves data collection and recording but volunteers can also participate in other phases of the research process, such as project conception, data interpretation, and dissemination of scientific results (Haklay et al., 2020). Waterkeepers and volunteer coordinators were also combined into a single stakeholder group for this study, which we named coordinators. Coordinators were those who held leadership roles with non-traditional and volunteer monitoring groups, whose responsibilities included planning and implementing volunteer engagement, collecting and validating data, and inputting data to the Chesapeake Data Explorer. Finally, service providers were members of the CMC administrative leadership team who were responsible for coordinating CMC activities and providing resources and support to CMC-affiliated monitoring groups and data users.

2.5. Survey distribution and respondent demographics

The web-based survey was distributed to CMC stakeholders using the CMC monthly enewsletter listserv. At the time the survey was sent out, the listserv had approximately 250 subscribers, consisting primarily of coordinators, managers, and scientists. CMC service providers also sent targeted emails to volunteers who were members of the three largest monitoring programs within the CMC network: Alliance for the Chesapeake Bay RiverTrends, ALLARM Stream Team, and Izaak Walton League of America Save Our Streams. These groups, in particular, were contacted because our research team had access to volunteers through CMC service providers who work directly with these groups. We also asked various coordinators to consider sending the survey to their volunteers; however, we do not have a record indicating to what extent this method of distribution occurred. Service providers also sent targeted emails to scientists and managers who were professional contacts or members of the Chesapeake Bay Program’s Scientific, Technical Assessment and Reporting Team.

2.6. Survey analysis

We used Anthropac software to conduct a cultural consensus analysis, which allowed us to identify patterns in how monitoring goals were shared or distinct among survey respondents. We conducted a cultural consensus analysis for the entire study population as one aggregate group, as well as individual analyses for each of the five stakeholder groups. Our cultural consensus analysis provided estimates of how much of the variation in each grouping of survey responses could be explained by either a single underlying cultural consensus (factor 1), or by patterns of agreement beyond what was captured by the consensus (factor 2). By convention, if the ratio of the first to second factor eigenvalues was at least three to one, the study population’s responses have enough shared variance to suggest that participants’ responses can be represented with a single set of answers (Weller, 2007). We determined that the formal cultural consensus model, rather than the informal model, was more appropriate and made the most ethnographic sense with our Likert-scale data. Cultural consensus analysis can be conducted with small sample sizes (Weller, 2007).

In addition to the cultural consensus analysis, we conducted a priority ranking analysis of stakeholders’ monitoring goals. For each of the monitoring goals, we used respondents’ Likert-scale ratings to calculate the mean survey response for all CMC stakeholders as an aggregate population, as well as for each of the five individual stakeholder groups. These mean responses allowed us to rank the monitoring goals according to their priority level for all stakeholders as an aggregate group, and for volunteers, coordinators, service providers, scientists, and managers, as independent groups. We also calculated the mean survey response for each goal category by averaging stakeholders’ responses for all of the questions within each of the five categories. These calculations allowed us to determine the relative priority level of the goal categories for all CMC stakeholders overall, as well as for each stakeholder group. For the seven instances when a respondent did not provide an answer for one particular monitoring goal, that non-answer was treated as missing data and was removed from statistical analyses. These missing data were distributed across the goal categories and occurred within multiple stakeholder groups, so we do not expect that these non-answers pose a significant limitation for our analysis.

We conducted a Kruskal-Wallis test for each of the five goal categories in order to determine whether the five stakeholder groups represent statistically identical populations (Appendices A and B). A significant Kruskal-Wallis test result signified that respondents belonging to at least one stakeholder group prioritized a particular monitoring goal category differently than members of at least one other stakeholder group. For each test yielding significant differences between stakeholder groups’ mean responses, we conducted Dunn’s multiple comparisons test to determine which specific means were different

(Appendix D). We chose this particular post-hoc test, along with the conservative Bonferroni correction in order to minimize Type 1 error, or inaccurate identification of differences between stakeholder groups (Lee and Lee, 2018). Additionally, we conducted Kruskal-Wallis tests for each of the stakeholder groups to determine whether their answers varied significantly between the goal categories. A significant Kruskal-Wallis test indicated that the particular stakeholder group had non-identical mean responses across the five goal categories, and a Dunn's multiple comparison test with a Bonferroni correction was again used to identify specific statistically-significant differences.

Finally, to determine which resources and services were the most valuable for CMC stakeholders in aggregate, we counted the total number of respondents who signified that a particular listed resource had been one of the most effective in helping them accomplish their monitoring goals (Appendix G). Respondents were also invited to further describe how their involvement with the CMC helped them achieve their highest-priority goals and were asked to share ideas for additional resources that would benefit the CMC community. All qualitative survey data were analyzed by inductively sorting free response text into emergent themes. We then used codes to identify sub-themes and key ideas of interest.

3. Results

For each type of analysis, we begin by sharing results in which all respondents were aggregated into one group. These aggregate analyses were performed in order to detect patterns across the entire study population. We then share results from analyses that grouped respondents according to their stakeholder group. Finally, we conclude this section with a discussion of stakeholders' feedback on CMC resources.

3.1. Respondent demographics

We received 75 responses from a diversity of CMC participants and partners, including members of all five stakeholder groups. The highest proportion or responses came from members of the Volunteer stakeholder group, while the service providers had the highest response rate (Table 1). Respondents represented over 40 organizations across the watershed, including local watershed associations, Master Naturalist chapters, regional non-profit environmental organizations, schools and colleges, research institutions, state departments, and federal agencies. Respondents had a large array of career experience, ranging from early-career professionals with several months of experience, to individuals who have worked in their fields for over 30 years. Respondents also possessed varying levels of familiarity with the CMC as an organization– some had been members or supporters of the Cooperative since its inception in 2015 and others became members within the weeks prior to the survey being distributed, or were considering partnering with the CMC sometime in the future. About 90% of respondents indicated that they had collected or used at least one type of CMC data, spanning all three tiers of data quality (Appendix H).

