

HOW TO Count Bats

In summer in New Mexico, the natural entrance to Carlsbad Cavern beckons, offering shade from the sizzling desert sun. The path is steep, dimly lit. Visitors to the national park pause to take pictures of the glowing cave formations. Rangers do a last pass before the natural entrance closes at 5:00 p.m., walking down the main corridor, past Witches' Fingers and Devil's Hump, shepherding visitors toward the elevators.



VIDEO MADE COURTESY OF NIKOLAY HRISTOV

The fascinating but challenging study of bats—small, fast-moving animals that live in darkness and travel in enormous numbers—is made possible by new technologies such as high-speed video photography.

While waiting for the evening bat flight, a dozen visitors of all ages take their seats in the theater of the visitor center. Ranger Eric begins his presentation with footage of bats circling through the air in front of the cave. His talk is illustrated with images gathered by researchers Dr. Nickolay Hristov and Dr. Louise Allen, biologists from Winston-Salem State University studying the Brazilian free-tailed bats, the main type that roost at Carlsbad Caverns.

Ranger Eric begins: “I’m an education ranger. I’ve been here four years, and I’m still figuring things out. Researchers are helping us understand our world and the world of bats.”

During his welcome, Ranger Eric begins by asking what questions are swirling in visitors’ minds based on their observations in the cave.

This is a departure from the typical ranger talk, which focuses on bats’ importance in the eco-system. Instead, in this research-based talk, Ranger Eric emphasizes how we know what we know, rather than bat facts alone. He is changing his talks based on his experiences in the pilot *iSWOOP* program (Interpreters and Scientists Working on Our Parks). Rangers learn from *iSWOOP* to hold back and guide visitors to answer their own or each others’ questions in order to build scientific literacy.



To better understand colony dynamics, researchers used a laser scanner to create a 3D representation of the bat cave.

The National Science Foundation-funded *iSWOOP* program aligns with the evolving mission of the National Park Service (NPS) in its second century. Once focused on maintaining land and building scenic roads, NPS will play a strong role in informal science learning. “There’s a lot of research going on in every national park in the country, but that’s pretty much invisible to the visitor,” according to Dr. Allen. Our nation’s parks are the site of a great deal of research because they are protected places. In turn, research in NPS’s more than 400 sites informs decisions about wildlife protection, visitor access, preservation for geologic formations, the microbial world, and plants adapted to harsh conditions—decisions made more complex by recent changes in both weather patterns and land use.

The dilemmas NPS faces in achieving its mission of protecting and preserving public lands call for public engagement, and *iSWOOP* opens a window into the park-based research underway. Dr. Allen sees *iSWOOP* as a way “to bring scientists, educators, and interpreters together to foster a better understanding of science that’s going on in national parks, to really enhance STEM learning for visitors.”

The National Parks Service’s 3,400 interpretive rangers are an essential part of the process. “When visitors come to the national parks, the people they are going to be interacting with are interpreters,” explains Ellen Rohn, a Carlsbad Caverns park interpreter. “We’re the front line staff in many ways. We’re supposed to hold the answers to their questions.”

In *iSWOOP*, TERC is designing a professional development process to help park rangers bridge the gap between the public and the researchers. Project staff seek to build expertise within the interpreter and ranger community. Staff engage with the researchers on site, and host sessions to help the rangers interpret complex data, and then to ask informed questions of the researchers. When the rangers come to a deeper understanding of the research, their interactions with visitors are also transformed. Dr. Hristov refers to *iSWOOP* as “a sandbox where researchers, park interpreters, and educators come together to hone their storytelling skills and celebrate learning.”

While many Americans have visited a national park within the past two years, most won’t have the opportunity to hear about the scientific research occurring on site. Interpreters like Ranger Eric are working to change this reality by giving

visitors a view into the questions and technologies at work. Presenting to the audience in the park’s theater, Eric first invites questions:

VISITOR: “How far do bats fly?”

VISITOR: “Do bats poop upside down?”

VISITOR: “Does the number of bats correlate with the insect population?”

RANGER ERIC: “Thinking like scientists! I love it.”

VISITOR: “Could we find out more if we attached a camera to the back of a bat so we could see what it’s doing?”

RANGER ERIC: “You’re funded!”

VISITOR: “Is there an alpha or queen bat?”

RANGER ERIC: “There might be if my sister were a bat.”

