

# Seeking Park-based Science Information: Interpreters at the Gate

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## Introduction

DURING THE 2015 GEORGE WRIGHT SOCIETY CONFERENCE PANEL “Redrawing the Boundaries: Science Communication in the National Park Service (NPS),” Park Service leaders discussed the shared responsibility for communicating science across job categories. Tim Watkins, science and education coordinator, and Julia Washburn, associate director for interpretation and education, acknowledged that making science prominent at parks has historically been neither an established nor a high-profile priority, and recommended scientist–educator partnerships to help increase science learning at parks. Interpretive rangers’ contacts with the public number in the millions annually. Clearly they are in a strong position to be part of initiatives that convey park-based science to the public (National Park Service 2015).

The most logical place for interpreters to gain familiarity with park-based scientific research is in the park. Resource managers are in the position of gate-keepers, or, preferably, gate-openers. They keep the calendar of scientists’ presence at the park, review permit applications, and generally have the technical background to appreciate the findings in annual and final reports. If the resource managers and leaders at parks facilitate communication with interpreters about independent researchers’ work and its relevance to management decisions, interpreters can highlight parks as our nation’s laboratories. Visitors stand to gain respect for national parks as active sites of research as well as lands set aside for scenic and historic preservation. Increased contact among researchers and interpreters can also increase interpreters’ and visitors’ science literacy—how we know what we know, build respect for the scientific process, and communicate important ideas about science, such as the fact that it can happen collaboratively, in beautiful outdoor settings.

When communication between divisions about the research on park resources is lacking, interpreters are at risk of disseminating information that is dated or only partially true, or of avoiding conversations with visitors about cutting edge science taking place at the park altogether. Two of the co-authors of the present article (Allen and Hristov) witnessed moments

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of misinformation when they were conducting research on the bat emergence at Carlsbad Caverns. To address these, they collaborated with park staff on a fact sheet, a living document about bats, which was circulated among interpreters. Further, they conceived of professional development that combined details about their studies with fieldwork. With funding from the National Science Foundation (NSF; DRL #1323030), Hristov, Allen, and a third co-author of this article (Merson) piloted their professional development model as an NSF Pathways project, Interpreters and Scientists Working on Our Parks (iSWOOP).

The purpose of this article is to demonstrate the need to bring interpreters into direct and frequent contact with those conducting park-based or park-relevant research (hereafter referred to as “scientists” or “researchers,” though this label is intended to encompass resource managers and can include historians, monitoring teams, or other researchers as well as scientists). The focus is on interpreters’ response to survey questions about their access and need for information, the frequency and type of interactions they have with scientist, and the benefits they perceived when they did have opportunities to interact with scientists. Although survey data reported here were collected as part of the iSWOOP project, this article is not primarily about iSWOOP’s intervention, features, or professional development model. Rather, it is intended to share insight into interpreters’ perspectives on missed opportunities and on the potential rewards for greater understanding of park-based research.

National Parks are important venues for science, technology, engineering, and math (STEM) learning as well as civic engagement. In its *Call to Action for the 21st Century: Preparing for a Second Century of Stewardship and Engagement* (National Park Service 2012) and *Vision Paper: 21st Century National Park Service Interpreter Skills* (National Park System Advisory Board Education Committee et al. 2014), the Park Service articulated a commitment to scholarship and stated its intention to be a stage for informal science learning. With these commitments, NPS has set high expectations of interpretive staff, whose mission is to facilitate visitors’ emotional and intellectual connections with the nation’s collective heritage and natural resources (Tilden 1957). Common sense suggests that knowledge of the resource is highly important. Recent studies offer evidence for a more nuanced understanding of what knowledge of a resource entails.

Stern and Powell (2013) offer a definition of “apparent knowledge”: the degree to which the interpreter appears well-versed in the content, capable of providing the answers to visitors’ questions, as well as knowledgeable about the area and its resources. To be perceived as knowledgeable is a key element of establishing competence and credibility.