Table 1
Respondent demographics by stakeholder group. Estimated population contacted values were determined by assigning stakeholder categories to subscribers of the CMC enewsletter. The survey was also distributed to three listservs of volunteers (Alliance for the Chesapeake Bay RiverTrends, ALLARM Stream Team, and Izaak Walton League of America Save Our Streams), so the estimated number of volunteers in those groups was added to estimate the total number of volunteers contacted.

Stakeholder group	Number of survey respondents	Percentage of study participants	Estimated population contacted	Estimated response rate
Scientists	9	12.0	40	22.5
Managers	9	12.0	20	45.0
Volunteers	27	36.0	450	6.0
Coordinators	15	20.0	50	30.0
Service providers	8	10.7	8	100.0
Other	7	9.3	10	70.0
Total	75	100.0	578	13.0

3.2. Cultural consensus analysis

We conducted a cultural consensus analysis for all CMC stakeholders as one aggregate group using respondents' Likert-scale ratings of 44 listed environmental monitoring goals. Our cultural consensus analysis revealed that stakeholders' responses were patterned enough to suggest that all CMC stakeholders were drawing upon one shared, underlying system of knowledge as they responded to the questions (Table 2). More specifically, the eigenvalue ratio of 3.25 indicated that there was enough shared variance between respondents' answers to suggest that stakeholders' perspectives could be represented with a single set of modeled answers (Table 2). The modeled response was calculated by assigning heavier weight to answers from "culturally competent" stakeholders, or stakeholders whose responses most closely aligned with the group's as a whole (Appendix A). This "culturally correct" modeled response functions as a sort of answer key, which indicates to what extent CMC stakeholders, as a group, prioritized each individual monitoring goal.

Looking at the modeled response in Table 2 (see also Appendix A), we see that of the 44 monitoring goals included in the survey, all but five goals received the highest possible response on our seven-point Likert-scale. In fact, only two of the goals received a modeled response below a six, and these goals were 1) to collect the first data on a new parameter in a particular area and 2) to answer a specific research question on a particular location, species, or environmental threat of interest. At first glance, this seemingly homogenous result might appear to be uninteresting and suggest that stakeholders rated almost every goal as "Top priority for me," with minimal variability both within and across individual respondents' answers; however, the reality is more nuanced.

Sharing a modeled response, or in other words, having cultural consensus, does not mean that all respondents answered in the same way for each question, or that they did not have disagreements. Indeed, there was variability in the way that different stakeholders prioritized certain monitoring goals, and we will tease apart many of these nuances in the next section. Instead, the strikingly homogenous modeled response

Table 2
Cultural consensus analysis results. The cultural consensus analysis provided evidence of cultural consensus among all respondents as a whole, as well as among volunteers, coordinators, and service providers as individual stakeholder groups. The modeled response represents the "culturally correct" answer key that indicates the extent to which all CMC stakeholders, as an aggregate, prioritized each of the 44 monitoring goals. The relatively consistent high Likert scale values in the modeled response suggests that CMC stakeholders share an underlying cultural understanding that environmental monitoring is valuable for a wide variety of reasons.

Grouping	Number of respondents	Eigenvalue ratio	Consensus? (EV ratio > 3.0)
All stakeholders	75	3.25	yes
Stakeholder groups			
Scientists	9	1.93	no
Managers	9	2.61	no
Volunteers	27	3.11	yes
Coordinators	15	5.22	yes
Service providers	8	4.29	yes
Other	7	–	–
Modeled response for all stakeholders			
These numbers represent stakeholders' consensus answers for each of 44 monitoring goals:			
7 7 7 7 6 7 7 7 7 7 7 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 4 7 6 7 4 7 7 7 7 7			
Likert scale: 1 (lowest priority) to 7 (highest priority)			

indicated that CMC stakeholders, overall, shared an underlying cultural understanding that environmental monitoring in Chesapeake Bay is useful for accomplishing a *wide diversity* of very important goals. This affirmative cultural consensus result meant that CMC stakeholders belonged to a group that shared an appreciation for the importance of almost all of the listed monitoring goals, even though individual stakeholders might not prioritize each particular monitoring goal for themselves.

Although the cultural consensus analysis suggested that there was cultural consensus among all respondents as one aggregate group of CMC stakeholders, analyses of individual stakeholder groups provided evidence of cultural consensus within some groups but not others. Interestingly, coordinators had the highest eigenvalue ratio (5.22), meaning that they had a more uniform cultural understanding of monitoring goals than any of the other more heterogeneous groups (Table 2). We also found evidence of cultural consensus among both service providers (4.29) and volunteers (3.11). The higher variance in volunteers' responses could be due to increased sample size of volunteers relative to the other stakeholder groups, or it could indicate that volunteers as a group had a less uniform cultural understanding of monitoring goals.

Interestingly, our analyses did not support evidence of cultural consensus among managers (2.61) or scientists (1.93), with scientists exhibiting the lowest eigenvalue ratio of all stakeholder groups. The higher variability in scientists' and managers' responses means that there was no indication that individual respondents within either stakeholder group were drawing from an extensively-shared cultural understanding when reflecting on their reasons for participating in environmental monitoring. The lower eigenvalues could perhaps be attributed to the fact that scientists and managers, in particular, often partner with the CMC in order to access volunteer-collected data for very specialized restoration and research purposes, which are not necessarily shared widely by peers and partners or included on the survey. The lack of cultural consensus could reflect the wide diversity of research questions and management priorities within the professional scientific and management community.