Bringing research to the visitor experience

Current research is particularly compelling for visitors, especially if they get a glimpse of real, ongoing investigations. We live in a world where we expect to find instant answers to any question, and curious park visitors are no exception. Every night, visitors ask how many bats there are, which is also an essential question for NPS’s conservation mission. Anyone who has witnessed bat flight can see firsthand that there are too many to count—bats are small and fast, and they come out when it’s dark. Thanks to *iSWOOP*, the Carlsbad Caverns rangers are able to tell the full story.

Questioning the data

Ranger Eric begins the story by recounting the research a naturalist named V.C. Allison conducted in the 1930s. Allison published his method and his claim that nine million bats exited the cave in 20 minutes, equaling a rate of 500,000 per minute (Allison, V.C., 1937). Two decades later, other observers estimated one million bats in the colony, which was a much smaller figure than Allison’s. This discrepancy sent researchers scrambling to determine causes of the sharp drop in the size of the colony. Did nearly eight million bats die off in twenty years? What could have caused this catastrophic decline?

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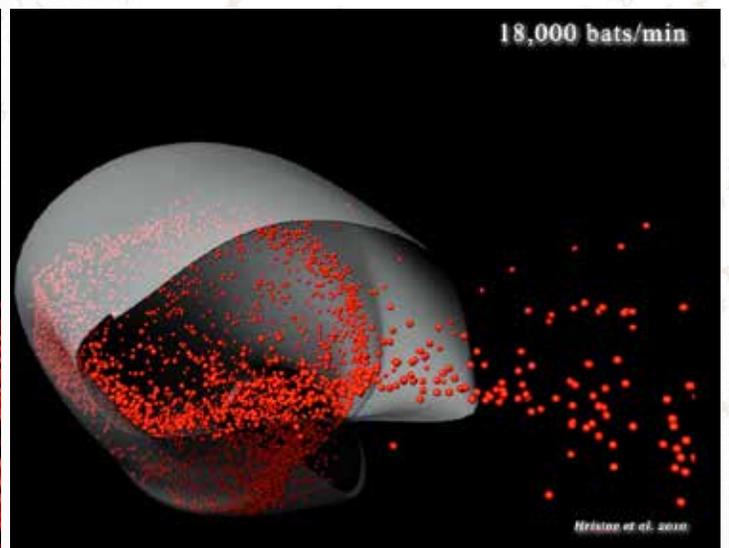
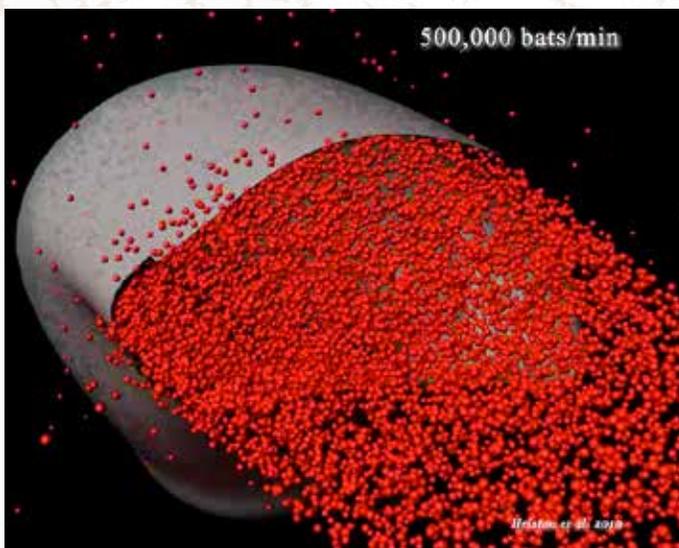
While early naturalists like Darwin recorded their observations in notebooks (still an important part of modern scientific research), Dr. Hristov and Dr. Allen study bats using new technologies originally developed for military purposes. Starting in 2004, a team from Boston University under the leadership of Tom Kunz began using high-speed and thermal video cameras to reveal details of bat flight, including the patterns in movements in and out of the cave. Like traffic study consultants, Drs. Hristov and Allen set up their video equipment in a spot where bats pass. The thermal cameras could sense and record warm bodies silhouetted against the cooler sky. They used a laser scanner to create a 3D exploration of the cavern's interior, or as Dr. Hristov calls it, "a cathedral of nature." And they used high-speed video to observe the flight patterns of individual bats within the undulating river of bats pouring out of the caves for their sunset feedings.

