ARTICLE

Climate Change Education at Nature-Based Museums

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Abstract The status of climate change education at nature-based museums (i.e., zoos, aquariums and nature centers) was examined, with a particular focus on centers participating in a National Network for Ocean and Climate Change Interpretation (NNOCCI) leadership training program. Study 1 revealed that, relative to nature-based museums that did not participate in the training, NNOCCI-participating institutions provided resources for staff to work on the topic and professional development programs and were more likely than non-participating museums to be comfortable with and provide climate change education programming. Study 2 confirms these results via visitor reports about the exhibits they observed. Study 2 also reveals that, relative to non-visitors and visitors to non-participating nature-based museums, visitors to NNOCCI-participating nature-based museums were more knowledgeable about and concerned about climate change and ocean acidification, hopeful about their ability to talk about the topic, and likely to engage in climate change actions than those who did not visit these centers. Importantly, results from both studies indicate that nature-based museums, especially NNOCCI participating museums, have an institutional culture supportive of climate science education and suggests that NNOCCI interpreter training programming facilitates this culture which in turn is reflected in visitor engagement.

INTRODUCTION

Nature-based museums (zoos, aquariums, nature centers, science centers, national parks, and natural history museums) represent a class of institutions that are an important source of public knowledge about environmental conservation issues. Many of these institutions include environmental education as one of their core goals (Fraser and Wharton 2007; Moss et al. 2015), and have developed programs educating visitors about important conservation issues related to the animals, plants, and ecosystems presented in exhibits (Falk and Adelman 2003). Those who have recently attended a nature-based museum report increased knowledge about conservation issues, even more than half a year after their visit (Falk and Adelman 2003; Falk et al. 2007; Fraser et al. 2010;). Until recently, these conservation issues have mostly included easily visualized and conceptualized threats such as endangered species die-off and the direct effects of air and water pollution on different species and encouraging personal sphere conservation behaviors. These issues have not tended to focus on complex, systemic ecological threats such as climate change where the problem is globalized and likely requires

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community level actions in addition to personal actions.

Climate change is considered by the scientific community to be one of the major environmental issues of the 21st century, and has received widespread international political recognition as a major threat to global civilization (Bellard et al. 2012; UNFCCC: United Nations Framework Convention on Climate Change 2015). Yet, despite political recognition and the threat it imposes, it has not received comparable public concern and engagement. Despite at least a decade of attempts to encourage public engagement about climate change (e.g., Sumner 2016), the topic remains below most Americans' scope of concern (Krosnick et al. 2006; Scruggs and Benegal 2012). The present paper offers insight into the role that a community of nature-based museums have in making climate change more salient and promoting public engagement in the topic by way of the institutional climate that they set to encourage and facilitate such discussion. The paper does so by examining the current culture for change education at nature-based museums.

Education and Public Engagement

One barrier to public engagement is lack of climate literacy (Geiger et al. 2017a). Many do not fully understand the basic science behind climate change (Swim et al. 2014). This may be partially due to the lack of coverage or manner in which the topic is taught in the classroom (Berbeco and McCaffrey 2016; Plutzer et al. 2016). However, even with improvements in classrooms, informal education is needed for those who have not had this exposure and for the public to keep up with changes in scientific knowledge (Falk and Dierking 2010). Plus, improving formal science teaching that permeates this discussion tends to focus on the next generation rather than those who are capable of making changes immediately. Focusing on the role of museums as core learning institutions for adults may offer an effective strategy for expanding climate literacy among the adult population and a method of supplementing youth education. Museums also have the potential to create an immediate national-scale impact because U.S. museums collectively record hundreds of millions in annual visitors; U.S. zoos alone report 175 million annual visits (AZA: Association of Zoos and Aquariums 2015).

Climate Change Education Programs in Nature-Based Museums

Environmental conservation topics are now expanding to include climate change. Many nature-based museums (e.g., zoos, aquariums, natural history museums, national parks) are incorporating climate change education into their exhibits, presentations, and educational missions (Anderson and Williams 2013; Bunten and Arvizu 2013). The Association of Zoos and Aquariums (AZA) has also adopted a collective commitment to climate change education as a priority for all of their member institutions (AZA: Association of Zoos and Aquariums 2013). This commitment is reflected in their 2013 statement which said the following ". . .communicating about the impacts of climate change on wildlife and habitats, AZA and its member institutions can play an important role in inspiring people to take personal and civic action that will help decrease atmospheric CO_2 concentrations to protect humankind's wildlife heritage" (AZA, 2013).

In the process of incorporating climate change into their educational programming, those working at nature-based museums are discovering communication difficulties. Many

museum educators find it difficult to fully incorporate climate communication into their exhibits and presentations (Swim and Fraser 2014). The difficulty can be accounted for at least in part because of the perceived politicization of the topic and concern that visitors will tune out information about climate change. Many educators further perceive a lack of support for climate change communication by their institutions (Fraser et al. 2013; Wijeratne et al. 2014). Even when museum educators attempt to incorporate climate change information into their material, they may not effectively encourage audience engagement in the topic. Without information accessible to the public, the concern that already exists among visitors to nature-based museums (Luebke et al. 2012), may not translate into well-developed climate literacy, scientifically grounded discussions, and behavioral engagement (Berbeco and McCaffrey 2016; Geiger and Swim 2016; Swim et al. 2014).

