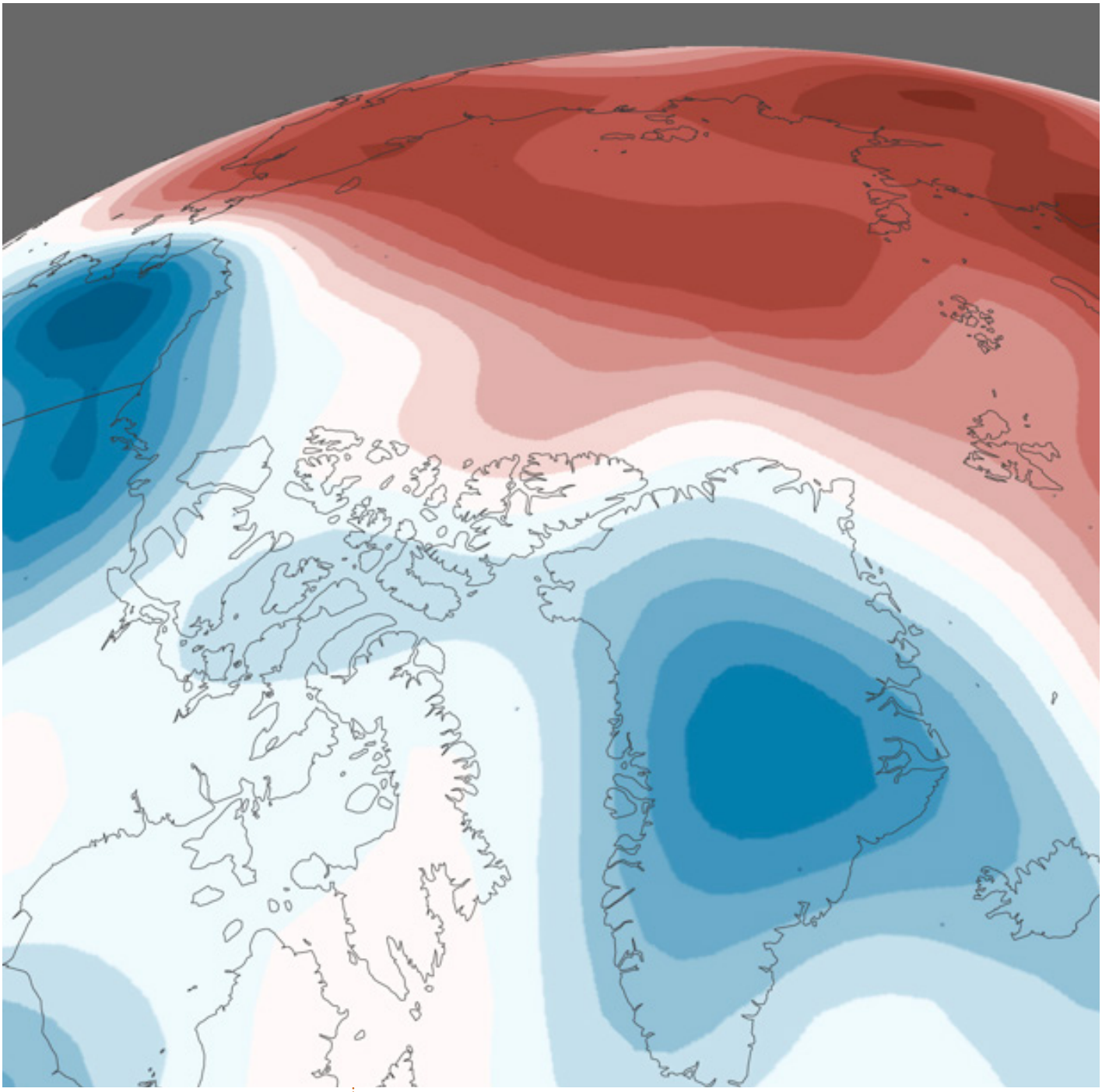

February 23, 2014

Visualizing Change: Context Briefing Report

NewKnowledge Report # NOAA.52.127.01

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Prepared for:
Visualizing Change Leadership Team: Aquarium of the Pacific, National Aquarium in Baltimore, New England Aquarium & Seattle Aquarium
William Spitzer, Principal Investigator, John Anderson, Project Director
New England Aquarium
Central Wharf
Boston, MA, 02140

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NewKnowledge is a non-profit research institute founded to pursue a deep understanding of how people engage with society's grand challenges. The organization works to expand understanding of how knowledge is acquired and acted upon in order to promote a strong democracy that enables all people to live to their greatest potential in harmony with the biosphere.

EXECUTIVE SUMMARY

A consortium of Aquarium of the Pacific, National Aquarium in Baltimore, New England Aquarium & Seattle Aquarium received a National Oceanic and Atmospheric Administration (NOAA) Grant to support Visualizing Change: Training and Tools to Support Informal Educators. The collaborators seek to address topics drawn from existing NOAA assets and companion materials, using different platforms to reach a broad audience across the US. Other key partners include the NOAA Environmental Visualization Laboratory (VisLab), the NOAA Pacific Marine Environmental Laboratory (PMEL), the Exploratorium in San Francisco, the Ocean Explorium (OE) in southern Massachusetts, FrameWorks Institute (FrameWorks) and New Knowledge Organization Ltd (NewKnowledge).

The project intends to work with strategic framing to construct the training and tools at the heard of the project, and will draw heavily on the "Mapping the Gaps" report outlining public perceptions of climate change (Volmert et al, 2013), an extensive summary of social and expert perspectives on the issue.

This report focuses on the context surrounding this effort as a supplement to the central document focusing on strategic framing. It seeks to provide scholarly summaries of how visualization tools might be influenced by the informal learning context. The report is prepared as part of the front-end evaluation by NewKnowledge, the independent project evaluator. The goal of this briefing report is to provide the PIs and project teams with information useful for guiding narrative tool development and to offer insight into promoting or mitigating factors that may arise in relation to the implementation of the project. We hope the material presented here will equip educators with a broad picture of how visitors may choose to engage with the content being crafted by the project team and serve as a road map for the subsequent stages of evaluation.

Prior to development of this report, the project team identified a series of topics and resources that might be used to develop the visualization tools and training materials. This report builds on those prioritized topics by creating an annotated bibliography to summarize key studies beyond the content covered in the Mapping the Gaps report that may provide different perspectives on how the public relates to the prioritized topics, and other findings on public engagement scientific content in informal learning settings. In particular, this report focuses specifically on recent findings in intergenerational learning, more general information about theories related to behavioral change. This briefing document relies primarily on recent material from the past five years. However, older resources are included when applicable.

The following topics are explored in this briefing report: visitor concerns regarding prioritized topics related to climate change (including sea level rise, glacier/sea ice change, ocean acidification, migration patterns and changes, impact of drought/rainfall, extreme events); findings concerning public perception of delivery; current psychological and sociological literature related to intergenerational learning; research related to behavior modification; and big picture synergy/meaning-making.

Findings reinforce a "strategic framing" approach to communication (Bales and Gilliam, 2004), which supports meaning-making by (1) building on careful empirical research to understand what people already value, believe, and understand, and then (2) designing and testing communication strategies that help translate complex science in a way that allows people to examine evidence, make well- informed inferences, and embrace science-based solutions. This is a "nonpersuasive communication" strategy (Fischhoff, 2007) that explains causes and consequences rather than advocating particular policies or actions. This approach is consistent with NOAA's emphasis on helping the public to become better-informed environmental decision makers.