3.3. Priority ranking analysis of stakeholders' monitoring goals

To better understand CMC stakeholders' specific monitoring goals, we first identified the five most highly-prioritized goals for all stakeholders in aggregate (Table 3). To do this, we used respondents' Likert-scale ratings to calculate the mean survey response for each of the 44 monitoring goals that were included in our survey. We then used these mean responses to create a ranked list of all the goals, ordered from highest to lowest priority (Appendix A). The highest-rated goal across all respondents, on average, was to collect data that are useful for watershed managers and decision-makers. Other highly-prioritized goals included contributing credible data to environmental assessments and reports, learning about the health of a local waterway, improving water quality and habitat, and collecting long-term data on waterways.

We wanted to discern if there were any broader patterns in how CMC stakeholders rated goals with overlapping themes. To do this, we grouped the goals into one of five designated goal categories. Each category contained a collection of 8 or 9 monitoring goals that all related to one of five themes: Data, Knowledge, Environment, Community, and Management. Again, respondents' Likert-scale ratings of the individual monitoring goals were used to calculate a single mean survey response for each of the five aggregated goal categories. We used the mean responses to rank the categories based on their overall priority level for CMC stakeholders as a whole (Appendix C).

We found that the Data category was prioritized higher, on average, than any other category, though only statistically significantly higher than the Management category ($p = 0.002$), which received the lowest mean response (Appendix C). Still, the higher mean response assigned to Data-related monitoring goals indicated that CMC stakeholders highly valued collecting baseline and long-term data and participating in science. The Environment category received the second-highest mean response, also statistically higher than the Management category ($p = 0.008$). This indicated that CMC stakeholders were also highly motivated to accomplish goals relating to identifying and addressing environmental problems, as well as improving environmental conditions.

Organizing the responses by CMC stakeholder groups allowed us to identify compelling differences between the groups that supplement the key findings from the aggregate analysis. We again used respondents' ratings of the individual goals to identify the five highest-priority monitoring goals for each stakeholder group (Fig. 1) (Appendix D). Several goals were rated high enough to rank among the top five highest priorities for only one stakeholder group. In Fig. 1, these goals that were unique to one group are positioned nearest the perimeter of the diagram. Conversely, many goals were ranked among the top five priorities by at least two stakeholder groups. These shared goals are positioned towards the center of the figure in areas where the circles representing the individual stakeholder groups overlap.

The goal that was prioritized by the highest number of stakeholder groups was to collect data that are useful for watershed managers and decision-makers (Fig. 1). Perhaps unsurprisingly, this was the same goal that was rated the highest, on average, across the entire CMC stakeholder population as an aggregate. This monitoring goal, alone, was rated among the five highest priorities by all but one of the individual stakeholder groups. Interestingly, volunteers rated this goal as their single-highest priority. One volunteer captured some of this sentiment, writing "It's more about helping CMC and local government achieve their goals than addressing goals that I would have - I view myself as a support role."

To complement our exploration of individual goals that were shared and unique among stakeholder groups, we also looked for patterns in how each of the stakeholder groups prioritized the five goal categories. To do this, we once again used respondents' ratings for the individual monitoring goals to calculate a mean response for each of the five goal categories, this time with the respondents disaggregated by stakeholder group (Fig. 2). Furthermore, we compared the mean responses across stakeholder groups and goal categories to identify whether or not there were any statistically significant differences 1) across stakeholder groups within each goal category and 2) across goal categories within each stakeholder group (Fig. 2). By combining observations from the analyses presented in Figs. 1 and 2, we can explore stakeholders' response patterns for each of the five goal categories and identify selected key differences and similarities between the stakeholder groups.

First, the Data category was the most highly prioritized category, on average, for scientists, managers, and volunteers. Scientists prioritized Data-related goals higher than all of the stakeholder groups, though their mean responses were not statistically higher than the other groups' responses (Fig. 2). In relation to the other goal categories, scientists prioritized Data-related goals significantly higher than Community-related goals ($p = 0.018$) (Appendix E), but otherwise, there were no other statistically significant differences in how any of the stakeholder

Table 3
The top five most highly-prioritized monitoring goals for all survey respondents as an aggregate group ($n = 75$). The mean survey response (Likert-scale 1–7) and standard deviation are reported for each goal.

Monitoring goal	Overall rank	Mean response
Collect data that are useful for watershed managers and decision-makers	1	6.51 (0.96)
Contribute credible data to environmental assessments and reports	2	6.43 (1.02)
Learn more about the health of a local waterway	3	6.37 (1.05)
Improve water quality or waterway habitats	4	6.31 (1.08)
Collect long-term data on waterways	5	6.20 (1.01)

