Climate Change Education

A Primer for Zoos and Aquariums

First Edition, Revised

Alejandro Grajal, Susan R. Goldman, and Tracy Marks

Chicago Zoological Society
Inspiring Conservation Leadership

Climate Change Education:

A Primer for Zoos and Aquariums

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First Edition, Revised: September 2012
Printed in the United States of America
ISBN 978-0-913934-44-9

Chicago Zoological Society
3300 Golf Road
Brookfield, Illinois 60513 USA

www.CZS.org

The Climate Literacy Zoo Education Network (CLiZEN)

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University of Illinois at Chicago

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The College of Wooster

Antioch University

Illinois Institute of Technology

Polar Bears International

Columbus Zoo and Aquarium, OH

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Chicago Zoological Society, Brookfield Zoo, IL

Suggested Citation: Grajal, Alejandro and Susan R. Goldman (2012). Climate Change Education: A Primer for Zoos and Aquariums (First Edition, Revised). The Climate Literacy Zoo Education Network (CliZEN). Chicago Zoological Society. Brookfield, Illinois. USA.

Acknowledgments

The editors thank the authors for working under tight deadlines to produce their manuscripts; Tracy Marks, book project manager and assistant editor, for keeping everyone moving along and in good spirits; and Dr. Stuart Strahl, president and CEO of the Chicago Zoological Society, for encouraging the institution to move forward with global climate change education efforts. Finally, we thank Robert Buchanan, president and CEO of Polar Bears International, for encouraging zoos and aquariums to be daring and think big in addressing climate change.

This material is based upon work supported by the National Science Foundation under Grant No. 1043284. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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PREFACE

The global scientific community agrees that global climate change is occurring and that human activity is the dominant factor (IPCC, 2007). A wealth of information has been shared with the American public about the potential catastrophic impacts of climate change if we continue our current course of action. Yet, many Americans still do not believe climate change is an important environmental issue and doubt their ability to make a difference even if the situation were serious (Maibach, Roser-Renouf and Leiserowitz, 2009).

Recognizing that American zoos and aquariums reach hundreds of millions of visitors each year, and realizing these institutions are uniquely able to teach in a way that transcends many of the psychological, cognitive, and behavioral barriers that prevent people from caring about climate change, in 2010, with a grant from the National Science Foundation, the Climate Literacy Zoo Education Network (CLiZEN) was formed. **The overarching goal of CLiZEN is to develop a new approach to climate change education, an approach that encourages people to make personal connections to climate change by activating their sense of caring and concern for charismatic animals whose very existence is threatened due to human behavior.** In particular, partner zoos aspire to establish these connections between visitors and polar animals in zoo exhibits. Once these personal connections have been established, the intention is that zoo educators, facilitators, and interpreters will leverage these connections to motivate changes in climate change knowledge, beliefs, and ultimately, behavior. Through the use of web-based tools such as simulations and interactive learning activities, a goal of this partnership is to extend the experience beyond the zoo visit. Activities will be crafted to address some of the cognitive barriers to understanding climate change, and create socially supportive contexts wherein people may overcome barriers and take new action.

Led by the Chicago Zoological Society/Brookfield Zoo, CLiZEN partners include climate scientists at Pennsylvania State University and the University of Illinois at Chicago; educators, education researchers, psychologists, and learning scientists at the University of Illinois at Chicago, The College of Wooster, and Antioch University; computer scientists at the University of Illinois at Chicago and the Illinois Institute of Technology; educators and scientists at Polar Bears International; and educators and scientists at nine U.S. partner zoos: Columbus Zoo and Aquarium, OH; Como Zoo and Conservatory, St. Paul, MN; Indianapolis Zoo, IN; Louisville Zoological Garden, KY; Oregon Zoo, Portland, OR; Pittsburgh Zoo and PPG Aquarium, PA; Roger Williams Park Zoo, Providence, RI; and Toledo Zoological Gardens, OH.

When CLiZEN partners first began discussing climate change communication and the role of zoos and aquariums, an initial priority became evident. Before solutions could be developed, it was necessary to understand the lay of the land and the challenges faced by an array of practitioners seeking to motivate people to care about climate change. The first task was to integrate a diverse and multidisciplinary group of partners, to share knowledge and best practice in ecology, biology, earth sciences, computer interfaces, video games, electronic media, social networks, psychology, education research, learning sciences, communications, interpretation, etc. in a robust, yet efficient manner. We quickly recognized that simply sharing the relevant literature from each discipline would be an overwhelming and time-consuming effort: much of the research is accessible only in weighty academic journals, and reviews are, in many cases, outdated. Instead, we asked CLiZEN representatives from each of these disciplines to review literature in their own field, synthesize the research into a 20-minute presentation, and share "the state of the discipline" regarding climate change education at a literature review meeting early in 2011. Participants were surprised by how much they learned from fields in which they were not expert. All agreed it was an extraordinarily enriching experience. CLiZEN zoo partners had opportunity to review these presentations as well, and we realized sharing these findings with a broader audience could lead to a ripple effect of understanding throughout the zoo and aquarium community and beyond. And so, the idea of this book – an e-book to trim costs, enable timely updates, and reduce our carbon footprint – was born.

Before we proceed, it is important to understand what this book is not. It is not a comprehensive review. Many approaches to climate change exist in the formal and informal education realms. We have included suggested resources throughout the book for further investigation. We hope and expect this book will become obsolete soon and we plan to update it on a regular basis. This is not a handbook on climate change education or interpretation, nor is it a complete amalgamation of all available tools for climate change education. However, this book is a compilation of what some of the best minds know so far about climate change science, electronic media, social networks, education research, learning sciences, communication, and interpretation. It is an exploration of the links between many fields and climate change education. This book is based on experiences primarily in North American zoos and aquariums. We recognize that many zoos around the world are investigating and experimenting with their own climate change education approaches. In fact, we hope soon to conduct an international sharing of information and best practice.

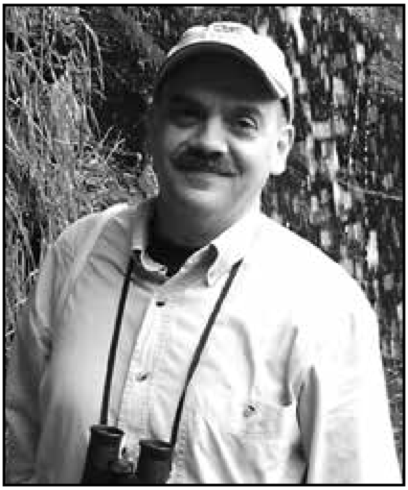
We hope this book provides valuable insights to the zoo and aquarium community, especially educators, facilitators, and interpreters about how people learn, feel, and can be encouraged to change behavior as it relates to climate change. We dare to hope it may revolutionize the way we inspire people to care about climate change in our own institutions, ultimately reaching, teaching, and mobilizing millions of zoo and aquarium visitors each year.

R e f e r e n c e s

IPCC (2007). Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Pachauri, R.K and Reisinger, A. (eds.). IPCC, Geneva, Switzerland, 104 pp.

Maibach, E., Roser-Renouf, C., and Leiserowitz, A. (2009). Global Warming's Six Americas 2009: An Audience Segmentation Study. Yale Project on Climate Change and the George Mason University Center for Climate Change Communication.

About the Author



Dr. Alejandro Grajal (pictured here) and Dr. Susan R. Goldman (Chapter 4) are the editors of this book, and along with Dr. Michael E. Mann (Chapter 1) are the principal investigators of CLiZEN. Dr. Grajal is senior vice-president for Conservation and Education. He leads the Center for Conservation Leadership, which combines the Chicago Zoological Society's conservation and education initiatives and develops the capacity of conservation leaders in Chicago and around the world. Dr. Grajal oversees field conservation programs in North America, Latin America, and Africa. He administers the Center for the Science of Animal Welfare and a dedicated population ecology research program for critically small populations. He oversees all education and interpretation programs at Brookfield Zoo. Dr. Grajal has participated in sustainable development and biodiversity conservation programs with the U.S. Agency for International Development, the Global Environmental Fund, the World Bank, and the European Union with an emphasis in Latin America and the Caribbean. He holds a Ph.D. in Zoology with a minor in Tropical Conservation and Development from the University of Florida, and a degree in Ecology at Simon Bolívar University in Caracas. Although he readily admits he is a latecomer to climate change, he recently changed nearly half of his home's light bulbs to LEDs and signed up for a 100% non-carbon electrical provider, which saves him money and significantly reduces the family's carbon footprint, while making them feel great.

CHAPTER 1

Climate Change Science: A Summary, Recent Updates, and Resources

By Michael E. Mann

- Climate change is an observable phenomenon rooted in nearly two centuries of basic science.
- Climate change is not controversial as naysayers and some media would convey. After decades of careful observation, collection of data, and tracking of changes in the climate system, there exists a solid, scientific consensus that human-caused climate change is a reality.
- By many measures, human-caused climate change is proceeding more quickly and with greater impact than projected.
- Climate change risk increases substantially as total warming progresses; many scientists believe that warming of the planet beyond even just a few degrees would represent a dangerous level of interference with the climate system.
- To mitigate these risks, people must quickly and substantially reduce greenhouse gas emissions in the decades ahead.

The causes and projected effects of global climate change are rooted in nearly two centuries of basic science, with some of the leading early 19th century scientists having contributed to our understanding of the atmospheric greenhouse effect. As science and technology advances and the ability to monitor and predict climate models improves, it becomes more evident that human activity is leading to rates of climate changes that are unprecedented in our planet's history, and that the anticipated global repercussions are progressing more quickly and with more impact than even the most aggressive initial predictions suggest.

The Greenhouse Effect: Two Centuries of Science

The greenhouse effect is neither a new idea nor a controversial scientific concept. In fact, scientists have known about it for two centuries, beginning with the work of Joseph Fournier, who in 1827, found that gases in Earth's atmosphere could trap the heat received from the sun. During the past 200 years, scientists have been refining this understanding, but it is a basic scientific fact that certain gases, because of their chemical properties, absorb energy and warm the planet.

In 1859, James Tyndall conducted careful laboratory experiments demonstrating that several gases – especially water vapor and carbon dioxide – could trap infrared radiation. In 1896, Svante Arrhenius performed numerical calculations indicating that when the amount of carbon dioxide in the atmosphere doubled, global surface temperatures would increase by several degrees Celsius. And, in 1939, Guy Callendar also argued that rising levels of atmospheric carbon dioxide were responsible for increases in Earth's surface temperatures. Callendar's and Arrhenius's early estimates of global warming caused by increased (doubled) concentrations of atmospheric CO_2 were on target, in the same range as current projections would indicate.

Nature's Greenhouse Effect

How does the greenhouse effect work? The sun impinges on Earth's surface, primarily in the form of visible solar radiation (i.e. sunlight). A bit less than a third of that radiation is reflected out to space by cloud, ice, and other reflective surfaces on or near the surface of the Earth, while the remaining two thirds is available to heat the Earth's surface. In the absence of any other physical considerations, Earth's surface and lower atmosphere would continue to heat up over time in response to that heating. The reason that does not happen is that Earth emits out to space its own form of radiation, invisible "infrared" radiation. For equilibrium to be reached, Earth must radiate out as much radiation as it absorbs from the sun. Since the amount of infrared radiation the Earth emits out to space is a function of its temperature (a fundamental physical law dictates that the greater the temperature, the more infrared radiation produced), Earth must warm up to that temperature whereby it produces just enough outgoing infrared radiation to precisely balance the absorbed incoming solar radiation. That temperature turns out to be roughly 0°F (-18°C).

However, so-called "greenhouse gases" that occur naturally in the Earth's atmosphere – CO_2, methane, and water vapor – absorb some of that outgoing radiation, sending a portion of it back toward Earth's surface. This means that the surface must now produce even more infrared radiation so it can overcome the fraction sent back down toward the surface. Once again, because the amount of radiation a body produces is related to temperature, to do that, Earth must warm up. That, in essence, is the atmospheric greenhouse effect.

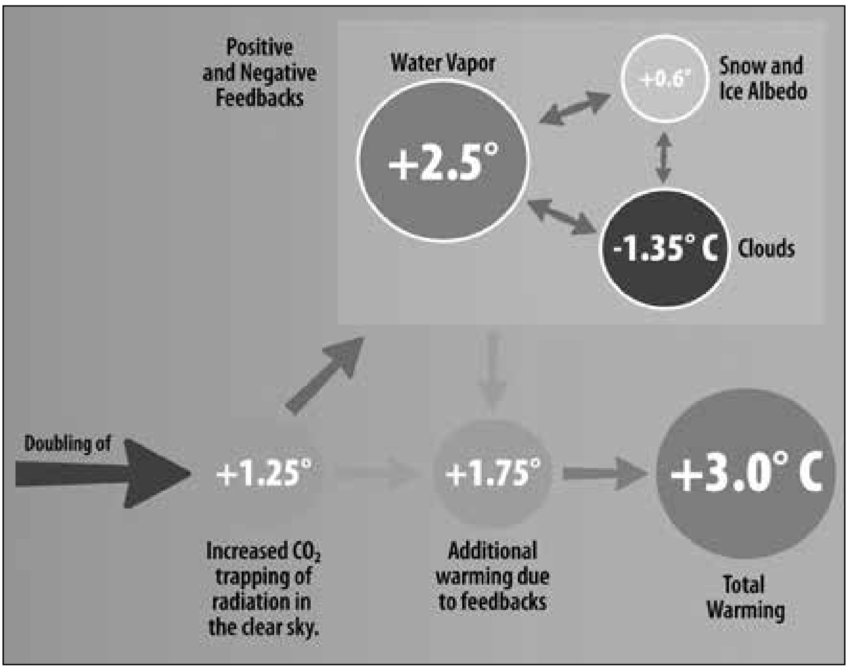
If not for the natural greenhouse effect, as we have already seen, Earth would be a frozen planet (average temperature 0°F or -18°C). The natural greenhouse effect warms the Earth, yielding the mild and more hospitable 59°F (15°C) average surface temperature.

Feedbacks in the Climate System

The role of water vapor in the greenhouse effect deserves special consideration. It is an even more potent greenhouse gas than CO_2, and therefore plays a particularly prominent role in the atmospheric greenhouse effect. Unlike other greenhouse gases like CO_2 or methane, however, water vapor cannot be added arbitrarily to the atmosphere. The amount of water vapor the atmosphere can hold is dictated by the temperature itself. Anyone familiar with the morning dew on the grass after a cool summer night has witnessed this phenomenon. The air cannot hold as much water vapor in the cool nighttime as it could during the preceding warmer daytime, and so as the air cools during the night, the water vapor condenses into liquid—in this case, accumulating as dew drops on the grass. The fact that a warmer atmosphere can hold more water vapor than a colder one, as we will see below, provides one of the most important "feedbacks" in the climate system.

Because the water vapor feedback is amplifying—it leads to even greater warming of the Earth than if we ignored it—we call it a "positive" feedback. The water vapor feedback appears to be the largest positive feedback in the climate system. In the absence of this (or any other) feedback mechanisms, a doubling of CO_2 concentrations would lead to only a little more than 2°F (roughly 1.25°C or 2.25°F). However, the increased water vapor due to that initial warming adds roughly another 4.5°F (2.5°C) to the warming. Water vapor is not the only important feedback relevant to modern climate change, however.

Earth's snow and ice serve as reflective surfaces bouncing radiation from the sun back into space. The ratio of the intensity of the light reflected is called albedo. But as these reflective surfaces melt, Earth absorbs more of the incoming solar radiation. That effect adds roughly 1°F (0.6°C) more warming—another positive feedback. The last, and perhaps most complicated, of the feedback mechanisms relevant to modern-day climate change involves clouds. Clouds react to warming temperature too, but in a variety of potentially competing ways. The main effect of high clouds is to absorb outgoing infrared radiation, while the main effect of low clouds is to reflect incoming solar radiation to space. High and low clouds thus have opposing impacts on surface temperatures. Depending on whether climate change and global warming leads to more or less of either of these types of clouds, various combinations of positive and negative cloud feedbacks are possible. Because clouds occur at scales smaller than can be resolved by climate models, their impacts have to be represented through approximations—and these approximations are uncertain. There is consequently a fair amount of uncertainty not only about whether there will be fewer or more clouds, but precisely what types of clouds will be impacted by anthropogenic global warming. The uncertainty range is extremely large, leading to the possibility of anywhere from a negative feedback that takes away more than 3.6°F (2°C) of the warming, to a modest positive feedback of approximately 1°F (0.5°C) additional warming.



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The effect of feedbacks in the climate system.

On average, though, climate models find that the net effect is likely to be a negative feedback (primarily due to more of the reflective low clouds in a warmer world), taking away roughly 2.4°F (1.35°C) of the warming.

When all the feedbacks are added for a CO_2 doubling scenario, the result is the initial 2.25°F (1.25°C) of warming from the CO_2 increase alone, plus 4.5°F (2.5°C) for the positive water vapor feedback, plus 1°F (0.6°C) for the positive ice feedback, minus 2.4°F (1.35°C) for the negative (as best we can estimate it) cloud feedback, giving a total 5.35°F (3°C) warming. Clearly, the net effect of the feedbacks is to change a temperature increase that while significant, would likely be moderate in its impacts, to a warming that—as we will see below—would have profound and potentially devastating impacts for society and the environment.

Increasing CO_2 Concentrations: The Human-Caused Greenhouse Effect

Our planet is a relatively balmy 59°F (15°C) rather than a frigid 0°F (-18°C) only because of the greenhouse effect. So, not only is the greenhouse effect not controversial, it would be impossible to explain why Earth is not frozen or the existence of life on Earth itself, without an understanding of it. What has been found to be more controversial (albeit politically rather than scientifically) is the extent to which the release of human-caused greenhouse gases has intensified the natural greenhouse effect. When the atmospheric concentration of greenhouse gases such as CO_2 and methane is increased through human practices, the greenhouse effect is magnified, and the planet is further warmed. Anthropogenic (human-caused) greenhouse gas increases result when we burn fossil fuels – coal, gasoline, natural gas. Other human-driven activities that release greenhouse gases include agriculture (livestock such as cattle release methane into the atmosphere; rice cultivation also releases methane).

To measure the buildup of CO_2 in the atmosphere, in 1958, Charles Keeling – at the urging of his Scripps Institution of Oceanography colleague Roger Revelle – began to measure CO_2 concentrations at the top of Mauna Loa in Hawaii. In the atmosphere, CO_2 is a well-mixed gas and the levels change relatively uniformly over time all over the globe, so one can monitor a single pristine location to track concentration levels around the world. After a few years, a trend became evident to Keeling – a steady increase in atmospheric CO_2 concentrations. For comparison, pre-industrial levels were roughly 280 parts of CO_2 per million[1] in the atmosphere. When Keeling began his measurements, CO_2 levels were at approximately 320 parts per million. Today, we are at 390 and continuing to increase over time. Longer-term evidence from ice cores suggests that current concentrations are higher than they've been in roughly a million years, and potentially longer. If we continue our release of fossil fuel emissions, by the end of this century, the concentration will be higher than anything Earth has witnessed in more than 10 million years!

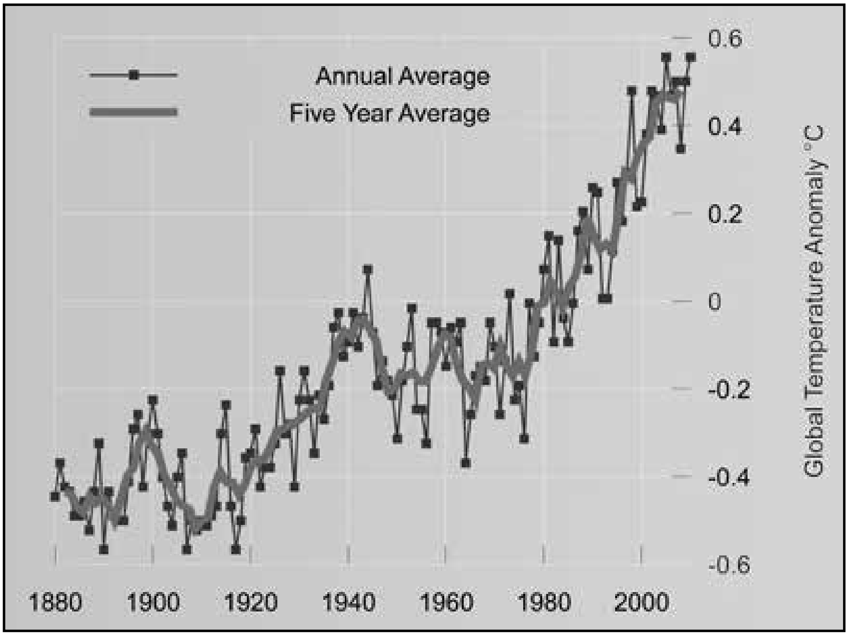
A word about warming levels. When it is said that the planet is warming a degree or two Celsius, this sounds insignificant. The temperature increases and decreases far more than that in an average day. But, it is important to remember that climate change is about long-term, sustained global average temperatures, and not day-by-day, or even year-to-year temperature increases. One degree (Celsius) of warming has already led to substantial loss of ice in mountain glaciers, and Arctic sea ice has experienced a significant retreat in the last few decades. Moreover, this seemingly small one-degree warming has measurably increased the destructive potential of hurricanes, and has worsened drought in the subtropics and middle latitudes. These changes are just the proverbial tip of the iceberg. As CO_2 concentrations continue to increase, and as Earth approaches a doubling of pre-industrial CO_2 levels by mid-century, far more drastic changes in our climate and associated impacts are likely to take place.