Generally, the summary suggests:

- Climate change and the associated content areas are considered challenging and remote to most visitors' experience;
- The public has a high level of respect for the interpreters in an ISEI to be reliable and trustworthy;
- Learning may not be constant for any particular visualization if it is delivered in a different setting or if the display format is altered, but studying these differences will expand knowledge for the field;
- That content to be conveyed through the visualization tools may be perceived as challenging and remote for many visitors;
- There is a need to create anchors for content that help visitors scaffold their own sense of place and relevance to help interpret content;
- Developing interpretive strategies that meet intergenerational learning needs shows higher level of promise for success than targeting any specific age or knowledge set;
- Any presentation should only be considered a step along the path to behavior change, not a change instigator in isolation; and
- Synthesis and meaning-making will be situated within the learner's entry narrative, not compared to a national baseline.

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Overview

A consortium of Aquarium of the Pacific, National Aquarium in Baltimore, New England Aquarium & Seattle Aquarium, received a National Oceanic and Atmospheric Administration (NOAA) Grant to support Visualizing Change: Training and Tools to Support Informal Educators. The collaborators seek to address four topics drawn from existing NOAA assets and companion materials, using different platforms to reach a broad audience across the US. Other key partners include the NOAA Environmental Visualization Laboratory (VisLab), the NOAA Pacific Marine Environmental Laboratory (PMEL), the Exploratorium in San Francisco, the Ocean Explorium (OE) in southern Massachusetts, FrameWorks Institute (FrameWorks) and New Knowledge Organization Ltd (NewKnowledge).

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The structure starts with an overview of possible public or visitor concerns regarding prioritized topics related to climate change (including sea level rise, glacier/sea ice change, ocean acidification, migration patterns and changes, impact of drought/rainfall, extreme events); findings concerning public perception of delivery. Subsequent sections focus on current psychological and sociological literature related to intergenerational learning; research related to the potential impact of an interpretive program on behavior change; and the issue of synthesis or meaning-making in relation to complex datasets.

Each section opens with a short contextual summary of findings followed by an annotated bibliography to situate each reference in the project context. These annotations outline the salient findings in the reported study with notes on how that particular reference might influence on the project. We conclude with a brief summary of findings in aggregate for consideration by the team.

Topic I: addresses **Visitor Concerns Regarding Prioritized Topics** summarizing key references that have been published on the core topics that have been explored in peer-reviewed literature or major institutional publications that highlight aspects of public perception related to the topic, based on the six dataset topics:

- Sea Level Rise
- Glacier/Sea Ice Change
- Ocean Acidification
- Migration Patterns and Changes
- Impact of Drought/Rainfall
- Extreme Events

Topic II: focuses on **Public Perception of Delivery Mechanisms in Informal Science Learning Environments** examining a) how ISEIs are regarded by the public, b) the credibility of "interpreters" responsible for delivering the message of ISEIs through programs and exhibits, and c) findings about the value of specific delivery mechanisms.

Topic III: Current psychological and sociological literature related to **Intergenerational Learning** will be presented to support thinking about the efficacy of different types of messaging in exhibits and programs at ISEIs.

Topic IV: summaries concerns related to promoting **behavior change through an ISE interpretive experience** and how interventions through an ISEI visit as part of life-course learning will help foster dis-

cussion about the relationship and expectations that can be placed on a visitor experience and subsequent action, asking whether these relationships can be causal in nature or what can be anticipated from these types of activities.

Topic V: Focuses on a central aspect that has now emerged in the Next Generation Science Standards, **Big Picture Synergy/Meaning- Making** representing the concerns or challenges learners might face in connecting and situating visitor experience in the landscape of information available through other sources. It considers how experiences and strategies might complement and reinforce other change efforts that visitors might have already encountered. It recognizes the importance of process and interaction as central to achieving effective learning.

Topic 1: Visitor Concerns Regarding Prioritized Topics

Climate change is an environmental issue that generates high levels of concern for the public (The Ocean Project, 2009; Miller, 2010). But the topic remains somewhat challenging because the scale, complexity, and proximity of effect tend to be less obvious to those who do not understand the details of long-range climate modeling. As a result, many of the studies that have focused on climate change understanding have tended to focus on the public's ability to explain the scientific model of change based on evolutionary science and causation, a level of scientific inference that far outstrips the capacity of an average citizen. The Mapping the Gaps report demonstrated that there are many countervailing narratives in the public, but that well-framed simplifying messages can help increase likelihood that a member of the general public can explain the climate change systems and more effectively situate the anthropogenic sources of climate change.

At a more detailed level, however, the consequences of a changing planet that are maintained in NOAA datasets represent specific issues that the public will continue to be challenged to understand. These datasets were assessed by the leadership team and determined to include:

- Sea Level Rise
- Glacier/Sea Ice Change
- Ocean Acidification
- Migration Patterns and Changes
- Impact of Drought/Rainfall
- Extreme Events

Each of these are overlapped with climate change issues, but each has a unique way of being interpreted by the public but has more tactical value in offering detailed insight into the future of our environment. This section will focus on the detailed topics rather than the larger question of understanding or acceptance of climate change science, but will provide a brief context in the following few paragraphs.

To summarize current thinking about understanding climate change science, we note that there have been a number of efforts to capture public understanding. These have resulted in a variety of interpretations, with the Mapping the Gaps report representing the dominant theory that will be used in this project. In 1997 to 2011, Krosnick and colleagues used a meta-analysis of the major reports published on climate change beliefs and found that a large majority of the public (on average 81% across the polls) has consistently reported belief that the planet has probably been warming (Krosnick, 2012). Their data also revealed that from, 2006 to 2011, a majority (71% in September 2011), believe that global warming has been caused by human activities (Krosnick & MacInnis, 2011). The Yale Project on Climate Change Communication surveys, also known as the Six Americas studies suggest that most Americans are at least cautious if not concerned and alarmed about climate change (Leiserowitz et al., 2012).[1] Krosnick argues that the discrepancy in conclusions from research about the public's beliefs about climate change beliefs are a result of differences in the wording of survey questions, and that variation within studies with the same wording can be accounted for by extreme weather events (Krosnick, 2010).

The partisan nature of climate change beliefs is another common media narrative (e.g., Marshall, 2010). Because only two parties dominate the U.S. political system, this narrative could lead to the perception that the U.S. public's beliefs are bi-modal. Yet, this partisan narrative does not match the overall pattern of beliefs. A possible reason for this discrepancy is that the description of the subgroups does not take into account the size of the subsamples. Thinking that the public's beliefs are bi-modal when a significant majority is concerned about climate change and believes humans are a significant cause of climate change would result in an overestimation of the percent of people who are unconcerned and disbelieve.

Research for the National Network for Ocean and Climate Change Interpretation (NNOCCI) undertaken by Swim and Fraser (ongoing) demonstrated that 5% of the population adamantly rejects the suggestion that the climate is changing, while the remaining 95% recognize that change is happening but most still struggle to situate the impact of that change on their daily life. Swim and Fraser found that the largest concern was not related to belief, but the willingness to discount concern because most people estimate that others are not as concerned as they are.

The media's portrayal of the public's diminished beliefs about climate change and the partisan divide suggests that the more the public attends to media, the less they will perceive that others are concerned about and believe in human-caused climate change, thus making them more inaccurate. The extent to which TV viewing increases inaccuracy may be depend upon the TV news source. Fox News, rela-

[1] Since the findings from the Six Americas study were outlined in the original grant proposal, we do not address this specific study in further detail in this summary since it is assumed that the project team is familiar with that content.

tive to other major news broadcasters (i.e., ABC, CBS, CNN, NBC, and PBS) is more dismissive of climate change (Feldman, Maibach, Roser-Renouf, & Leiserowitz, 2011). Preliminary results for the NNOCCI study suggest that that FOX News portrayal of climate change disbelief as common, and their practice of favoring news stories that reinforce the claims of those who dismiss climate change has an influence on FOXNews viewers' beliefs.