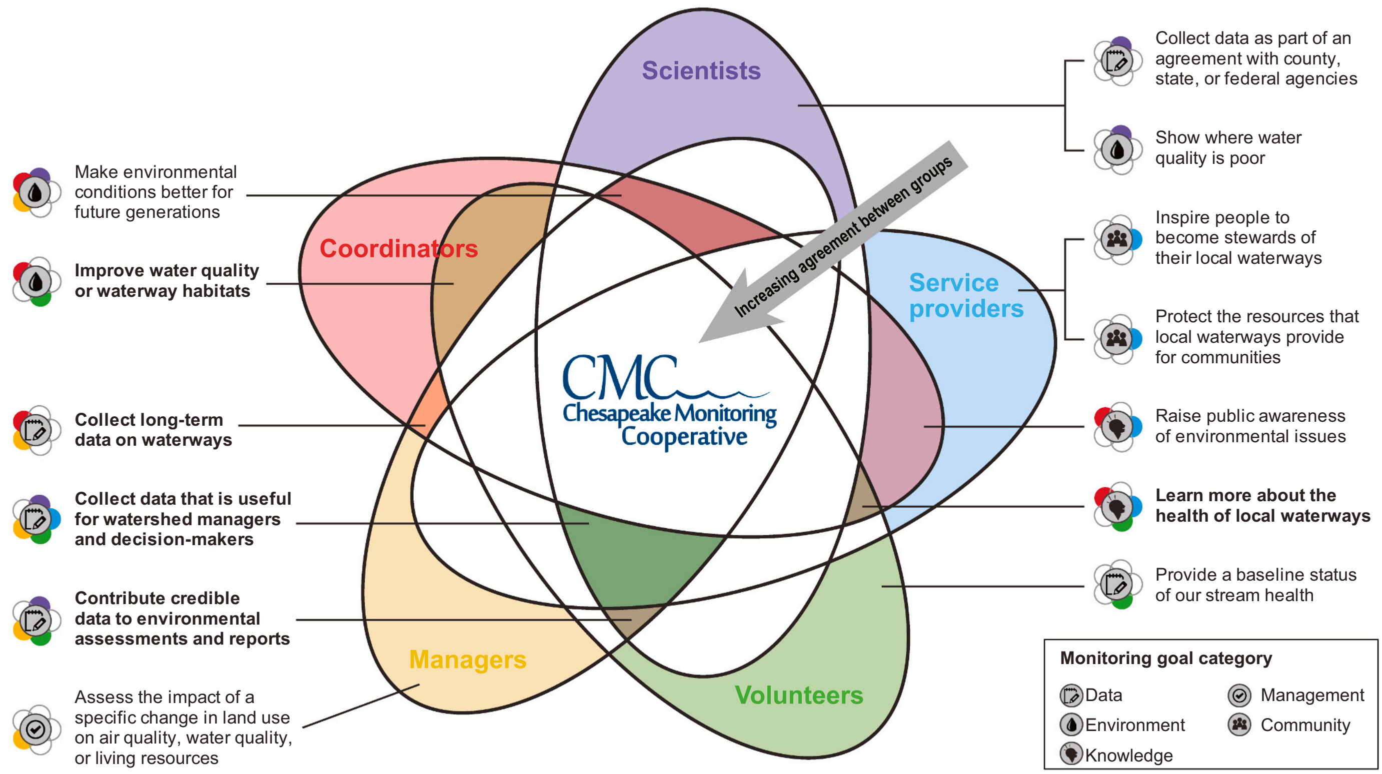

Fig. 1. The five most highly-prioritized monitoring goals for each CMC stakeholder group. Goals that are included within overlapping areas of the diagram were prioritized highly by multiple stakeholder groups, whereas goals nearest the periphery of the figure were uniquely prioritized by a single stakeholder group. Icons indicate the goal category. Bolded text indicates that the goal was among the top five highest-rated priorities for all CMC stakeholders as an aggregate group.

	Data	Environment	Knowledge	Community	Management	Kruskal-Wallis p-value across goal categories
Scientists	5.92 (0.76)	5.41 (0.97)	4.80 (1.30)	4.16 (1.22)	4.90 (0.83)	0.025 (*)
Managers	5.33 (0.70)	5.24 (0.91)	4.78 (1.09)	4.73 (1.18)	4.98 (0.97)	0.649
Volunteers	5.66 (0.77)	5.63 (1.01)	5.33 (1.06)	5.18 (1.25)	5.07 (1.41)	0.358
Coordinators	5.88 (0.94)	5.92 (0.94)	5.93 (0.76)	5.76 (0.81)	4.99 (1.34)	0.141
Service providers	5.73 (0.89)	5.83 (0.71)	5.63 (0.79)	6.28 (0.39)	5.06 (1.37)	0.197
Kruskal-Wallis p-value across stakeholder groups	0.344	0.395	0.066	0.002 (**)	0.967	

Fig. 2. The mean response (and standard deviation) for each stakeholder group, for each of the five goal categories. Data-related goals were rated highest priority for scientists, managers, and volunteers. Coordinators rated goals within the Knowledge category highest, on average, while service providers prioritized Community-related goals. Kruskal-Wallis tests (bottom row) indicated that the average ratings were not statistically distinct across stakeholder groups for each of the goal categories, with the exception of the Community category. Additional Kruskal-Wallis tests (right column) indicated that the average ratings were not statistically distinct across goal categories for each of the stakeholder groups, with the exception of Scientists. Asterisks indicate level of significance, with (*) meaning $p \leq 0.05$ and (**) meaning $p \leq 0.01$. Multiple comparisons tests determined which distinct differences existed within the Community category (Appendix D) and within the Scientist stakeholder group (Appendix F).

groups rated the Data category compared to the other categories (Fig. 2). Still, these groups' general affinity for Data-related goals was evident, as scientists, managers, and volunteers each rated three Data-related goals among their top five highest priorities. Taking a closer look at some of these most highly-prioritized goals within this category, we discovered that a shared priority for all three stakeholder groups was to contribute credible data to environmental assessments and reports (Fig. 1). Furthermore, volunteers uniquely prioritized providing a baseline status of stream health, while scientists were the only group to prioritize collecting data as part of an agreement with county, state, or federal agencies.

Although none of the stakeholder groups prioritized the Environment goal category above every other category, it is interesting to note that Environment-related goals were rated as the second-highest priority for every individual stakeholder group, on average, without exception (Fig. 2). In the case of volunteers and coordinators, the average response for goals within the Environment category only very narrowly trailed the groups' average response for their highest-prioritized category. The Environment goal category was also ranked second-highest by CMC stakeholders as an aggregate, narrowly following the Data category (Appendix C). Four individual stakeholder groups rated Environment-related goals within their top five priorities (Fig. 1). Scientists prioritized showing where water quality is poor, while volunteers and coordinators both valued improving water quality or waterway habitats. In fact, improving water quality stood out as coordinators' single-highest priority. The most widely held Environment-related goal was to make environmental conditions better for future generations, which was shared by scientists, managers, and coordinators. One respondent elaborated that they were especially motivated to "save the planet and our species."