Knowledge about the resource comes from a variety of sources, including resource managers. According to a survey conducted by the San Francisco Bay Area Network, the primary means for sharing information was personal communication between staff members (De-Backer et al. 2009). Staff from the park’s Division of Resource Management familiarize new staff with the resource and critical management issues. At some parks, resource managers and science or education coordinators arrange for scientists to present their relevant research (Abe Miller-Rushing and Bruce Connery, pers. comm., 2015).

After orientation, interpreters are expected to take charge of their own learning. Interpreters can turn to a virtual storehouse of scientists’ permits and annual reports maintained

by the Park Service. Respondents to a survey by O'Herron (2009) had not heard of some information sources and most found it hard to get information, as it was scattered among various websites and local network drives. Science coordinators at Research Learning Centers make research briefs available to staff, though their use appears uneven according to emails exchanged in 2016 by NPS employees Tara Carolin, David Shelley, Paul Super, and Shannon Trimboli. Conducting internet searches yields article abstracts, but accessing full texts quickly becomes prohibitive. Clearinghouses charge fees, often \$50 or more per article.

Pursuing new information is in keeping with the Park Service's Interpretive Development Program (IDP) stance on professional development, which is explicitly in favor of ongoing, career-long learning (<https://www.nps.gov/idp/interp/theprogram.htm>). Interestingly, in its *Foundations of 21st Century Interpretation*, the IDP has shifted its emphasis. Knowledge about resources still has a place, but increasingly one that serves audience engagement and audience-centered interpretation (National Park Service 2016).

After conducting interviews with visitors who participated in ranger-led interpretive programming at six NPS sites, Forist and Knapp (2013) found visitors were more likely to recall information when interpreters took advantage of timing and location to impart information. For example, visitors who encountered a lizard while hiking and heard about it remembered it more vividly than visitors who participated in a patio talk about lizards. This finding amplifies the need for interpreters to have depth of knowledge about the resource (and park-based research studies) that they can coordinate with activities, wildlife sightings, and locations within the park.

In a different study of interpreters' programs, Stern and Powell (2014) aimed to identify the techniques and features of ranger-led programs that led to high levels of visitor satisfaction. Knowledge played a foundational role. The authors posited that presenters who are more familiar with their topics generally experience less anxiety and therefore project more confidence. When interpreter confidence was perceived as low, it stood out as one of the characteristics associated with participants leaving ranger-led programs before the program's conclusion. However, too much knowledge could be a liability as the perception of someone as a "walking encyclopedia" also surfaced as a characteristic associated with attrition.

The most recent effort to identify the training needs of NPS personnel points to the need for knowledge alongside the need for science communication strategies (Powell et al. 2014). Respondents assigned a level of importance from 1 (unimportant) to 7 (extremely important) to each of 80 specific competency questions related to six overarching categories. Among items in the "Finding and Assessing Knowledge" category, those interpreters with 3–5 years of experience assigned the highest importance to "Developing ongoing collaborative relationships with subject matter experts to remain current with issues and research." They also attributed high importance to articulating "complex concepts in layman's terms without using jargon or losing accuracy." These areas of importance are very much in line with the survey responses the iSWOOP project gathered from Carlsbad Caverns interpreters.

## Research questions

At the beginning of iSWOOP's work with interpreters at Carlsbad Caverns, the project staff

and evaluator wanted to know about interpreters' science background, opportunities they have had to learn on the job, and how they have informed themselves about park-based science research. This information helped the project understand the ways iSWOOP was bringing new approaches and content to interpreters. The data are useful apart from the project, yielding a more nuanced picture of:

- The challenges interpreters said they faced in accessing and understanding park-based scientific research;
- The frequency with which interpreters sought information;
- The sources they relied on; and
- The advantages interpreters cited as a result of greater contact with scientists.