Public understanding of climate change lags far behind consensus of the scientific community not merely because the public lacks information about climate change (Brechin, 2003; Kahan et al., 2012). In fact, too much information is available, much of it complicated and some contradictory. A recent psychological review identified several factors that make this topic particularly challenging (Gifford, 2011; Weber and Stern, 2011); for example, when people lack "real-world experiential conditions" that could help further understanding of issues that are invisible and difficult to comprehend (Corbett & Durfee, 2004).

The media play a significant role in shaping public perception of climate change. Corbett & Durfee (2004) explored how the certainty of climate change was communicated through media coverage, addressing a gap in research related to audience responses to media discourse. Scientific uncertainty in news stories is altered through a focus on controversy or disagreement among scientists. This conflict fulfills traditional news values and adds drama to journalistic reporting, adding a pretext of objectivity by presenting multiple sides and "balancing" the story.

Corbett J., & Durfee, J. (2004). Testing public (un) certainty of science: Media representations of global warming. *Science Communication* (26) 2, 129-151. Sage Publications. Available at: http://www.sagepub.com/boc2e/study/articles/Ch12_Article.pdf

This communication research focused on media portrayals, public opinion and understanding, and how both scientists and journalists construct scientific certainty and/or ignorance using 209 participants. The exploratory study tested readers on the actual effects of textual variations in news stories that have long been discussed in the literature; whether readers' assessments of the certainty of scientific findings depend on characteristics of news stories. Experimental design manipulated two key factors: the inclusion of controversy and context. The experiment explored how the presence of controversy and context influenced scientific certainty. Overall, there was a significant difference in readers' assessment of the certainty of global warming based on the treatments offered. The context treatment produced the highest level of certainty about global warming and differed significantly from the control treatment (with neither context nor controversy) and from the controversy treatment. Control and controversy treatments resulted in the lowest levels of certainty. Participants who held high levels of pro-environmental concern were less swayed by the treatments.

Various studies of visitors to science centers, zoos and aquariums (ie: Why Zoos and Aquariums Matter: Falk et al, 2007 & Fraser & Sickler, 2009; CLIZEN: Grajal & Goldman, 2012; NNOCCI, Swim & Fraser, ongoing research) have demonstrated that visitors are actively open to exploring science content, that conservation messages are expected, and that zoos and aquariums are considered authorities that have legitimacy to present this content. Miller (2010) has also demonstrated that those least likely to have lower levels of science literacy and less engagement with science learning are more likely to visit museums, choosing instead to be regular attendees at faith services. These findings are consistent with the finding from the Why Zoos and Aquariums Matter study of the anti-zoo constituencies by Fraser and Sickler (2009) whose populations tend to be more suburban, had not visited zoos or aquariums in the recent past, and were likely to be over 50 years of age without children in their households.

Therefore, we suggest that other studies on more general understanding of climate change be considered as a guide, but that the other general studies of public understanding such as the 6 Americas be tempered as not likely representative of the willingness of visitors to engage in discussions of climate change.

Maibach, E., Roser-Renouf, C., & Leiserowitz, A. (2009, June 19) Global warming's 'Six Americas' 2009: An audience segmentation analysis. Available at: http://www.climatechangecommunication.org/images/files/Global WarmingsSixAmericas2009c.pdf

The Yale Study entitled Global Warming's Six Americas identified six unique audiences within the American public that each responds to the issue in their own distinct way. As one of the most frequently updated studies, the assessment over time demonstrates an increased polarization of the audiences but most notably suggests that 18% of the population is already taking individual, consumer, and political action while only 7% remain dismissive of the problem.

Weber, E.V. & Stern, P.C. (2011). Public understanding of climate change in the United States. *American Psychologist* 66 (4), 315-328.

This article considers scientific and public understandings of climate change and addresses the following question: Why is it that while scientific evidence has accumulated to document global climate change and scientific opinion has solidified about its existence and causes, U.S. public opinion has not and has instead become more polarized? A review supports a constructivist account of human judgment. Public understanding is affected by the inherent difficulty of understanding climate change, the mismatch between people's usual modes of understanding and the task, and, particularly in the United States, a continuing societal struggle to shape the frames and mental models people use to understand the phenomena. The article concludes by discussing ways in which psychology can help to improve public understanding of climate change and link a better understanding to action.

Sea Level Rise

Boyle, P., Breslin, V., Brisson, L.C.; Fraser, J., Friedman, A. J., Gardner, K., Schoedinger, S., Schubel, J., Uzzo, S., & Yalowitz, S. (2014), COSEE Ocean Inquiry Group Report: Opportunities for Creating Lifelong Ocean Science Literacy, *Paper 1.* [DRAFT]. *School for the Environment Publications.* Available at http://scholarworks.umb.edu/environment_pubs/

This Report for the Centers for Ocean Sciences Education Excellence Ocean Communities in Education And Social Networks (COSEE OCEAN) provides a broad assessment of the current state and opportunity for advancing ocean science literacy. Several chapters provide a survey of useful materials and websites, while others focus on opportunities and venues where this enterprise is pursued. With regard to Sea Level Rise, this report focuses more generally on the issue of proximity, noting that sea level rise is generally considered out-of-sight/out-of-mind for those who do not live directly on the water's edge. The authors consider the ocean to be challenging due to the lack of direct experience except for the near-shore and the role of tidal changes as shifting perceptions away from average change. They suggest that unless the concepts are linked to daily life.

Harvatt, J., Petts, J., & Chilvers, J. (2011). Understanding householder responses to natural hazards: flooding and sea-level rise comparisons. *Journal of Risk Research*, 14(1), 63-83.

This UK paper reports on householder experience, understanding and response to flooding and sea-level rise – in three high-risk regions in order to assess the Individual Understanding and Response Framework (IURF). They explore how individuals think about hazards and the dynamic processes that *"appear to heighten or attenuate understanding and drive or constrain responses to specific natural hazards."* The authors describe sea-level rise as an 'unknown' hazard in local contexts and claim that perceived responsibility to take action is commonly seen as the responsibility of others. The authors claim that social networks were important sources of information considered more reliable than government officials. They noted that the respondents to their survey were more likely to evaluate protection or mitigation measures based on perceived efficacy, cost and implementation barriers.

Glacier/Sea Ice Change

A critical finding of recent research on risk perception is that public perceptions are influenced not only by scientific and technical descriptions of danger, but also by a variety of psychological and social factors, including personal experience, affect and emotion, imagery, trust, values and worldviews – dimensions of risk perception that are rarely examined by opinion polls (Slovic, 2000). Leiserowitz (2005) addressed this topic as part of his Six Americas work and found that associations to melting glaciers and polar ice were the single largest category of responses, indicating that this current and projected impact of climate change is currently the most salient image of global warming among the American public. The affective image results reported above demonstrate that when Americans think of global warming, they are already predisposed to think of melting ice and glaciers in the Arctic, with strongly negative affect. Satellite images in the media of tabular floating icebergs bigger than cities continually reinforce that image, but so have other reports showing icebergs expanding. (http://www.iceagenow.com/ Growing_Glaciers.htm), thus leaving the public confused, feeling that the media is manipulating their perceptions, and/or there is no agreement in the scientific community. Leiserowitz's study (2005) also pointed out that an image of glaciers and polar ice may also help to explain why Americans perceive climate changes as a moderate risk and think it mostly impacts people and places geographically distant. Americans get that it may be a serious issue in the Arctic but don't see the local connection. This is fertile ground for educators and communicators to present concrete, vivid, local images, details and stories on people, places, economies and cultures to bring the issue to life to them personally. The public also needs to understand the science better between expanding and shrinking glaciers.