With the help of computers, Drs. Hristov and Allen tallied the numbers of bats over many seasons. Like the naturalists before them, they observed large numbers: up to 18,000 bats emerging in one minute, crowding the mouth of the cave. Dr. Hristov reevaluated Allison's estimate of 500,000 bats per minute and found these early findings to be unrealistic. If 500,000 bats had exited in a minute, spectators would have witnessed thousands of collisions. But how could he prove it?

“The experience for these visitors goes far beyond answering the question “How many bats are there?” They have encountered a moment of real scientific inquiry and leave wanting to learn more at other national parks.”

Based on the dimensions of the cave opening and the amount of space each bat occupies in flight, Dr. Hristov created a 3D animation of the bat emergence.

The resulting 3D animation is now part of the *iSWOOP* image library, making it possible for Ranger Eric to play it for the park visitors, who observe for themselves that Allison's estimate is likely inaccurate. They are quick to share their impressions of the cave model and the red dots emerging from it: “Looks like a bat meat grinder.” “Looks like ants.” As they view the numbers of bats spewing out of the cave, visitors laugh and express their disbelief as they come to an understanding that Allison's estimate cannot be right. Eric concludes the *iSWOOP* program by encouraging visitors to observe all they can, to walk with their eyes open, and to be curious.



To test the 1937 estimate of nine million bats, Drs. Allen and Hristov created computer models of bats flying out of the cave at a rate of 500,000 per minute, demonstrating the improbability of that estimation. Modern tracking software has recorded a much lower rate of 18,000 bats per minute.

Wanting to learn more

The visitors are not ready to leave the theater just yet. They continue to call out questions about the cave, the bats, threats to this fragile population like disease, fire, and drought, and about the life of a park ranger. The experience for these visitors goes far beyond answering the question “How many bats are there?” They have encountered a moment of real scientific inquiry and leave wanting to learn more at other national parks.

Dr. Hristov feels that everyone has benefited from the collaboration between the researchers and interpreters. “It is very clear how invested, interested, and excited the interpreters are.” As for the researchers, Dr. Hristov reflects “we realized we lack significantly in the ability to communicate in an accessible way with the public so that we don’t rely on the traditional scientific jargon.”

“It could pave the way for a lot more interaction between other researchers here and the interpreters,” comments Ranger Rohn. “We have lots of people who come—microbiologists, cave climatologists, biologists on the surface—and yet we never have interaction with them, so I hope that *iSWOOP* could be a foundation to build on.”

When visitors to Carlsbad Caverns now ask how many bats there are, rangers have a number, a story, and a visual. They can show a video of the bats’ flight with the tally running at nearly 1,700 bats passing in a 10-second interval. They can tell the story of how Drs. Hristov and Allen and their colleagues figured out that on most summer nights, about 350,000 bats fly out of the cave. They can show graphs to illustrate fluctuations by season and precipitation. Through its focus on active research, *iSWOOP* builds public awareness of scientific processes and research, and reveals aspects of parks and their species that are complex, beautiful, and fragile.

REFERENCES

Allison, V. C. , (1937). Evening bat flight from Carlsbad Caverns. *Journal of Mammalogy*, 18:80–82

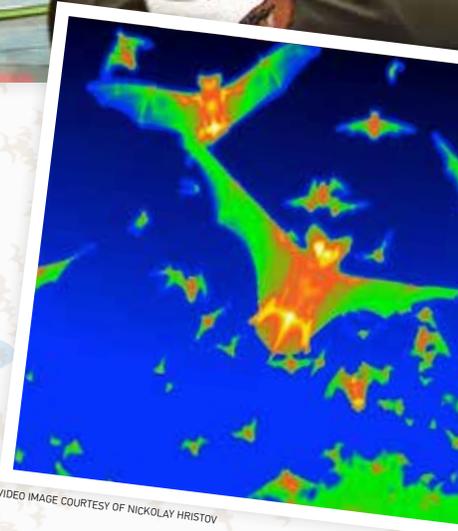
Martha Merson (TERC) is principal investigator and Nickolay Hristov (Winston Salem State University) is co-principal investigator for *iSWOOP*. Louise Allen (Winston Salem State University) is senior staff for *iSWOOP*.

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VIDEO IMAGE COURTESY OF NICKOLAY HRISTOV

Park rangers, biologists, and informal education experts have come together to learn from one another. As a result, park visitors are drawn into the process of scientific inquiry, examining data like this thermal image.



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LEARN MORE ABOUT *iSWOOP* AT:

 iswoopcave.com

See images and video from Hristov and Allen’s research, read about high-tech research methods, Select Locations > Carlsbad for images and an interview with Dr. Hristov.

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