Climate Change Leadership Training Program

To address communication barriers many nature-based museums are participating in a large-scale effort to use the benefits of up-to-date climate science fused with communication research and integrated into science education on how to best communicate climate change messaging to visitors to these institutions. To date nearly 150 institutions have participated in a leadership training program on climate change education led by the National Network for Ocean and Climate Change Institutions (NNOCCI), funded by the National Science Foundation Climate Change Education Partnership (NSF-CCEP). NNOCCI, led by the New England Aquarium, represents a partnership among informal science educators, climate scientists, and social scientists working together to improve the U.S. national discourse about climate change

(National Network for Ocean and Climate Change Interpretation 2015). The goal of NNOCCI was to create a community of educators in nature-based museums distributed across the US and skilled at using research-based communication strategies that will change the discourse on climate change to focus on the climate science and to be solution-focused.

NNOCCI introduced their NSF-CCEP funded training program that teaches a research based communication strategy for educators' interactions with visitors in 2011. The blended online and in-person program includes each participating museum sending two educators to three workshops over a 6-month period and completing weekly assignments in between the face-to-face workshops. Each learning cohort is made up of approximately 20 interpreters from a nature-based museum and two scientists from Woods Hole Oceanographic Institute. Alumni are encouraged to stay connected after the training via social media, invited to continuing education webinars, and are encouraged to share what they learned with their colleagues and peers.

The training is grounded in research with the general public conducted by FrameWorks Institute (Simon et al. 2014; Volmert 2014; Volmert et al. 2013). Key components of the training are to start messages with value frames that connect visitors to a larger reason for the need for engagement, use of metaphors and simplifying models to communicate climate systems and the role of carbon dioxide on this system and ocean acidification, and encourage discussions and community level solutions. Rhetoric techniques include metaphors or models that were selected to be easily understood, recalled, and repeated which should increase visitor concern about climate change and ocean acidification and their hope in their ability to

communicate the information with others (e.g., Geiger et al. 2017a,b). For example, referring to the carbon aggregating in the upper atmosphere as a "heat-trapping blanket" is a simplifying model that helps a listener understand both the insulating effect of carbon dioxide and the concept that the temperature is rising because heat cannot escape as is the case when being covered by a blanket.

The ability to talk was a prioritized outcome because talking with others was viewed as ground work for developing community level solutions (Liu and Hanauer 2011) and community level solutions was encouraged as a way to provide a new and empowering construal of behavioral engagement. Many climate change mitigation campaigns propose small-scale personal actions such as using energy-efficient lights and turning off unused electronics (e.g., EPA: Environmental Protection Agency 2016) that may be viewed by the general public as a weak response given the scale of the problem or, alternatively, focus on changing state or federal policies that may be perceived by the general public as beyond the capacity of most of those visiting to influence. Thus, key goals of the program were to increase visitor psychological engagement in climate change (i.e., increase knowledge about the topic, concern about climate change and ocean acidification, and hope about their ability to talk about climate change), and to increase behavioral engagement (i.e., increase personal and, especially, community behaviors).

Present Research

The present research is part of a larger set of research designed to evaluate the NNOCCI training program. Other parts of the evaluation include assessment of the impact of the training on the educators (Swim and Fraser 2013) and educators' communications with visitors (Geiger et al. 2017b).

Here, we take a broader view by examining the cultural context where education programs are occurring. We assess two research questions: (1) Do nature-based museums provide a culture conducive to encouraging public climate change engagement, and is evidence of this culture particularly strong among those museums who supported staff attendance to NNOCCI training program?; and (2) Is a conducive culture reflected in visitor psychological and behavioral engagement post attendance, with visitors being more engaged than the general public, and visitors to museums that participated in the NNOCCI training program being particularly engaged. Differences between NNOCCI participating and non-participating museums are suggestive of: (1) the influence of the training on museum activities; and (2) of the impact of museum culture on visitors.

In Study 1, representatives from nature-based museums reported their coverage of and institutional support given to climate change education. We compared the culture of early adopting institutions to the NNOCCI climate change education programming with potential later adopters. We predicted that participating nature-based museums would be more supportive of climate change education than nonparticipating nature-based museums. We predicted this because participating in the program is a signal of support and the program helps support such activities.

In Study 2, people who had visited and had not visited nature-based museum visitors over the previous 12 months were identified in a national survey. Approximately half of the visitors had attended museums that had participated in the NNOCCI program in at least 12 months prior to the survey distribution and half attended museums that had not

participated in the program. They reported their psychological and behavioral engagement in the topic as defined by the goals noted above. We made three predictions: (1) Visitors exposure to climate science programming would coincide with reports from nature-based museums in Study 1 such that visitors to participating museums would report more exposure than visitors to nonparticipating museums; (2) Conceptually replicating previous work (Luebke et al. 2012), visitors to nature-based museums would be more psychologically and behaviorally engaged than the general public; and (3) Visitors to NNOCCI participating museums would be more engaged than visitors to nonparticipating museums potentially because the culture and programming at these museums influenced visitor engagement.

Both studies can be considered quasi-experiments because they make comparisons based upon naturally occurring groups. This means that, in Study 1, museums were not randomly assigned to be in the NNOCCI training. Yet, we would argue that the museums in Study 1 have some strong commonalities because they all are members of the AZA suggesting that differences may be a result of one set of museums having attended the training. Similarly, in Study 2, respondents were not randomly assigned to not visit a nature-based museum, visit a nature-based museum not participating in the NNOCCI program, or visit nature-based museums participating in the NNOCCI program. Yet, the latter two groups were likely similar on many regards given similar interest in attending nature-based museums. Further, as is often done with quasi-experiments, differences that account for many factors that would explain self-selection into groups is taken into account in the analyses and we replicate the findings at two different points in time.