### Setting and project overview

Carlsbad Caverns National Park is famous for its dramatic cave formations and the spectacle of bat emergence and return. The park has been the site of landmark scientific work on rabies and population dynamics. Co-principal investigators Hristov and Allen have conducted scientific research at Carlsbad Caverns and in other caves in the region since 2004 (e.g., Betke et al. 2008; Allen et al. 2009; Kunz et al. 2009; Hristov et al. 2010). Their research on the Brazilian free-tailed bat formed the centerpiece for the professional development sessions. They shared a collection of scientific visualizations that interpreters could show visitors to make prominent the research on this charismatic species. Fourteen interpreters participated in the iSWOOP project's first two rounds of training in January and June 2014. As a result of training, interpreters crafted a program using a subset of the material in the visual library that they subsequently drew on in their interactions with visitors (Figure 1).

### Sample, methods, and analysis

The sample consisted of 14 interpreters who participated in approximately 20 hours of iSWOOP professional development. A mixed methods approach was used, with data sources including pre- and post-project interpreter surveys, observations of visitor programs, and

**Figure 1.** Wildlife biologist Nickolay Hristov shows Carlsbad Caverns National Park interpreters an improvised tripod and reflective sphere. Interpreters and scientists strategically placed 72 spheres as reference points for laser scans of the cave. Photo courtesy of Isaac Banks.



open-ended feedback forms interpreters submitted that described visitor learning occurring during programs. Of interest here are the survey responses from the 14 interpreters (100% return rate) who completed surveys online prior to the first day of training, and post-program surveys after they had at least ten weeks in which to implement iSWOOP visitor programs. Interpreters answered a mix of open-ended short-answer, multiple choice, and rating-scale items on the surveys (18 pre-program items; 22 post-program items). Several items were designed to capture the working knowledge and prior experience that interpreters might draw on to explicate science processes or to build science literacy with visitors. Quantitative survey data were analyzed using descriptive statistics and frequency distributions. Open-ended prose responses were coded for emergent themes (Charmaz 2006), and cross-checked among two researchers to establish consensus on the coded data.

Supervisors did not have access to individuals' survey responses and there was no financial benefit for participating in either the project or the evaluation. Thus interpreters were not under pressure to give impressive answers or to over-state their competence in finding and interpreting science. In reports and articles, including this one, interpreters are given pseudonyms.

### **Participants: Interpreters' backgrounds**

As a group, the iSWOOP interpreters constituted a relatively young workforce. Most of the 14 were in their twenties or thirties; two were in their fifties. Over half (8) had worked in national parks for five or fewer years. Interpreters had worked at a number of different national parks. Over half (9) had experience in four or more different parks across the country with just four mentioning working at only one or two parks total. Only four had been working at the caverns continuously for four or more years. However, four of the seven seasonal staff participating had worked at the caverns previously.

Almost two-thirds of the interpreters held degrees and training in the sciences (e.g., wildlife science, park management and conservation, bioenvironmental sciences, earth science). One-third had non-STEM backgrounds with degrees in history and anthropology, for example. In their off-hours, nearly all pursued activities related to their park work (e.g., trail restoration, doing talks for school groups, photography, hiking and caving, and reading magazines about science and nature.) Thus, individuals were engaged in learning and doing in fields related to their paid positions as park guides (the GS-5 pay grade).

### **Findings**

The interpreters' responses in their surveys provided a window into how they informed themselves about park-based research. To supplement their working knowledge of park phenomena, interpreters sought information out weekly or more often, relying mostly on on-line sources. Contact with scientists was rare. However, when interpreters had conversations with scientists, they reported benefits, anticipating they would draw on these conversations for content and stories in their work with the public. Survey responses also suggested actions from resource managers and scientists that could be helpful to support interpreters in their work.