Ocean Acidification

Studies conclude that current unaided awareness of ocean acidification is very low. Yet The Ocean Project (2012) suggests that visitors to zoos and aquariums are very likely to welcome information about the problems and solutions associated with ocean acidification, while at the same time highly unlikely to want to increase their knowledge on the issue, (such as the chemical processes at play or the logarithmic nature of the pH scale). The Ocean Project study indicates that to help people take action, ISEIs do not need to make visitors scientifically literate on the issue, but do need to provide some ways they can take action.

The Ocean Project. (2012, Summer). Special report: Public awareness of ocean acidification. Available at: http://theoceanproject.org/wp-content/uploads/2012/09/Special_Report_Summer_2012_Public_Awar eness_of_Ocean_Acidification.pdf

The data strongly suggest that now is the time for zoos, aquariums, and museums (ZAMs) to reach out to their visitors on this issue. Current unaided awareness of ocean acidification is very low. Yet once aware of the issue, concern spiked significantly. Therein lies the opportunity for aquariums and other informal science education centers. Research suggests that visitors are very likely to welcome information about the problems and solutions associated with ocean acidification, especially when framed in the context of conserving shellfish or corals, for example, but highly unlikely to want to increase their knowledge on the issue, such as the chemical processes at play or the logarithmic nature of the pH scale. In other words, to help people take action, ZAMs do not need to make them scientifically literate on the issue, but do need to provide some ways to help.

Migration Patterns and Changes

The Earth's human population continues to increase rapidly, while growth in the global economy places ever-growing demands on natural resources. Consequently, we face growing scarcities of vital renewable resources. Thomas Homer-Dixon (1999) argues that these environmental scarcities will have profound social consequences—contributing to insurrections, ethnic clashes, urban unrest, and other forms of civil violence, especially in the developing world. His work was the first research project to systematically investigate the relationship between environmental stress and violence, using a clear theoretical and conceptual structure and grounding the analysis in detailed empirical study of multiple cases. They involved over one hundred experts and researchers in fifteen countries on four continents. The findings and materials generated by this work were disseminated widely to policy-making communities around the world. (See http://www.homerdixon.com/research/for additional research and resources). While not all migration and population will necessarily instigated by environmental causes, this area of study may offer some insights useful to the Visualizing Change project.

Homer-Dixon, T. (1999). *Environment, scarcity, and violence.* Princeton, NJ: Princeton University Press.

This book focuses on environmental stress as one of a series of factors, such as the failure of economic institutions and government that lead to conflict. It is suggested that some societies can adapt smoothly to environmental stress, while others suffer from migrations, worsened poverty, and institutional failure. The author suggests that the central characteristic of successful adaptation is "ingenuity" to meet the demands placed on them by worsening environmental problems. The book draws on recent examples from economics (endogenous growth theory). The book focuses on water shortages in China, population growth in sub-Saharan Africa, and land distribution in Mexico, to explore scarcities that stem from degradation and depletion of renewable resources, increased demand for these resources, and unequal distribution. While Homer-Dixon is more interested in environmental scarcity and war, the concept of ingenuity as a central attribute of successful adaptation is likely a useful tool for exploring the idea of change and environmentally induced migration.

Impact of Drought/Rainfall

Globally, very little data exists linking public perception of drought to climate change. Dessai and Sims (2010) undertook research to gain a greater understanding of people's perceptions of drought and of climate change, with particular reference to the UK drought in 2004 – 2006, and how people's perceptions of these issues affect water consumption.

Dessai, S. & Sims, C. (2010). Public perception of drought and climate change in southeast England. *Environmental Hazards*, 9, 340–357. Available at: http://www.tyndall.ac.uk/sites/default/files/Dessai-Sims.pdf

A water shortage occurred in the UK in 2004 – 2006 in part due to lower than average rainfall and consistently high water demand. With climate change predications indicating that drought frequency would increase in the UK in the near future, the project sought to explore

UK citizen's perceptions of drought, climate change and behavior change that would result in sustainable water management. Most respondents claimed to conserve more water during 2006. Scenario testing demonstrated that UK citizens were more inclined to accept water restrictions than to pay more for their water. These UK citizens were concerned about climate change and anticipated that more frequent water shortages may occur but that anticipation was unrelated to their behavioral choices. The authors stated that barriers to behavior change included a lack of available information, lack of knowledge about environmental systems, awareness of the resources at their disposal, and a perceived lack of institutional engagement.

Extreme Events

Two studies summarized public perspectives on extreme events that may relate to the visualizing change program. Once again, the Six America's study and the work at The Earth Institute both tackled these topics. The Six America's study also explored beliefs about extreme weather and increased severity of climatic events. Consistent with Krosnick's meta-analysis, the Six America's found that two out of three Americans say weather in the U.S. has been worse over the past several years with 51% of Americans say weather in their local area has been worse over the past several years. (Leiserowitz et al., 2013) In a paper entitled "Perception of Risk Posed by Extreme Events," Slovic and Weber (2002) examine the interplay between emotion and reason that drives risk perceptions for extreme events and discuss the need to think creatively about what this means for the management of such risks.

Leiserowitz, A., Maibach, E., Roser-Renouf, C., & Feinberg, G. (2013) How Americans communicate about global warming in April 2013. Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change Communication. Available at: http://www.climateinterpreter.org/sites/default/files/resources/How%20Americans%20Communicate%20about%20Global%20War ming%20Communication-April-2013.pdf

The report revealed that 85 percent of Americans report that they experienced one or more extreme weather events in the past year. Most of those who did were keen to talk about it, and most of their communication took place face-to-face (77%) or over the phone (66%). They experienced one or more types of extreme weather in the past year, most often citing extreme high winds (60%) and extreme heat (51%). Over half of Americans (54%) believe it is "very" or "somewhat likely" that extreme weather will cause a natural disaster in their community in the coming year.

Slovic, P. & Weber, E. U. (2002). Perception of risk posed by extreme events [working paper]. Columbia University: Center for Decision Sciences (CDS). Available at: http://www.rff.org/Documents/Events/Workshops%20and%20Conferences/Climate%20Change%20and%20Extreme%20Events/slovic%20extreme%20events%20final%20geneva.pdf

The field of risk analysis has grown rapidly, supported by research on both risk assessment (the identification, quantification, and characterization of threats to human health and the environment) and risk management (mitigation of such threats and communication about them). They explore risk analysis that is both political and scientific, informed by perception of risk, In the authors summary of studies carried out within the psychometric paradigm have shown that perceived risk is quantifiable and predictable. They claim that psychometric techniques seem well suited for identifying similarities and differences among groups with regard to risk perceptions and attitudes. Not surprisingly, experts' were more capable of aligning their risk perception to those predicted by technical parameters, while the lay public used a more relative scale that considered catastrophic potential, anticipated fatalities, and perceived sense of control which were more likely to exaggerate or underestimate. This suggests that the public is more likely to exaggerate or underestimate than the reasoning that would accompany an expert view of data.