STUDY 1

Study 1 assessed the culture for climate change education at nature-based museums, particularly those that chose to be part of the NNOCCI training program.

Method

Data were collected as part of a membership-wide study conducted by the AZA. At the time of the survey, the vast majority of program participants represented zoos and aquariums. National parks, nature centers and science centers joined in the latter part of the program. Thus, focusing on this set of nature-based museums is appropriate. As data collected by AZA, this study consisted of archival data analysis on our part based on questions crafted and approved by AZA staff including one author of this paper. AZA, as a core partner in the NNOCCI project, however, were well aware of the research undertaken by this team and used the project data as a key point of departure for the development of their member survey.

Participants

The survey was distributed by AZA to its multi-tiered institutional representative contact lists containing one or more representatives from each of 230 accredited institutions. In some cases, we received responses from multiple representatives of a single institutions; we averaged these responses to form a single institutional score. After averaging, representatives from 81 zoos and aquariums participated in this study (35% institutional response rate). Fifty-eight institutions that had not yet scheduled any employees to participate in a NNOCCI Study Circle (*non-participating museum*) and 23 who had employed someone who attended a training (*participating museum*). The participating

museums included both those who had an employee in the midst of the program and those who had an employee scheduled to attend in the future. We did not distinguish between these two types of participating organizations because we had insufficient statistical power to test differences between the two.

Measures

Respondents completed a survey containing the following items: (1) the importance of and comfort presenting climate education and recommending personal and civic mitigation behaviors; (2) the extent to which their center provided educational programming; (3) the presence of 12 barriers to educators' climate change interpretation efforts; (4) the presence of eight different resources for climate change interpretation; (5) whether their institution had been involved in or executed educational opportunities for their staff, the public, and other museums or interpretive centers; and (6) the breadth of the information resources used at their institution. (See supplementary material for detail).

Results

Table 1 provides a summary of all statistical tests.

Climate change education

Overall, a majority indicated that climate change education was important and, on average, all claimed they were at least somewhat comfortable with that work. These responses were stronger at participating museums than non-participating museums. Despite the professed importance of climate change education and claiming comfort with incorporating this education, on average, climate change education was actually occurring at low to moderate levels at both types of museums. Participating museums, however, were more likely to claim they were providing climate change education as part of their programming efforts as indicated by the number of types of educational opportunities provided and the extent of informal and formal educational opportunities offered.

Recommended actions made at nature-based museums

A large percent of responding museums valued personal sphere and civic action, and energy conservation, and, on average, were somewhat to very comfortable encouraging these actions. There were no differences between participating and nonparticipating museums related to reported efforts to encourage personal and civic action and energy conservation programs.

However, the direction of effects for the personal and civic action is notable. Relative to nonparticipating museums, there was a marginally significant tendency for museums participating in the NNOCCI training to be more comfortable encouraging personal *and* civic action. If training was successful at increasing the tendency for museums to emphasize civic action, then nonparticipating museums and participating museums that had not yet finished might be more similar to each other than to museums that had completed the program. Consistent with this argument, the percent encouraging personal and civic action at nonparticipating museums (79%) is similar to the percent at among those in the midst of the training (82%) and the latter percent is less than participating museums that had completed the training (100%).

Barriers and support of staff

There was little reported concern about audiences resisting education and lack of support from their museums (including fellow

Table 1.
Climate change relevant activities at AZA centers

	Non-participating museums (n = 58)	NNOCCI participating museums (n = 23)	Comparison (two-tailed tests for p-values)
Climate change education			
Climate change education important (yes/no)	62%	96%	$X^2(1) = 9.14$, $p < .01$
Climate change education comfort (no = 1, very = 3)	1.99 (.70)	2.38 (.47)	$t(78) = 2.50$, $p = .02$
Public educational opportunities (out of 6)	.96 (1.18)	1.81 (.47)	$t(79) = 2.73$, $p = .01$
Informal (1 = nothing; 4 = considerable amount)	2.07 (.70)	2.64 (.79)	$t(78) = 3.15$, $p = .02$
Formal (1 = nothing; 4 = Considerable amount)	2.01 (.82)	2.48 (.70)	$t(78) = 2.43$, $p = .02$
Recommended actions			
Encouraging personal and civic action (yes/no)	79%	91%	$X^2(1) = 1.49$, $p = .22$
Comfort encouraging personal and civic action (no = 1, very = 3)	2.12 (.65)	2.40 (.56)	$t(78) = 1.82$, $p = .07$
Encouraging energy conservation (yes/no)	80%	78%	$X^2(1) = .08$, $p = .77$
Comfort encouraging energy conservation (no = 1, very = 3)	2.46 (.65)	2.53 (.55)	$t(78) = .53$, $p = .60$
Support staff			
Barriers from resistant audience (out of 6)	.86 (1.00)	.84 (.96)	$t(79) = .08$, $p = .94$
Barriers from own Institution (out of 3)	.26 (.60)	.40 (.59)	$t(79) = .73$, $p = .46$
Barriers due to skills (out of 4)	1.08 (1.11)	.72 (1.01)	$t(79) = 1.35$, $p = .18$
Professional development for staff (out of 5)	.58 (.90)	1.72 (1.07)	$t(79) = 4.83$, $p < .01$
Barriers due to job prioritization (out of 3)	1.20 (.81)	.78 (.75)	$t(79) = 2.12$, $p = .04$
Breadth of sources (out of 10)	1.02 (.76)	1.78 (1.51)	$t(79) = 3.03$, $p < .01$
Assisting development at other centers (out of 3)	.12 (.32)	.99 (.98)	$t(79) = 6.07$, $p < .01$

educators and management) and these concerns did not differ by type of museum. Yet, participating museums reported more investment in climate change educational programming: Participating museums not only sent staff to the NNOCCI training program but had more access to professional development opportunities to help with their climate change education and reported fewer job related barriers (e.g., time and budgets) to develop educational opportunities suggesting that participating museum prioritized climate change education or had more staff resources available to them. Participating museums reported a wider breadth of resources available to them that could help them develop their programs. Last, though at low levels, participating museums were more likely to help other institutions develop their educational programming than nonparticipating museums.