Finally, the results indicated that Service providers, or the people coordinating the CMC, were the only stakeholder group to prioritize monitoring goals within the Community category above all other goal categories, on average (Fig. 3). Furthermore, service providers were the only stakeholder group to rank Community-related goals anywhere within their top five priorities (Fig. 1), and indeed not one, but two of this group's top-five highest rated goals fell within the Community category (Appendix D). These goals were to inspire people to become stewards of their local waterways and to protect the resources that local waterways provide for communities. Unlike other more subdued differences in how the stakeholder groups prioritized the five goal categories (Fig. 2), service providers' average rating of Community-related goals was statistically higher than both scientists' ($p = 0.004$) and managers' ($p = 0.039$) (Fig. 3), who both rated the Community category as their lowest priority overall (Appendix F). Several respondents elaborated on the topic of building community, including individuals who indicated that they are motivated to "give back to the community" and "create connections with communities and the recreational fishing and crabbing industries."

3.4. Stakeholder perspectives of CMC resources

Respondents were asked to consider a list of 20 tools, resources, and services that the CMC offered and select up to five that had been the most effective in helping them achieve their personal monitoring goals (Appendix G). The three most-selected resources of value were data storage and data access through Chesapeake Data Explorer, as well as hands-on water quality training. These perspectives were echoed in the free-response portions of the survey that asked participants to detail how involvement with CMC has had an impact on achieving their highest-priority goals. Respondents repeatedly mentioned that a major contribution of the CMC had been providing a centralized database for organizing, storing, and sharing regional data.

Furthermore, the CMC's various efforts to increase both the quality and quantity of available monitoring data did not go unnoticed. In particular, individuals shared that the CMC had provided them with funding, equipment, training, and certification that ultimately increased their capacity to collect and share larger quantities of higher-quality data. Also widely recognized were the CMC's efforts to work with monitoring groups to fill recognized data gaps and standardize their data collection and reporting so that their data could be integrated into the regional dataset and "more accessible and readily usable for a variety of decision-making needs" (Fig. 4).

Respondents also expressed appreciation for the CMC "playing the role of mediator" between various stakeholder groups, and "establishing networks…that have not existed in the past, across jurisdictional boundaries." The value of these new partnerships was acknowledged by scientists and managers at the Chesapeake Bay Program and various state agencies, who described benefitting from easier access to a new

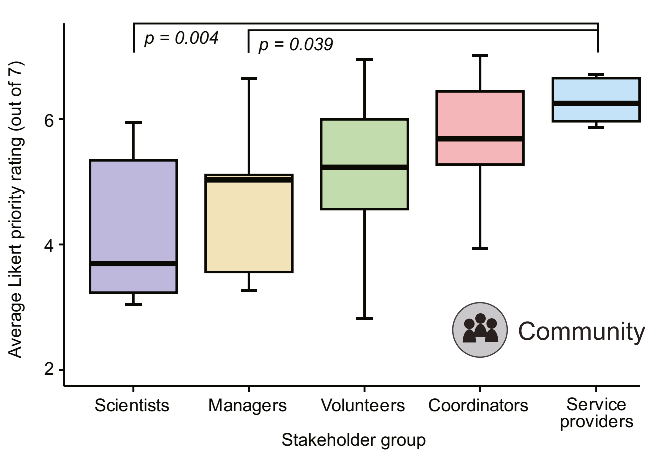

Fig. 3. Stakeholder prioritization of goals within the Community category. Service providers rated Community-related goals higher, on average, than all other stakeholder groups, and statistically higher than both scientists and managers.

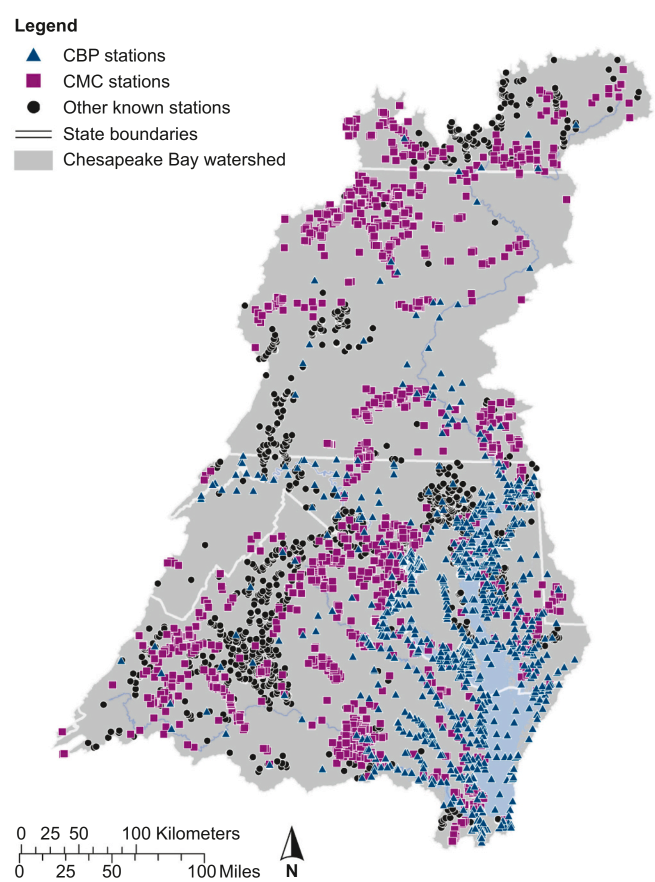

Fig. 4. Map of the Chesapeake Bay watershed and environmental monitoring data stations. The CMC helped many groups contribute their data into the Chesapeake Data Explorer platform (purple squares), where they can be integrated with Chesapeake Bay Program monitoring data (blue triangles). Other known stations (black circles) are locations where data were being collected by county, city, nonprofit, or non-traditional agencies, but had not yet been incorporated into the CMC framework as of January 2021.

frontier of standardized and quality-controlled data. Furthermore, volunteers and coordinators indicated that their affiliation with the CMC "gives credibility to volunteers' efforts and ultimately our data" and has directly aided in recruiting new participants and "reassuring volunteers that the data they collect will be used".