Climate Models and Their Predictions

Climate models incorporate our basic physical understanding of the atmosphere, and unlike weather predictions, these models account for longer-term factors such as Earth's radiation

[1] Gas concentrations in the atmosphere are regularly measured and expressed in parts per million (abbreviation: ppm). So 280 ppm means that the volume of the gas in question (in this case CO_2) is 280 volume units per each million volume units of air (the sum of all gases in air).

budget, and the interactions of the atmosphere with oceans, ice sheets, and the Earth's biosphere. The models represent our best understanding of the relevant physics, chemistry, and biology that characterize Earth's climate system.



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Global surface temperatures recorded since reliable measurements were available in the late 1800s. Image compiled by NASA's Goddard Institute for Space Studies. The data set used follows the methodology outlined by Hansen, J., et al. (2006). Image 1-2 Image created by Robert A. Rohde / Global Warming Art.

Climate change contrarians often argue that climate models are untested and that their projections should not be taken seriously. That assertion is simply false. Climate models have become increasingly realistic over the past two decades, capturing key details of atmospheric circulation patterns, ocean current systems, and subtle phenomena such as El Niño with increased fidelity. In many cases, one would be hard-pressed to distinguish the simulations of a state-of-the-art climate model from actual observations. The models, moreover, have passed some key tests with flying colors.

One of the most prominent early successes was James Hansen's famous predictions in 1988 of the future course of global warming. Hansen used a model that is quite primitive by today's standards to predict global temperatures several decades in advance based on three possible future fossil fuel emissions scenarios: high, medium, and low emissions. His projections, based upon the NASA Goddard Institute for Space Studies climate model in 1988, closely match actual observations made for the years 1958 through 2005.

The only significant difference between the actual global temperatures and those projected by Hansen is a four-year drop in global temperature beginning in 1991. A critic might point to this unanticipated drop as evidence that Hansen's predictions were flawed. To do so would be misguided. That cooling was the result of the 1991 massive volcanic eruption of Mount Pinatubo, which nobody—including Hansen—could have predicted in advance. That highly explosive eruption sent large amounts of tiny sulphate particles into the lower stratosphere with a resulting global cooling effect that lasted several years. Hansen recognized, however, that the eruption—when it occurred in June 1991—provided a critical additional test for his climate model. When a volcano like Mount Pinatubo erupts, it takes about six months for the planet to cool, so in effect, one can make predictions with six months lead time, which Hansen did. Using the same model he had used for his future global warming predictions, Hansen placed the estimated distribution of the volcanic sulphate particles into the atmosphere, and ran the model forward. His simulation accurately predicted the cooling of roughly 0.5°C six months after the eruption and lasting several years.

Climate models are validated in many more mundane ways (e.g. by comparing the basic statistics of the various variables in the model with actual atmospheric and oceanographic data), but these early predictions underscore that even those climate models from decades ago which are primitive by today's standards, have been validated in their ability to make meaningful predictions of the future. Therefore, there is reason to take these projections of the future quite seriously.

Climate models can be applied retrospectively to the past century and a half to address the roles of various natural and anthropogenic factors in explaining observed temperature changes. When these simulations are performed, natural factors alone (changes in solar output and volcanic eruptions) are unable to explain the warming of the past few decades—indeed, they suggest the climate should have cooled over the most recent decades. Not only can climate change not be explained in terms of natural factors, warming is happening in spite of natural factors. Only including the human impacts of increasing greenhouse gas emissions can explain the warming of the past few decades. In fact, only increasing greenhouse gas concentrations can explain the "vertical pattern" of warming scientists have observed—Earth's surface and lower atmosphere have warmed while the stratosphere has cooled. That pattern bears the fingerprint of greenhouse gas increases, which warm the surface at the expense of cooling the upper atmosphere.

Scientists are therefore confident that the warming of the globe, and the pattern of climate change associated with it, is the result of human-caused impacts. Given that climate models have passed important tests that validate their predictive abilities, and that the models can only explain historical changes in climate when fed anthropogenic emissions, the next logical step is to project those models forward with various possible scenarios of future anthropogenic activity, and see what they predict.

Model Projections

Climate models predict that "business-as-usual" carbon emissions will lead to dramatic and, in some cases, catastrophic changes in our climate. As explained earlier, the best current estimate is that a doubling of CO_2 will lead to a 3°C warming of the globe, but warming as little as 2°C or as much as 5°C cannot be ruled out.

The impact of global warming of just one degree causes substantial changes to the planet. A warming of 3.6°F (2°C) above the pre-industrial era has been defined by many (including the European Union) as constituting a level beyond which changes in Earth's climate will be dangerous for civilization, ecosystems, and the environment. It is thus often used as a benchmark for "dangerous anthropogenic interference" that must not be breached. With this amount of warming, dramatic further increases can be expected in the frequency and severity of extreme weather including heat waves and destructive hurricanes, as much as three feet or more of sea level rise, worsened summer drought over the major continents, a potential disappearance of Arctic sea ice in the summer, and many other changes in the climate system.

These changes could have devastating impacts on the global economy, with losses as great as 2% to 3% of global gross domestic product (GDP) predicted by 2100. Climate change would lead to a loss of freshwater resources in many regions, decreased agricultural productivity (particularly in tropical regions), adverse health effects, loss of land and property near coastlines, and numerous other detrimental impacts for human society.

Such changes would also threaten key ecosystems from the tropics to the poles. Coral reefs, a major source of ocean biodiversity, could largely disappear due to the joint impacts of increasingly acidic ocean waters and the impacts of warming sea surface temperatures on coral bleaching. As discussed further in Chapter 2, in the Arctic, animals such as polar bears could be endangered by the loss of the summer/fall sea ice they rely upon for feeding. These are but just a few of the threats of ongoing warming of the globe.

Changes are Surpassing Projections

In 2009, *The Copenhagen Diagnosis* was published as an update to the 2007 Intergovernmental Panel on Climate Change (IPCC, 2007) Report. The report demonstrated that in many respects, the changes taking place as a result of human greenhouse gas emissions are proceeding more quickly than originally predicted. Comparing actual emissions to various IPCC projections demonstrates findings that exceed even the most extreme of the previously envisioned fossil fuel emissions scenarios.

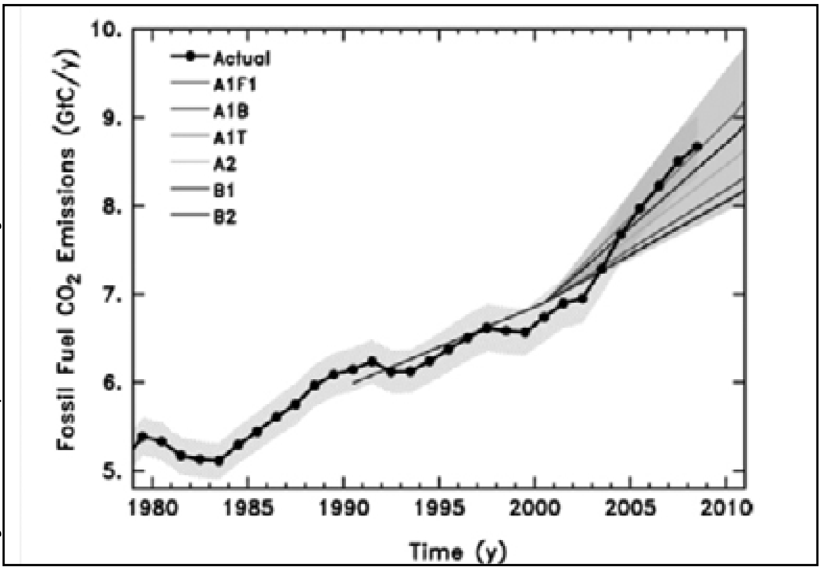
Even if global emission rates stabilize at present-day levels, just 20 more years of continued emissions will cause us to breach the warming threshold noted above as dangerous. Every year action is delayed, the greater the chances of disastrous implications.

In this chapter, we have explored how human impacts have led to observed climate changes and documented observed increases in

CO_2 concentrations over the last decades. How are the documented changes in the climate itself matching up against previous projections? In many respects, they are in fact exceeding them.

A Matter of Economics… And Ethics

Economists have been grappling for more than a decade with the problem of estimating the inherent costs of climate change, but there is great uncertainty. As noted above, the estimated impacts of a 2°C warming of the globe leads to as much as 2% to 3% loss in GDP. On the other hand, taking action requires some costs: to develop and deploy a new global energy infrastructure that is considerably less carbon intensive, and switching over to new alternative sources of energy, some of which may be more expensive – at least in the short run – than fossil fuel sources. Therefore, the problem is sometimes viewed as a simple cost-benefit analysis – a challenge that economists can solve. How much do we gain in averting dangerous climate change impacts but lose, economically, due to the costs of developing and deploying new energy sources?



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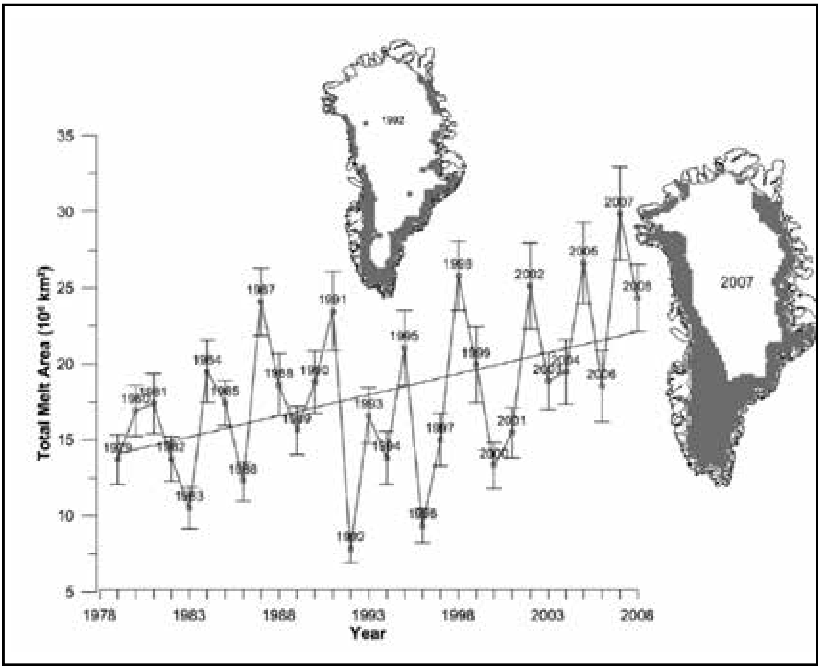

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Satellite measurements reveal beyond doubt that both Greenland and Antarctic ice sheets are now losing mass and thus contributing to global sea level rise. The red areas in the Greenland map represent areas of permanent ice loss. Melting of glaciers and ice caps in other parts of the world has also accelerated since 1990. (Updated from Steffen et al., 2008). Courtesy of Allison et al. (2009).

(Left) Observed vs. Predicted Fossil Fuel Emissions. The current level of actual CO_2 *emissions is surpassing even the worst case scenario projections. In this figure, the black dotted line represents actual emission trends. The red line represents the projected worst case scenario whereby fuel emissions from developing countries increases, but population does not stabilize as it generally would with industrialization. Observations are from the US Department of Energy Carbon Dioxide Information Center (CDIAC) up to 2006 [http://cdiac.ornl.gov]. Data for 2007 and 2008 are based on BP economic data [http://tinyurl.com/3lmov36]. The emission scenarios are averaged over several iterations of various scenarios presented in IPCC (2000). Courtesy of Allison et al. (2009).*

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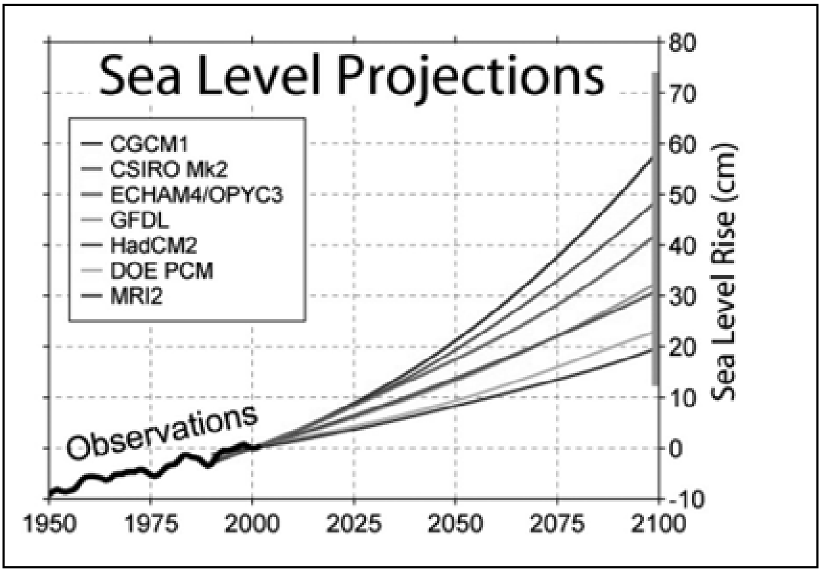

Observed vs. Predicted Sea Level Change. The current measurements of average sea level change are at the high end of the various scenario projections (Cazenavea et al., 2009). Image created by Robert A. Rohde / Global Warming Art, adapted from the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2001) (Figure 11.1)

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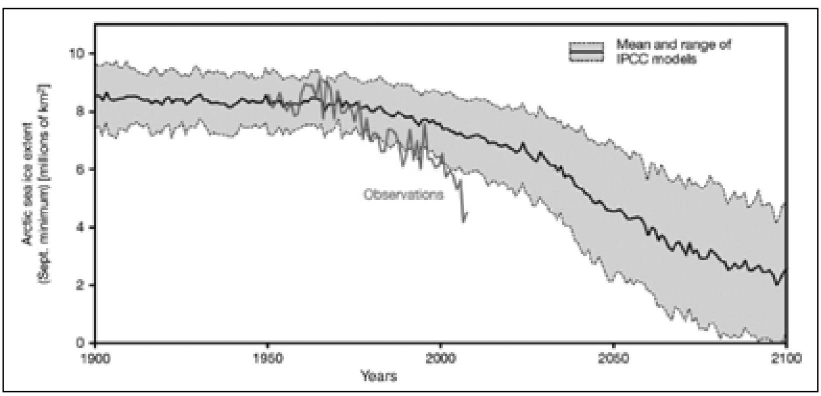

Observed vs. Predicted Change of Arctic Sea Ice Extension. The actual measurements of Arctic sea ice extension, represented by the red line, are surpassing even the worst case scenarios of projected decline in summer sea ice in the Arctic (presented here within the shaded region). Zero refers to a period of no ice at all. From Stroeve et al. (2007) updated to include data for 2008. Courtesy of Allison et al. (2009).

But, the scenario is not that simple. First, the costs of inaction are highly uncertain, because the projected impacts of climate change themselves are uncertain. We cannot predict the possibility of surprises. For instance, when the Arctic permafrost melts and coastal shelves warm, it is possible that huge amounts of previously trapped methane will release into the atmosphere. Tipping points are also possible – "points of no return" – especially related to sea level rise. When major ice sheets collapse, an unstoppable domino-effect collapse may be set into motion with uncertain results.

Critics sometimes argue that such uncertainty is a cause for inaction; steps should not be taken to solve the problem unless there is 100% certainty about the extent of the problem and associated level of threat. Yet, economists argue just the opposite is true. Uncertainty can impact in both directions – it can lead to actual results far surpassing expectations, and therefore costing more than current best estimates… or not. Because of the potential for exceedingly costly and catastrophic outcomes, it is even more important to mitigate against future climate change. It is the same reasoning by which most homeowners invest in fire insurance; not because they expect their home to burn down but, rather, because if their home *did burn down*, the impact would be catastrophic, had they not hedged against that potential outcome by purchasing insurance. Using this analogy, decreasing carbon emissions is a highly advisable modest insurance policy against planetary catastrophe.

Of course, treating climate change as a purely economic problem, one that can be solved by cost-benefit analysis, is short-sighted. A number of fundamental ethical considerations make the problem more complex. First is the disaggregation between those who would bear the greatest costs from climate change, and those who caused the problem in the first place. The industrial nations of the world have been the primary beneficiaries of fossil-fuel emissions to date, with developing nations such as China and India becoming increasingly powerful players. Yet the most devastating impacts of climate change are in the undeveloped world, particularly tropical regions which currently struggle with food and fresh water needs, and are likely to see these precious resources diminish. How do we build such inequities into our plans for mitigation?

An intergenerational factor also complicates the problem. Current generations created the problem by using fossil fuel sources for cheap energy. But, it is future generations, who had no part in creating the problem in the first place, who will bear the brunt of climate change impacts decades and centuries down the road.

The only truly safe solution to the threat of climate-change-caused environmental hazards is to control our carbon emissions and stabilize atmospheric greenhouse gas concentrations before it is too late.

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Dr. Michael E. Mann is a member of the Penn State University faculty, holding joint positions in the Departments of Meteorology and Geosciences, and the Earth and Environmental Systems Institute (ESSI). He is also director of the Penn State Earth System Science Center (ESSC). He received his undergraduate degrees in Physics and Applied Math from the University of California at Berkeley, an M.S. degree in Physics from Yale University, and a Ph.D. in Geology & Geophysics from Yale University. Current areas of research include model/data comparisons aimed at understanding the long-term behavior of the climate. Dr. Mann was a lead author on the "Observed Climate Variability and Change" chapter of the Intergovernmental Panel on Climate Change (IPCC) Third Scientific Assessment Report and in 2007, shared the Nobel Peace Prize with other IPCC authors. He is author of more than 140 peer-reviewed and edited publications, and has published two books including *Dire Predictions: Understanding Global Warming* and *The Hockey Stick and the Climate Wars: Dispatches from the Front Lines,* due out in early 2012. In 2002, Dr. Mann was selected as one of the 50 leading visionaries in science and technology by *Scientific American*. He is also a co-founder and avid contributor to the award-winning science website RealClimate.org. Mann personally tries to mitigate climate change by educating citizens about the nature of the climate change threat, so they can better hold their policymakers accountable for representing their concerns and he also does what he can to minimize his own carbon footprint (especially the “three Rs”: reducing, reusing, and recycling).

CHAPTER 2

Polar Animals in a Warming World: Certainties, Uncertainties, and Hope

By Steven C. Amstrup and Barbara Nielsen

- Human-caused increases of greenhouse gases are leading to climate change—a warming of our planet—and we are already witnessing the impact on Arctic habitats and animals.
- With only a few species on the Arctic food web, when one is affected, the result is dramatic. Especially threatened are polar bears, Pacific walruses, and ringed seals.
- Rapid Arctic warming has resulted in the melting of sea ice, at a rate consistently exceeding projections. Different ecoregions within the Arctic are being affected at different rates and different ways, but ultimately the whole of the Arctic as we know it is threatened.
- Research has shown that an immediate decrease in greenhouse gas emissions will preserve much of the present Arctic ecosystem, but individuals, business, and government must prioritize climate change action if we want to save polar bears and other key species.

Chapter 1 describes how even small increases in global climate can lead to dramatic impacts on everything alive on our planet, altering ecosystems all around the world. An area where we are already witnessing the damaging effects of climate change is in the Arctic (Serreze, Holland & Stroeve, 2007). Because of human-caused increases in greenhouse gases in our atmosphere, our planet is warming. This warming has resulted in melting sea ice, upon which several polar animals, including polar bears, rely for food. Polar bears hunt for food from a platform of sea ice. They are capable swimmers, but need a stable sea ice surface to access their main prey, seals. The retreat of sea ice from productive shallow waters means less time to feed and more time fasting. It also can separate bears from critical habitats like on-shore denning areas.

We begin with an investigation of the Arctic and how it shapes the lives of the animals that inhabit this rich and increasingly fragile ecosystem.

Arctic Connections

The Arctic may appear a simple habitat of tundra, water, and ice. However, these beautiful but harsh environments host many different food webs. Because Arctic food webs can be simple—with few species in the chain—the health of the entire food web is placed at risk when one species is affected.

Similarly, on the tundra, an Arctic food chain begins with vegetation (grasses, berries, etc.) that small rodents like lemmings eat. Other animals including snowy owls hunt these rodents, and these carnivores, in turn, become prey for apex predators like wolves.

Because apex predators sit at the top of these relatively simple food webs, they can serve as effective sentinels: they literally integrate all of the pieces of the system below them. Declines in population indicators such as birth or survival rates, or distribution and behavior can indicate a serious problem in the whole ecosystem.