Discussion

Results are consistent with the AZA's commitment to add climate change in their environmental education program (AZA, 2013; Fraser et al. 2010). Both participating and non-participating museums consider it important to include climate change education programming. Yet, consistent with climate change programming being new additions to the museums (Fraser and Wharton 2007; Moss et al. 2015), they reported greater comfort with energy conservation than climate change education.

Further, while a large majority addressed conservation actions, few addressed climate change.

Results point to nature-based museums that have participated in the NNOCCI training program leading the inclusion of climate change programming. Given that these institutions supported their staff attending the programming as part of their professional development, it is not surprising that these participating museums believed climate change programming was of higher importance than their counterparts who did not send staff. Yet, our data indicate that these difference go beyond sending staff to the training program. Participating museums were also more likely to invest in a range of other resources and have fewer barriers to developing programming. Given differences in investment, it is interesting to note the lack of differences in perceived institutional barriers. The lack of perceived difference suggests that those from nonparticipating museums may be unaware of the types of resources that could improve their efforts and these barriers could be holding them back from implementing programs.

Several differences between museums that had and had not participated in the NNOCCI training program suggest that the training program contributed to differences between these museums. First, participating nature-based museums apparently translated their valuing of climate change programming into more public, formal, and informal climate change programming. NNOCCI programming may have contributed to increased confidence and skills (Swim and Fraser 2013). Second, the NNOCCI training program encouraged participants to expand their outreach to other institutions and this was evident in participating museums. Third, while measures did not allow separate tests of individual vs. civic action, findings suggest that NNOCCI institutions may be more likely to attend to civic actions than nonparticipating institutions—something we return to in the next study.

STUDY 2

Study 2 addressed two questions: (1) Is visitor exposure to climate science information consistent with that reported in Study 1 such that visitors to nature-based museums that had participated in the NNOCCI training report more exposure than those visitors to other nature-based museums; and (2) Do visitors to nature-based museums, particularly participating museums, report more psychological and behavioral engagement than the general public? Those visiting participating museums will be referred to as NNOCCI-visitors and those visiting museums that had not participated will be referred to as non-NNOCCI visitors. Analyses control whether or not the museum they attended was a zoo or aquarium in order to control for possible effects of different types of nature-based museums. Analyses also control for visitor demographics that might account for engaged participants being more likely to attend museums and more likely to seek-out museums that would have climate change programming.

Method

Data were collected in the spring of 2014 and the late summer of 2016. Many events occurred between these two dates that could have changed the overall US culture for climate change education and impacted visitor engagement outside of the museum context. This includes a large climate change rally in New York City in the fall of 2014, the Pope's visit to the United States in the fall of 2015 where he emphasized the need to address climate change, and the attention given to

climate change during the U.S. presidential nomination period. These larger cultural events could diminish differences between visitors and non-visitors and between visitors to participating and non-participating museums. Thus, we test whether time of completing the survey impacted results.

Sample

Two nationally representative stratified samples of individuals completed surveys online. Respondents were screened to obtain approximately equal numbers of visitors to participating museums, visitors to non-participating museums, and non-visitors. Respondents in 2014 were 1169 members of the U.S. adult general population, with about one-third having not attended a nature-based museum in the past year (nonvisitors: 35%, n = 404). Of those that had attended at least one of these types of nature-based museums, more had attended institutions that participated in the program (NNOCCI-visitors: 41%, n = 475), than not (non-NNOCCI visitors: 25%, n = 290). Respondents in 2016 were 1426 members of the U.S. adult general population, with nearly half having not attended a nature-based museum in the past year (non-visitors: 45%, n = 568). Of those that had attended at least one of these types of nature-based museums), about an equal number had attended institutions that participated (NNOCCI-visitors: 26%, n = 368) and did not participate in the program (non-NNOCCI-visitors: 30%, n = 421). (See supplemental information.)

Demographic information is presented in Table 2. The samples provided representation from a large breadth of the American public: respondents comprised a broad range of ages (18–88), had political views and party affiliation with rates similar to that of the general U.S. public, was composed of a variety of racial/ethnic groups, and had a range of educational experiences. Relative to the general population, our sample had an overrepresentation of respondents who were white, well-educated, and female. Respondents in 2014 were slightly more likely to be White (90% vs. 87%) and women (61% vs. 55%) than respondents in 2016. All other demographics did not differ by sample. Demographics differed dependent upon the status of our visitors suggesting that the mismatches with overall U.S. population may be a result of screening participants to achieve relatively equal numbers in our three types of visitors. Relative to non-NNOCCI visitors and non-visitors, NNOCCI visitors were more likely to be younger, nonwhite, more educated and politically liberal. Relative to non-visitors, non-NNOCCI visitors were younger and more educated. Last, non-NNOCCI visitors and NNOCCI visitors had more women than men while non-visitors were equally likely to be women and men. Demographic differences are consistent with the results from prior national surveys of zoo and aquarium visitors (Fraser and Sickler 2009).