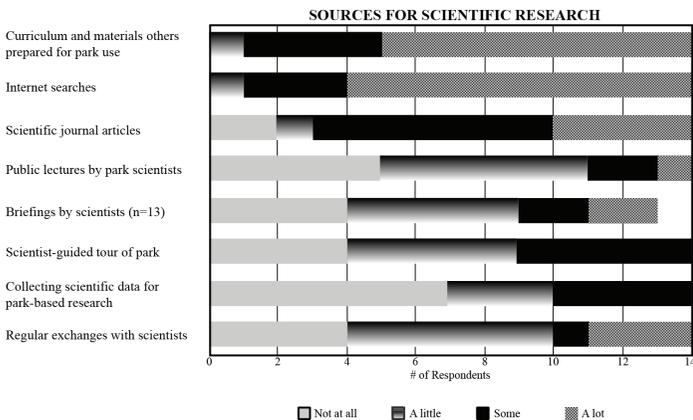
Interpreters mentioned a wide range of challenges, starting with simply knowing that scientific research is going on at all. Kate, a seasonal interpreter, said, “There is a massive dividing line between outside research and our interp divisions, at most parks. Simply knowing that research is happening is the toughest hurdle to overcome.” However, Nancy, a permanent staff member, felt that “maintaining regular communication between researchers and interpreters, so we have the most up-to-date research to interpret” is a challenge. While Nancy and Kate located the challenge outside themselves, Winston made it personal: “The biggest challenge for me is my ability to understand the science research so that I may incorporate it into programs. I find that science research now is very specialized and complicated.” Thus, interpreters stated a range of challenges, starting with simply knowing that scientific research is going on at all, to being kept up-to-date on it, and finally being confident in interpreting it.

In pre-program surveys, interpreters described their pressing needs for scientific information about park phenomena. The vast majority of interpreters reported frequent searches for scientific information. Half (7) indicated that they searched for information several times a week, while an additional five reported that they did so “almost weekly.”

Interpreters tended to rely most heavily on the Internet, followed by materials prepared by others for use in the park, and then, scientific journal articles related to science in the park (Figure 2).

Interpreters indicated that they were generally successful in finding the information they sought. Some reported having strong research skills. One interpreter (Jill) commented, “Sometimes it feels like a wild goose chase, but I usually find what I’m looking for.” Some interpreters mentioned their strategies, such as consulting co-workers, which significantly heightened their success.

For most interpreters, direct contact with scientists was rare. A large majority reported the frequency of contact as “a little” to “none” regarding public lectures by scientists at the park, participating in actual scientific data collection for park-based research, or regular ongoing exchanges (in person or by email) with scientists (Figure 2). Briefings by scientists (n=13) were also quite rare. In commenting on the dearth of



**Figure 2.** Sources for scientific research.

information, one interpreter (Samuel) observed: “It seems that often research being done is being kept for the scientists while the interpreters are being left with the public domain information.” An interpreter (Rico) pointed out that in their initial training, there is lots of contact with researchers, but that future contact only seems to occur when he is seeking answers to questions. Such comments show that interpreters are aware that they are missing out.

When information flowed, interpreters noticed and appreciated this. Abe said: “At [one park] there was a great deal of informal contact between resource management and other park employees and I would credit those individuals with keeping people informed of projects and offering opportunities ... to assist.”. Interpreters made suggestions for increasing their contact with scientists. A seasonal employee (Yvonne) wrote that “I would love it if short talks and briefings with park staff would be built into research permits....”

When commenting on engaging the public, some interpreters highlighted the challenge of offering effective translation, while others focused on the challenge of encouraging visitors to listen and engage. Comments about effective translation were grounded in awareness of the audience, their prior knowledge, and their background. “Interpretive programming must effectively translate scientific research in a limited time frame to an audience with possibly little to no background in a topic or even the processes of research,” Yvonne commented. Her colleague Jill wrote: “The biggest challenge is avoiding the trap of jargon! Science research can sound like a foreign language to many people, and I have to remind myself that while I may be familiar with certain concepts and vocabulary now, it is the visitor’s first time hearing it.”