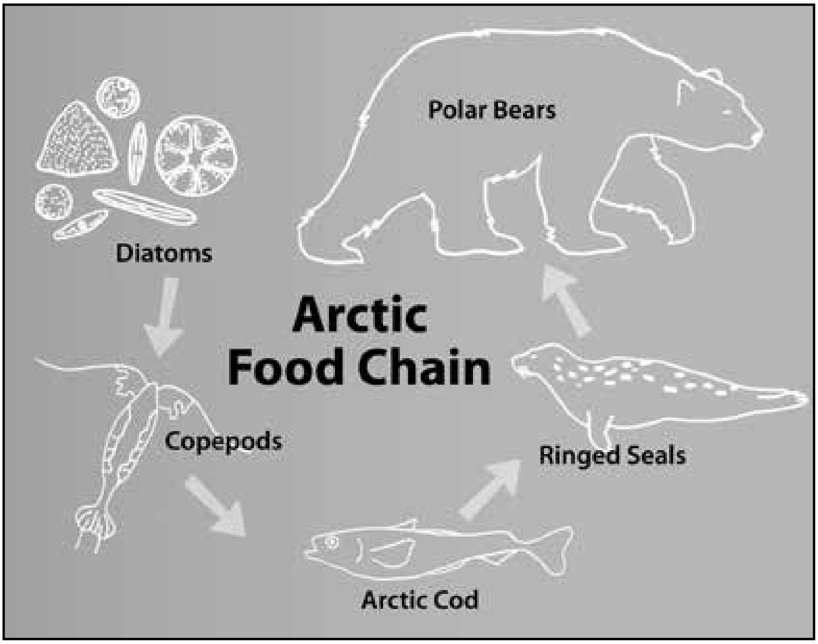

Image 2-1. For a color pdf, visit www.clizen.org.

Polar bears are the top (apex) predator in the Arctic marine environment. Primary production in this food web begins with the photosynthetic activity of single-celled algae such as diatoms on the underside of sea ice. Herbivores such as copepods feed on the algae, which, in turn, become food for first-order carnivores such as Arctic cod. Ringed seals then eat the cod, and the chain finally ends with polar bears preying on seals.

Arctic species have adapted physically and behaviorally to the area north of the Arctic Circle: ecologically speaking, the area north of treeline or the northern edge of the boreal forest. In the marine environment, the characteristically cold, low-salinity Arctic waters meet Atlantic and Pacific waters.

Marine species like polar bears, walruses, seals, and some whales derive their sustenance from the marine environment. True Arctic species (in contrast to many migratory animals) make their living year-round in the Arctic, finding food, shelter, and mates in this region.

Arctic sea ice, the frozen surface of a cold ocean, fulfills the lifecycle needs of several creatures that are found nowhere else on Earth. In the best circumstances, the Arctic makes for an uncertain habitat due to extremes in temperature, weather conditions, and the dynamics of ice. Here, we'll take a brief look at three interrelated species that call this sea-ice environment home.

Highly Adapted Arctic Animals

Polar Bears

The polar bear evolved about 200,000 years ago from brown bear ancestors. They are superbly adapted for survival in the Far North. They range throughout the Arctic in areas where they hunt seals at openings in the sea ice called leads (Amstrup, 2003).

Polar bears are well adapted to the Arctic's night skies and fiercely cold weather. Just how cold is it? Winter temperatures often plunge to -40º or -50º F (-40 to -45C) and stay that way for days or weeks. The average January and February temperature in the High Arctic, for example, is -29º F (-33C).

Two layers of fur and fat under the skin provide polar bears with such excellent insulation that they don't need to burn extra energy even when temperatures reach -34º F (-36C). Compact ears and a small tail also help prevent heat loss. On bitterly cold days with fierce winds, polar bears may dig shelters in snow banks and curl up in a tight ball. Sometimes they cover their muzzles, which radiate heat, with their thickly furred paws.

The polar bear's livelihood depends on the sea ice as a platform from which to hunt blubber-rich seals and, occasionally, other marine mammals such as walruses and beluga whales. Polar bears catch these aquatic animals when they surface at breathing holes in the ice or when they are resting on the surface of the sea ice. Polar bears in some areas are seasonally stranded on land when the sea-ice melts in summer. Because they depend on the ice surface to catch their prey, polar bears are essentially food-deprived while onshore (Obbard et al., 2006). They have been known to snack on terrestrial foods such as goose eggs and berries, but these foods do not meet their nutritional needs.

Polar bears also rely on sea ice for finding mates, following scented trails deposited by footpads as bears walk across the ice. Scientists are concerned that melting and fragmented ice floes will break up these trails, making it difficult for male polar bears to find potential mates.

As the sea ice retreats farther off shore, polar bears in some parts of the Arctic are forced to swim farther and more frequently between ice areas and land. This is especially challenging for mothers with cubs, particularly those that have emerged from their den in spring after a fast of up to eight months (Regehr et al., 2010). If ice has retreated far offshore, the mother must balance her need to return to the sea ice to hunt—a need on which the survival of the entire family depends—with the ability of her cubs to survive a long swim. Scientists have correlated lower cub survival rates with reduced availability of sea ice (Regehr et al., 2007, 2010; Rode, Amstrup, & Regehr, 2012). Many cubs just can't keep up and, because they lack a thick fat layer, have less buoyancy in the water and a diminished ability to survive cold.

Pacific Walruses

Pacific walruses are highly specialized ocean bottom feeders, with clams their most common food source, along with sea cucumbers, crabs, and segmented worms. They move seasonally depending on ice availability but, unlike many seal species, have a limited diving depth. Therefore, they stay primarily in shallow continental shelf waters. Walruses drift around on the floating pack ice, diving to the bottom to feed. Because the ice is continually in motion, it carries them over fresh terrain for feeding. They also use floating sea ice for birthing and nursing calves, for resting, and for protection from predators.

Because walruses use sea ice to rest, when ice is unavailable, they must rest or "haul out" on land. When they are forced to rest on land, populations are crowded and, because their foraging areas are limited by how far they can swim from haul-out areas, food sources can be over exploited. Also, walruses are more vulnerable to predation in crowded land haul-out areas. In addition to animals killed directly by predators such as polar bears, alarmed adults often trample young in their haste to escape. Because of these factors, walrus populations are expected to decrease due to climate change and may have already declined in some areas.

Ringed Seals

The ringed seal, named for the ring-like marks on its fur, is the smallest and most widespread seal in the Arctic, likely numbering in the millions. They rarely if ever come to land, feeding on creatures on the underside of sea ice. Ringed seals breed in the water under the ice and give birth in small caves they create above the ice surface. Like the walrus, ringed seals prefer shallow, coastal waters where productivity is highest. Unlike walruses, they do not require ice surfaces for resting. Like all mammals, ringed seals require air to breathe. In the past, the oceans have been covered by ice most of the year, so seals have adapted by clawing breathing holes. Ringed seals are thought to be most common in landfast ice (sea ice that is attached to land, not drifting with ocean currents), which tends to be more stable, making it easier for them to maintain breathing holes and defend underwater territories. With global warming, ringed seals could face large losses of the stable ice habitat they need for giving birth and rearing their young. If the sea ice breaks up too early, or if there is too-little snow on the surface, birth lairs may collapse and pups may be exposed prematurely to the outside environment, making them more vulnerable to predators.

Arctic Sea Ice in a Warming World

All three of these species are beautifully adapted to the dynamic Arctic sea ice environment, and this specificity makes them especially vulnerable to a warming Arctic.

The sea ice that provides a platform from which polar bears can hunt, on which walruses can rest, and under which ringed seals can feed is in rapid decline. The National Snow and Ice Data Center reports that 2010 winter's Arctic sea ice tied for the lowest coverage since satellite tracking began in 1979: nearly eight percent less than the average recorded from 1979 to 2000. And as discussed in Chapter 1, the area of sea ice melt during 2007-2009 was about 40% greater than the average prediction based on IPCC models.

The Arctic's rapid warming also has led to unprecedented summer sea ice losses, with warming taking place much faster than computer models projected (Comiso 2006, Kerr 2007, Strove et al., 2007). Large expanses of darker, open water are absorbing more heat and accelerating the process. Since the 1980s, Arctic sea ice has melted dramatically, with the most extreme loss occurring in the summer melt season.

Changes in the distribution and quality of sea ice affect the entire Arctic ecosystem. Ultimately, declining sea ice will endanger all ice-dependent species, but because some regions are colder than others, the timing of impacts will vary across populations and over time.

In the High Arctic, for example, polar bears have traditionally been able to hunt year-round on the sea ice. For more southerly populations, like those of Western Hudson Bay, summer's melting ice forces them ashore each year, where they are food deprived until the ice returns. But warmer temperatures in recent years have greatly shortened the hunting season for Western Hudson Bay bears, with early melt-offs forcing them to begin their summer fast weeks earlier than usual.

Scientists have identified four different ice ecoregions in the Arctic (Amstrup et al., 2008, 2010):

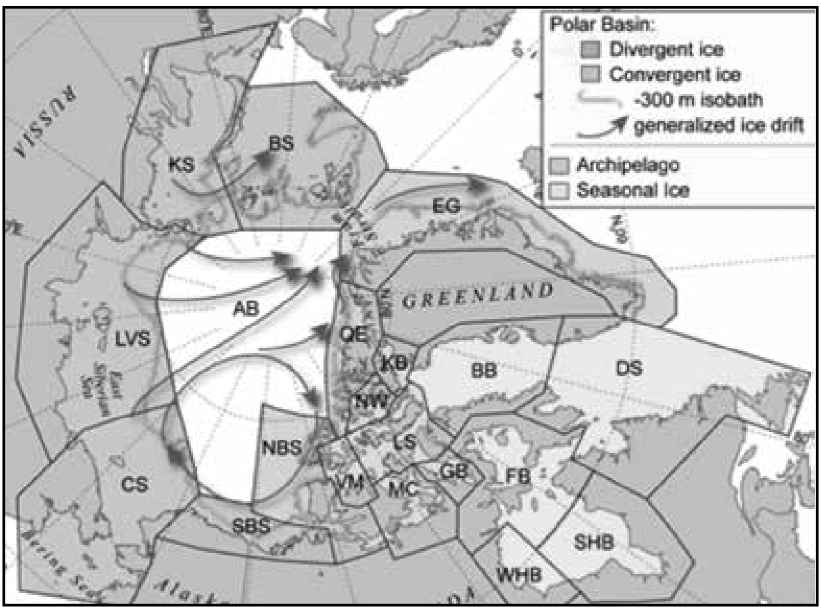

Image 2-2. For a color pdf, visit www.clizen.org.

Polar Bear Seasonal Ice Ecoregions. Image courtesy of the US Geological Survey. http://www.usgs.gov/newsroom/special/polar_bears/docs/USGS_PolarBear_Amstrup_Forecast_lowres.pdf. Image 2-2. For color pdf, visit www.CliZEN.org.

Seasonal Ice Ecoregion – Located in the more southerly portions of the polar bear's range, this ecoregion includes Canada's Hudson Bay. Throughout this region, sea ice melts entirely in summer. Polar bears that live here are forced ashore for extended periods during which they are food deprived. Ringed seals remain in the water, but polar bears must wait for freeze-up in autumn before they can hunt them again. Polar bears in these regions are at great risk, with longer ice-free seasons testing the limits of their fat reserves. Walruses that live in seasonal ice areas are forced ashore in summer and must rely on the bottom-dwelling foods available within their limited swimming range.

Divergent Ice Ecoregion– In this region, sea ice continually forms in shallow areas along the shore but then retreats into the center of the polar basin, where it piles up in the Convergent Ice Ecoregion (see below) or leaves the polar basin. This pattern of motion means that, in summer, as the temperature warms, sea ice moves farther offshore. Walruses and polar bears are faced with a choice: come ashore or swim long, exhausting distances to reach remaining pack ice. In the case of polar bears, those that choose to land must fast until the ice returns in the fall. Polar bears in these regions are at great risk: from longer and longer swims, prolonged fasting periods, or encounters with humans on shore. For walruses, the choice is much the same, but their choice to stay ashore may result in too many walruses competing for the same food source, and as mentioned, more predation as well as the risk of stampedes.

Convergent Ice Ecoregion – Currents and winds move sea ice formed in other parts of the Arctic along the shore of these habitats, providing seals and walruses with sea ice and, consequently, polar bears with access to seals. Polar bears in these regions may be faring well now, but scientists predict (Amstrup et al., 2008, 2010) that even in these areas, unless action is taken to reduce CO_2 concentrations, ice may disappear within 75 years—and, with it, resident polar bear populations.

Archipelago Ice Ecoregion – Islands in the Canadian High Arctic and Greenland are far enough north that sea ice remains along the coast even in summer, again providing habitat for seals and walruses and food for polar bears (Overpeck et al., 2005). This region and the adjacent portions of the Convergent Ice Ecoregion are predicted to be the last strongholds of the sea ice, but they, too, are ultimately at risk if the warming continues, with the loss of polar bears predicted by the end of the century if we continue on the present course.

The Uncertainty in a Warming World

As revealed in Chapter 1, the physics of global warming and its relation to greenhouse gas concentrations has been understood for nearly 200 years. The science is certain. The uncertainty concerns the timing of future warming and possible effects. Natural fluctuations in the climate system prevent us from confidently predicting, for example, the first year it will be too hot to grow wheat in Kansas—or the first summer the Arctic will be ice-free. Crossing both thresholds is ensured, however, unless greenhouse gas emissions are reduced.

In May 2008, the U.S. listed the polar bear as a threatened species under the Endangered Species Act. The research models that led to the listing projected a dire future for the animals, with two-thirds of the current world population disappearing by mid-century, and possible worldwide extinction by the end of the 21^{st} century (Amstrup et al., 2008).

We know less about the impact on seals and walruses because they have not been studied as closely as polar bears. But one thing is certain: unless we take action to drastically curb greenhouse emissions, all ice-dependent species in the Arctic face grave threats.

There is Hope

A recent study by one of us (S.C. Amstrup) and a team of scientists shows that polar bears and their sea-ice habitats could benefit greatly if present levels of greenhouse gases are significantly reduced (Amstrup et al., 2010). Indeed, polar bears could persist across much of their current range if we arrest the increase in greenhouse gas emissions. Much uncertainty exists regarding the future range of polar bears, and even with the mitigation tested in the study, substantial population reductions are still likely. But, if we greatly reduce anthropogenic CO_2 emissions, polar bears will occur in more areas and greater numbers than if we do not, and these actions benefit the rest of life on Earth, as well.

Amstrup et al. (2010) also revealed that "tipping points" – points of no return – are not expected to impact the melting of sea ice. Tipping points in the sea ice would mean melting would reach a threshold beyond which an unstoppable, domino-like effect would set into motion highly catastrophic results (Lenton et al., 2008; Lindsay & Shang, 2005). Instead, this most recent study shows a linear relationship between rising temperatures and sea ice melting: higher temperatures lead to less sea ice. This means that saving polar bears and other Arctic species is all about keeping global temperatures from rising.

What can be done to inspire humans to decrease our fossil fuel emissions? Our organization, Polar Bears International, is dedicated to ensuring polar bear survival by encouraging people to help stop climate change. We believe educating others is critical to making a difference in saving polar bear habitat and the habitats of the other species described in this chapter. The best way we know how to do this is to work through partners like zoos to reach their large audiences.

Individuals may engage in both long- and short-term actions to mitigate climate change. Energy savings, as a class of conservation behaviors, are the most effective way for individuals to decrease their carbon footprints. Actions related to home efficiency and transportation also are highly effective and can be accomplished at low—or sometimes no—cost, often saving money at the same time. Changes in how our society does business are also required to dramatically reduce greenhouse gas emissions. There is, however, a difference between what we can accomplish physically and what is plausible politically. We have the physical ability to achieve a reduction in CO_2 necessary to protect imperiled Arctic animals, but we must have the social and political will do so. If policymakers believe nothing can be done, they will do nothing. In addition to changing our own conservation behavior, we must each become advocates on behalf of our planet's health and the survival of Earth's living creatures.

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Dr. Steven C. Amstrup is chief scientist and vice-president of conservation science with Polar Bears International. He joined PBI's staff in July of 2010 after retiring after 30 years as project leader for Polar Bear Research at the U.S. Geological Survey, Alaska Science Center, Anchorage, AK. He earned a B.S. in Forestry from the University of Washington (1972), a M.S. in Wildlife Management from the University of Idaho (1975), and a Ph.D. in Wildlife Management from the University of Alaska Fairbanks (1995). He has been conducting research on all aspects of polar bear ecology in the Beaufort Sea since 1980. He is a past chairman of the IUCN Polar Bear Specialist Group and has been an active member of the group for 30 years. He has authored or coauthored over 100 peer reviewed articles on movements, distribution and population dynamics of large mammals, and is the senior editor of a recent text on population estimation methods. Dr. Amstrup led the team of researchers that prepared nine reports that became the basis for the recent decision to list polar bears as a threatened species in 2008. He also is an adjunct professor at the University of Wyoming in Laramie, and an associate professor at the University of Alaska in Fairbanks.

Barbara Nielsen is director of communications at Polar Bears International. She is a professional writer whose articles on nature, wildlife, travel, and gardening have appeared in a number of national magazines. She is the author of *Hummingbird Gardens*, *Night Creatures*, and *Great Barrier Reef* and a field editor for *Better Homes & Gardens* and its garden magazines. Nielsen saw her first polar bear while on assignment in Churchill in 1983. Her article for *Modern Maturity* on the polar bear migration there, with photos by PBI founder, Dan Guravich, helped jump-start the town's tourism industry. Nielsen has remained passionate about the bears ever since. She lives in hot, humid Louisiana and has been involved with PBI since the organization was founded in 1992. Her favorite greenhouse gas mitigation actions: the decision to have just one child, along with the habit of making daily choices based on their environmental impact, such as buying locally and taking shorter showers.

Teaching about Climate Change: The Roles of Zoos and Aquariums in Formal and Informal Science Education

By James W. Pellegrino

- A newly developed framework for science education standards may change the way science is taught in K-12 classrooms. An important element of this framework is an investigation of climate change.
- Informal learning institutions like zoos and aquariums captivate visitors' interest and provide real, memorable experiences upon which formal learning can build.
- Climate change is an ideal topic to promote science literacy.
- Formal and informal educational institutions can and should work together to provide rich, in-depth science learning experiences.

In classrooms around the country, students watch eagerly as the liquid in test tubes changes color and bubbles, build and test electric circuits, and map the life cycle of a butterfly. In the structured environment of school, teachers involve children in scientific experiences to explain the natural world. In American zoos and aquariums, families spend unstructured time together, marveling at animals they may never otherwise see, discovering the importance of habitat in animal survival, and learning how human beings can impact the ability of animals to thrive. Through attentive dialogue with facilitators, interactive technology, or guided activities, the visitor comes to appreciate the interconnectedness of all life on Earth, and the role of humans in sustaining a delicate balance.

Together, formal and informal educational institutions offer a powerful "one-two punch," providing opportunities to learn about scientific theories and models, observe these ideas in practice, and discover the ways science generates answers to questions about the "hows" and "whys" of our planet. Because of their unique and complementary strengths, together, these institutions can bolster our country's science literacy in general, and climate change literacy in particular.

Aside from the critical implications of learning about climate change and working to offset its effects on our planet, the subject is an ideal one to promote science literacy: it is a topic hot on the political agenda, it is highly visible and accessible in the media, and therefore it evokes curiosity about both the arguments and the supporting evidence. Curiosity and concern make for fertile ground in which to seed and sustain new learning. What's more, climate change is a rich example of the complexity of a scientific issue and debate, including the need to understand the interconnectedness of a variety of systems and perspectives: from the microbial to the macroscopic, from our own backyards to environments spanning the globe, from our planet's birth to its distant future. In both formal and informal settings, teaching about climate change can help drive environmentally friendly behaviors and provide opportunity for dynamic scientific investigation.

But science learning in the USA has been criticized as being "a mile wide and an inch deep," leaving learners with bits and pieces of information, but not a comprehensive science understanding. This has renewed calls to improve science education, particularly since America's global leadership and economy are heavily based on technological and scientific innovation. Several important initiatives in the area of science learning recently have been unveiled, and these may reshape the way science is taught in schools and informal settings, focusing on learner-centered approaches that invite inquiry, exploration, and discussion.

Science in the K-12 School Setting

The National Research Council just released its long-anticipated Framework for K-12 Science Education Standards, a first step toward creating new standards to guide the teaching of science (National Research Council, 2011). The framework builds upon previous studies, but also recognizes that science has progressed tremendously in the past decade. Combined with a wealth of experience and best practices incorporating science standards in the classroom, this new framework blends core scientific ideas with the practices of scientific inquiry and reasoning. It is designed to emphasize growth of students' knowledge and understanding of science throughout their academic careers, beginning by engaging youngest students' curiosity of how the world works and providing a solid scientific foundation focused on core scientific concepts. The framework expects that over the years, classroom experiences will build, enrich, and reinforce ideas already introduced and invite students to deepen and broaden their exploration. The overarching goal of the new framework is that by grade 12, all students will have an appreciation of the beauty and wonder of science that includes an understanding of the scientific principles underlying how the world works and how science develops such understandings.