Measures

Respondents completed an online survey with several measures. Here we address only the measures noted in the introduction regarding psychological and behavioral engagement goals of the NNOCCI training goals. More details about measures noted below can be found in the supplemental materials. Results with other measures assessed in the surveys and tests of models predicting changes in public discussions about climate change are presented elsewhere (Geiger et al. 2017a).

Exposure to information. Those who reported visiting a nature-based museum in the past year

Table 2.
Demographics for study 2

		Visitor status			
	Total sample	**Visitors to NNOCCI participating museums**	**Visitors to non-NNOCCI participating museums**	**Non-visitor**	**Comparing three types of visitors**
Sample size	2696	843	771	1041	
Age	$M = 48.26^{a}$	$M = 44.70^{a}$	$M = 48.48^{b}$	$M = 51.04^{c}$	$F(2,2558) = 40.88$,
(Range 18 to 88)	$SD = 15.56$	$SD = 14.61$	$SD = 15.71$	$SD = 15.62$	$p < .01$, $\eta^2 = .03$
Percent women	56%	58%[a]	66%[b]	49%[b]	$X^2(2) = 49.08$, $p < .01$
Percent white	88%	86%[a]	91%[b]	88%[b]	$X^2(2) = 9.46$, $p < .01$
Education	$M = 4.10$	$M = 4.40^{a}$	$M = 4.35^{a}$	$M = 3.68^{b}$	$F(2,2558) = 40.49$,
	$SD = 1.67$	$SD = 1.67$	$SD = 1.66$	$SD = 1.60$	$p < .01$, $\eta^2 = .03$
<High school	1.4%	1.1%[ab]	0.3%[a]	2.4%[b]	$X^2(12) = 128.95$, $p < .01$
High school	18%	14%[a]	15%[a]	25%[b]	
Some college (1–3 years)	25%	30%[a]	28%[a]	18%[b]	
Associates (2 years)	12%	10%	12%	13%	
College graduate (4 years)	25%	30%[a]	28%[a]	18%[b]	
Some post graduate study, no advanced degree	4%	5%[a]	5%[a]	3%[b]	
Advanced degree	14%	17%[a]	17%[a]	10%[b]	
Political ideology (1 = very liberal to 5 = very conservative)	$M = 2.99$ $SD = 1.05$	$M = 2.86^{a}$ $SD = 1.03$	$M = 2.95^{a}$ $SD = 1.08$	$M = 3.12^{b}$ $SD = 1.02$	$F(2,2558) = 13.60$, $p < .01$, $\eta^2 = .01$
Political party identification					
Democrat	36%	40%[a]	36%[b]	32%[b]	$X^2(6) = 21.22$, $p = .02$
Republican	26%	25%	27%	26%	
Independent	30%	28%	29%	32%	
Other	8%	6%[a]	7%[b]	10%[b]	

Notes: Percentages and Means with different superscripts differed within visitor status at $p < .05$. When no subscripts are present the means do not differ within visitor status.

indicated whether or not they had seen exhibits, heard a presentation, or talked with an educator about climate change and about ocean acidification. Due to skewed data, we created a measure of exposure to any of these three modes of delivery of information. One measure assessed exposure to climate change information and the other exposure to ocean acidification information.

Concern about social and environmental topics. Participants self-categorized into one of the following six groups based upon the labels to the categories (e.g., Swim and Geiger 2017): (1) Dismissive; (2) Doubtful; (3) Disengaged; (4) Cautious; (5) Concerned; or (6) Alarmed when thinking about topics covered in the NNOCCI training (climate change, ocean acidification) and, for comparison purposes, three topics not covered in the NNOCCI training (sexism, income tax, and air pollution).

Hope. Hope was assessed through a six-item modification of Snyder and colleagues' Hope scale (Snyder et al. 1996; Swim and Fraser 2013). These scales assessed agency and pathways toward the goal of discussing climate change, ($\alpha = .92$).

Climate change knowledge. Participants completed a 15-item multiple choice knowledge test that assessed the role of CO_2 and the oceans in the climate system and ocean acidification (α = .86). Items include addressing the public's tendency to inaccurately attribute climate change to holes in the ozone and ocean acidification to dumping garbage in the ocean or acid rain. They also include knowledge about the role of oceans in regulating the climate. The recommended communication tools taught in the training program were based upon tests indicating that these tools improved scores on this test (Simon et al. 2014; Volmert 2014).

Individual, household, and community level actions. Participants indicated the extent to which they engaged in eight climate change mitigating behaviors over the past year. Response options ranged from "Never" (0) to "Several times a week" (8). Three behaviors addressed individual and household actions (took public transportation, walked, biked, or traveled by other means instead of taking a car in order to reduce my use of fossil fuels; made purchasing decisions based upon the impact of the product on climate; made purchasing decisions based upon a company's actions that affected the climate change; α = .86) and five addressed community level behaviors (donate money to environmental groups that address climate change and ocean acidification, political participating such as voting for a candidate based upon stance on climate change, actions to address own communities contribution to climate change, talked to friends and family about climate change or ocean acidification, and used social media to share information about climate change or ocean acidification; α = .91).