Most of the interpreters acknowledged the challenge in actively engaging visitors by encouraging them to share their thoughts and questions. Provocation is a part of the interpretive tradition (Larsen 2003) and iSWOOP encouraged interpreters to elicit visitors’ reactions. Two comments spoke to the tension that can surround the invitation to visitors to participate actively. Lena’s comment highlighted the expectations or norms that govern the interpreter–visitor interaction: “I think visitors are used to being talked to and not involved in the scientific process. Children were more willing to answer questions but adults have a few more inhibitions.” Patricia’s comment suggests that the unpredictability of park audiences was an obstacle: “As a presenter we need to tailor our talk to our audience, but the audience can be inquisitive or not and you don’t want to expect them to do the lifting if they don’t want to.”

Rico summarized the progression of challenges in the following way: “The biggest challenge is presenting research that can capture an audience’s attention to begin with, to present it in a way that keeps the information in lay terms, and allows the visitor to understand the ‘so what?’ factor—why it’s meaningful to [the] place and to themselves.” This comment shows that there is not just one challenge to surmount, but rather a series of challenges that require attention and on-the-spot adjustment.

iSWOOP professional development offered approximately 20 hours of direct contact with researchers and access to the researchers’ scientific visualizations, as well as strategies and techniques to promote visitor interaction. When asked to reflect on how iSWOOP had benefited them, most interpreters cited access to scientific research being conducted at the park. All but one indicated an increase in their understanding of the kinds and extent of on-site research being conducted at the park, and of the scientific techniques and technological

tools used to conduct that research. Comments from interpreters fell into two categories: one that named their own better understanding of science process and the other that referenced expanding visitors' ideas about parks (Table 1). Several interpreters linked gains in their own understanding to improving or expanding interactions with visitors. This is most clearly evident in Patricia's words: "We are all inquisitive and curious. . . . I am helping visitors explore the possibilities and ways in which technology has advanced our understanding of bats [in this case] and how we interpret/process what we see."

In summary, interpreters in the iSWOOP pilot were dedicated to their craft—conducting online searches, seeking out information from co-workers, and spending personal time on related activities. They struggled with the challenges of access and commented on the lack of opportunities to connect with scientists and resource managers. When offered, these conversations were appreciated. Interpreters welcomed information that is not readily available to the public and expressed wanting to pass on their enthusiasm for it to visitors. Interpreters said that contact with scientists increased their understanding of the research.

## Discussion

Survey responses enabled the iSWOOP team to gain insight into this small subset of early-career interpreters' perspectives and experience interpreting scientific research. NPS priorities such as its commitment to scholarship and providing a venue for lifelong learning carry an obligation for interpreters who have to turn NPS priorities into interpretive opportunities. Without access to researchers, interpreters spend time searching out relevant resources. As

**Table 1.** Benefits of direct contact with scientists.

<i>Theme &amp; Key Ideas</i>	<i>Examples in Survey Responses (Quotes from Interpreters)</i>
<i>Insight into science process</i>	
Deepening understanding of the scientific method, how research is done, and the scientist's personal experience in research	"My understanding of scientific method was not very deep. Being part of iSWOOP definitely added to my knowledge of how scientific research is being done and the details that go along with it, as well as the scientist's personal experience in the research." (Lena)
Increased understanding of the tools used to study bats	"I have a greater understanding of the tools used by researchers to study the bats. I knew the results of the research but now I have a better understanding of the data that was gathered to come to that understanding." (Patricia)
Better understanding of data gathered to come to new understandings	"... We are all inquisitive and curious. . . . I am helping visitors explore the possibilities and ways in which technology has advanced our understanding of bats [in this case] and how we interpret/process what we see." (Patricia)
Perception of research as happening behind the scenes, behind the curtain. Understanding the process, contrasted with taking findings on faith	"In many parks it [research] happens behind the scenes and the interpreters are only told about the end result. We are asked to talk about something we are expected to take on faith." (Samuel)
<i>Expanding visitors' ideas of parks</i>	
Parks synonymous with active research	"I want all visitors to see their parks as hotbeds of active research!" (Yvonne)
Scholars use parks for their work	"I think the most beneficial thing from my experience is that it has led me to take a step back and see this park not only as a precious resource and visitor attraction, but also as a site for research. This is a theme which . . . makes our parks seem more fresh and alive, if we can alert our visitors to the fact that many scholars use the NPS locations on a continuing basis for their work." (Winston)