Those dedicated to teaching about climate change will be heartened to know the framework's core ideas center on life and earth sciences, promoting a deeper understanding of complex issues such as the diversity of life on our planet, our human connections with all life on Earth, and changes to our planet over time – all subjects intimately connected to the issue of climate change. In fact, the study of climate change, itself, is a major theme of the framework. Students are expected to engage in a learning process whereby they discover not only facts and ideas, but also develop a process of reasoning and become able to build explanations for the complex phenomena of our everyday world. They develop critical thinking skills, not in the abstract, but by personally delving into real-time, real-world issues that relate to climate change and other scientific, engineering, and technological subjects. So, yes, they gain knowledge about the science behind Earth's greenhouse effect; they discover the impacts of human population growth and dependence on fossil fuels; they witness the cause and effect of ecosystem degradation; and they understand the global impacts of climate change. But, even more important, they become expert at assessing and evaluating the coherence, credibility, and scientific legitimacy of arguments about human actions in relationship to the natural world.

Science in the Zoo and Aquarium Setting

Informal learning institutions play an important role in providing rich experiences in the natural world. Each year, North American zoos and aquariums welcome over 130 million visitors – families, couples on dates, groups of teenagers, senior citizens. Because of their broad demographic reach, zoos and aquariums provide informal learning opportunities to virtually every segment of society, including those currently in school and those who are not.

Zoos and aquariums provide learners with real experiences that would be difficult to introduce in a formal classroom setting. For instance, in school, students can learn about polar bear biology and behavior, even see a video of polar bears in their natural habitat, but at a zoo, they can see an actual polar bear, appreciate its grandeur, and connect with it on a more personal level. From animal to animal, they can appreciate the richness of our planet's diversity first-hand and, via cognitive and emotional processing, discover our connections to all living things on Earth. To capture and sustain this initial interest, informal and formal education can collaborate. Back in the classroom, a memorable, visceral zoo experience can serve as a foundation upon which formal and more extended types of learning can build.

Just one year before the K-12 Framework, the National Research Council released the landmark study *Learning Science in Informal Environments*, which explores the value of informal science environments, such as zoos and aquariums (National Research Council, 2009). Among its main findings, the report points out that all too often informal educational institutions like zoos and aquariums are overlooked as opportunities to learn science. Evidence indicates that structured, informal learning, the kind that takes place in zoos and aquariums, can spark science interest (National Research Council, 2009), reinforce conservation connections (Falk, Reinhard, Vernon, Bronnekant, Deans, & Heimlich, 2007), and even inspire careers in science (National Research Council, 2009). Everyday experiences can serve as science learning incubators for everyone – children and adults – providing a personalized understanding of the natural world. Zoo and aquarium visitors are presented with real-world wonders, and with the help of savvy facilitators, technological innovations, and relevant messaging, visitors can engage in scientific inquiry, reflection, and dialogue.

The 2009 NRC study builds upon prior studies (e.g., National Research Council, 2007) and introduces six "strands of science learning," explaining how schools and informal education institutions can complement each other for a powerful combination of lifelong science learning. The six strands specify that through engaging experiences in both these types of institutions, learners should:

- Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world.
- Come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science.
- Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.

- Reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena.
- Participate in scientific activities and learning practices with others, using scientific language and tools.
- Think about themselves as science learners and develop an identity as individuals who know about, use, and sometimes contribute scientific knowledge.

Recommendations for Zoos and Aquariums Working with Schools for a Lifetime of Science Learning

The six strands of the *Learning Science in Informal Environments* report largely coincide with the recent K-12 framework, providing a coherent direction in both formal and informal science education environments. Both reports strongly advocate for direct science experiences that are meaningful and relevant. Both call for an additive lifelong experience that emphasizes science inquiry and personal reflection about the natural world. Within this context, zoos and aquariums should play a significant role in advancing science education in general and climate change education in particular.

Zoos and aquariums are strategically positioned to bring remote or elusive science concepts, such as climate change, to the personal realm. For example, many zoos and aquariums provide science education opportunities in grades K-12, mainly though school field trips, field classes, and teacher training opportunities. These interactions should be used to advance K-12 science needs within the school system. Using the K-12 framework, zoos and aquariums can provide real-world opportunities with live animals, naturalistic settings, interactions between scientists and teachers, and training opportunities for teachers.

However, the strongest opportunities in science education lay in the informal education environment for which zoos and aquariums are exquisitely predisposed. Although specific zoo-based recommendations would require a separate treatise, here we provide a series of general recommendations based on the six strands identified for informal learning institutions:

Exhibit and program designers should create informal environments for science learning according to the following principles: Informal environments should be designed with specific learning goals in mind (e.g., the strands of science learning); be interactive; provide multiple ways for learners to engage with concepts, practices, and phenomena within a particular setting; facilitate science learning across multiple settings; prompt and support participants to interpret their learning experiences in light of relevant prior knowledge, experiences, and interests; and support and encourage learners to extend their learning over time. As such, zoos and aquariums should invest in understanding their audiences (see Chapter 6) and experiment with interactive opportunities (see Chapters 7 and 9).

From their inception, informal environments for science learning should be developed through community-educator partnerships and whenever possible should be rooted in scientific problems and ideas that are consequential for community members. Thus partnerships with school districts and local community organizations are essential for zoos and aquariums to remain relevant science education institutions.

Front-line staff should actively integrate questions, everyday language, ideas, concerns, worldviews, and histories, both their own and those of diverse learners. To do so, they will need support to develop cultural competence and to learn with and about the groups they want to serve. To achieve this, zoos and aquariums should develop training modules for staff and volunteers that take into account the diversity of audiences (see Chapter 10).

Rich science literacy becomes possible when zoos and aquariums provide real, memorable, emotional experiences that are reinforced in the classroom with science curriculum and further opportunities for discovery and exploration. Zoos and aquariums intrinsically encourage role playing, provide role models for exploration, and facilitate self-discovery. This provides strong encouragement for zoo visitors to think about themselves as science learners and to develop an identity as users and contributors to science (Strand 6). In the case of climate change literacy, the planet urgently needs a new generation of science-savvy citizens with finely tuned critical thinking skills that can take individual and collective action to avert one of our planet's greatest environmental threats.

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CHAPTER 4

Understanding and Responding to Climate Change: Psychological Barriers

By Susan Clayton, Susan R. Goldman, and Carolyn Celio

- A complex relationship exists between what people understand about climate change, their emotions about climate change, and the actions they take with respect to climate change.
- Barriers to changing understanding and behavior involve thoughts, feelings, values, and affiliations, so solely providing more information may not inspire desired changes in understanding or behavior.
- Climate change is perceived by many as remote both in time and geography. These factors may inhibit people from understanding the issue and changing behavior. When combined with scientific climate change information that may conflict with individuals' previous experience, perceptions, or with other information received from media, barriers may be further reinforced.
- Social identities and desire to fit in can be either powerful motivators or disincentives when adopting new attitudes and behaviors.

- In addition to psychological barriers, real barriers to behavior change exist, such as a true lack of control and economic realities that shape people's actions. To motivate behavioral change, these barriers must also be addressed.
- To promote behavior change on behalf of the environment, informal educators must engage audiences, share new information in non-threatening ways, and provide learners with actions they can take to positively impact the environment.

Even as scientists continue to accumulate evidence and share information about global climate change with the public, most people have not completely digested this information and have not been motivated to change their behavior. The relationship between cognition (in this case understanding the issue of climate change), motivation to act, and action is complicated and involves both what people think and how they feel. In turn, what they think and feel reflects values, norms, and affiliations. Creating communication about climate change that is effective in changing behavior depends on understanding the dual role of thoughts, feelings, values, and affiliations. These thoughts, feelings, values, and affiliations can act both as barriers to change and as levers to motivate change. In this chapter we focus on barriers; the next chapter focuses on strategies for motivating change.

What Does It Take to Change Behavior?

Actions and intention to act originate from many sources. An obvious influence is a person's attitude toward the behavior. This attitude is a function not only of what a person believes about the outcome of a behavior, but also how much the outcome is valued. The social environment, that is, what someone believes other people think they should do, is also significant. In addition, intentions to act are affected by perceptions of behavioral control:

do individuals think they can effectively perform the behavior (Azjen, 1991)? Finally, knowledge, or what people understand about the issue, exerts significant influence. In the case of climate change, potential target behaviors are based on personal understanding of climate change.

People strive for consistency in and across their beliefs, emotions, knowledge, and actions. So when they detect discrepancies (what psychologists call "dissonance"), they act to reduce or remove those inconsistencies (Festinger, 1957). However, it is difficult to predict how people will reduce inconsistencies. It depends on the relative strength of each of the factors that impacts intentional action and behavioral change. For example, people sometimes change their behavior to make it more consistent with a belief, knowledge, or norm, but at other times they may change their beliefs to make them more compatible with the behavior. A new experience may cause changes in knowledge that may stimulate changes in attitudes and beliefs. Sometimes when people join a new social group, they are exposed to different norms and values. If the discrepancies between their own norms and values and those of the new group are large, people may take one of two paths: they may adopt the new norms and values and maintain group affiliation, or alternatively, they may retain their own norms and values and drop out of the group. Of course, all gradations of these outcomes may also occur. The point is that there is a strong tendency for people to bring their attitudes, knowledge, beliefs, norms, and behavior into alignment, but changing behavior is only one way to do so.

While true environmental literacy depends upon a certain level of understanding, changing what people understand about climate change poses its own set of challenges. Furthermore, barriers to change involve what we know and how we feel so simply providing more information is often insufficient to change attitudes and behavior. Given that behavior and behavior change involve multiple, interacting facts, beliefs, and norms, we need to engage all of these to bring about change in actions.

Barriers to Understanding

What People Know about Climate Change

Several barriers impede the ability to understand an issue like climate change. In general, it is difficult for people to understand complex systems, and the issue of climate change is even more complicated because its effect involves vast spans of time and space (see Chapter 1).

An important general principle of learning is that people build up what they know and understand through direct, personal experiences and formal and informal educational experiences (Bransford, Brown, Cocking, Donovan & Pellegrino, 2000). These experiences can lead to knowledge about a complex system like climate change that is incomplete, inaccurate, or contradictory. Pre-existing knowledge strongly impacts how people perceive new information. These understandings, correct or not, are notoriously difficult to change. Generally, people try to make new information meaningful by relating it to what they already know, and if new information is inconsistent with prior beliefs, people tend to reject the new information. Efforts to present new information on climate change may not lead to anticipated outcomes because audiences lack the conceptual background to make the new information meaningful.

For example, some people do not distinguish between "weather" and "climate." They are perplexed that global warming can be happening if they experience an especially cold or snowy winter. This is because weather is both temporally and geographically closer and a more tangible part of daily direct experiences. On the other hand, new and powerful personal experiences, such as a flood, can dramatically change perceptions about climate change (Spence et al., 2011).

Climate refers to patterns over time and is not part of everyday experience in the same sense as weather. Thus, the impacts of climate change are temporally and geographically removed and are easier to ignore than what is right before people's eyes. They disregard or have difficulty absorbing information when an event is predicted to take place years from now or in a faraway place. In addition, humans are prone to assess current conditions by comparing them to previous ones, but in the case of climate change, it may be hard to recall what the previous conditions were. Environmental generational amnesia (Kahn, 2001) refers to the idea that humans quickly adapt to the state of the environment as it currently exists, while failing to recognize how much it has already changed. Few people leap out of bed one morning and say, "Wow, the air quality has really declined in the past few years."

Adding to the complexity of increasing the public's understanding of climate change is the fact that even experts may be uncertain about specific predictions about climate change. For example, scientists tend to couch their predictions in statistical or mathematical terms (e.g., "the probability of all ice melting in glacier X is 80% in the next 50 years"). Moreover, environmental change is usually considered to be incremental and fixed, but climate change challenges that notion because it may progress quite differently: some regional or local climate processes will likely be non-linear, with tipping points and unexpected outcomes. As discussed in Chapter 1, the mathematical ways scientists deal with uncertainty have been used sometimes by the media to create a sense of unpredictability or even controversy. Of particular note are segments of the news media that have created a false sense of controversy about a topic on which 97% of scientists agree (Anderegg, Prall, Harold, and Schneider, 2010). Moreover, the public does not have an intuitive way to deal with uncertainty and when trusted media or other authoritative sources sound uncertain, it can muddle comprehension.

Given all these factors, it is no surprise that access to scientific information about climate change frequently produces cognitive dissonance with the public's existing knowledge and can induce confusion about the "truth" about climate change. People's reactions to cognitive dissonance and confusion may vary. Sometimes they seek additional information; sometimes they deny or reject the new information; and sometimes they distort new information to make it fit with pre-existing knowledge. They rely on social networks to tell them which information they should trust. If they feel there have been deliberate attempts at misinformation, people may conclude that no one can be trusted. In such cases, they will probably hold fast to the status quo and assume that the future will be much like the present. These reactions depend, in part, on how they feel about the topic – their attitudes, beliefs, and emotions surrounding climate change, and the importance they place on it.

How People Feel about Climate Change

Human behavior often is driven by emotion. Moderate levels of emotional arousal are optimal for learning and behavior change. Too little arousal leads to apathy; too much arousal leads to anxiety that often impedes thought and action. It is less clear how arousal level is determined, and different people may react to similar situations or information differently. To motivate a response, educators and communicators at zoos and aquariums must evoke emotion, but also must take care with how much and which types of emotional appeals to employ. In a study using different levels of fear-inducing information in videotapes about the environment, Spratt (2008) found that worrying people too much or too little about environmental outcomes did not motivate them to switch to energy-efficient light bulbs, but moderate concern encouraged them to change.

People generally are empathic to environmental messages, but in the case of climate change, there may be a lack of perceived urgency and emotional connection to it. If climate change is thought of as a remote problem, audiences will respond apathetically. This apathy does not imply a lack of caring about nature; research suggests people do care about the environment, but if they are not experiencing a threat, they do not feel compelled to react. Audiences react most strongly to immediate problems as compared to those perceived distant into the future (e.g., caring more about the economy than climate change). Similarly, people respond to issues that are closer to home than farther away.

Too much emotional arousal may lead to inaction. Experts have noticed that people have only a finite pool of worry (APA, 2009). When the public is barraged with a never-ending stream of catastrophic events, the overwhelming nature of the problem diminishes their sense of urgency to act. Under these conditions, people hit an "emotional wall," no longer capable of caring, helping, or investing emotional resources in the issue. This may also lead to denial that the problem exists, especially if negative emotions (depression, anxiety) become associated with thinking about it. Likewise, the enormous scale of climate change may seem disproportionate to the impact of a single individual, which can lead to feelings of helplessness. This perceived lack of control fosters inaction (e.g., "the problem is too big for me, so government or big business should be dealing with this").

Understandably, most people do not embrace new information when they feel attacked or criticized. Environmentalists often make the mistake of pointing out what other people are doing wrong and then showing them the right way. This strategy can work at times, but sometimes it will be met with a response of "who are you to tell me what to do?" The likelihood of this response increases if audiences' "wrong actions" are reinforced by attitudes, opinions, stereotypes, social norms, and strong feelings. The situation activates a defensive desire to protect perceived self-images, values, social group cohesion, or desired lifestyles, all of which can inhibit the ability to even hear a message, let alone adopt new behaviors. If people are engaged in behavior that threatens something they value (such as their own health, their children's, or the planet's), one way to reduce dissonance is by changing the behavior; an easier way, however, is to find excuses that justify an otherwise conflicting behavior. For example, telling someone they can't be serious about the environment when they're driving an SUV is not an effective way to encourage them to abandon the gas-guzzling vehicle. It's far more likely they'll find a way to reconcile their climate change concerns with their SUV (e.g., "I know my Hummer is a gas-guzzler, but I mostly use it for short trips.").

Social identity is another barrier to change and an especially tenacious barrier for Americans. In fact, Americans' political party affiliation is one of the strongest predictors of climate change attitudes – even stronger than gender, education, or age (Maibach, Roser-Renouf, and Leiserowitz, 2009). In light of these powerful affiliations, the way people respond to a message depends on the context – who is the messenger? For example, when audiences with a politically conservative agenda receive information about environmental issues from Fox TV News, they will likely respond differently than if that information is delivered by Al Gore. Zoos and aquariums are perceived as politically neutral and highly trusted, so messages may be received with less resistance than through other channels.

Barriers to Action

Just as social identities obstruct the ability to absorb new information, they also make it difficult to change behaviors. Political parties are not the only type of association to sway behavior. For example, professional identities (people in stereotypically "macho" jobs may not want to be perceived as "flaky tree-huggers") and religious beliefs ("God will protect us from causing serious problems for our planet") may also preclude people from changing behaviors. Similarly, when someone defines different groups of people in negative ways ("they are not like us"), they will resist behaving like the other group, even if such behaviors make sense. On the flip side, when people perceive actions by similar groups ("they are like us"), then they will tend to believe in similar ideas, or follow suit, even when specific opinions may differ. So, confronting environmental beliefs can escalate into an assault on our identity. Fortunately, individuals sometimes are able to break free of these constraining social identity boxes, and exceptions to the rule abound. Republicans like John McCain and Arnold Schwarzenegger have openly acknowledged that climate change is a legitimate scientific issue, and members of conservative religious groups have taken action to protect the environment as a way to provide stewardship for God's creation. Even the way an issue is framed can make all the difference in its appeal to different social groups. For example, Hardisty, Johnson, and Weber (2010) found that 65% of Republicans would pay a fee for a carbon "offset" but only 27% would pay if it was called a carbon "tax."

Both real and perceived obstacles of an economic, political, or technological nature can inhibit action to mitigate climate change. For example, some people may feel strongly that increasing the mandatory mileage rate for all vehicles would be a positive environmental solution, but that option is not within

an individual's control. At a more local level, employees may want to reduce the level of air-conditioning in a workplace, but may be unable to do so. Institutions like government and business can constrain the possible actions available to individuals. Technological barriers also reduce individual options, for example when energy-saving devices are feasible but not made available to the public. Economic barriers, such as weatherizing a home and installing solar panels, pose real challenges to those who would like to "do the right thing," but cannot afford the price to implement such changes in
their homes.

A number of psychological barriers inhibit the ability to change behavior. People lack understanding of the impacts their actions have on the environment. Nor do they recognize the most effective ways to change their behavior. Conflicting goals may lead individuals to prioritize comfort, convenience, or keeping the family happy rather than reducing their environmental footprint. The delayed, abstract, and somewhat uncertain benefits resulting from behavior change may compete with the immediate and tangible costs. In the near term, people seem to find it easier to continue with established patterns than to change them. Finally, people want to make their own behavioral choices and will resist suggestions for change that seem too directive or constraining.

The challenge in transforming an individual who denies climate change into a citizen advocating on behalf of the environment is significant, especially if that person is an adult. More often it will be more realistic to transform someone who does not feel personally engaged in the issue than to transform someone who denies climate change. In either case, the task requires a shift in the way a person thinks about herself, to reinvent an established self-identity. Although this is difficult, it is not an impossible task, and is more akin to a gradual journey. The first step in bringing changes to behaviors or attitudes is to understand the person's worldview and what she considers valuable, particularly within her social context.

Zoos and aquarium educators must capture attention and provide new information in a non-threatening way, while offering easy, concrete action steps, nurturing subsequent steps with consistent encouragement and reinforcement. Using the powerful, emotion-rich attraction of live animals, and presenting them in a supportive social environment, zoos and aquariums are already fulfilling a number of these conditions. We discuss ways to reinforce such approaches in the next chapter.

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Dr. Susan R. Goldman (Ph.D., University of Pittsburgh) is distinguished professor of Liberal Arts and Sciences, Psychology, and Education and co-director of the Learning Sciences Research Institute at the University of Illinois at Chicago. She conducts research on subject matter learning, instruction, assessment, and roles for technology, especially in literacy, science, and mathematics. A major interest in her current research is increasing climate literacy through activities occurring in informal education settings, such as zoos and aquariums. Among her favorite ways to reduce her carbon footprint are walking, taking public transportation, and recycling.

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CHAPTER 5

Applying Psychology to Zoo Messaging about Climate Change

By Carol Saunders

- Before crafting a climate change message, consider the audience and connect with their interests and values.
- The same message can be interpreted different ways, depending upon how it is framed. Choose frames that are accessible and inspirational to distinct audiences.
- Sharing compelling stories, rather than simply relaying information, sparks attention and results in more memorable communication.
- People are persuaded by many factors: environmental cues, social norms, desire to minimize loss, and desire to be well-regarded by peers. All these factors can be harnessed to encourage learning and drive behavior change.
- Humans' natural affinity and empathy toward animals makes zoos and aquariums ideal settings for new knowledge and behavior change.

The previous chapter addressed some of the barriers people encounter to changing behavior. In this chapter, psychological findings are applied to guide the most effective communication for these audiences. But, before communicators decide what to say, they must understand whom they are trying to reach and what they hope to achieve. Audience-based communication speaks to the needs and interests of audiences, not communicators, and outcome-based communication is designed to achieve a specific impact.

Understanding Audiences

Two people can hear an identical message – "global climate change is leading to catastrophic environmental effects" – and have very different interpretations. One may decide to change habits to try to make a difference; the other may decide that if the world is coming to an end, why not drive a big car and live in a big house? People have unique mental models and thought processes based on prior experience, accumulated knowledge, and intuition (see Chapter 4).