Results

Overview of analyses

Museum experiences were analyzed with a 2(Visitor status: non-NNOCCI vs. NNOCCI visitors) × 2(Time of survey) ANOVA. Remaining dependent measures were analyzed with a 3(Visitor Status: Non-visitor, non-NNOCCI visitor, NNOCCI visitor) × 2 (Time of survey) ANOVA. Unless noted, there were no interactions between visitor status and year that the survey was taken and the pattern of means were the same for significant effects indicating that reported visitor status effects held across time. Follow-up analyses controlled for variables that could account for differences among visitor status. These control variables were: (1) in the first follow-up analysis, Attendance at zoos and aquariums because of the tendency for more of the NNOCCI participating museums to be zoos and aquariums; (2) in the second follow-up analyses, Demographic information was also added (age, gender, whether or not respondents identified as White, education, political ideology) to account for pre-existing differences that co-vary with visitor status; and (3) in the third follow-up analyses concern about environmental issues was also added (climate change, ocean acidification, air pollution, in analyses were these were not the dependent measures) in case these predicted self-selection into museums that emphasized these topics. Unless otherwise noted, all effects remained significant and pattern of means were the same in these follow-up analyses.

Museum experiences

Visitors reported more exposure to information about climate change than ocean acidification. While exposure to information about climate change decreased in time for both groups, importantly for the present research,

NNOCCI visitors were more likely to encounter both types of information than non-NNOCCI visitors (see Figure 1).

Psychological engagement

Concerns. Consistent with predictions, non-visitors reported less concern about climate change and ocean acidification than non-NNOCCI visitors, and non-NNONCCI visitors reported less concern than NNOCC visitors (see Figure 2). The same pattern was found for the control topic of Air pollution perhaps because carbon dioxide was thought of as an air pollutant. The only effect of time was that respondents reported more concern about ocean acidification in 2016 (M = 4.52) than in 2014 (M = 4.33), $F(1, 2478) = 10.22$, $p = .001$, $\eta^2 = .004$.

There were no notable effects of visitor status on the two control topics of income tax and sexism. There was no significant effect of visitor status on concern about income taxes. There was an effect of visitor status on concern about sexism that followed the same pattern as found for the environment related topics, (non-visitors: M = 3.94, non-NNOCCI visitors: M = 4.05, NNOCCI visitors: M = 4.18), $F(2, 2478) = 5.63$, $p = .004$, $\eta^2 = .005$, but the effect was smaller than the effects of visitor status on environmental concerns and the effect for sexism was not significant in follow-up analyses controlling for type of museum visited, $F(2, 2476) = .70$, $p = .50$, $\eta^2 = .001$, and visitor demographics, $F(2, 2476) = .73$, $p = .73$, $\eta^2 < .001$.

Hope. Consistent with predictions, NNOCCI visitors were more hopeful about their ability to talk about climate change (M = .23) than the other two groups, $F(2, 2574) = 71.66$, $p < .001$, $\eta^2 = .053$. However, inconsistent with predictions, both non-NNOCCI visitors (M = −.21) and non-visitors (M = −.22) were both not hopeful and the two did not differ from each other. Hope increased over time with those

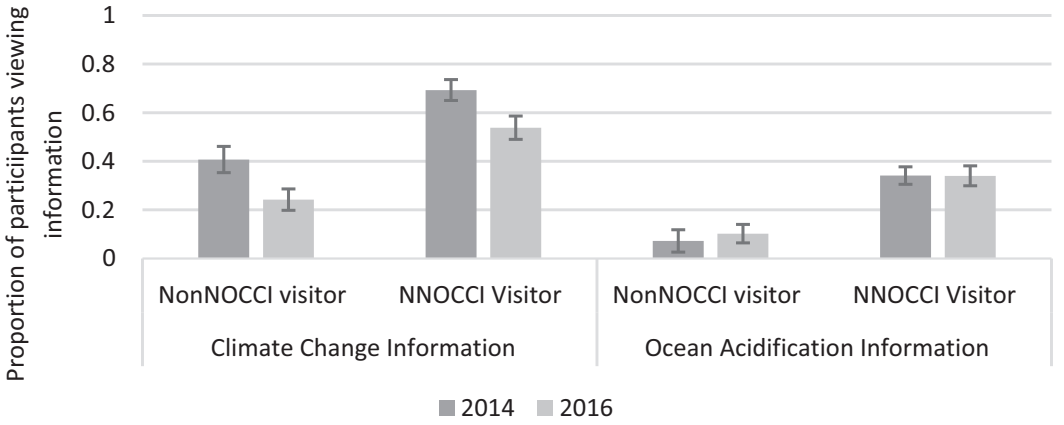

Figure 1. Visitor status differences in exposure to climate science information at nature-based museums (Study 2). *Notes.* Error bars represent 95% Confidence Intervals around the proportions. Climate change information–Main effect of visitor status: $F(1,1550) = 144.85$, $p < .001$, $\eta^2 = .09$; Main effect of time of survey: $F(1,1550) = 43.65$, $p < .001$, $\eta^2 = .03$. Ocean Acidification information–Main effect visitor status: $F(1,1550) = 150.79$, $p < .001$, $\eta^2 = .09$.