noted in the literature, interpreters' apparent knowledge is tied to credibility and influences visitor satisfaction and outcomes. Finding and assessing knowledge on park resources is an ongoing part of interpreters' work. Yet interpreters at Carlsbad Caverns faced challenges in finding, accessing, and understanding park-based scientific research. They saw advantages to having contact with scientists and resource managers, and envisioned how such contact could translate into communication of science with the public. Survey responses contained implied and explicit requests, naming actions from resource managers and scientists that would be helpful in their work.

**Challenges to finding out and using park-specific research.** To be effective interpreters, rangers need appropriate techniques and knowledge of the resource. To those who say that everything is online nowadays, this over-simplification of access obscures several challenges. First, the available content is daunting. There is so much to wade through. Even those with stellar research skills have limited time to sift through and make sense of search results. Second, for those seeking out scientists' papers, steep fees often apply to accessing peer-reviewed journal articles. Third, once in hand, most journal articles assume a readership with a technical background, making the text impenetrable for a person with a different academic background. Though many interpreters felt equal to the challenge and successful in finding pertinent scientific information, a level of uncertainty plagued some interpreters, who questioned whether they were interpreting the studies correctly.

Feeling uncertain about park-based research can affect interpreters' interactions with the public. Visitors who perceive a lack of confidence or competence may choose to leave a program (Powell 2013). Without confidence in their knowledge and the ability to reveal something special about the resource, interpreters may choose to say nothing about park-based research, falling back on facts or trivia, which perpetuates the idea that science is a collection of established facts rather than a process driven by questions.

Interpreters displayed a nuanced understanding of the challenges in communicating about scientific research in an interactive way. Interpreters described challenges related to complexity of the material, visitors' expectations for involvement, visitors' background knowledge, and motivation for participating. When tracking down research studies becomes consuming, little time is left to plan how best to convey the content to visitors and establish a dynamic that welcomes and fosters questions.

**Advantages to contact with scientists.** Interpreters attributed increased understanding, first-hand experience, and enthusiasm about on-site scientific research happening at their parks to direct contact with scientists. An external evaluator of the iSWOOP project found that on-site professional development with scientists over a number of hours, both in seminar style and in the field, were rarely utilized forms of contact and collaboration (Char 2015). Even seasoned rangers with multiple years of experience at the park welcomed the on-site, place-specific professional development. This finding echoes the needs assessment in which "developing ongoing, collaborative relationships with subject matter experts to remain current with issues and research" was seen as important (Powell et al. 2014). While not the focus of this article, it is important to note that these benefits do not accrue solely from contact

between interpreters and scientists, and from access to scientists' visual images. Structuring mutually beneficial interactions takes time and planning. Further, iSWOOP modeled the use of interactive techniques to communicate science. Reflecting on iSWOOP professional development, interpreters expressed not only fewer concerns about their own access to information but revealed a heightened awareness of techniques appropriate for engaging visitors with scientific research. Interpreters stated that iSWOOP had helped them better engage visitors in the ongoing research occurring at their park and for conveying the process of doing science, including researchers' applications of cutting-edge technology. Most interpreters also reported that they more actively seek to engage visitors in conversation, rather than focusing on delivering their message.