The Global Warming's Six Americas Study (Maibach, Roser-Renouf, & Leiserowitz, 2009) reveals how Americans think about climate change. Six population segments emerged from the study. The "alarmed" group believes climate change is happening, that it is human-caused, that it is a very serious problem, and they have already begun taking action to ameliorate the effects. The "concerned" believe climate change is happening and human-caused, but that ill effects are still a generation or more away, so they don't really need to worry yet. They have not yet engaged in behavioral change. The "cautious" are not sure whether climate change is happening or whether it is human-caused. They are not sure if there is a risk and they don't pay much attention to the issue. The "disengaged" have heard of climate change but have no further awareness of it. The "doubtful" believe climate change may be occurring, but that it is entirely natural, that nothing can be done about it and worry is unnecessary. The "dismissive" believe climate change absolutely is not happening, and in fact the whole issue is likely to be a hoax.

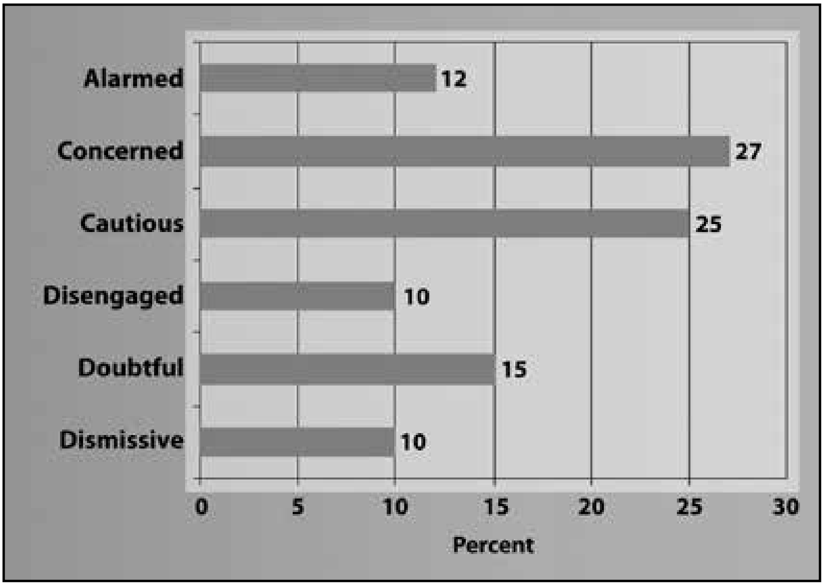

Image 5-1. For a color pdf, visit www.clizen.org.

Proportions of six population segments for May 2011 in the USA. Based on results from Global Warming's Six Americas Study May 2011 results (Leiserowitz, Maibach, Roser-Renouf, & Smith, 2011).

In the years from 2008 to 2010, the percentage of "alarmed" and "concerned" Americans declined by 5%. Conversely, 5% more Americans came to feel "cautious" about climate change, 1% more became "doubtful," and 5% more dismissed climate change entirely (Leiserowitz, Maibach, Roser-Renouf, & Smith, 2011).

Despite increased agreement in the scientific community that climate change is indeed a serious human-caused problem, and despite saturation in the media about the issue, the alarmed and concerned groups are shrinking. Some of this decline can be attributed to people being more concerned about the economy; to weather patterns that to those who do not understand the long-term nature of climate change appear to contradict global "warming"; and to fabricated scandals that flare up in the media. As mentioned in the previous chapter, the recent deluge of doubtful media messages, most of which are not based in scientific fact, has power to sway or at least confuse public opinion.

Does the zoo and aquarium community reflect the Six Americas sample? While zoo visitors do fall into each of the six categories, more are "alarmed," "concerned," and "cautious" as compared to the national average. A national study assessing zoo visitors' perceptions on climate change was conducted during the summer of 2011. Visit www.CliZEN.org for a full report (Luebke, Clayton, Saunders, Matiasek, Kelly, & Grajal, 2012).

With a better understanding of audiences, targeted outcome-based messages can be constructed. Studies reveal that different messages will resonate with different audiences based upon their underlying values. For example, members of the "alarmed" group generally hold more egalitarian values (e.g., believe the world would be more peaceful if wealth were divided more equally among nations, support affirmative action) while "dismissers" tend to have individual-based values (e.g., government should get out of our way, life sorts those out that try hard from those who do not, etc.) (Schultz & Zelezny, 2003). To communicate effectively to a variety of audiences, it is important to consider and connect with their underlying values, whether one agrees with the values or not. Educators, interpreters, and facilitators in zoos and aquariums can deliver a similar message different ways to resonate with audiences based on their values.

Related to, but slightly different than values, is determining what people care about. As it relates to the environment, different people care about different kinds of impacts. For example, some care more about biospheric impacts (plants, marine life, birds), some about egoistic impacts (me, my lifestyle, my health), and others about altruistic impacts (people in the community, children, future generations) (Schultz, 2000, 2001). Again, tailoring messages to appeal to personal concerns can engage audiences more effectively.

Risk perception is another influence that shapes world views and values. Whether an issue is rated as high- or low-risk will impact perceptions of a particular problem. As one might expect, "dismissers" rate the seriousness of global warming, or the likelihood of immediate danger, as a less likely risk than do "alarmists." And, generally speaking, people respond differently to risk depending on whether it is stated positively versus negatively (Leiserowitz, 2003). When people hear the message "Save the birch forests," they are less inclined to act then if they hear "Without intervention, we will lose our birch forests." They are motivated to minimize loss. So, the idea of imminent loss is a good way to motivate action. But care must be taken to provide audiences with a tangible behavior that will help, or else otherwise they may feel helpless and choose to do nothing.

Framing the Message

The way a message is framed can instantly captivate or alienate audiences. Frames are mental structures people use to perceive the world: labels, metaphors, stories, images, words, etc. Generally speaking, people strive for cognitive efficiency. Frames provide handy shortcuts to understanding and problem solving. So, for instance, if the goal is to encourage people to care about water pollution, the audience must first be considered – what interests them, what values they prize. Then, communicators choose a frame that best connects with these interests and values. The issue is the same regardless – in this case, water pollution – but it can be framed either as an environmental issue or a human health issue. Human health is an underutilized frame as it relates to climate change. Consider the topic of alternative energy sources. People may be more encouraged to invest in them because they help alleviate fossil fuel emissions or because new energy sources can result in new jobs and minimize American dependence on foreign oil. The same holds true with energy efficiency. People can be encouraged to drive less, turn down the thermostat, or weatherize their homes as a way to be more energy efficient or as money saving strategy. Saving forests can be framed as a way to mitigate climate change or to preserve camping and fishing sites for future generations. In fact, one study (Kaufman, 2010) showed that despite subjects' skepticism about climate change, focusing on values like thrift, patriotism, spiritual conviction, and economic prosperity led to a 5% decline in energy use.

Narrative stories are another way to share information in a memorable way. Elements of an engaging story are: coherence (events gel together in a storyline), problem resolution, mystery, characterization (a person or element the reader cares about), concreteness (helps connect the dots of everyday life), imageability (we can imagine how a problem can be solved), challenging previous knowledge (sometimes, incongruities can lead to learning) (DeYoung & Monroe, 1996). Storytelling is another technique that has been underutilized by zoos and aquariums. Yet, keeper chats are so appealing because keepers usually narrate these chats as a first-person story.

Inspiring Action

Psychology offers several theories of persuasion that are commonly demonstrated in product sales. One of the most influential persuasion theories (Petty & Cacioppo, 1986) demonstrates that two distinct types of psychological processes lead to attitude change. Central processing requires analytical assessment, is high-effort, and works best when an audience is highly engaged, already motivated, and when they are able to pay attention. This method works for zoo and aquarium audiences because generally they are excited and interested in learning. Alternatively, the peripheral route often is used in advertising when audiences are not investing attention. Knowing that people are lured by surface characteristics, advertisers use peripheral cues (a sexy model, sumptuous ingredients) to draw audiences into the message. It is possible for peripheral route messages to lead to attitude change, but the path is not as direct, and the results may be short-lived.

The previous chapter revealed how social group affiliation can inhibit behavioral change. However, peers can also encourage action and provide new norms and positive reinforcement for new behavior. When people learn and make decisions in a social context (at a zoo or aquarium, for instance), they feel rewarded for trying new behaviors. Working together to address climate change can create or strengthen social ties within a group. It is important to remember to provide concrete steps for what can be done so those who are trying out a new idea can feel good about a positive step and not guilty about an overwhelming problem. While there exists the potential for a "one and done" response, if someone is persuaded to try a small or easy pro-environment activity (switching light bulbs) and they feel rewarded by this behavior, they may be more likely to try increasingly more difficult behaviors (biking to work, weatherizing homes, contacting elected officials, etc.).

The actions of others can be a powerful motivator for change. Consider this example – if a hotel guest is told that other people in the hotel are reusing towels (rather than having them laundered after one use), the guest is more likely to reuse his or hers. That likelihood increases when the guest is told that the previous occupant of his or her room reused towels, too. During telethons, when audiences are told "if you get a busy signal, keep trying," instead of "operators are standing by," they perceive that their peers are calling, so they should, too. Peer pressure can backfire, though, changing "good" behavior to "bad." In one example, door tags were placed throughout a neighborhood telling each resident how his energy use compared to neighbors' (Cialdini, 2001). With this information, energy hogs were likely to reduce their consumption to match their neighbors', but energy angels would actually increase their usage to be more like everyone else. The problem was solved when a simple smiley-face drawing accompanied the energy angels' report. When they received a socially approved statement that they were doing a good job, they continued doing so.

Human beings are eager to forge social groups, and it takes very little to facilitate this inclination. Sometimes, however, peer pressure is tempered by environmental cues. For instance, in a parking garage litter study (Cialdini, Reno, & Kallgren, 1990), the subject sees someone exhibit "bad" behavior – a confederate litters, tossing a flyer to the ground. Will the subject litter, too? It depends on the environment. If the garage is clean, the subject generally will not litter. But, if the garage already is littered, the subject will likely add his or her flyer to the mess. Most people are drawn in and captivated when communication uses emotion, instead of the simple recounting of facts and figures. Understanding the interplay between cognition, emotion, and behavior, communicators can be intentional about how information is shared. As mentioned in the previous chapter, human behavior often is driven by emotions, such as fear – it can stall the adoption of new behaviors, but fear can motivate new behavior, too. If people fear the impact of an undesirable outcome more than they fear a new action, they may be driven to do something differently. Fear operates according to the Goldilocks principle: too much or too little and behavior will not change; it must be just the right amount. As referenced in the previous chapter, a study using different levels of fear-inducing information in videotapes about the environment found that worrying people too much about environmental outcomes or too little did not motivate them to switch to energy-efficient bulbs; moderate concern encouraged them to make the switch (Spratt, 2008).

As discussed in Chapter 4, there are potential drawbacks to using emotion as a driver for behavior change. When people receive too much information about catastrophic events, they shut down. Issues closer to home generate more response than those farther away. Examples that are closer both in time and geography may be most effective.

Of particular interest to zoo and aquarium communities is how the powerful emotional connection between humans and animals can help inspire climate change action. Animals are powerful bridges to behavior change, a subject further discussed in Chapters 7 and 9.

Inspiring behavioral change in a zoo context works best when communicators first consider visitors' values and interests, establish personal connections between visitors and a particular animal, and encourage people to feel empathy for this animal. When this is followed by a compelling story that touches emotions to convey the plight of animals imperiled by climate change, and tangible solutions – solutions being implemented by zoogoers just like them around the country – facilitators and educators can begin to foster empathy and action by millions of people each year.

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About the Author

Much of Dr. Carol Saunders' career has been devoted to wildlife and biodiversity conservation. Acknowledging that humans are both the source of many problems and the hope for a better future, she co-founded the field of conservation psychology (www.conservationpsychology.org) which has great potential for making the powerful tools and methodologies from psychology more available to conservation professionals. She is on the research faculty at Antioch University New England. Prior to that, she directed the Communications Research and Conservation Psychology department at the Chicago Zoological Society. Under her leadership, the department conducted a wide variety of studies about how people connect to animals and possible links to conservation behavior. She helped to develop programs and exhibits based on conservation psychology principles and then measured their success. Dr. Saunders received a Masters in Psychology from the University of Virginia and a Ph.D. in Behavioral Biology from Cornell University. She sees her contribution toward addressing climate change in two ways: being mindful of the daily choices she makes and focusing on aspects of her life that are her greatest sources of joy – in particular anything involving animal behavior or perception – and using those passions as the source for her work.

CHAPTER 6

Zoo Audiences and Climate Change

By Jerry Luebke and Kathryn Owen

- Most zoo visitors have a general understanding of climate change and are concerned about the impact on wildlife, especially polar bears.
- Most zoo visitors believe human behavior can impact climate change and that adopting eco-friendly actions can ameliorate some of the effects of climate change. Many zoo visitors already participate in such actions.
- Younger visitors, families, and zoo members expect to learn about climate change during a zoo visit more than other visitors, but three-quarters of all visitors believe zoos and aquariums should make recommendations for how the public can protect the environment.
- Areas where visitors have information gaps and topics they have identified as interesting can serve as starting points for education and interpretation programs.

Zoos attract millions of visitors each year, representing a wide array of backgrounds, social affiliations, and perspectives. As mentioned in the previous chapter, just as in the Six Americas audience segmentation study (Maibach, Roser-Renouf, & Leiserowitz, 2009), zoo visitors include a number of "dismissers," "doubtful," and "disengaged." Based upon results from an internal 2010 study, the Chicago Zoological Society (CZS) found that in general, zoo visitors are more responsive than other Americans to the idea that climate change is happening and feel empathy for the animals impacted by global warming.

The following is a summary of findings about zoo visitors' knowledge, understanding, and attitudes related to climate change, based upon five different surveys with a total sample size of 3,600 people: 2009 and 2010 surveys conducted by the Northwest Zoo and Aquarium Alliance (NWZAA) at the Oregon Coast Aquarium, Oregon Zoo, and Woodland Park Zoo; and 2008 and Summer and Fall 2010 surveys conducted with visitors and members of CZS. A new national study, which is part of the Climate Literacy Zoo Education Network (CliZEN), assessed zoo visitors' knowledge of, attitudes about, and action on behalf of climate change. As the first zoo and aquarium study of its kind, this audience survey provides new and interesting insights. Please visit www.CliZEN.org for the full report (Luebke, Clayton, Saunders, Matiasek, Kelly, & Grajal, 2012).

Knowledge and Concern about Climate Change

Most zoogoers are concerned about climate change and believe human actions are directly responsible for it. Seventy percent agree that the most important environmental issue confronting the world is climate change (NWZAA, 2009). They are concerned about potential outcomes of climate change with melting ice caps rated highest, followed by threats to wildlife, loss of habitat, extreme weather events, negative impacts on agriculture, and negative impacts on water supply (NWZAA, 2010).

Most visitors' understanding of climate change is not grounded in direct experiences, though approximately 30% are able to point to phenomena they believed were signs of climate change they noticed themselves or heard about from a friend or relative (such as temperature extremes, decreased snowpack on local mountains, change in bloom times, and animal migration). Most visitors reported getting their information about climate change from the news media (Internet, social media, and traditional sources), college courses, or TV documentaries (Discovery, Animal Planet, etc.) (NWZAA, 2010).

A small group (10%) is not concerned about climate change. This is slightly less than the Six Americas' 18% who are "doubters" or "dismissers" (Maibach, Roser-Renouf, & Leiserowitz, 2009). Either they do not believe climate change is happening, they agree that climate change is happening but believe it is part of a natural cycle, or they admit there is a threat, but that it has been exaggerated and/or is not as immediate a threat as other issues (NWZAA, 2010). Notably, nearly half of those surveyed at CZS in 2008 believe climate change is part of a natural cycle and not connected to human actions. But that proportion decreased by about 10% in 2010 (CZS, 2008, 2010).

When asked if they feel personally threatened by climate change, 50% of respondents say yes, similar to the Six Americas' findings (CZS, 2008; Maibach, Roser-Renouf, & Leiserowitz, 2009). Visitors' ratings regarding attitudes and beliefs about climate change are significantly related to key cognitive, affective, and behavioral perspectives, such as their general interest in animals and environmental issues, feelings of connection to nature, understanding of wildlife conservation issues, previous behaviors surrounding conservation and environmental activities, whether they feel personally threatened by climate change, and whether they actively engage in conservation efforts in their everyday life (CZS, 2010).

Concern about the Impact of Climate Change on Wildlife

Visitors to Northwest zoos and aquariums consider climate change a significant problem for local and global wildlife, and rank climate change in the top three problems facing wildlife in the Northwest.

Visitors under the age of 45 and zoo/aquarium members who visited six or more times per year show significantly higher levels of concern about climate impacts on wildlife (NWZAA, 2009). These results are similar to a recent study at science and technology museums, in which frequent visitors are far more concerned about climate change than the national average (Leiserowitz & Smith, 2011). At zoos and aquariums in the Northwest, the most frequently expressed concerns are: loss or alteration of habitats, disruption of food supply, the impact of melting glaciers on Arctic and Antarctic wildlife, and impacts on marine life such as warming water temperature and changes in water availability (NWZAA, 2010).

Knowledge of and Concern about Specific Species

Polar bears are named time and again as the animal species most affected by climate change. Twenty-one percent of Northwest zoo/aquarium visitors identify polar bears as an animal threatened by climate change, with salmon the second most frequent mention, cited by 16%, with another 8% citing fish (in general) and 6% citing birds (NWZAA, 2010). About 50% of zoo visitors report they are somewhat or very knowledgeable of the environmental conditions of polar bears (CZS, 2008, 2010). In addition, nearly 60% believe polar bears cannot adapt to the effects of climate change (CZS, 2008). Approximately half of zoo visitors strongly believe polar bears need help from people to survive in the wild. Despite these findings, only 38% understand wild polar bears cannot survive by eating animals that live on land. Very few (9%) strongly believe they personally can help polar bears in the wild (CZS, 2008), reinforcing the barriers to behavior changes discussed in Chapter 4.

Taking Action

Most visitors (about two-thirds) believe they can do something to slow the effects of climate change, a percentage that increased slightly from 2008 to 2010 (CZS and NWZAA). While the respondents were from different pools, this reflects a notable contrast to the few (9%) mentioned above who believe they can personally help polar bears in the wild (CZS, 2008). Slightly more than half want to learn more about climate change, and most (77%) believe that if everyone could conserve and reduce carbon emissions, the effects of climate change could be considerably slowed (CZS, 2008).

Actions that NWZAA survey respondents are most likely to say they "always do" include turning down the thermostat at night or when away from home, and swapping incandescent light bulbs for fluorescents. Other actions the majority of visitors say they do, either sometimes or always, include buying food locally and in-season, avoiding single-use water bottles, using cloth grocery bags instead of plastic, eating at least one meatless meal a week[2], and avoiding idling the car when waiting more than 30 seconds. Visitors are least likely to be engaged in the transportation actions on the list (buying a fuel-efficient car or leaving the car at home at least one day a week), although many report "thinking" about doing these actions in the future.

The Role of Zoos and Aquariums

More than three-quarters of respondents agree zoos and aquariums should suggest recommendations for how the public can help protect the environment. Fewer than half expect to learn about climate change during a zoo or aquarium visit, except for families visiting with children and members who visit more than six times per year – groups that are significantly more likely to say they expect to learn about climate change during their visit. It is important to note these findings are based on a handful of small studies. As we learn more about zoo visitors, we expect to discover new ways in which zoos and aquariums can engage visitors about the subject of climate change.

Opportunities for Zoo Education

In developing primary topics for education, zoos and aquariums should take note of areas where visitor information gaps still exist and of issues visitors identify as interesting – where they would like to learn more.

Visitors understand the major threat climate change poses to wildlife habitat; at the same time, when they think about habitat needs they focus primarily on animals' need for food. This initial understanding could be expanded by addressing other aspects of habitat, such as impacts on breeding and implications for migratory wildlife (NWZAA, 2010).

Visitors' basic understanding of ecosystem relationships can serve as the foundation for discussing the multiple impacts of change in one area of an ecosystem. (For example, the impacts of climate change on salmon and the resulting impacts on everything from soil composition to brown bears, eagles, and humans) (NWZAA, 2010).

Visitors are confused about whether temperature or precipitation changes they are witnessing represent longer-term trends. In other words, are they seeing weather fluctuations or climate change? An overview of the relationship between weather and climate could help clarify some of this confusion (NWZAA, 2010).

In the Northwest, visitors do not perceive potential threats to terrestrial wildlife as they do to marine wildlife (with the exception of polar bears, which they may categorize with marine wildlife). More than three-quarters of visitors could list animals facing threats from climate change, yet nearly all were species found in freshwater or marine environments or along the sea ice.

Visitors identify a lack of knowledge and a desire to learn more about the relationships between climate change and alterations in water chemistry, changes in water currents, and algal blooms (NWZAA, 2010).

Many visitors already are taking action on behalf of climate change. The implications of these behaviors could translate into two different approaches: reinforcing current behaviors by making a clear link between these behaviors and wildlife sustainability or focusing on behaviors with significant barriers but with greater conservation impact (e.g., transportation), and developing strong partnerships with government, business, and others to help reduce external barriers to participation (NZWAA, 2009).