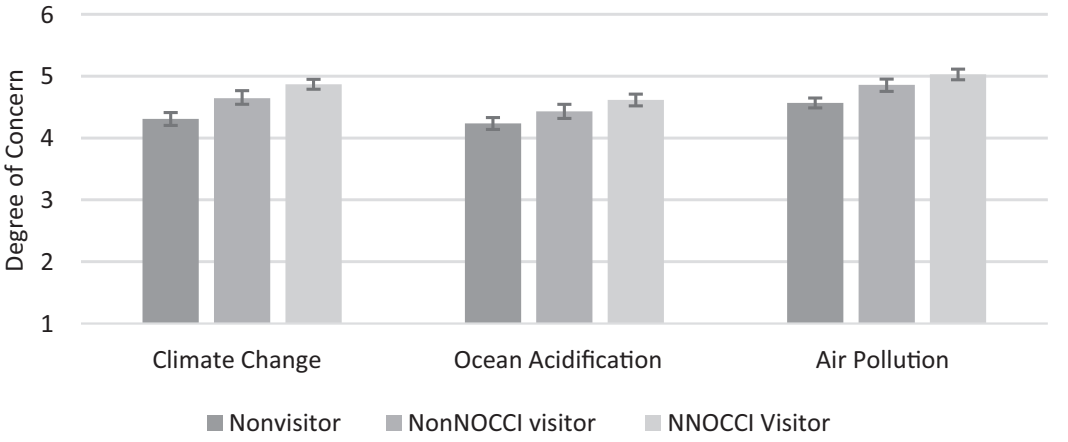

Figure 2. Visitor status differences in concerns about environmental problems (Study 2).
Notes. Concern ranges from 1 = Dismissive; 2 = Doubtful, 3 = Disengaged, 4 = Cautious; 5 = Concerned, 6 = Alarmed. Error bars represent 95% Confidence Intervals around the mean. Main effects of visitor status: Global Climate Change, $F(2, 2478) = 25.98$, $p < .001$, $\eta^2 = .02$; Ocean Acidification, $F(2, 2478) = 13.95$, $p < .001$, $\eta^2 = .02$, Air Pollution, $F(2, 2478) = 30.80$, $p < .001$, $\eta^2 = .02$. All pairwise comparisons for visitor status within topics are significant at $p \leq .02$.

in 2014 being unhopeful ($M = -.15$) and those in 2016 being neutral in their hope, $M = .02$), $F(2, 2574) = 21.93, p < .001, \eta^2 = .008$.

Climate change knowledge. Consistent with predictions, non-visitors scored poorer (45%) than non-NNOCCI visitors (55%) on the knowledge test, who scored poorer than NNOCCI visitors (58%), $F(2, 2589) = 65.47$, $p < .001, \eta^2 = .05$. Participants scored better in 2016 ($M = 54\%$) than in 2014 (52%), $F(2, 2589) = 3.79, p = .05, \eta^2 < .001$. Despite results fitting predictions, scores were low across all groups and the difference between NNOCCI and non-NNOCCI visitors was practically very small.

Behavioral engagement

Consistent with predictions, non-visitors were less likely to do personal and civic behaviors than non-NNOCCI visitors, who were less likely to report engaging in both behaviors than NNOCCI visitors (see Figure 3). Respondents reported engaging in more civic behaviors in 2016 ($M = 1.30$) than in 2014 ($M = 1.14$), $F(2, 2587) = 8.41$, $p < .01$, $\eta^2 = .003$. Even with this more frequent engagement, civic behaviors were engaged in less frequently than personal behaviors. Although main effects remained significant after controlling for type of museum and demographics in follow-up analyses, the pattern of means were different for the personal behaviors: Pairwise comparisons between non-visitors and non-NNOCCI visitors indicated that they had similar likelihoods of engaging in these types of behaviors and both were less likely to do them than NNOCCI visitors.

Discussion

Results confirmed different climate change education cultures that were documented in Study 1. Visitors to NNOCCI museums were more likely to encounter educational material about climate change and ocean acidification

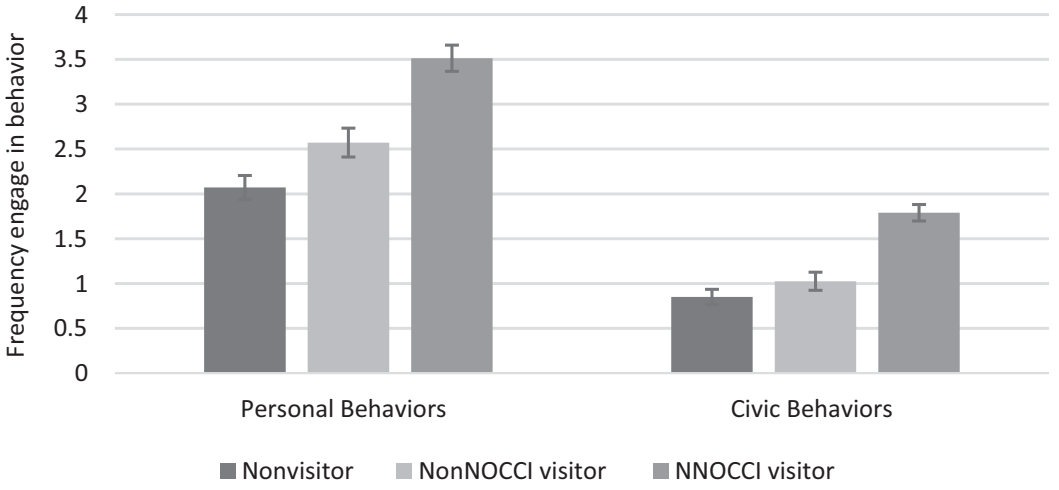

Figure 3. Visitor status differences in personal and civic behaviors (Study 2).
Notes. Frequency of engagement ranges from 0 = "never" to 4 = "about once a month". Error bars represent 95% Confidence Intervals around the mean. Main effects of visitor status: Personal behaviors, $F(2, 2587) = 117.06$, $p < .001$, $\eta^2 = .08$; Civic behaviors, $F(2, 2587) = 117.06$, $p < .001$, $\eta^2 = .08$. All pairwise comparisons for visitor status within topics and time are significant at $p \leq .01$.

than visitors to non-participating museums. Plus, consistent with training advice to include civic behaviors, visitors to NNOCCI museums were more likely to report engaging in community level responses than non-NNOCCI visitors.