**Helpful practices and directions for future research.** Practices that are common at individual park units could be adopted more widely, customized, and refined. Early in the process for approval or initiation of a new study, park staff and scientists could:

- Agree to scheduling briefings for staff at a variety of times to accommodate schedules.
- Generate a list of images and artifacts to share with interpreters and the public to support explanations of the process and technology or instruments.
- Shape opportunities for interpreters to accompany scientists into the field, thereby increasing their first-hand knowledge and supporting the scientists' on-site work.
- Co-create and design mutually beneficial research activities from an educational and management perspective.
- Seek input from interpreters on their preferred format for research briefs.

These suggested practices, which are similar to those listed in a summary of a panel discussion on science communication held at the 2009 George Wright Society Conference (DeBacker et al. 2010), seek to increase opportunities for personal communication and create predictable mechanisms for communication. Adopting these practices would increase interpreters' access to active site-based (place-based) science research.

An effort to understand the value interpreters give to such opportunities would be helpful in establishing priorities. NPS Research Learning Centers have experimented with producing condensed summaries of studies. To the authors' knowledge, however, there has been no formal investigation into how interpreters use these. Observations, interviews, and even surveys could reveal how distilled versions of scientists' work are referenced and woven into programs for the public. As the iSWOOP project progresses, we hope to share with the field how opportunities to interact with scientists informs interpreters' programs and informal interactions. Perhaps there will be multiple factors that influence the translation, the level of detail, and the confidence of interpreters as they communicate about park-based scientific studies with visitors.

## Conclusion

Interpreters have a pressing need for park-based science to augment their understanding of park resources. With proper background, they can present on active park-based scientific

research to the public with more credibility and confidence. Their messages about preserving public lands can include the importance of having sites that host cutting-edge science research as well as providing recreation, enjoyment, and habitat protection.

Challenges abound for park interpreters who seek information on park-based scientific studies. Peer-reviewed articles are costly to access and require time to vet for relevance. Like annual reports and permit applications, they tend to assume that the reader has the necessary technical background, which can leave interpreters unsure if they have fully grasped the findings. Contact with scientists and resource managers can help bypass these obstacles, creating a pathway for interpreters to inquire about research questions, methods, findings, and relevance.

Resource managers and park leaders tempted to ignore or defer professional development needs of interpretive staff do a disservice to their colleagues and the public. If the time is taken to build a robust understanding of park-based research among interpreters, they can maximize opportunities in their interactions with the public to convey that understanding of the park's resources and their significance. Interactions between interpreters and visitors can add to the public's awareness of foundational research as well as predicted impacts of climate change. In the long term, these formal and informal interactions have the potential to increase engagement in strategic decisions.

Resource managers can be gate-openers, using various ways to bring scientists and interpreters together. They can facilitate more opportunities for contact between these groups and elevate their communicators as conduits for research stories in parks. iSWOOP interpreters at Carlsbad Caverns National Park now have a model for bringing content and strategies together to increase visitors' awareness and curiosity about scientific research on public lands.

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## References

- Allen, Louise A., C.S. Richardson, G.F. McCracken, and Tom Kunz. 2010. Birth size and postnatal growth in cave- and bridge-roosting Brazilian free-tailed bats. *Journal of Zoology* 280: 8–16.
- Betke, Margrit, Diane E. Hirsch, Nicholas C. Makris, Gary F. McCracken, Marianne Propcopio, Nickolay I. Hristov, Shuang Tang, Angshuman Bagchi, Jonathan D. Reichard, Jason W. Horn, Stephen Crampton, Cutler J. Cleveland, and Thomas H. Kunz. 2008.