Finally, CMC stakeholders suggested several additional resources that the CMC could potentially offer in the future to help stakeholders achieve their monitoring goals. For example, respondents expressed interest in increased communication from the CMC, including more outreach to increase stakeholders' knowledge of available resources, as well as regular updates that highlight CMC success stories and show examples of how the data are being used and what has been learned. Stakeholders also requested more CMC support with understanding their data, and expressed interest in one-on-one help with data analysis and tools that enable groups to more easily create regional summary reports and visualizations based on data sourced from Chesapeake Data Explorer.

4. Discussion

While the specific results of this study may be unique to the CMC, we believe that the processes that we used to understand stakeholders' goals and perspectives can be widely applied, and that many of our lessons learned are transferable across other volunteer environmental monitoring programs. In this section, we share four key recommendations that can be used to inform the design and coordination of other collaborative monitoring programs.

4.1. Cultural consensus provides a foundation for collaboration

The result that there is cultural consensus among CMC stakeholders suggests that, despite their differences, CMC stakeholders share an underlying system of cultural knowledge, from which they draw upon to think about environmental monitoring priorities and goals in the Chesapeake region. Specifically, the modeled response indicates that members of the CMC share a cultural understanding and appreciation for a wide diversity of environmental monitoring goals. This result is especially important considering the current dynamic that exists within the CMC community; that is, in many cases, stakeholders believe that members of other stakeholder groups have a select number of priorities, which are fundamentally different from their own.

Such perceived misalignments in goals can be barriers to effective collaboration. For example, Burgess et al. (2017) found that when scientists had limited awareness of citizen science efforts that align with their needs, their lack of understanding created a barrier to using available volunteer-collected data in their research. Another study reported that volunteer coordinators were more confident in their project's ability to meaningfully contribute to broader international goals when those goals were easier to directly connect to their own project and its objectives (Sprinks et al., 2021). All of this is not to say that stakeholders must have the same goals in order to have a successful and productive collaboration. Critics of the cultural consensus analysis method indeed worry that in emphasizing the shared nature of culture, the approach presents or even idealizes a homogenized ethnographic representation of culture (Dengah, 2013; Aunger, 1999).

Instead, we argue that the cultural consensus approach is useful for its ability to both highlight sharedness and provide insight on disagreement within a group. Cultural consensus analysis helps stakeholders better understand similarities and differences in the implicit and explicit knowledge, beliefs, and values they bring to an environmental problem. The collaborative learning approach can draw from cultural consensus results and facilitate learning among stakeholders. This process involves working together to develop a deeper understanding of each others' fundamental cultural knowledge and values, and often the societal, economic, and environmental reasons why individuals and groups sustain their cultural knowledge. This deeper understanding can help stakeholder communities to better comprehend the drivers of their agreements and disagreements, and in turn, can lead to more collaboration and more effective conflict resolution, even if individuals do not change their perspectives (Daniels and Walker, 1996; Feurt, 2008).

Our analysis shows that CMC stakeholders share an understanding of environmental monitoring, despite the fact that they differ in how they prioritize various aspects of it. Cultural consensus suggests that stakeholders have enough overlapping contextual cultural knowledge to be able to understand, though not necessarily agree with, the value of others' priorities (Paolisso, 2015). This overlapping cultural knowledge could stem from a generally high level of interest, knowledge, activity, and concern for the Chesapeake Bay among residents in the watershed, which can be understood as Chesapeake Bay environmentalism (Paolisso, 2006). This environmentalism arises from a shared sense of connectivity to the landscape, as well as a shared appreciation for the Bay as a cultural, natural, and economic resource (Paolisso, 2006). In the case of the present study, an understanding of their shared appreciation for environmental monitoring, specifically, can help stakeholders overcome the barriers presented by their perceptions that others are fundamentally different. Stakeholders can instead foster partnerships in which differences in priorities are viewed as opportunities to embrace a more holistic approach to environmental monitoring, and accomplish multiple and complementary objectives in pursuit of a shared goal.

4.2. Shared and unique goals can inform organizational priorities and strategic outreach

Our analyses indicate that CMC stakeholders share a number of environmental monitoring priorities. For example, Data was the most highly-prioritized goal category for scientists, managers, and volunteers, as well as for all stakeholders in aggregate. Furthermore, when respondents were asked to share their perspectives on the organization's most valuable resources, they primarily called attention to the value of the CMC's data-related services, including increasing data quality, quantity, storage, and access. Interestingly, and without exception, all stakeholder groups rated environmental goals as their second-highest priority, overall. These results were consistent with several previous studies on environmental monitoring motivations, in which helping the environment emerged as the strongest motivation among volunteers (*e. g.* Alender, 2016; Jacobson et al., 2012; Bruyere and Rappe, 2007). However, our study takes this recurrent finding one step further, as we found that all stakeholder groups within the CMC community were united by a shared desire to improve environmental conditions in the Chesapeake region.