Topic II: Public Perception of Delivery

This section investigates how ISEIs are regarded by the public, the credibility of those responsible for visitor engagement, and findings about the value of specific delivery mechanisms such as Science on a Sphere.

In the former case, a study of European museums presenting the topic of global warming (Trautman, 2007) found programs and exhibits have "the best chance of inspiring changes in visitor understanding and behavior if they tell a compelling story that (1) provides hope and a roadmap to a sustainable future, and (2) helps visitors understand how their personal actions can make a difference." Fraser & Sickler's (2009) study found that zoos, aquariums and museums are trusted arbiters of technical data for the general public if the content aligns with the type of exhibition content found in the institution. Fraser and Sickler also found that the source of the information has a direct influence on trustworthiness, with volunteers garnering lower trust than educators, and

Perception of Informal Science Education Institutions by the Public

Generally, ISEIs elicit favorable responses from visitors, who trust them and the information they provide. In many cases, these institutions have adequately informed the public about reality of problems, but paid less attention to exploring potential solutions. The media, which plays an enormous agenda-setting role, reinforces this by focusing disproportionately on the negative aspects of human- environment interaction (Climate Access, 2014). People expect ISEIs to raise awareness, but not stop there. There exists an opportunity to frame issues – even crises – by providing solutions. The Ocean Project (2012) notes "these efforts are most likely to be successful when the problems are put in the context of specific species, and the solutions in the form of personal actions."

It may also be the case that individuals do understand the scope of concern but remain unconvinced that political or educational institutions are capable of dealing effectively with such complicated, high-level problems.

Fraser, J., & Sickler, J. (2009). *Why zoos and aquariums matter: Handbook of research key findings and results from national audience surveys.* Silver Spring, MD: Association of Zoos and Aquariums.

This study sought to better understand how the public values zoos and aquariums in their communities and lives. The results were overwhelmingly positive, with strong and consistent public support for the conservation work, social value, and personal experiences fostered by zoos and aquariums. The nuances of these positive values suggest new ways that zoos and aquariums can focus their conservation education efforts by working with these perceptions.

Institute for Learning Innovation, the Monterey Bay Aquarium, & the Association of Zoos and Aquariums (2007). Visitor evaluation toolbox: A component of the multi-institutional research program and companion to the report *Why zoos and aquariums matter: Assessing the impact of a visit to a zoo or aquarium.* Silver Spring, MD: Association of Zoos and Aquariums.

One aspect of this multi-year research initiative was the assessment of the conservation impact of a zoo or aquarium visit on adults. The results demonstrated that zoo and aquarium visitors are highly diverse, and that the entry narratives of visitors influences the degree to which they accord authority to the institution. The project developed segmentation study that revealed five identity related motivations influence degree to which information will increase knowledge.

Trautman, C. (2007, November-December). Global warming at European museums. *Informal Learning Review* 87. Available at http://www.sciencenter.org/monograph

This study considered how the topic of climate change indicated the degree to which museums are responding to the changing needs of society. This survey research revealed that public trust in museums is higher than in any other ready source of information. Unfortunately, the data also showed that the time delay in the development of exhibitions and programs made the content less capable of responding to emerging concerns. It noted that this lag will remain a problem when data is emerging quickly around any topic. The author developed a set of eight suggestions on how to increase the impact of educational efforts to communicate global warming and sustainability to public audiences; and c) a new self-assessment tool for museums and other informal educational organizations called the "Museum Sustainability Index (MSI)" that fosters communication within and between organizations relative to sustainability and helps in evaluating competing demands, setting priorities, and assessing the results of investments in sustainability.

Credibility of ISEI "Interpreters"

Skilled interpreters (used interchangeably with "informal educators" herein) can facilitate visitor experiences that link affective connections (e.g., with live animals) to the social setting and to information

about climate change and oceans (Ballantyne, Packer, Hughes, & Dierking, 2007). They are seen by the public as well- trusted sources of information (Leiserowitz & Smith, 2011), and teens in particular can be highly influential in calling attention to important issues (The Ocean Project, 2009). However, job title and degree of connection to scientists who generate knowledge mediate the degree of trust in any specific interpreter. Interpreters can serve not merely as educators disseminating climate change information, but as "communication strategists" engaging in conversations with visitors based on audience research, role playing, and reflective feedback on their practice (Nisbet, 2010). They influence public perceptions, given their high level of commitment, knowledge, and public trust; engagement in social and professional networks; and extensive contact with visitors. Although many educators identify teens as primary interpreters or "communication vectors" through their own social networks as well as their interactions with visitors, the degree of trust in these sources remains open to question. On the sociological scale, Fraser and colleagues have suggested that interpreters, whether volunteer or staff, can be viewed as a "tiny public" who advocate for social change in all their interactions in other social circles, creating the foundation for larger-scale civic engagement.

Sheppard, B. & Fraser, J. (2009, April 13). Communicating the mission: Emerging trends in live programming and volunteerism: Implications for educational program delivery and management. *National Museum of the US Army* [NMUSA Memorandum 3].

In a memorandum created for NMUSA, the authors explored the impact of exhibition space planning and programs venue on the live interpretation. They focused on the need to create a sense of respect for the emotional responses of the visitor and the core need for a welcoming ambiance as central to creating a sense of equity and authority for opinion in an interaction. The memo focused on the value of drawing out each interpreters' unique talents or capacities based upon personal experience related to exhibition content and working with these interpreters to engage in a sense of respectful exchange of information. They claimed that the goal of live program planning is to find the intersection between the knowledge of staff and volunteers on the one hand with the prior knowledge and learning needs of visitors on the other. They suggest that allowing room for controversy and debate can promote deeper engagement with material.

This memo focused on the history of the US Army including current conflicts and historical civil rights conflicts as potentially controversial content. The authors suggest that presenting controversy and debate about historical content will benefit an institution's reputation as a center of knowledge. Visitors often welcome the opportunity to explore their own knowledge with an interpreter, engaging in sharing and comparing points of view. The emotional nature of controversy is often the catalyst for deeper participation.

Fraser, J., Taylor, A., Johnson, E. & Sickler, J. (2008). The relative credibility of zoo-affiliated spokespeople for delivering conservation messages. *Curator: The Museum Journal*, 51(4) 407-418.

This study examined whether job title impacts credibility of conservation messages at zoos. Visitors assessed seven environmental messages and selected the zoo-related job titles they deemed most and least credible. Results revealed that behavioral asks were considered most reliable when they were offered by someone named as a scientist, followed by educator and then to a lesser extent, by volunteer. President or administrative supervisors were considered to have the lowest level of credibility of all job titles assessed in the study. The study did not the credibility of teen interns or teen volunteers.

The value of delivery mechanisms

Interpreters can engage visitors, focus attention, and stimulate critical thinking when they use new media in their delivery. Russo (2011) acknowledges a dramatic rise in the number of participatory media technologies used by museums for visitor engagement, including institutional blogs, wikis, podcasts, photo and video sharing, virtual environments, tagging, annotation, and other authoring tools. These new ways of interacting with museum processes allow for co-creation and participatory cultural experiences, co-creation experiences that are increasingly expected by the media-savvy visitor. According to Russo (2011), "these platforms and tools are creating new relationships between institutions and the public."