- Thermal imaging reveals significantly smaller Brazilian free-tailed bat colonies than previously estimated. *Journal of Mammalogy* 89(1): 18–24.
- Char, Cynthia. 2015. *To Be More Inquisitive in then Natural World: Evaluation of the Interpreters and Scientists Working on Our Parks (iSWOOP) Pathways Project*. Online at [http://iswoopcave.com/?page\\_id=32](http://iswoopcave.com/?page_id=32).
- Charmaz, Kathy. 2006. *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis*. London: Sage.
- DeBacker, Michael, Bruce Lombardo, Sara Melena, Sherry Middlemis-Brown, Michelle O'Herron, Lindsay Paulding, Adam Prato, and Dafna Reiner. 2010. Science Communications: Successful Strategies for Collaboration (panel discussion summary). In *Rethinking Protected Areas in a Changing World: Proceedings of the 2009 George Wright Society Biennial Conference on Parks, Protected Areas, and Cultural Sites*. Samantha Weber, ed. Hancock, MI: George Wright Society, 37–40. Online at <http://www.georgewright.org/0906debacker.pdf>.
- Forist, Brian, and Doug Knapp. 2013. Leaving Muir and Tilden behind: Visitor-centered interpretation through dialogue. Paper presented at the National Association for Interpretation National Workshop, 8 November. Online at <http://www.storylinedesigns.co.uk/blog/files/tilden-forist-knapp-ppt.pdf>
- Hristov, Nickolay I., Margrit Betke, Diane E.H. Theriault, Angshuman Bagchi, and Thomas H. Kunz. 2010. Seasonal variation in colony size of Brazilian free-tailed bats at Carlsbad Caverns based on thermal imaging. *Journal of Mammalogy* 91(1): 183–192.
- Kunz, Thomas H., Margrit Betke, Nickolay I. Hristov, and Maarten J. Vonhof. 2009. Methods for assessing colony size, population size, and relative abundance of bats. In *Ecological and Behavioral Methods for the Study of Bats*, 2nd ed. Thomas H. Kunz and Stuart Parsons, eds. Baltimore: Johns Hopkins University Press, 133–157.
- Larsen, David L. 2003. Be relevant or become a relic. *Journal of Interpretation Research* 7(1): 17–23.
- National Park Service. 2014. *A Call to Action: Preparing for a Second Century of Stewardship and Engagement*. Washington, DC: NPS. Online at [https://www.nps.gov/calltoaction/PDF/C2A\\_2014.pdf](https://www.nps.gov/calltoaction/PDF/C2A_2014.pdf).
- . 2016. *Servicewide Interpretive Report*. Washington, DC: NPS.
- National Park Service, Interpretive Development Program. 2016. *Foundations of 21st Century Interpretation—Version 2016—Foundational Competencies for NPS Interpreters*. Washington, DC: NPS. Online at [http://idp.eppley.org/sites/default/files/Foundations of Interpretation-Version 2016-NPS-IDP-with cover \(1\).pdf](http://idp.eppley.org/sites/default/files/Foundations of Interpretation-Version 2016-NPS-IDP-with cover (1).pdf).
- National Park System Advisory Board Education Committee, National Education Council, and George Washington University. 2014. *Vision Paper: 21st Century National Park Service Interpreter Skills*. Online at <http://www.nps.gov/resources/upload/REPORT-Interpretative-Skills-05-22-14.pdf>
- O'Herron, M. 2009. San Francisco Bay Area Network Natural Resources Communication Strategy. Natural Resource Report NPS/SFAN/NRR-2009/169. Fort Collins, CO: NPS. Online at <http://www.nature.nps.gov/publications/NRPM/nrr.cfm>.

- Powell, Bob, Brett Wright, and Gina L. Depper. 2014. *National Park Service Interpretation and Education Training Needs Assessment*. Clemson, SC: Clemson University Department of Parks, Recreation and Tourism Management. Online at [http://idp.eppley.org/sites/default/files/NeedsAssessmnt-NPS\\_IE\\_Final\\_Report\\_10-15-14.pdf](http://idp.eppley.org/sites/default/files/NeedsAssessmnt-NPS_IE_Final_Report_10-15-14.pdf).
- Stern, Marc J., and Robert B. Powell. 2013. What leads to better visitor outcomes in live interpretation? *Journal of Interpretation Research* 18(2): 9–43.
- Tilden, Freeman. 1957. *Interpreting Our Heritage*. Chapel Hill: University of North Carolina Press.

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