In crafting messages to inspire and motivate zoo audiences about climate change and wildlife, the values that resonate most strongly for visitors include: connections (the interdependence of people and wildlife, the connections between people living in different parts of the world, and the link between one generation and the next), the need to take responsibility, positive visions of the future, the global scale of the challenge, and the need for worldwide involvement in finding solutions. The message that visitors found least compelling as it relates to climate change was an appeal to national pride; visitors on both ends of the political spectrum disliked the message of America playing a leadership role in responding to climate change. Visitors are skeptical about whether meaningful actions are being taken here and around the world to address climate change. Very often, the issue is disheartening. To encourage hope, zoos and aquariums are well-suited to provide visitors with concrete examples of positive actions being taken locally and globally (NWZAA, 2010)[3].

In conclusion, zoo audiences in general are positively predisposed to know about climate change and understand some of the implications for wildlife. They believe changing human behavior can help alleviate some of the potential global impacts. Zoo educators can build upon existing visitor knowledge, fill information gaps, and reinforce environmentally friendly behaviors.

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Dr. Jerry Luebke, senior manager of audience research at the Chicago Zoological Society-Brookfield Zoo, is responsible for conducting visitor research studies, exhibit evaluations, and educational program assessments. He also leads a multi-disciplinary team of senior managers responsible for overseeing audience research strategies and helping to ensure that CZS meets its mission goals and the needs of its diverse audiences. Dr. Luebke brings more than 20 years of experience in education, business, and social services. Prior to coming to CZS, he served as a senior manager with Arthur Andersen, coordinating program evaluation service delivery within a professional education division. Dr. Luebke also has conducted course and curriculum assessments on learning needs and the effectiveness of learning strategies. He taught high school special education and college-level psychology and holds an Ed.D. in Educational Psychology with an emphasis in research and evaluation. In addition to his own eco-friendly choices, Dr. Luebke enjoys talking to others about the importance of addressing climate change in their everyday lives.

Kathryn Owen, education research supervisor at Woodland Park Zoo in Seattle, Washington, oversees audience research, exhibit, and program evaluation activities. In addition, through the New Directions in Evaluation partnership, she teaches graduate students in the University of Washington's Museology program, who gain real-world experience by conducting visitor research projects in museums throughout the Seattle area. Owen has worked in the field of informal learning as an educator and evaluator for nearly 20 years. Prior to this, she worked in the union and social justice movements. She has a M.Ed. with a focus on research and practice in the field of informal learning. Her favorite way to mitigate climate change is working alongside others in her neighborhood on many habitat restoration projects, planting trees and shrubs to take in carbon plus meet the needs of urban wildlife.

CHAPTER 7

How Technology Can Enhance the Zoo Experience and Foster Environmentally Friendly Behavior

By Leilah Lyons, Tom Moher, and Brian Slattery

- A review of research reveals that although logistical and social constraints exist, zoos are beginning to incorporate technology not only as a way to share information, but to engage visitors actively in a learner-driven experience.
- Technology is most successful in zoo settings when it provides a unique zoo experience for each visitor.
- It is important that technology promotes shared experiences rather than isolates visitors.
- Zoo visits are more memorable when technology helps visitors drive their own learning, making their own observations and conclusions about animals.
- Because behavior change is correlated with empathy, zoos are encouraged to use technology that helps visitors better understand animals and relate to them.
- Not all visitors find technology to be an improvement to the zoo experience, so it should be used carefully to enhance, rather than replace, real experiences with real animals.

- A separate review of research reveals how technology can be used in the home or in everyday life to motivate conservation behaviors.
- Some of these studies used technology simply to raise awareness of current behaviors; others applied reinforcement as a way to inspire emotional change; several sought to change conceptions; and the last group sought to drive behavioral change.
- Of the studies investigating how technology can drive pro-ecological behaviors, the most success was found when technology:
  - Elicits emotion or empathy with a virtual animal or icon.
  - Encourages the use of emotion to cause people to reflect upon perceived norms.
  - Provides frequent behavioral assessments and promotes competition.
  - Encourages ownership of and a connection to information/findings.
  - Considers the unique needs and goals of a particular community when attempting to foster social action.
- Drawing upon the best practices and recommendations from the aforementioned research, the CliZEN consortium is developing a range of designs, including a learner-driven, technologically rich, embodied zoo experience that allows visitors to appreciate the scale of the effect of climate change on polar bears. More information about the project will be available by mid-2012.

Although zoos have long been involved in conservation education, the forms of media most often used to present this content (for example, signage or videos) have been largely didactic. More interactive opportunities arise when visitors engage in personal discussions with zoo educators or docents. Visitors may come away with a deeper understanding after consuming information on conservation, but it is not always clear if this information translates into changes in conservation behaviors. As mentioned in Chapters 4 and 5, theories of behavior change suggest that taking even the smallest action steps can influence larger behavior patterns. So, if the goal of zoos and aquariums is to encourage visitors to take action to mitigate global climate change, one strategy may be to use highly interactive technology to motivate those first steps.

Unlike signage or videos, interactive technology impels visitors to be active, not passive; it allows users to make decisions and take action. Moreover, technology has the capacity to involve visitors in virtual experiences, which can function as "safe places" where they may explore the consequences of different decisions, and into immersive "places" where users may literally view a situation from a new perspective.

It is important, however, not to employ technology simply because it is possible, but instead to deliver targeted experiences that actually encourage behavior change. To do so, practitioners must be sensitive to the context of use (the technological enhancements likely to be effective within a zoo setting) as well as the type of interactive experience (the forms of technology known to motivate eco-friendly behaviors). For guidance in designing technology-based experiences for zoos that encourage conservation behavior change, we investigated technology currently used in zoos and other informal learning settings, along with technology used in homes and communities that drive eco-friendly behaviors.

Technological Enhancements to the Zoo Experience

Highly interactive technology has not been widely used in zoos, owing to two main constraints: logistical constraints on the types of technology that can be used in outdoor settings, and social constraints arising from visitors' desires and expectations for their visit. From our research, we have found that a few zoos have incorporated limited technology in weather-protected exhibits, and we encourage others to share their information and best practice with us for future editions of this e-book.

Generally speaking, because zoos are large and weatherproofing high-tech experiences is costly, incorporating mobile devices has been an attractive way to offer visitors interactive experiences in a cost-efficient manner. Cell phones and PDAs give visitors extensive information about animals being observed (behavioral, biological, anatomical, dietary, evolutionary, etc.) along with opportunities to move around, explore, draw comparisons and contrasts between the animals, and share information with other visitors. Below, we review a few examples of some of these technological solutions.

Mobile Labels: Animal Information

Several institutions use technology to provide information about animals being observed. The technology provides a more dynamic experience than signage and enables updates and customization. At the Woodland Park Zoo, visitors can purchase and download the WPZoo app for mobile phones, which, among other features, invites visitors to browse a list of animals at the zoo to obtain additional information about species and their habitats. In a prototype mobile zoo application developed by Austrian and German researchers, radio frequency ID tags (RFID) are mounted on animal enclosures and visitors retrieve multimedia information about the animal they are observing by scanning the RFID tag with a WiFi-capable phone or PDA. A database enables zoos around the world to share presentations about a particular species, and an added benefit for international audiences is presentations are available in many languages. These approaches far surpass the abilities of signage, but their primary purpose still is to deliver content, not to provide an interactive experience that inspires visitors to reflect on or change behavior with regard to climate change. Another limitation is that because of small screen sizes, it is difficult to share information with companions, and this may isolate visitors, detracting from the social experience of zoo-going. This "heads-down" effect has been observed in a number of informal learning environments (Bellotti et al., 2002; Hsi, 2003).

Mobile Breadcrumbs: Customized Zoo Exploration

A London Zoo study (O'Hara et al., 2007) employed 2D barcodes (QR codes) mounted on animal enclosures. Visitors borrowed a camera phone upon their arrival at the zoo, and traveled from exhibit to exhibit scanning codes and gathering information about the animal. They were able to share with friends and family the information they "collected" about animals. This design improved upon passive information consumption by providing a customized zoo experience – from "here is information from the zoo" to "here is what I discovered during my trip to the zoo," a shift that promotes retention of learned information. And, the "breadcrumb" design (visitors shared information anywhere, not just at the animal exhibit) may be easier and less expensive for zoos and reduces competition for visitor attention at each exhibit. Several North American zoos are implementing similar technologies.

Mobile Worksheets: Visitor-driven Learning

The prior two examples use mobile devices to deliver information, albeit in slightly different ways. Several other studies use technology to help visitors more actively construct their own knowledge, often by inviting visitors to observe, compare, and contrast several zoo animals. One example (Suzuki et al., 2009) encouraged visitors to use GPS-equipped mobile phones to learn about animals' bodies from an evolutionary viewpoint. The program identified animals in proximity to the visitor and asked questions about the animal's physiology as a way to enhance observation skills and explain evolution and adaptation. As with the "breadcrumb" model, this design made information personally relevant, even more so than the previous example because visitors were actively involved in their own learning.

Mobile Post-its: Visitor Connections with Each Other

Recognizing that mobile devices can make people feel isolated rather than engaged, a recent study (Ohashi et al., 2008) used technology as a way to enhance a zoo visit, while also fostering communication between visitors. While the main application was a multimedia mobile guide similar to the examples of mobile "labels" described above, this study enabled visitors to record audio messages to accompany content delivered at a given enclosure. Other visitors to the site could experience these audio "post-its," and hear what prior visitors thought about the animals.

Mobile or Stationary Pokes: Establishing Empathy with Animals

Several studies and practices use technology to deepen the human/animal relationship, encouraging a sense of empathy with the individual animals. Conservation education research has shown that developing empathy can be a key precursor to behavior change. One such example comprises the Wild Research computer interactive stations developed by Miami University in collaboration with the Wild Research zoo consortium (www.wildresearch.org). At these computer stations, visitors are asked if the gorillas in a nearby exhibit have similar "personalities" to someone in the visitor's family. Visitors project their personality traits onto zoo gorillas, prompting rich social discussions and affective links with charismatic apes.

Part of developing empathy involves recognizing that an animal has its own unique perceptions and lived experiences, and another part involves recognizing that those lived experiences, while different in the specifics, are in principle not dissimilar from our own experiences as human beings. In another mobile applications example, the WPZoo app for the Woodland Park Zoo allows visitors to tweet or post on Facebook experiences they currently are having at an exhibit. Unlike sharing vacation photographs or stories, sharing images or observations of animals via real-time channels situates the animal's existence within a human social sphere, which can elicit anthropomorphic responses or accord the animal more empathy. One recent social media phenomenon occurred when a venomous cobra went missing in the Bronx Zoo. A fake Twitter feed went "viral," filling news and social media for days (http://twitter.com/#!/BronxZoosCobra).

Barriers to Zoo-based Technology

Technology is not always perceived as positive. Some view technology as an impediment, rather than a facilitator; a disruption instead of an enrichment of the zoo experience. Visitor age often is a factor. Generally speaking, children and younger guests enjoy virtual experiences like video and computer-based learning in informal learning institutions, while older adults tend to be intrigued by authentic objects and artifacts (Korn, 1995). To address these learning differences and preferences, zoos must offer access both to the virtual and the authentic. A recommendation is to use technology to augment, rather than replace an authentic experience; provide information or experiences that enhance the experience of observing a real animal.

Recognizing the potential for technology to isolate, museum studies have investigated how devices can be employed to foster parent-child interactions and group learning. A key recommendation is that interactive display technology should include large shared screens, visible by many people. For example, tangible interfaces such as tabletop displays encourage interactivity and engagement. The focus on learning and sharing should be readily apparent: input actions should be easily observable so the group shares and discusses individual actions.

Zoos and aquariums are in the early phases of using technology to engage visitors, to inspire active visitor-driven learning experiences. Interactive technologies can help educate and inspire attitude and behavioral change, but logistical barriers such as cost and infrastructure, combined with social barriers such as visitors feeling isolated, uncomfortable, or afraid of technology have dampened informal learning institutions' enthusiasm for these technologies. Of the studies explored, the best results were seen when institutions used technology to:

- Provide customization so each visitor enjoys and takes away a unique zoo experience.
- Ensure opportunities for visitors to share experiences with one another, both at the zoo and after the visit.
- Engage visitors in developing their own conclusions about the animals they see.
- Foster empathy with the animals with which they are interacting.
- Enhance, rather than replace, real, authentic experiences.

The studies mentioned above explore technology used currently or proposed for use in zoos and other informal learning institutions. The research does not focus specifically on technology employed to promote conservation or eco-friendly behaviors. Alternatively, the following studies focus on technologies used to promote environmentally conscientious behaviors, but they are based in homes, schools, or within a community. Evaluated in tandem, these zoo-based examples and conservation-focused studies may provide a roadmap whereby zoo and aquarium exhibit designers and educators can incorporate technology most likely to result in changed attitude and behavior about climate change.

Technology that Drives Eco-Friendly Behaviors

How can technological advances be employed to promote eco-friendly behaviors in everyday life? A review of 70 studies provides strategies for using technology to raise awareness, change emotional responses, foster conceptual change, and motivate action.

Raising Awareness

Technology can be used simply to increase individuals' awareness of current behaviors as they relate to home energy usage. Examples include a home sensor system that summarizes thermostat use; a sink monitor that illuminates water in different colors to convey the amount of hot (red) or cold (blue) water being used; e-mails sent to homeowners summarizing total energy usage for a given period of time; and a faucet sensor that determines the appropriate water temperature depending upon what is placed under it (e.g., warm water for hands, cool water for vegetables, etc.) (Arroyo et al., 2005). The goal of these technologies is not necessarily to change energy consumption, but simply to raise awareness about energy being used.

Using Emotion to Drive Change

Applying positive and negative reinforcement in response to particular home energy use practices can drive change. One example invited homeowners to care for a virtual polar bear (Dillahunt et al., 2008). To begin, each member of the household set conservation goals (use less water, turn down the heat). When family members met their goals, the polar bear thrived and looked happy; when they did not meet their goals, the polar bear's ice receded and the bear looked sad. In a similar study (Kirman et al., 2010), a virtual rabbit-like creature responded to energy use in the home. When household members engaged in wasteful behaviors (left water running, kept the refrigerator open), the creature became agitated, made noises, turned red, and exhibited "monster-like" behaviors. People were encouraged to be more eco-friendly to avoid upsetting the creature.

Conceptual Change

Encouraging people to change what they believe about their own consumption and climate change may alter behavior. One example (Strengers, 2008) studied how smart-metering demand technology could be used to address household use of natural resources (water and electricity), while recognizing people's expectations for cleanliness and convenience. By providing households with information about critical peak electricity pricing and up-to-the-minute feedback about energy or water consumption, the study evaluated if with this feedback, people would change their opinions about what constitutes cleanliness/dirtiness or comfort/discomfort. The study found technology did not necessarily impact people's beliefs as much as society's norms did; however, these norms are not fixed and can be affected by other types of influences, such as appeals to emotion. When applying technology in an attempt to change beliefs, this study indicated that simply providing usage feedback is not enough. Social norms also must be confronted by appealing to emotion as a part of or as a complement to the technology being used.

Fostering Action

Technologies that provide real-time assessments of home energy usage along with positive reinforcement for eco-friendly behaviors were more successful in driving change. In one example, family members set individual energy usage goals. Real-time data allowed them to monitor their performance continuously, rather than waiting for the monthly bill. As a result, family members became involved in friendly rivalry, which then motivated them to perform even better (Abrahamese et al., 2005). Finally, a study conducted in the San Francisco Bay Area sought to raise community awareness and inspire action about the area's poor air quality (Aoki et al., 2009). This study differed from others because it sought to drive community collaboration instead of individual action. In an effort to address concern that official air-quality sensing was inadequate, subjects were provided with technology (air quality monitoring sensors) and social support (networks to one another) and participated in a community-wide study to track air quality. The study explored the practical issues of using technological innovation and collaboration to improve environmental decision-making and the implication of these issues for environmental action. The technology enabled activist groups to collect their own data and reposition themselves as informed researchers instead of simply critics. What is more, subjects actively gathered their own data, rather than relying upon information served to them, a critical difference that connected them personally and directly to the data and encouraged feelings of "ownership" for the findings. Regarding recommendations for community-based activism, the study found that for change to endure, community members must be able to participate in eco-friendly activities directly relevant to their own ecological concerns. Moreover, they must be able to determine their own specific goals, methods, and focus. The study found that each community is different, and a one-size-fits-all approach and focus are not effective in the long run.

These studies demonstrate how technology can be used to foster an array of eco-friendly behaviors by raising awareness, driving cognitive and emotional change, and motivating collective action. Successfully using interactive technology to change behavior depends upon myriad variables, such as perception of norms, the sophistication of the technology used, the amount of time required by the intervention, and whether or not it is fun! However, generally speaking, the types of technologies that had the most profound impact on behavioral change in these studies were those that:

- Evoke an emotional attachment to a virtual animal or icon.
- Use emotion, in addition to technology, to encourage people to change beliefs.
- Provide real-time information and promote friendly competition.
- Encourage ownership and a connection to information/findings.
- Respect the unique needs/concerns/goals of individual communities.

In evaluating studies of zoo-based interactive technology along with findings from research using technologies to promote eco-friendly behaviors in everyday life, we are able to tease out best practices and make recommendations for zoos and aquariums seeking to use interactive technology to promote pro-ecological behaviors.

- Use technology that provides a unique zoo experience for each visitor.
- Technology should facilitate shared experiences between visitors (both on-site and post-visit); technology should not isolate visitors.

- Visitors should be encouraged to drive their own learning, constructing their own observations and conclusions.
- Technology should enhance visitor empathy with animals, not remove the visitor from a one-to-one experience with a real animal.
- Activities geared toward raising awareness and changing conceptions work best with repeated exposure and constant feedback to the participant. Since a zoo visit permits only a limited window of attention, technology that provides post-visit follow up and reinforcement may be more effective in changing perceptions.
- Community-based interventions relied upon existing social groups like families, activist organizations, towns, etc. with pre-established social ties. To drive social action, zoos and aquariums should look within their own already-established socially groups (e.g., members) or work to find/create shared interests or experiences among general zoo visitors so they feel a sense of community and camaraderie.
- Driving emotional change is likely the most effective way to change behavior, and fortunately, zoos and aquariums already are experts at creating emotional connections with animals.

Engaging Zoo Visitors: Piloting a New Interactive Experience

In an effort to bring together and test these recommendations, CliZEN will pilot an interactive, zoo-based activity that connects visitors to the challenges experienced by polar bears (the animal most visitors associate with climate change). The scenario for this educational experience is focused on how global climate change affects polar bears. As discussed in Chapter 2, polar bears currently are struggling because sea ice melts earlier each year as the climate changes, making hunting a challenging (and calorie-consumptive) experience. With this embodied interaction experience visitors will come to understand and estimate the relative effort experienced by these animals. Visitors will be asked to engage in actions with intentionally varied levels of effort. To make clear that bears must do more work now compared to decades earlier, visitors will be required to expend less effort when they traverse territory in past decades. We hope that this multimodal learning experience will help visitors who struggle with interpreting mathematical representations (such as the famous "hockey stick" graph). We expect to pilot this project by mid-2012 and will include findings in the next version of this book. For updates, visit www.CliZEN.org.

While we have presented in this chapter a variety of "methodology takeaways," it is clear that potentially many more exist. The focus here has been on two "big picture" strands of technological interventions, namely: (1) what we know about the use of technology in zoos, and (2) what we know about the use of technology to foster pro-conservation behaviors. As such, we began to explore which "lessons learned" conflicted with one another and which were compatible (for example, many behavior change approaches require frequent reinforcement, but zoo visits are infrequent, a conflict which drives the need for a new approach). Nevertheless, this is clearly a promising new field, and we suspect (and hope) better interventions will sprout quickly. The ability to experience and present these technological tools in the context of zoos and aquariums is one of the opening frontiers to deepen the conservation mission of these institutions.

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CHAPTER 8

What Roles Can Online Social Information Networks Play in Climate Literacy?

By Cindy Hood

- Online social and information networks have revolutionized how people maintain connections with one another and how information gathering takes place.
- Delving deeper, it is evident that these networks often reflect real life: people have many acquaintances, but few real friends; people are more likely to share low-risk information with a wide range of people and more controversial information with fewer people.
- Understanding how people use social and information networks can help to harness the medium's immediacy and reach to promote climate literacy, but it is important to carefully attend to what the objectives are and the best ways to share information.

Online Social Networks

Remember when people called friends on the phone to share news; held meetings to discuss important issues and to mobilize action; reconnected with former classmates at school reunions; and shared funny jokes and cute photos via e-mail? The advent of Twitter, Facebook, YouTube, blogs, and other social media and networks has dramatically changed the way many communicate, network, build and reestablish friendships, and keep in touch. People are far more connected than before – at least electronically. Freed from the restraints of time and geography, it is possible to maintain friendships from every stage of life and establish and maintain relationships without regard to international boundaries. A generation ago, social networks included 10, 20, maybe 30 people with whom regular interactions took place. Today, thanks to the Internet, this number reaches into the hundreds. Online social networks facilitate not only friendships, but business, commerce, advocacy, and collaboration. It is easier than ever to work with people around the world.