Goldman, K. H., Kessler, C., & Danter, E. (2010, September) Science on a Sphere: Cross-site summative evaluation. Available at: http://www.oesd.noaa.gov/network/sos_evals.html

Evaluation of the Science On a Sphere® program (SOS), have revealed that there are unique learning outcomes from this delivery tool. The Institute for Learning and Innovation undertook a meta-analysis on behalf of the NOAA SOS program staff in 2008 to provide deeper understanding the overall user impact of this new technology. At the outset of the project, a literature review found that geovisualization and related fields face had similar challenges to those that emerged in assessments of the spherical display. There were no definitive

results on the role of: dynamic representations or animations, comparisons of two dimensional versus three dimensional (on a screen) visualizations, immersive visual environs, user control, gender, and age. Secondly vast majority of the literature was derived from either formal learning environments or flat screen visualizations. These results provided little basis for understanding the impact of three-dimensional projections and data visualizations in informal learning settings, where viewers fall within many contexts, including different levels of knowledge, varying social groups, ages, genders, and ethnicities.

Based on these findings, the report made an effort to set a baseline for outcomes, testing which potential outcomes are most likely for Sphere users to determine which outcomes and questions bear further investigation. The authors concluded that: Visitors felt they learned new information; The sphere supports understanding complex processes and phenomena; Visitors feel seeing information on the sphere is more realistic and provides more perspective; and Effective facilitation correlates with higher learning outcomes. Not surprisingly, the findings also suggested that comparative data between delivery techniques would advance the field.

Phipps, M. & Rowe, S. (2010). Seeing satellite data. *Public Understanding of Science* 19 (3), 311-321. doi 10.1177/0963662508098684. Sage Publications.

This study indicated that modifying a satellite visualization to include familiar cultural tools like conventional colors and landmarks helped increase learning outcomes. Phipps & Rowe concluded that images commonly used by experts were not sufficient to convey meaning to or serve as meaning making tools for novice users of satellite visualizations. Those authors recommended leveraging culturally relevant meanings for color to help make visualizations of satellite data more accessible to a wider range of learners. Not only did the markers and altered color strategies help novice users, they are visible to those with some forms of vision impairment. While the color schemes and other tools may not be acceptable to those in the scientific community, these adjustments were considered central helping people make meaning from the visualizations of satellite data.

Russo, A. (2011, July 3). Transformations in Cultural Communication: Social Media, Cultural Exchange, and Creative Connections. *Curator: The Museum Journal*, 54 (3), 327-346

The author focused on ''transformation in cultural communication'' as a mutually beneficial exchange between audiences and museums. The paper characterizes interpreters as agents of cultural change who must be conversant in how a participatory culture will drive our future institutional missions. The author offered two examples of strategic social media programs intended to drive online interactions that could reach more diverse audiences. While this paper focuses on social media, the relevance to the visualizing change project is the shift towards developing agency and networking opportunities for individuals and communities as a cultural co-creation of knowledge beyond the one-time experience, leveraging motivations and the opportunity to engage with data in a more contemplative relationship with the institution.

Fraser, J. & Sheppard, B. (2009, April 13). Changing realities: Emerging trends on education media use in museum exhibitions. *National Museum of the US Army* [Memorandum 1].

This report focused on how media is redefining the museum experience as an interaction with a campus that might have a more significant role in advancing knowledge and increasing learning beyond the institution if parallel online tools and engagement opportunities are created to leverage the media experience at an institution. This memorandum addresses the changing realities that museums are facing as they grapple with new technology, and proposed a specific strategic direction for NMUSA to address these challenges. The paper raised the questions of how social networking, technology convergence, and changes in computer server technologies have revolutionized how Americans consume information, suggesting that media has been democratized and social networks have sprung up as distributed learning networks linking scholarly work and gossip in a sea of information. The authors suggest that this changing reality involves embracing online technologies as part of any media experience design and developing policy for managing change as that media world shifts. They suggest that self-directed inquiry with media tools and deep experiences in media content are the hallmark of the technically savvy lifelong learner.

Topic III: Intergenerational Learning

Intergenerational learning is commanding increased attention by ISEIs and those who design and implement visitor programs. According to Wood and Wolf (2010), a movement away from child-centered experiences and toward family-centered experiences has slowly permeated the collective attention of leaders in children's museums. Fenichel and Schweingruber (2010) cover similar foci in their exploration of learning from others and across the lifespan. They suggest that the inordinate focus on child-centered approaches have overlooked adults as critical members of the learning cohort. These authors and others have started to change the dialogue about how museums might engage the full family unit into learning experiences. This approach shifts the center from one-way discourse toward an interpretation strategy that focuses on collaborative thinking among a visiting group, that accessibility of content, activity, and level of abstraction be assessed as feeding material for discussion across the generations rather than any specific age cohort.

Intergenerational learning can be a tool for transferring values, teaching about environmental justice, and instilling advantageous social norms in children who accompany older adults to exhibits. According to Palmquist (2005), family conversations in everyday settings can act as a mechanism through which islands of expertise knowledge supports early understanding of scientific thinking.

Palmquist and Crowley (2007) explored how a shift in parental engagement is considered in terms of interest and knowledge development in informal settings, highlighting how islands of expertise might facilitate and in some cases hinder learning through shared family activity.

Palmquist, S. D. (2005, July 1). Islands of expertise: Describing and investigating the impact of knowledge on parent child talk [Masters thesis, University of Pittsburgh]. Available at: http://d-scholarship.pitt.edu/9195/

This research explored how young children's nascent scientific thinking is supported and encouraged in the context of everyday family activity. Using children's knowledge of dinosaurs as the focus, the research investigated how child knowledge influences family interactions in an informal learning environment. The study found that parents acted as primary information mediators for children with novice understanding. In some cases, expert children, empowered by their knowledge, assumed responsibility for initiating more sophisticated topics of conversation that led the family group. It demonstrated that family conversations act as a mechanism through which islands of expertise knowledge supports early understanding of systems and processes at categorical and taxonomic levels.

Palmquist, S. & Crowley, K. (2007, April 12). From teachers to testers: How parents talk to novice and expert children in a natural history museum. doi 10.1002/sce.20215. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.94.8576&re p=rep1&type=pdf

This study expanded on the earlier study by addressing how the family context influenced learning outcomes. The authors' parent surveys revealed that expert children were more likely to have home environments where family members shared interests in the topic and provided a variety of learning resources. Analysis of family conversations demonstrated that parents with novice children more actively engaged them in learning conversations than parents with expert children.

Palmquist, S., Danter, L., & Yalowitz, S. (2011, Feb). *Life Changes: Communicating pre-evolutionary concepts to young children in informal settings* [summative evaluation]. Edgewater, MD: Institute for Learning Evaluation. Available at: http://informalscience.org/images/evaluation/Life_Changes_Summati ve_2012.pdf

The project explored how a set of educational principles that could support children's development of understanding of pre-evolutionary concepts. Summative evaluation determined that children's pre-evolutionary thinking and reasoning were influenced by exposure to this concept in a museum context. Following their experiences in the exhibition, children were more aware that species can change overtime, that there are relationships between dinosaurs and birds and that there are evolutionary explanations for these relationships. In contrast, parent beliefs and understanding regarding species change over time was not influenced by their experiences in the exhibition. These findings suggest that museum learning experiences have the potential to shift young children's awareness of a topic and support recognition of a phenomena while their parents do not necessarily follow the same learning trajectory.

Pattinson, S. & Dierking, L. (2012, September). Exploring staff facilitation that supports family learning. *Journal of Museum Education* 37(3), 69 – 80

This study described the results of a qualitative study of 63 staff-family interactions in a science center, focusing particularly on the role of adult family members. The team observed three distinct phases of interaction during which adult family members acted as gatekeep-

ers to deeper staff engagement. The results suggest that in order to successfully facilitate family learning, museum educators consider adults role in the social context of museums learning.