Reflecting the cultures of nature-based museums suggested by these findings, visitors to nature-based museums, particularly NNOCCI museums, reported more psychological engagement (concern, hope, and knowledge) and personal and civic behavioral engagement than the general public. Overall knowledge was poor. This could be because the knowledge test included many items about ocean acidification and NNOCCI and non-NNOCCI museums were unlikely to present such information.

Because we did not randomly assign people to visit NNOCCI and non-NNOCCI nature-based museums, we cannot rule out the possibility that group differences are a result of self-selection into these museums. Yet, these results remained significant when demographic differences and concern about climate change were controlled for in the analyses suggesting that nature-based museums are a source of differences across visitors that go beyond typical predictors of attending museums and interest in climate change.

Difference in engagement occurred across time. Visitors reported more concern about ocean acidification and hope about their ability to talk about climate change, demonstrated improved knowledge, and reported more frequent engagement in community action. Differences across visitor status remained constant across these wider cultural changes.

GENERAL DISCUSSION

This study sought to explore the culture for climate change education at science museums and the impacts of collective action by

coordinated work to assess in these educational efforts. Results demonstrate that nature-based museums are engaging in efforts consistent with AZA goals of expanding to include climate change in their conservation related educational programming. Further, nature-based museums that are making efforts via participating in a training program offered by NNOCCI had cultures more supportive of climate change education than non-participating museums as revealed by their comfort with and amount of climate change programming they provided (Study 1) and visitors to participating museums reporting more encounters with programs about climate change and ocean acidification than visitors to non-participating museums (Study 2).

The study also sought to test whether cultures of museums were reflected in psychological and behavioral engagement of visitors up to 12 months after visiting the museums. Study 2 results indicated that visitors relative to non-visitors, and visitors to museums participating in NNOCCI training relative to visitors to museums that had not yet participated in training, were more concerned about climate change and ocean acidification, more hopeful about their ability to discuss the topic, more knowledgable about climate change, and more likely to take personal and community based actions that help mitigate climate change. These differences are consistent with the goals of the training program suggesting that differences between visitors to NNOCCI participating and non-participating museums may have been a result of encountering information at participating museums. Plus, these differences were over and above demographic differences and concerns about environmental problems. On-site data collection validate claims about the impact of programming on visitors (Geiger et al. 2017b).

Despite what appears to be success of the NNOCCI program, results indicate more efforts are needed to improve knowledge. Central to NNOCCI training was developing the public's climate change knowledge, but there was only a small difference between NNOCCI and non-NNOCCI visitors' climate science knowledge. Further, both of these groups, though performing better than the general public on the knowledge test, did not perform well overall. Poor performance may have been a result of many of the questions addressing ocean acidification, a topic infrequently addressed at museums. Yet, effective discourse about climate change and development of community solutions may require more in depth understanding of the science, including ocean acidification. Thus, additional efforts to improve knowledge are still warranted.

Despite weak performance on knowledge tests, behavioral engagement suggests that visitors, and particularly visitors to NNOCCI centers, may have sufficient knowledge to understand the threat of climate change. We suggest that climate education programming may serve to make climate change more salient, increase confidence in visitors' knowledge and ability to talk about climate change, and provide role models for talking about climate (Geiger et al. 2017a,b). These effects could serve to break a social norm about not discussing climate change (Geiger and Swim 2016; Norgaard 2011). Thus, while not having great impacts on knowledge, public interpretation at museums may help those already somewhat knowledge be more likely to embrace the topic and promote solutions.

Limitations

As noted above, museums were not randomly assigned to participating in the

program and visitors were not randomly assigned to NNOCCI participating nature-based museums. Other characteristics of museums and visitors might account for the results beyond those we controlled for in the analyses. In many cases, it is likely that early adopter institutions engage in climate change education because their public support reinforces their commitment to climate change action and are more likely to draw individuals whose values and commitments match those of the institution. Another interpretation is that certain locations and populations are receptive to improved climate change educational programming.

Another limitation is that most of the training to date has occurred at zoos and aquariums. All the museums in Study 1 were from zoos and aquariums and most of the visitors who attended a NNOCCI museum had attended zoos and aquariums. Results remained significant when controlling for this tendency in Study 2. Yet, the generalizability of findings to other types of nature-based settings and museums needs to be examined.

Future Research

This research suggests that category-wide initiatives at museums, whether science centers, art museums or other types of museum, may be able to develop a strategy for increasing national literacy and response to issues that impact their nation.

CONCLUSION

Some nature-based museums appear to be developing cultures that support visitors' active motivations to engage in climate change mitigation (e.g., concerns and hope) and visitors' engagement in climate change actions via museums expanding their conservation programming to include more climate change and ocean acidification. Importantly, results suggest that institutions that are able and/or motivated to invest in training staff and provide other resources are taking the lead in developing this culture. Results of the present research suggest that this investment is paying off in terms of changing their programming. Further, results are consistent with these latter museums having visitor cultures supportive of such programming and/or being influenced by such programming to be more knowledge and actively engaged in climate change activities. END

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SUPPORTING INFORMATION

Additional supporting information can be found in the online version of this article:

Data S1: Supplemental material