Volunteer monitoring efforts such as the CMC can use this detailed knowledge of their stakeholders' priorities to build their brand so that it is clear to all stakeholders how the organization helps them accomplish specific goals. To start, volunteer monitoring efforts could draw from stakeholders' monitoring goals to develop mission statements and strategies that allocate an organization's limited resources towards balancing the needs of various stakeholder groups and maximizing benefits for all members. For example, the present study confirmed that most stakeholders care deeply about data, so the CMC could consider investing in improving their resources and outreach efforts that contribute directly towards helping stakeholders collect higher-quality data, efficiently manage and share their data, and easily access other groups' data. Previous research shows that environmental monitoring collaborations can be more productive when stakeholders work together to explore questions of mutual interest and accomplish shared goals (Buytaert et al., 2014). Furthermore, Verbrugge et al. (2017) noted that when participants and program organizers have differing driving motivations, taking the time to align stakeholders' expectations and wishes can provide a foundation for sustained participation. Therefore, volunteer monitoring efforts might also benefit from strategically communicating their priorities to members in a way that highlights goal alignment between stakeholder groups and also shows that the organization is providing services that are highly valued by its members. Our results suggest that if the CMC frames itself as an organization that prioritizes improving environmental conditions throughout the Chesapeake Bay watershed, this message would resonate with their entire environmentally-motivated audience.

The shared goal of improving environmental conditions also presents an opportunity for volunteer monitoring efforts to increase organizational focus and outreach on areas where underrepresented communities are living with higher levels of environmental pollution. Indeed, a future priority for the CMC, as well as many other organizations, should be to target outreach efforts towards underrepresented communities, to both better understand their environmental priorities and to engage them in monitoring. Within the context of volunteer monitoring, participation is often concentrated among more privileged communities in areas of lower environmental justice concern (Burgess et al., 2017; Pandya, 2012), which has implications for data quality and environmental justice (Blake et al., 2020). Improving the accessibility of volunteer science programs is not only an important step along the path of increasing diversity, equity, inclusion, and accessibility within the broader environmental research and management community, but it also leads to improvements in the quality of science and decision making due to more representative sampling and synergies between stakeholders with different values and skill sets (Hermoso et al., 2021; Blake et al., 2020). Misalignment between community priorities and research objectives is one factor that can contribute to a lack of diverse participation in volunteer science efforts (Pandya, 2012). For example, focusing primarily on improving environmental conditions for the sake of wildlife would not align well with a community seeking to reduce the human health impacts of pollution in their backyard. Our results suggest that the CMC has an opportunity to develop the shared goal of improving environmental conditions throughout the Chesapeake to include working with regional partners to reach out to new and underrepresented audiences and align their engagement strategies and research objectives so that they promote environmental justice throughout the region.

Finally, volunteer monitoring efforts can use knowledge of specific stakeholder groups' unique monitoring goals to coordinate targeted outreach efforts and showcase how their services can support stakeholders in addressing their particular priorities. Previous research suggests that understanding and acknowledging stakeholders' specific goals can improve volunteer recruitment and retention (Alender, 2016); thus, targeted outreach could help the CMC and other similar monitoring efforts to recruit volunteers, coordinators, scientists, and managers and then retain them as long-term members.

4.3. Community-driven boundary spanners help build social capital

Although our survey uncovered many similarities and differences in how each of the five stakeholder groups prioritized the goal categories, the only statistically significant difference was that service providers rated goals within the Community category higher than other stakeholder groups. This result highlights service providers' focus on building community across the CMC, which is especially fitting considering this group's boundary-spanning role within the Chesapeake environmental monitoring community. Boundary-spanning organizations are institutions that link communities together by creating a more neutral, hybrid space for knowledge co-production and sharing (Guston, 2001; Jensen-Ryan and German, 2019). Bednarek et al. (2018) defines this practice of boundary spanning as "work to enable exchange between the production and use of knowledge to support evidence-informed decision-making". Boundary organizations, such as the CMC, create bridges between science and policy, environmental research and management, and scientists and nonscientists by building social relationships, facilitating communication, mediating among stakeholders' varying interests, and negotiating power differentials (Crona and Parker, 2012).

The CMC plays a crucial role in the Chesapeake Bay environmental research and management community because the organization joins together previously-disconnected stakeholders to create an extended peer community that can exchange knowledge and collaboratively address complex problems. Our study found that service providers, uniquely among other stakeholder groups, placed high emphasis on individual monitoring priorities relating to building community. While other stakeholder groups prioritized monitoring goals related to collecting and exchanging high-quality data, service providers embraced the broader opportunity to deliberately shape the Chesapeake environmental monitoring community and create a space for connection and communication.

This focus on community and social capital is essential for expanding the CMC and helping its constituents achieve their goals. Social capital has been conceptualized in many ways across the literature; however, broadly it refers to people's ability to work together (Coleman, 1988), to trust each other and share a sense of common purpose (Fukuyama, 1995), and to draw benefits from their social network of relationships, if needed (Snidjers, 1999). Communities with more social capital are more likely to achieve their goals (Krishna, 2002), and this result has also specifically been observed among watershed groups (Floress et al., 2011). For example, Overdevest et al. (2004) found that participation in a volunteer stream monitoring project increased feelings of community connectedness, personal networks, and political participation among volunteers, suggesting that volunteer monitoring can enhance local adaptive management and social capital. CMC stakeholders will likely experience similar benefits as a result of the organization's leadership focusing on engaging groups and building ties between members. Furthermore, although CMC stakeholders appeared to value the CMC primarily for its more traditional services such as providing data storage, promoting increased data quantity and quality, and offering hands-on training and other support, stakeholders specifically acknowledged the role that the CMC has played in building community partnerships throughout the watershed, and expressed interest in increased levels of communication and outreach from the CMC in the future.