Fraser, J. (2009, October). The anticipated utility of zoos for developing moral concern in children. *Curator* 54 (12), pp. 349-361. Available at: http://pdfs.altamirapress.com/Cu/rat/CuratorV52N4sample_article.pd f

This study asked why parents value zoo experiences for themselves and their children. It proposed a new theory regarding the psychological value of such experiences for the development of identity. The study explored parenting perspectives on the value of zoo visits to suggest that parents use zoo visits as tools for promoting family values. The parents in this study felt that experiences with live animals were necessary to encourage holistic empathy, to extend children's sense of justice to include natural systems, and to model the importance of family relationships. The author concluded that parents find zoos useful as a tool for helping their children to develop skills with altruism, to transfer environmental values, to elevate children's self-esteem, and to inculcate social norms that they believe will aid in their children's social success in the future.

Wood, E., & Wolf, B. (2010, April). When Parents Stand Back Is Family Learning Still Possible? *Museums & Social Issues*, 5 (1), 35–50. Available at: http://www.maneyonline.com/doi/pdfplus/10.1179/jme.2012.37.1.29

This series of exhibition studies conducted at The Children's Museum of Indianapolis illustrated the impact of planning for family learning with a focus on support for parent scaffolding of learning. That is, constructing an experience that allows a family to build on simple concepts and work toward mastery of ideas that a child might adopt but also inform adults who are helping their children stretch to new levels of understanding and achievement. The authors' strategy requires curators, educators and exhibit developers to work collaboratively to determine various levels of accessibility of content and activity moving from entry level ideas through more complex and abstract ones for older children and adults.

Topic IV: Behavior Modification

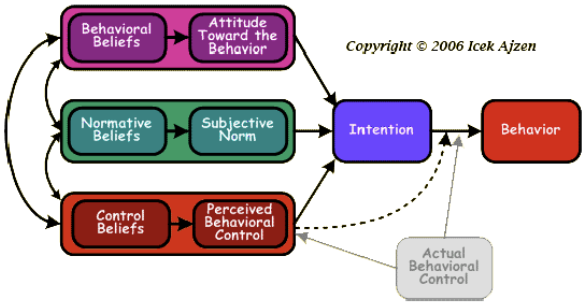
This section addresses the issue of behavior change or behavior modification that might result from a presentation or experience at a zoo or aquarium. A long-standing critique of zoos has claimed there has been little research that can demonstrate the outcomes of zoos' education programs in terms of either attitude or behavior change (Mason, 2000) or that the form itself is capable of accomplishing such change (Acampora, 2005; Hancocks, 2003; Jamieson, 2006; Rowlands, 2002). The majority of these critiques explore the micro-experience of a one time visit as a treatment and conclude that zoo visiting does not result in direct change because pre/post surveys do not reveal direct change. Such tests, however, represent a limited view of the causal contribution of any intervention at a zoo because they do not account for the social experience, the contextual value of a particular intervention, the shifting of perspectives on norms, or control beliefs that visitors might have about a behavior, or that visitor's stage in implementing a change.

Prochaska, J. O., & DiClemente, C.C. (1986). *Toward a comprehensive model of change* (pp. 3-27). Springer US.

Health research has, for many decades, come to accept that behavior change occurs in stages. Prochaska and colleague's research described a health model that is now widely accepted as the base for understanding the mental processes of behavior change as a set of stages: precontemplation, contemplation, action, and maintenance. These stages suggest that in any attempt to change a behavior that is considered an alternative to a habit requires awareness that a behavior should change, and then the conscious consideration of all aspects of any particular change. For purposes of imagining what stage a visitor might be in related to a behavioral ask at a zoo or aquarium, the theory of change should assume that without a pre- existing narrative related to contemplation, it is doubtful that any particular recipient of a message might move toward action, but might be spurred to move further toward an action.

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, 50(2), 179-211.

Ajzen and colleagues developed a model that elaborated on the contemplation/action model to develop a predictive theoretical structure that can be used to both describe the forces that act on the decision process and how these forces can estimate whether any particular behavior is likely to occur. Theory of planned behavior (TpB) describes the social context that influences the contemplation phase of taking an action. This predictive model can be used to measure the degree to which someone is likely to act on any behavioral ask. The theory situates a particular behavior as a function of an individual's intention (the stage when contemplation transitions to action) and predicted by three unique attributes: the perception of oneself once engaged in the behavior; degree of deviation of that behavior to what is considered typical behavior within the community that the individual holds as central to their sense of themselves; and the belief that they have control to do that particular behavior as prescribed.



Values/Beliefs/Norms Theory (Stern, 2000) and the Collective Identity Values/Beliefs/Norms Theory (Fraser, 2009) elaborate on this theory for environmentally significant behavior. Stern considers the beliefs and attitudes related to the level of concern one holds for any particular environmental entity such as an animal or river, while Fraser demonstrated that subjective norms are not only a function of understanding the behavior, but also the degree to which that behavior might create social acceptance or rejection within an important social groups. Both of these variations on TpB suggest that any behavioral ask that might be linked to a data presentation should be assessed based on the degree to which it moves a visitor through the stages of behavioral contemplation toward action rather than assuming that all steps will be achieved in one event.

A civic engagement strategy (Nisbet, 2010) views individuals as potential active learners, decision makers, and participants in social and civic issues. To achieve this potential, visitors need inspiration, motivation, and empowerment as well as knowledge.

Gifford, R. (2011). The dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation. *American Psychologist* 66 (4), 290-302. Available at: http://psychologyforasafeclimate.org/resources/The%20dragons%20of%20inaction%20Robert%20Gifford.pdf

Recently, Gifford explored how people engage with high-greenhouse-gas-emitting behavior and mitigating behaviors and suggested there are cognitive structural barriers that limit the movement to action.

Structural barriers such as a climate-averse infrastructure (lack of actual control) may be a challenge, but Gifford focused his work primarily on the psychological barriers that impede behavioral choices. His seven categories of psychological barriers (dragons of inaction: limited cognition about the problem, ideological worldviews that tend to preclude pro-environmental attitudes and behavior, comparisons with key other people, sunk costs and behavioral momentum, discredence toward experts and authorities, perceived risks of change, and positive but inadequate behavior change. Gifford suggested that structural barriers must be removed to achieve any behavior change, but also expressed limited belief that such change might be possible given the scale of the challenge. For this report, we suggest that changing perceptions even one domain would be a relatively successful intervention because it advances the contemplation efforts necessary to achieve change, even if these incremental changes cannot be solely responsible for solving the magnitude of the environmental problem.

Heberlein, T.A. (2012). *Navigating environmental attitudes.* New York: Oxford University Press.

Recently, a new book summarized a variety of attitudinal variables that are implicated in raising awareness, changing attitudes, and altering behaviors among a heterogeneous "public." Heberlein eschews the trope that information will lead to attitude change and result in more pro-environmental actions. He summarizes the typical categories to describe environmental remediation ("fixes") – technological; behavior choice based on new information; and structural change to the context that leads to specific human behaviors. Heberlein then unpacks attitudes toward environmental entities and how these attitudes are implicated in any behavioral ask. This helpful tool concludes with a focus on invoking social norms as behaviors that can be achieved if the person seeking to accomplish a change acknowledges that knowledge is emotionally laden, and that the structural relationship to the ask must be situated within a discussion of the control any particular recipient can enact. Heberlein concludes that many of the past efforts to effect behavioral change have failed to fully account for the emotional and structural barriers that arise during the contemplation of change.