Information Networks

Remember when world news was revealed on the radio, TV, and in newspapers? People waited hours, even days before discovering events unfolding in their own neighborhoods and around the world. What is more, the public held a deep and abiding trust in these limited news sources. If a journalist or news reporter said it was so, he or she was believed. Today, information can easily be gathered on the Internet about virtually any topic – some of these sources are credible, many are not. There exists infinite variation in quality, perspective, reliability, truth, and motivating intentions behind each story (Rogers, 1995). Audiences are also afforded unprecedented access and immediacy, watching and learning about a tornado across town or a revolution across the globe in real time, as recorded by a credentialed photojournalist or someone with a cell phone.

Determining the Appropriate Medium for the Message

To assemble a coherent picture of how to address climate change in this new world of communication, it is important to understand the intricacies of how these social and information networks work. Fortunately, their use can now be monitored and measured on a large scale. It is possible to investigate the social media applications people use (e.g., do they choose Facebook, Twitter, YouTube, etc.?), the structure of how they are connected, and the flow of information through the connections or networks. Because social and information networks can be monitored, it is easier to understand how they are used and how they can be used to share information and to mobilize action.

Online, as in real life, it is easy to establish superficial links, but then it takes a commitment of time and energy to strengthen those ties. And certain ties are better for sharing different types of information. Strong ties make it easier to encourage others to adopt ideas, to change behavior, to innovate.

Facebook

A close investigation of Facebook networks and interactions reveals a broad network of loose connections – sometimes hundreds of "friends" who interact infrequently. But deeper relationships more closely mirror real life. Most Facebook users have a much smaller group of friends with whom they communicate regularly (Marlow et al., 2009).

- Facebook friendship requires mutuality – if an individual wants someone else to be a friend, an invitation is sent and the potential friend accepts or declines. Once the connection is established, there are several channels for two-way communication (e.g., status updates, wall posts, messages, chat).

- Facebook communication is generally intended to be private amongst friends.

Twitter

Twitter is used more for information sharing in contrast with Facebook which is more a social network.

- Two different classes of relationships exist on Twitter: followers (individuals may choose to follow just about anyone) and people who follow each other. Users follow people from whom they want to receive information.

- Twitter does not require reciprocity. Users can follow or subscribe to the tweets of other users. Although users can opt to approve of "followers," most do not choose this option.

- Twitter lends itself less to multi-friend groups or highly connected networks of friends. Although tweets are explicitly sent only to followers, they are considered public by default unless a user protects the tweets by restricting access to followers (Danah et al., 2010; Huberman et al, 2009).

How does information spread through Twitter and Facebook? At each point, a person receives information, either from another online source or from direct experience. Then, that person must make a decision about whether to share with his or her social network. It is a complex decision-making process that we do not entirely understand. Much depends upon the perceived level of risk. When people choose to "like" a Facebook page, it is relatively low risk: cute kittens and funny jokes are good examples of low-risk likes. Similarly, on Twitter, a cascade effect of retweets will result with low-risk information. People tend to retweet to entertain or inform a specific audience, to comment on someone else's tweet, to validate others' thoughts, and sometimes for their own self-promotion. The result is that through Facebook likes and Twitter retweets, information can spread quickly through a network. But, if the information is in any way controversial, it is a higher risk, and many factors determine whether or not that information will be sent forward: how controversial is the information, how strong is the tie, what are the chances the information will be forwarded, etc.

Facebook and Twitter can be used to generate common knowledge. They provide a coordinated distribution of information – everyone can receive the same information. Sharing information via Twitter and, to a lesser degree, Facebook can help to counter pluralistic ignorance or groupthink. For example, individuals may make assumptions that people who live in neighborhoods like theirs have lives similar to theirs – they mow their lawns the same number of times per week, earn similar salaries, and hold similar values and concerns. As discussed in Chapters 4 and 5, often, when one learns that his or her behavior deviates from that norm, he or she will change behavior to what is perceived as normal. Social and information networks enable communicators to inform huge audiences very quickly about what actually is happening. For instance, climate literacy can be promoted by sharing information about how much energy people are using in their homes. Details can be relayed about the links between energy efficiency and the health of our planet. When people observe that their energy usage exceeds the norm, they may make changes to be more like everyone else.

Changing Attitudes and Behavior via Social and Information Networks

To maximize the power of social networks to spread innovative ideas, such as ways to address climate change, several factors must be considered. First, intentions must be clear: is the goal to spread a message, and if so, what is the message? Is the goal to provide new information or to inspire people to change behavior? Communicators must ensure the information shared is simple, not complex, that it is easily and quickly understandable. The information also should be observable. If the purpose is trying to get others to try something different, it helps to make them aware of other people's behavior, and to demonstrate the benefit of that behavior (Easley & Kleinberg, 2010).

Social media is changing rapidly – both the technology itself and the strategies and applications available to users and audiences. As new trials are undertaken and research continues to monitor use, nascent findings may provide zoo and aquarium communicators with best practices and further recommendations for using these media to inform and mobilize audiences about climate change. Please visit www.CliZEN.org for updates.

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CHAPTER 9

Zoo Experiences in Climate Change Education

By Ricardo Stanoss

- Zoos define themselves as conservation and education leaders.
- Climate change is an urgent issue that provides zoos opportunity to combine these two roles.
- To effectively educate and encourage climate change action, zoos must examine and improve current teaching methods to:
  - Focus on the learner.
  - Activate affective pathways instead of solely cognitive pathways.
  - Set behavioral goals and assess behavioral outcomes.
  - Provide professional development training so interpreters and facilitators become fluent in climate change and the most effective educational methodologies.
- Several innovative zoo programs have shown promise in creating learner-based, climate-change-focused programming geared to motivate behavior change.
  - Indianapolis Zoo's My Carbon Pledge Program
  - Polar Bears International's Arctic Ambassador Network
  - Chicago Zoological Society/Woodland Park Zoo's Youth Collaborative
- Much can be learned from aquarium examples and by continuing to share experiences and best practices between the zoo and aquarium communities.

Leading zoos have become increasingly active in a worldwide conservation and education effort. A recent study revealed that the word "conservation" was mentioned in 83% of the mission statements of participating AZA institutions, and the word "education" was part of 70% of such statements (Luebke and Grajal, 2011).

One of the most urgent conservation issues zoos can address with their visitors is climate change, especially since despite a wealth of scientific information made available to the public about climate change, many Americans feel confused or conflicted about the subject. A recent report from the American Psychological Association (APA, 2009) summarizes a number of potential barriers to behavior, including ignorance, uncertainty, mistrust, denial, habit, social norms, and lack of self-efficacy. To address this serious challenge, zoos – which are among America's most trusted sources of environmental information – must change the way they inform and inspire audiences.

In the past few years, zoos and aquariums have begun to adopt education practices suggested by contemporary research. As well, gradually, zoo education programming has moved into alignment with the recommendations of UNESCO's 1978 Tblisi Declaration (UNESCO, 1978; Ogden and Heimlich, 2009) calling for the creation of new patterns of behavior in individuals, groups, and society as a desired outcome for environmental education. Zoo education programs have changed from simply providing natural history and animal fact sheets (often developed without considering visitors' interests, attitudes, and needs) to burgeoning efforts to make content more relevant, meaningful, and dynamic. Today, programs seek to engage hands and minds in learning. Program assessments, which were once almost non-existent, now increasingly include indicators that go beyond measures of customer satisfaction and cognitive gains to feature assessments of visitors' feelings and intention to change behavior.

Although zoos and aquariums have gathered quite a bit of information about the impact that exhibits and education programs have on guest satisfaction, they still struggle to connect learning outcomes directly with conservation missions – to ensure visitors truly understand what facilitators are trying so hard to communicate. Newer research areas, such as conservation psychology, which focuses on human/nature relationships, are identifying key drivers for the development of conservation behaviors. The research demonstrates that the classic zoo education paradigm of information leading to awareness leading to conservation is an inaccurate understanding of how conservation behavior truly is motivated. Conservation psychology has been instrumental in informing learning experiences that develop strong emotional bonds with nature as an entry point for zoo education (Ballantyne, Fien, and Packer, 2001; Myers, Saunders, and Birjulin, 2004) and learning sciences research is clarifying how people learn, public understanding of science information, and the design of effective learning environments – both formal and informal.

These new advances may be particularly relevant to climate change education, which until now has been driven primarily by a desire to share information. Experts communicate with the public through many channels, but ironically, increased media attention to the subject of climate change has resulted in decreased understanding and concern about the issue. The proportion of Americans who believe evidence supports climate change decreased by 14% in the last few years (Pew Research Center, 2009). Data indicate that people rely upon social relations, values, and emotion-driven processes when assessing the risk of climate change rather than scientific evidence (Chapter 4 of this book and APA, 2009).

As trusted, non-ideological sources of science-based information and experiences, zoos and aquariums have great potential to redirect the climate change conversation; to provide a fresh new approach to climate change education— one that employs the associative and affective pathways that exert great influence on individuals' decision-making. Imagine… millions upon millions of visitors each year, rethinking climate change and acting on behalf of the environment!

But before zoos and aquariums can change the way others think, they first must think differently about themselves: revisiting teaching methods, focusing on how visitors learn, and adapting programming to meet learner needs. Unlike many other conservation issues, climate change can be impacted by the collective behavior of zoo and aquarium visitors, so it is crucial that educators engage visitors on this issue.

As expectations of zoo and aquarium interpreters and facilitators expand to include fluency in the science of climate change and human psychology, institutions must address the type and amount of professional development provided to them. As explored further in Chapter 10, the aquarium community has begun making great strides in this arena. Institutions also must evaluate expectations for visitor learning outcomes and adjust measures for success.

Several zoos have taken exciting steps in that direction, providing captivating and illuminating education programming geared to increase awareness of and concern about climate change. The following case studies represent only a small sample of the exciting work happening in zoo-based climate change education. These examples are not meant to be representative or complete. In fact, we urge other institutions to share their innovative programs with us so they may be included in the next incarnation of this book.

Indianapolis Zoo's My Carbon Pledge

In 2007, the Indianapolis Zoo's Board of Trustees passed a resolution recognizing that a quickly warming planet caused by human activities poses a dangerous threat to wildlife and wild places. The Trustees also mandated the zoo's staff to develop and implement programs designed to increase awareness and address the problem on a regional basis. Attempting to lower carbon emissions in Indiana and its seven neighbors that comprise America's Midwest has global significance. The Midwest is one of the largest contributors of greenhouse gas emissions in the world, surpassed only by China, India, Japan, and the former Soviet Union. About 40% of Indiana's greenhouse gas emissions are from residential electrical usage. Indianapolis Zoo recognized that mitigating climate change would require cooperation and participation of Indiana residents as well as others across the globe. In response, the Indianapolis Zoo created the website mycarbonpledge.com in 2008, with the goal of educating people about climate change, helping them understand their potentially powerful impact, and motivating them to pledge to take one specific action to reduce their carbon emissions. In 2008, the "ask" was changing one incandescent bulb to an energy-saving CFL bulb. The 2009 ask was to unplug unused appliances. In 2010 and 2011, the ask was to turn the thermostat up 2° in the summer and down 2° in the winter. The mycarbonpledge.com website is strongly visual; people can see how "green" their homes are based on their pledge on a Google Earth map. As the map begins filling with green pledge dots, the idea is reinforced that when everyone works together, small actions make a significant difference.

Pledgers can educate themselves about climate change issues via environmental article links and can engage in discussions about original articles covering Arctic wildlife, climate science, climate change solutions, as well as the journey to being green. Participants can also opt to receive RSS feeds when articles are updated as well as updates when specific milestones are met.

Mycarbonpledge.com uses grassroots efforts, such as "green teams" to help spread the word and motivate people to take the pledge. Businesses and organizations sign on to become a green team and set goals for how many light bulbs they will change, appliances they will unplug, or thermostats they will adjust. Teams compete against other area businesses and organizations to achieve the best CO_2 emission reductions. The site's address is promoted on Indianapolis Zoo grounds at the polar bear and walrus exhibits as well as in presentations to guests. In the summer, staff and Zoo Teens recruit pledgers at various zoo locations and the site is promoted at area festivals and farmers' markets. The site makes resourceful use of social networking tools such as Twitter and Facebook to increase exposure.

Outcomes and Measuring Success

The website conveys a sense of urgency in addressing climate change. The most important measure of success is the reduction in CO_2 emissions. As of September 2011, participants have reduced more than 15.5 million pounds of CO_2 emissions, the result of more than 8,700 pledges. Just three years into the program, 63,367 bulbs have been changed. To understand the success of mycarbonpledge.com, it was compared to similar programs. The U.S. Environmental Protection Program's Change a Light, Change the World initiative saw 30,000 CFL bulbs distributed over 10 years. A particular high point in the mycarbonpledge.com program was when the map of Indianapolis literally was covered with green pledge dots; so many data points, in fact, that the Google Earth map ceased to load properly! The involvement of the business and civic community has been an important success measure as has been the geographic reach: pledgers come from 42 states and six countries.

Polar Bears International: Arctic Ambassador Program

Polar Bears International strives to ensure polar bear survival by motivating people to help halt climate change. The organization seeks maximum efficiency by working through a business-to-business model, whereby Polar Bears International provides tools for like-minded partners such as zoos to reach their own audiences with correct, impactful, and effective communication tools and call-to-action programs. Polar Bears International conducts an array of innovative, successful conservation education programs which inspire, inform, and empower people to make a difference by reducing carbon emissions and motivating others to do the same. The focus here is on Polar Bears International's Arctic Ambassador Center network.

The Arctic Ambassador Center network features leadership camps for exceptional teens, zookeepers, and zoo communicators. Graduates from the program go on to create CO_2-reduction programs in their own communities. These action plans help change personal behaviors and habits in ways that are measurable, accountable, realistic, and most important, impactful.

The network's Leadership Camp is an incomparable experience for people who are already proven leaders in their communities. Selected individuals spend a week in Churchill, Manitoba, Canada, the "polar bear capital of the world" to observe the animals in their habitat and learn to take action to save them. Participants gain first-hand experience from experts while aboard mobile classrooms on the tundra, and they leave camp educated, inspired, and empowered to make a difference and lead others to do the same.

A partnership between Polar Bears International and the American Association of Zoo Keepers brings together a motivated group of keepers, who spend a week studying polar bears and their habitat, while also focusing on communication and presentation skills; enhancing program planning and delivery; furthering professional skills; and networking and sharing information and experiences with peers. Before returning home, keepers create a forward action plan to reduce CO_2 in their communities.

Graduates from the program use the words "amazing" and "life-changing" to describe their experience at Leadership Camp. Participants come away with new appreciation for climate change and the impact that it has, and indicate their intent to "do something about it." Like the aquarium facilitators and interpreters introduced in Chapter 10, most of the individuals who participated in the Polar Bears International program already placed a high priority on protecting wildlife and nature, yet camp participation strengthened their commitment even more. Especially inspiring, a number of camp participants saw their role shift into one of greater responsibility to do something about climate change. These individuals indicated they were ready to return home and begin working on their wider-reaching forward action plans.

Chicago Zoological Society Youth Volunteer Corps and Woodland Park Zoo's Zoo Corps

In summer 2011, the Chicago Zoological Society (CZS) was invited to develop interpretive programming for visitors regarding climate change and its effect on animals exhibited at the Brookfield Zoo and Woodland Park Zoo. The project goal was to examine the effectiveness of youth as climate change interpreters as well as the efficacy of inquiry-based interpretation on zoo visitor learning.

Inquiry-based education actively involves people in their own learning as contrasted with traditional learning models whereby the learner passively receives information provided to him or her.

This pilot project is part of a larger Climate Literacy Zoo Education Network (CLiZEN) initiative, and through the collaboration, CZS and Woodland Park Zoo (WPZ) sought to determine if inquiry-based programming results in expanded visitor climate literacy and their intent to engage in conservation behavior more than traditional techniques. The program took place in summer of 2011 and the analyses were being completed as this book was going into publication. Results will be available early in 2012.

The young people who participated in this pilot (CZS's Youth Volunteer Corps and WPZ's ZooCorps) are among the next generation of conservation leaders, a cadre of high-school students who are actively involved with the zoos and receive hands-on project experience and mentoring. Through participation in the project, teens received training both in climate change science and inquiry-based learning theory and techniques. For eight weeks, CZS youth stationed at two exhibits – penguins and polar bears – engaged visitors in conversation about the animals and how climate change is affecting their populations. For the first half of the summer, youth were given animal specimens to engage guests in these conversations. During the second half, youth facilitated an inquiry experience. Visitors were asked if they would be willing to watch animals for two minutes and complete observation worksheets. Upon completion, visitors were invited to record their data and reflect on patterns of observed animal behavior and climate change messaging. Visitors were surveyed randomly to explore the cognitive (what do they know about climate change?), affective (how do they feel about protecting zoo animals?), and behavioral (what can they do, or what have they done, to limit their personal carbon footprints?) domains. A comparison was made between visitors who participated in the teen-led, inquiry-based interpretations to those who did not participate. Teens were evaluated with a pre- and post- survey assessing the same domains and their sense of confidence as science practitioners.

Moving Zoo Education Forward

This small sample of innovative programs demonstrates the evolution of zoo education models, as zoos move from hands-on, educator-directed learning experiences to immersive, learner-driven, behavior-changing experiences that often extend beyond the zoo gates, reaching far into communities, across state and international borders. Hallmarks of success in the programs featured here include: providing learners with direct, personal experience; offering a way to observe the power of individual action when combined with the action of others; and promoting socialization (via a network of peers, or in the mycarbonpledge.com example, a network of fellow pledgers).

As discussed later in Chapter 10, several promising aquarium-based programs are already underway and can serve as inspiration to our zoo community. Zoos and aquariums can learn by sharing successful practices and through collaboration on new initiatives. Zoo programs, like those included here, are still in their infancy, but as more are developed, launched, and evaluated, and as experiences are shared, the quality of these endeavors will improve with the quantity.

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Additional Resources

Chicago Zoological Society (www.czs.org)

Indianapolis Zoo (www.IndianapolisZoo.com)

Polar Bears International (www.polarbearsinternational.org)

Woodland Park Zoo (www.zoo.org)

About the Author

Dr. Ricardo Stanoss joined the Chicago Zoological Society in 2006 as director of education and international training. In this role, he develops, implements, and directs a comprehensive program to establish formal and informal public education initiatives and training of conservation professionals with the ultimate goal of developing capacity to lead conservation efforts in Chicagoland and around the world. Prior to this position, Dr. Stanoss served as assistant director of the National Audubon Society's International Programs, and associate director of education at Miami Metrozoo. Fluent in Spanish, English, and Portuguese, Dr. Stanoss has a strong background in environmental leadership training, strategic planning, organizational management, fundraising, and communications. He received his D.V.M. from the University of Buenos Aires. In an effort to reduce his own carbon footprint, Dr. Stanoss enjoys turning each new purchase into a green choice and riding his bike to work when Chicago weather allows.

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Aquarium Experiences in Climate Change Education

By William Spitzer

- Interpreters at zoos and aquariums are in a preferred position to educate visitors and motivate action.
- Aquariums across the country are collaborating to provide training and empower facilitators to increase their knowledge about climate change and their comfort in engaging visitors about this important topic.
- As a result of this collaboration, participating institutions have prioritized climate change, reaching multiple staff levels and departments.
- Frontline staff members have found that reframing the climate change message in ways that are meaningful to individual audience members is a compelling way to inspire action.
- Zoos and aquariums are uniquely positioned to use human connections with animals as a starting point for a conversation about climate change.
- Incorporating green principles in everything they do helps institutions build credibility with visitors.
- Collaboration participants valued opportunities to share information and best practices.
- As part of the collaboration process, participants identified learning more about psychology and motivation as priorities.

- Information and social media are powerful ways for institutions to reach visitors and for visitors to share aquarium experiences with their own social networks.
- There is always room for improvement, and collaboration participants recommended several ways to enhance communication with one another.

Zoo and aquarium interpreters and facilitators come in direct, day-to-day contact with visitors – curious people with a wide variety of backgrounds, knowledge, and affiliations. Facilitators are perceived as trusted experts, and visitors encounter them during an enjoyable activity, while engaged and eager to learn. For these reasons, zoo and aquarium frontline staff and volunteers have an enviable ability to educate visitors about climate change and help shape attitudes and behavior. Yet, interpreters may not feel confident about their own knowledge of climate change and may feel intimidated by confronting deniers with information about climate change.

Building institutional capacity to provide these key staff members and volunteers with the information, training, tools, and support most helpful to them can initiate a ripple effect, ultimately reaching millions of Americans each year.

Aquarium Collaborations

In 2008, the New England Aquarium began a collaboration with Monterey Bay Aquarium, National Aquarium and others to lead a national effort to enable aquariums to communicate effectively about the impacts of climate change and ocean acidification on marine animals, habitats, and ecosystems – to build on visitors' emotional connection with ocean animals, connect to their deeply held values, help them understand causes and effects of climate change, and motivate them to embrace effective solutions. The objectives of this collaboration[1] were to:

[1] Major funders for this work include the Institute of Museum of Library Services, National Oceanographic and Atmospheric Administration, and the National Science Foundation.