4.4. Stakeholders' priorities could shift with continued participation

Having a clear understanding of stakeholders' current monitoring goals can certainly help an organization like the CMC better serve and communicate with its members; however, stakeholders' priorities and motivations are dynamic and may change over time. For example, Rotman et al. (2012) found that volunteers' motivations stemmed from personal curiosity at the beginning of their involvement in a project, but then other factors influenced whether or not they continued to participate, such as feeling like part of a community and receiving feedback and acknowledgement for their contributions. Larson et al. (2020) reported that while volunteers report a wide diversity of motivations, those that are conservation-oriented are most likely to grow with continued participation. Still, in their synthesis of peer-reviewed journal articles about participatory environmental monitoring, Stepenuck and Green (2015) identified that while many studies confirm that participants' attitudes and behaviors change as a result of their volunteer work, there is a persistent lack of understanding of the nature and extent of that change over time.

As CMC stakeholders participate in the Cooperative and achieve their goals over time, resulting changes in individual attitudes, as well as environmental conditions, management strategies, community dynamics, environmental literacy, and the volume of available data might cause a shift in the way stakeholders prioritize goals relating to Environment, Management, Community, Knowledge, and Data, respectively. Indeed, Dengah (2013) reminds us that cognition is not static, and our cultural consensus analysis and ranking analysis provide only a snapshot in time of stakeholders' underlying cultural understanding of environmental monitoring priorities. Therefore, as the CMC network continues to grow, it will be essential to continue conversations with stakeholders in order to understand and effectively respond to their changing goals and motivations. Follow-up research to characterize CMC stakeholders' changing needs and priorities would answer the call for more data-rich assessments of environmental monitoring communities' engagement over time (Stepenuck and Green, 2015).

Furthermore, there are such a high number of potential reasons why stakeholders might participate in environmental monitoring, that it is likely impossible to capture them all in a single survey. For example, we know from our respondents' free-response survey answers that CMC stakeholders are also monitoring in hopes to "enhance the reputation" of their watershed organization, "motivate local governments to take ownership" over addressing environmental concerns, and enjoy various intrinsic benefits, such as "increased personal wellness" from spending time outdoors. Additional research could explore how CMC stakeholders prioritize these and other goals that were not included in this study, and assess how the CMC community's priorities compare with other studies of stakeholder goals and motivations (*e.g.* Robinson et al., 2020; Wright et al., 2015).

4.5. Gaps to be addressed in future research

To our knowledge, the present study is the first instance that the cultural consensus conceptual and methodological approach has been used to investigate stakeholder goals and motivations in the context of volunteer monitoring. As Wehn and Almomani (2019) suggest, further research into stakeholder motivations would allow for comparative analyses across different studies. In particular, it would be useful to apply the cultural consensus approach in other stakeholder communities in order to advance collective understanding of stakeholders' diverse goals, which would ultimately help to inform volunteer monitoring organizations' priorities and stakeholder engagement strategies.

Additionally, the time duration of the present study did not allow us to measure how stakeholders' cultural knowledge and monitoring priorities change over time, or how those changes are later translated into programmatic, political, institutional, and environmental changes. The present study could serve as a baseline dataset for additional research with the CMC stakeholder community as the organization continues to evolve and expand. As this was the first research conducted with this stakeholder group, our analyses provided many first-time insights on this community's monitoring priorities. With this more sophisticated ethnographic understanding of the stakeholder community, it is likely that future survey questions could be further refined and new questions could be added to incorporate monitoring goals that were initially overlooked or less explored. Furthermore, this study allowed us to build rapport with the CMC community. We suspect that more stakeholders could be inclined to participate in future research efforts, and that a greater sample size may strengthen our understanding of some of the less-represented groups in this initial study.

5. Conclusion

As anthropogenic pressures on the Bay increase, the management approach for Chesapeake Bay continues to evolve (Bilkovic et al., 2019), and stakeholder coordination remains an essential component. The present study shows that while individual stakeholder groups within the Chesapeake environmental monitoring community have their own specific monitoring goals, all CMC stakeholders share an underlying system of cultural knowledge that provides a foundation for collaboration. Furthermore, there are compelling similarities and differences in how stakeholder groups prioritize certain monitoring goals over others and in what resources they perceive to be the most valuable. At the end of the day, CMC stakeholders are united by their shared motivation to collect useful, high-quality data that can be used to inform environmental assessments and decision making and ultimately improve the environment. With this new fine-scale knowledge of stakeholders' goals, the CMC is better positioned to highlight shared goals while also reconciling and balancing varying priorities. Thus, the CMC is poised to truly live up to its name: by integrating volunteer data into traditional datastreams and fostering a more *cooperative* mentality throughout the environmental monitoring community, the CMC can make coordinated volunteer monitoring even more impactful for Chesapeake science and management.

Although this research represents a case study of the CMC community, our broader approach to culture was useful and we suspect that methodology and resulting recommendations can be widely applied in a variety of volunteer monitoring contexts in order to help ascertain how to best serve multiple stakeholder groups and build successful and enduring partnerships. "The CMC family has created the engine to keep evolving and growing," said one of its members. "The sky's the limit for this strong group to grow its powerhouse presence in the region, the nation, and as a global model for such work."

Ethics and consent

This research was approved by the University of Maryland College Park Institutional Review Board (1436359-1).

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Suzanne E. Webster: Conceptualization, Project administration, Methodology, Investigation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **E. Caroline Donovan:** Writing – original draft, Visualization, Writing – review & editing. **Elizabeth Chudoba:** Writing – original draft, Investigation. **Christine D. Miller Hesed:** Methodology, Formal analysis, Writing – review & editing. **Michael Paolisso:** Conceptualization, Methodology, Writing – review & editing. **William C. Dennison:** Writing – review & editing, Funding acquisition.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.

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