Topic V: Big Picture Synergy/Meaning-Making

This section discusses ways of connecting and situating visitor experience in the landscape of information available through other sources and experiences, and exploring ways of complementing and reinforcing other change efforts by tapping into synergistic possibilities. The data in this section simplifies resources used in the proposal for purposes of aggregation and is not intended to supplant the more fully descriptions covered in other project documents.

Meaning making in museums is a layered experience, as noted in earlier sections, built on interaction among visitors in their social cohort along as well as their interactions with interpreters and display content. We note that this is a robust field and that many of the participants in the Visualizing Change project are familiar with this literature. We summarize a few of the recent papers on this topic not as an expert overview, but as provocative materials to encourage discussion about the project.

The project proposal suggests that instead of conveying information about climate change, the project would facilitate "meaning-making"—helping individuals process information relative to their personal experiences and context. The project proposes to create a "strategic framing" approach to communication base on Bales and Gilliam's (2004) work. These authors demonstrate that strategic framing supports meaning-making *by (1) building on careful empirical research to understand what people already value, believe, and understand, (2) designing and testing communication strategies that help translate complex science in a way that allows people to examine evidence, make well-informed inferences, and embrace science-based solutions.* This is described as "nonpersuasive communication" strategy (Fischhoff, 2007).

According to Fischoff:

People tend to make reasonable choices if they get key facts in a credible, comprehensible form; have control over themselves and their environment; are judged by their own goals; and have basic decision- making competence.

Reasonable choices are sensible, given people's beliefs and values, but need not be rational, in the exacting sense of following the utility theory axioms. Credible facts come from sources trusted for their competence and honesty. Comprehensible facts allow people to extract as much information as is needed for decision-making purposes. Control means freedom from social coercion (although not from social norms) and from emotional distraction (although not from appropriate emotions). Their own goals may include consequences of both climate change and climate-related actions, affecting both themselves and valued others (e.g., people, communities, species). Decision-making competence entails mastery of essential skills (e.g., assessing uncertainty, applying decision rules)

Fischhoff, B. (2007) Non-persuasive communication about matters of the greatest urgency: Climate change. *Environmental Science and Technology.* 41, 7204-7208. Available at: http://www.cmu.edu/dietrich/sds/docs/fischhoff/NonpersuasiveCommMatters.pdf

Fischhoff suggests that climate science advocacy makes many scientists uncomfortable, but claims that science is inextricable from advocacy because researchers make the case for the importance of their studies, the soundness of their methods, and the robustness of their results. The attributes of public advocacy are related to political norms, facts are the basis of any claim, but uncertainty is avoided and facts are not always present. Fischhoff suggests that non-persuasive communication lets science speak for itself, a strategy that may reach conclusions that may not be in the best interests of the planet. However, the issue of persuasive communication is challenging because scientists who use political norms may erode scientists' status as trusted observers and reporters.

Kahan, D., Peters, E., Wittlin, M., Slovic, P., Larrimore Outellette, L., Braman, D., & Mandel, G. (2012). The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Climate Change* 2, 732-735.

This study found that result public divisions over climate change stem not from a lack of scientific knowledge, but from a distinctive conflict of interest. They found that personal interest individuals have in forming beliefs in line with those held by others with whom they share close ties and the collective one they all share in making use of the best available science to promote common welfare.

Silverman, L. H. (1995). Visitor meaning-making in museums for a new age. *Curator: The Museum Journal*, 38(3), 161-170.

This paper focuses on an approach to understanding the visitor's active role in creating meaning of a museum experience through the context that person or group brings to the experience. The author shows that meaning making is influenced by identity, companions, and visiting motivations. The significance of any experience are derived from the basic human needs including the need for individualism and the need for community. The author suggests that interpretive strategies are best achieved when they consider the dynamics

of the "fit" between people and museums in two critical areas: (1) between human meaning-making and museum pedagogical beliefs and (2) between the visitors strivings and the purpose the museum seeks to serve in society.

Falk, J. H., Heimlich, J., & Bronnenkant, K. (2008). Using identity-related visit motivations as a tool for understanding adult zoo and aquarium visitors' meaning-making. *Curator: The Museum Journal,* 51(1), 55-79.

This aspect of the Why Zoos and Aquariums Matter studies focused on understanding the motivations of museum visitors. The investigators sought to categorize motivations to identify how identity related motivations influenced learning outcomes for adults. The five motivational categories directly influenced the temporal learning outcomes, with those focused on novel experiences or facilitating others' learning least likely to attend to the content, and those with specialist knowledge likely to move well beyond the goals of the interpreters script. The categories appeared to be related to visitors' desires to use the museum for fulfilling identity-related needs. They suggest that this meaning making is situation-specific.

Rahm, J. (2004). Multiple modes of meaning-making in a science center. *Science Education*, 88(2), 223-247.

This author employed a "microanalytic" case study of meaning- making to explore the specific interactions that occur in one interpretive exchange. It demonstrated that the exchange occurs through multiple modalities—by doing, talking, and the manipulation of the exhibit. These multi-layered exchanges created a dialogues that exceeds the perception of talk to include action and physical communications that are idiosyncratic but lead to more expanded understanding of meaning-making. The author suggested that dialogue would be considered a rather unremarkable event when considered in isolation, but in situ, that verbal and nonverbal interactions shifted meaning and that the full body be considered as part of the transfer of knowledge. It suggests a focus on performance and venue as interacting with ideas of authority and social expectation. The author suggests that any assessment of impact focus on movement, expression, and attention to interactions were all factors that create the context for learning exchange.

Summary

This briefing report focused on the prioritized topics for the Visualizing Change project. It summarized research beyond the Mapping the Gaps report to focus on studies related to climate change (including sea level rise, glacier/sea ice change, ocean acidification, migration patterns and changes, impact of drought/rainfall, extreme events); findings concerning public perception of delivery; current psychological and sociological literature related to intergenerational learning; research related to behavior modification; and big picture synergy/meaning-making.

Generally, the summary suggests:

- Climate change and the associated content areas are considered challenging and remote to most visitors' experience; it notes that many of the topics involve long cycle change that are not necessarily evident in human experience, or that the phenomena is not experienced in a manner that can recognize change over time.
- The public has a high level of respect for the interpreters in an ISEI and considers them to be reliable and trustworthy. There are variations within that level of trust, with more abstract concepts and source for trust being dependent as much on the individual interpreter, their role in an organization, and the focus of the institution.
- Learning may not be consistent for any particular visualization if it is delivered in a different setting or if the display format is altered. The spherical projection has not been the subject of comparative study and may preference different types of learning. Studying these differences will expand knowledge for the field.
- The synthesis study undertaken by the OCEAN COSEE found that there is a plethora of sources for engaging in science literacy around global issues or ocean content, but noted that the abstraction and distance from terrestrial daily life may make that content difficult to conceive for lay person. This may mean that some concepts unrelated to temporal weather patterns will require context specific interpretation to make them salient and useful for many visitors;
- One unique study focused on abstraction and technical representations from current data streams. It found that there is a need to create anchors using familiar colorations and landmarks to help visitors situate their own sense of place in the visualization. It also suggested that tying the data to temporal phenomena that are commonly discussed may help increase the relevance of the content;
- Research into intergenerational learning has suggested that families actively learn together. Developing interpretive strategies that meet intergenerational learning needs shows higher level of promise for success than targeting any specific age or knowledge set.
- The summary of behavioral change theory suggests that any presentation should only be considered a step along the path to behavior change, not a change instigator in isolation.
- Synthesis and meaning-making will be situated within the learner's entry narrative, not compared to a national baseline.

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