- Build a national coalition of aquariums and related informal education institutions collaborating on climate change education.
- Develop an interpretive framework for climate change and the ocean that is scientifically sound, research-based, field tested, and evaluated.
- Build capacity of aquariums to interpret climate change via training for interpreters, interactive exhibits and activities, and communities of practice for ongoing support.

In October 2008, the New England Aquarium received an Institute of Museum and Library Services grant to launch a partnership among six U.S. aquariums: Aquarium of the Pacific, Birch Aquarium, Monterey Bay Aquarium, National Aquarium, New England Aquarium, and Vancouver Aquarium. The result was the formation of the Ocean Change Education Aquarium Network (OCEAN) Project, the goals of which were: to expand institutional capacity to address ocean change via interpretive staff and volunteers; to enable aquarium interpreters to increase public awareness of ocean change issues; and to position OCEAN as a model and resource for other institutions. Specific objectives of the project were to provide interpreters with up-to-date information about global changes to oceans, especially as they impacted marine animals and to share techniques and tools to make them feel more comfortable educating the public about climate change's impact on oceans and how individual actions can help.

The OCEAN project began with a two-day workshop to assess and enrich interpreters' knowledge of climate change issues and to provide framing strategies[2] to convey climate change messages most effectively to a variety of audiences. Through annual workshops, conference calls, and sharing of video examples and training tools, project participants have continued to advance their ability to interpret climate change to the public. With the project now completing its third year, more than 1,000 interpreters have been trained in climate change science, communication strategies, and interpretive techniques. A final product of the project will

[2] More information on strategic framing can be found on the website for the Frameworks Institute, www.frameworksinstitute.org.

be an online "toolkit" that will include training activities, videos, articles, PowerPoint presentations, and other materials.

In December 2008, the Monterey Bay Aquarium, National Aquarium in Baltimore, New England Aquarium, and Association of Zoos and Aquariums co-hosted a three-day summit of aquarium leaders in Monterey, California. The Communicating Climate Change and the Oceans Summit was a pivotal step toward mobilizing a multi-aquarium effort focused on presenting messages about climate change and the ocean to aquarium visitors. In attendance were representatives from more than 40 aquariums (mostly from North America, with a combined 50 million annual visitors), as well as the national office of NOAA and several national marine sanctuaries.

The summit focused on developing a shared understanding of the underlying climate change science (especially related to the ocean), policy solutions, public opinion research, and effective communication strategies for visitors to informal science education centers, such as zoos, aquariums, and museums. Participants heard from experts in climate science, communications, and advocacy, and then generated messages and ideas for engaging visitors on this critical issue. Perhaps most importantly, the summit linked a network of institutions committed to addressing the issue.

During the final session, participants made verbal pledges of at least one specific activity their institution would carry out. Pledges included providing staff and volunteer training; creating climate change exhibits; strengthening messaging on websites and in exhibits; establishing a regional climate change learning network; creating teacher development and school programs; completing and implementing facility carbon footprint audits; and providing community leadership programs and collaborations. Several participants also committed to continue connecting with one another to create innovative ways for their institutions to take effective action.

Following the summit, participants were invited to use an array of vehicles to share information and ideas, to provide updates, and to relay experiences with one another. Vehicles for supporting the Aquariums and Climate Change coalition have included a website (www.climateinterpreter.org), online webinars, a blog, e-newsletter, and e-mail check-ins.

A result of the summit is that institutions are renewing their climate change focus. While institutions differ regarding levels of implementation, climate change communication is being integrated into the day-to-day operations and organizational infrastructures as an institutional priority. The subject of climate change is becoming front-of-mind and is, in many cases, reaching all corners of the institution – from frontline staff to senior staff to boards of directors.

In September 2010, the New England Aquarium received a grant from the National Science Foundation to further deepen and expand its work with interpreters by creating the National Network for Ocean and Climate Change Interpretation (NNOCCI). This climate change education partnership is a collaboration with the Association of Zoos and Aquariums, FrameWorks Institute, and the Woods Hole Oceanographic Institution, with evaluation conducted by the Institute for Learning Innovation. This initiative will provide comprehensive training, tools, and support to help aquarium and informal science education (ISE) professionals interpret climate change for their visitors, focusing on the impact of climate change on coastal zones and marine life.

NNOCCI will synthesize research from the fields of climate and ocean sciences as well as social and cognitive sciences; deepen the content knowledge of interpreters by engaging researchers studying the impacts of climate change on fisheries, coastal ecosystems, coral reefs, and ice-dependent animals; build a research base on effective interpretive practices and document impact on visitor learning; and facilitate "communities of practice" among interpretive staff and ocean scientists by creating a sustainable, social context for ongoing learning. By the end of this initiative, we will have developed an interpretive framework for climate change and the ocean that is scientifically sound, research-based, field tested, and evaluated; a pilot-tested model for facilitating communities of practice; a multi-tiered communication strategy and network to guarantee widespread delivery and dissemination; and tools that can be replicated and distributed.

Initiative Recommendations

Based upon assessments with participants in these national initiatives, the following are recommendations from participants' reported best practices as well as their challenges and opportunities.

1. Connect Visitors with Animals. When facilitators begin conversations drawing upon a visitor's curiosity about an animal, it becomes easier, more engaging, and personal to share information about climate change. The interaction may begin simply with a facilitator talking to a visitor about the type of fish he is observing, and transforms into an extended discussion about climate change and the impact on our oceans.

2. Reframe the Message for Better Engagement. Staff members are working to re-word and re-frame climate change topics to engage visitors of differing knowledge and opinions. Recommendations from interpreters include: start conversations with visitors about something other than climate change and build up to it; identify small actions, especially easy steps visitors can take in their own homes that can help, rather than focusing on the enormity of the situation; focus on community-based or regional solutions; understand that visitors may be experiencing "green fatigue," a feeling of being overwhelmed by what they should be doing, and to try to focus on what is hopeful; at the same time, do not be afraid to confront the severity of the issue; de-politicize climate change by making connections to the personal or local implications.

3. Partner with Scientists. Expert information has helped staff and volunteers feel more confident in their ability to engage visitors in dialogue about climate change science. Participants have been successful in tailoring messages about climate change issues to their particular audiences; now the challenge is to shift the focus to meaningful solutions.

4. Dedicate Ourselves to Institutional Greening. Institutions are taking to heart the issue of climate change. Furthering this commitment, participants believe that "institutional greening," incorporating eco-friendly practices within the organization, is

an important way to build credibility with visitors about helping to mitigate climate change. In fact, a number of participants themselves are making eco-friendly personal lifestyle changes, such as selling their cars, sharing "green" information (an important component of climate literacy) with friends and family via blogs, etc.

6. Enhance Opportunities for Collaboration. Participants recognize the value and importance of establishing and nurturing a learning community, and they seek new, broader-reaching forums where they can learn from peers' experience and work through common issues.

7. Use Social and Information Networks. Gaming, Facebook, Twitter, text messaging, YouTube, and more… information and social media are powerful ways to engage communities around climate change both as a way for institutions to reach visitors and for visitors to share with their own networks.

8. Improve Understanding of Psychology and Motivation. Participants recognize that inspiring visitors to change behavior can be daunting. Facilitators are eager to learn more about and understand better the psychology involved in motivating behavior change. As a way to monitor and assess their success in reaching visitors, participants are interested in being involved in visitor evaluations and in sharing those results with other peers/institutions.

9. Continue to Support Communication Among and Between Participants. Recommendations for ongoing communication include an online forum to enable participants to observe what other participants are working on and to share challenging issues; webinars as a way to hear concerns and respond to needs of participants as well as to communicate with other staff members; opportunities for face-to-face networking; and a follow-up summit (planned for April 15-17, 2012, in Baltimore) to continue dialogue.

It is our hope that these recommendations help other informal learning institutions to bolster frontline interpreters' ability to motivate action on behalf of the environment. Recognizing that many people visit zoos and aquariums to see animals they may not otherwise encounter and to learn more about them, we may leverage this human-animal connection to teach about climate change and to foster new attitudes and behavior.

Zoo and aquarium interpreters are in direct, daily contact with visitors and are sought out as animal experts. As such, these staff and volunteers are uniquely able to interact with visitors, building upon their interest in and empathy with animals to share information and insights, and to make recommendations. Providing key staff with tools and resources they need to captivate and motivate visitors is central to fostering climate change action.

Our aquarium collaboration experience has begun to provide us with best practices to empower our interpreters. As we move forward, we plan to share new knowledge with and learn from the experience of the zoo community. Please visit www.clizen.org for updated information.

The potential to drive lasting change is great when we combine the extraordinary reach of zoos and aquariums with a team of confident facilitators and our deep commitment to mobilizing climate change action.

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About the Author

Dr. William Spitzer, vice-president for programs, exhibits, and planning at the New England Aquarium, is responsible for development of mission-driven exhibits and programs, including oversight of exhibit design, animal husbandry, volunteer, and education programs. He also has overall responsibility for monitoring and reporting on the aquarium's progress toward achievement of its Strategic Action Plan initiatives, across all departments and programs throughout the institution. He has served as principal investigator for a number of informal science education projects funded by the National Science Foundation, National Oceanic and Atmospheric Administration, Institute for Museum and Library Services, and other agencies and foundations. In addition to extensive experience in informal science education and curriculum development, Dr. Spitzer has a background in physics, chemistry, and oceanography. He holds a Ph.D. in Oceanography from MIT and the Woods Hole Oceanographic Institution, and a B.A. in Chemistry and Physics from Harvard University. His two favorite ways to mitigate climate change are biking to work and eating low on the food chain.

Climate Change Education at Zoos and Aquariums: Where Do We Go from Here?

By Alejandro Grajal, Susan R. Goldman, and Michael E. Mann

Science has revealed that Earth's climate is changing dramatically due to human behavior. The impact of this change will be catastrophic to many plants and animals (including humans). Moreover, already we are seeing devastating impacts of climate change, such as the melting of polar ice, far more quickly and significantly than even the most dire predictions. Yet, efforts to educate people about climate change and mobilize actions aimed at combating it have realized limited successes. Despite decades of experts relaying information to the public via myriad media, and the increasingly strong scientific consensus that has emerged in recent years, the proportion of Americans who believe that evidence supports the occurrence of climate change has changed little (Pew Research Center, 2009). Why? We believe it is in large part because climate change education has not taken into consideration the ways people learn and change their behavior.

Another factor is that American journalism has confused the issue, nurturing a false sense of scientific controversy by continuing to present "both sides" of an issue about which there is an overwhelming scientific consensus. Ninety-seven percent of climatologists believe human-caused climate change is a reality, yet in an attempt to provide "balance" or manufacture tension and controversy, some media tend to portray far greater controversy in the basic findings of climate change than actually exists. This misconstrued "balance" has undermined the public's confidence in and support of incontrovertible scientific evidence. Furthermore, even those who do believe climate change is a problem may not be motivated to act. A recent report from the American Psychological Association (APA, 2009) and as discussed in Chapters 4 and 5, a number of potential barriers impede action, including ignorance, uncertainty, mistrust, denial, habit, social norms, and lack of self-efficacy. To change behavior, we must employ strategies to address these barriers which stem both from misunderstanding the climate change risks and from gaps in comprehension, attitudes, and behavior.

Solely providing more information, more data, is not in and of itself an effective way to address these barriers and gaps. Most Americans do not directly perceive the effects of climate change, nor are they likely to within the near future, since climate change expresses itself in terms of slow shifts in the statistics of weather events. Their resulting apathy about the issue means that many messages about climate change go ignored. Moreover, human beings are only able to process a limited amount of catastrophic news and so priority is shifted to a more immediate concern such as the economy. A more insidious barrier to action is that the issue of climate change has been polarized by politics (Leiserowitz, 2007). Sadly, a topic that concerns all human beings has become an issue of "us versus them," and purely scientific information has been discredited as motivated by political bias. To enhance understanding, foster concern, and spark action, climate change education issues must be reframed to be relevant to Americans regardless of political affiliation. Knowing that traditional communication about climate change has not yielded satisfactory results, we need to consider fresh alternative approaches to climate literacy.

Defining Climate Literacy

Our CliZEN project defines climate literacy as an outcome, but we have adopted a relatively unorthodox definition of climate literacy borrowed from the U.S. Global Change Research Program (USGCRP) (www.globalchange.gov). Climate literacy is defined as "an understanding of your influence on the climate and climate's influence on you and society."

Until now, the prevalent approach to climate change education has been academic – communicating fundamental knowledge about climate and earth systems sciences and studies of climate change impacts. Understanding that climate change knowledge is based upon nearly two centuries of scientific investigation, involving basic physical principles, detailed observational evidence, and well-tested models is essential to communicating the potential threats of climate change, which is why it is included in this book's first chapter. Yet, far too often, the message to the public stops there or gets bogged down in details that are overwhelming or meaningless to non-experts. For example, one approach explains the extreme global consequences that will occur if CO_2 levels are increased from 350 ppm to 450ppm, or that annual loss of Greenland Ice Sheet has risen from 20 to 30 cubic miles in the last decade. Without context, these numbers and events, while significant, may have little relevance to the general public. Another approach highlights an international policy agreement on gas emissions as prerequisite to avert a global disaster. Since many people believe their own individual actions will not impact climate change, focusing on such international policy proposals, combined with the perceived shortcomings of the Kyoto and Copenhagen agreements, has reinforced the belief that individual actions matter little. When individuals believe their behavior is insignificant, psychological barriers to action are reinforced (see Chapter 4). Yet, the cumulative impact of individual decisions can be very powerful. Actions taken by individual households could potentially reduce U.S. carbon emissions by a significant 7.4% percent with virtually no personal sacrifice (Dietz, Gardner, Gilligan, Stern, & Vandenberg, 2009). Furthermore, activities at the individual and local level can send strong symbolic messages to engage others and foster social learning (Arroyo & Preston, 2007). These activities also may create a wellspring of political and economic pressure that may unite diverse social groups and interests to form coalitions and leverage strengths (US EPA, 2000). Climate change education can reveal that changes at the micro and macro level are required to inspire large sectors of society to engage in larger, deeper changes at the policy and societal levels (Moser & Dilling, 2007).

Using the USGCRP's definition of climate literacy, our goal is that a climate-literate person would:

- Understand the essential principles of Earth's climate system.
- Know how to assess the scientific credibility of information about climate change.
- Communicate about climate change in a meaningful way.
- Make informed and responsible decisions and actions to help mitigate climate change.

Why Zoos and Aquariums?

Recent reports (Falk & Dierking, 2010) show that lifelong science learning happens mostly outside the classroom or school. This is particularly true for science issues heavily filtered by personal values and social context (climate change and evolution, as examples). For these issues, experiences outside the classroom – or informal learning experiences – become even more powerful.

The public perceives zoos and aquariums as non-partisan, trusted sources of information (Falk et al., 2007). By couching initial exposure to climate change within a zoo or aquarium visit, we hope to dispel mistrust that may otherwise block climate change understanding (APA, 2009). In addition to providing a non-threatening learning environment, zoos and aquariums have impressive reach: more than 130 million people visit North American institutions each year – the largest audience share of all cultural institutions in metropolitan areas. Zoos and aquariums offer unparalleled experiences with live animals within a rich emotional context. The experience is fun, meaningful, and personally relevant. Climate change communication can be provided in a politically neutral environment by a knowledgeable voice that visitors trust. Moreover, informal learning institutions like zoos and aquariums have been heralded as wellsprings of science learning for schoolchildren and adults, alike (NRC, 2009). For these reasons, zoos and aquariums are uniquely poised to enhance climate change literacy; to fill critical gaps in science. The challenge for zoo and aquarium educators is to capitalize on these priceless attributes and to transform a meaningful visit into new personal behaviors that benefit the environment. Recent studies reveal a link between the zoo visit and environmental attitudes, but more must be done to fortify these connections (Packer & Ballantyne, 2004).

Many zoos and aquariums are reluctant to approach the subject of climate change because of the potential for controversy. Interpreter and educator hesitancy or fear in confronting climate change naysayers or touching upon a "hot topic" has hampered our ability to develop a coherent, cohesive approach to climate change education. We hope this book and other efforts by zoos and aquariums will help inform how to inspire millions of visitors.

Zoos and aquariums face additional obstacles in teaching about climate change. For one, it is unrealistic to expect dramatic behavior change to be catalyzed by a single zoo or aquarium visit. The zoo visit is rich in personalized learning, to be sure, but usually is an ephemeral experience, lasting only a few minutes or hours. Preliminary evidence shows that even with a personally rich and rewarding experience, learning outcomes decline over time (Adelman, Falk, & James, 2000). Our alternative hypothesis is that richer experiences at the zoo or aquarium, when accompanied by remote experiences after the visit (such as electronic learning tools, virtual social media, web 2.0 sites, etc.), slow the loss of climate literacy over time. When we account for a diversity of learning styles and individual experiences, we expect a more realistic hypothesis in which post-visit supplements may lead to varying results.

Conclusions

Scientific evidence reveals that the consequences of fossil fuel burning, including warming temperatures, sea level rise, icecaps melting, and ocean acidification, are being witnessed at rates and magnitudes greater than even the most pessimistic previously predicted scenarios. Yet evidence of the reality and threat posed by climate change, alone, has been insufficient to mobilize popular support for actions to mitigate it.

The psychological components of climate change learning are complex, but we are gaining a better understanding of personal motivations and barriers to action and behavior.

North American audiences (and likely other audiences as well) are complex and defy simple segmentation analysis. Averages about the public perceptions and responses to climate change must be carefully considered. In Chapters 4 and 6, we see a plurality of knowledge, attitudes, and preconceptions about climate change, therefore climate change communication must be tailored to that diversity.

Live animals at zoos and aquariums provide humans with a powerful emotional link to natural processes, including issues as intangible as climate change.

Our perception and understanding of the climate change threat is heavily influenced by preconceptions and biases based upon political, spiritual, and social values. Simply providing more scientific information is not, in and of itself, an effective tool to educate and motivate all audiences. "Merely amplifying or improving the clarity of information on climate change science won't generate public consensus if [risk] communicators fail to take heed of the cues that determine what climate change risk perceptions express about the cultural commitments of those who form them. In fact, such inattention can deepen polarization" (Kahan et al., 2011).

Opportunities and Next Steps

Zoos and aquariums are the "sleeping giants" of environmental awareness and action. How do we capitalize on this potential to help mitigate the effects of global climate change – the greatest environmental threat of our time? No one single approach will be universally effective, but we can and must learn from missteps and successful practices. Zoos and aquariums are among the most trusted cultural institutions in the United States, and the live animals in their collections provide powerful emotional, cognitive, and spiritual connections to the natural world.

How do we best engage diverse audiences and drive meaningful action? How can we extend the ephemeral nature of the visit to the zoo? How can we overcome the personal, political, and social barriers of climate change education?

First, we may need to adjust our goals. We certainly hope our environmental education interventions will result in positive changes in environmental behavior and action. However, not all audiences are ready to take immediate action (particularly when they don't perceive climate change as "their problem"). We must recognize that many Americans doubt individual actions can make a difference. They believe their actions are insignificant compared to the responsibilities of governments and big business. We must first engage Americans in a meaningful dialogue about climate, an opportunity where zoos and aquariums can be quite influential since conversations can begin while a visitor is emotionally engaged with a live polar bear or a vibrant coral reef. It is our assertion that these types of conversations are the first and perhaps most critical step to building climate literacy. Interpreters and facilitators can gauge visitor knowledge of climate change; establish emotional connections between a vague topic and a real animal; and provide clear steps to simple actions.

Second, we must use our living collections to create interpretive tools and teaching methods. North American zoos and aquariums boast some of the richest and most diverse animal collections in the world. Institutions, including those in CliZEN, may choose to focus on iconic animals affected by climate change, such as polar animals or coral. Others may just as easily start the conversation with snow leopards, seahorses, Andean frogs, or blue crabs.

Third, we must further our knowledge in methods of establishing climate literacy. Below is a preliminary list of research questions and education practices for zoos and aquariums to explore in the near future:

- How does climate literacy evolve over time for different audiences (a longitudinal study of attitudes)?

- How can digital media and learning extend and amplify the "zoo visit effect"? What are the demographics and technological trends that may affect this powerful new vehicle?

- How do spirituality and emotions affect learning and climate literacy? How can zoos explore these fields of cognitive engagement?

- How can we best use the tools in our toolbox – how can we harness the power of the interpretation and education methods available to us (interpreters, signage, storytelling, electronic media, exhibit design, etc.)?

These are just a few ideas we would like to explore in the future. In the meantime, we hope this book—an initial investigation—provides useful information for zoos and aquariums to develop new approaches to climate change education. Our hope is that through the leadership of American's trusted and cherished informal learning institutions, visitors will make personal connections to climate change via their empathy and caring for imperiled animals.

When zoos and aquariums engage visitors intellectually and emotionally, when we can share "stories" of threatened animals, when we successfully extend the experience into everyday life, we may begin to see an impact. Our institutions have the power to change the course of climate change – galvanizing millions of visitors who are mesmerized by animals.

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