

# Using citizen science for long-term monitoring of Gila Monsters in Saguaro National Park



Photo of a Gila monster taken by a “citizen scientist” visitor at Saguaro National Park, 16 July 2015

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## **Abstract**

The University of Arizona and Friends of Saguaro National Park expanded our long-term study of the Gila monster, a unique and charismatic reptile that may be as abundant in the park as anywhere in its natural range. Since 2008 we have searched for Gila monsters, collected natural history and genetic data on them, studied their habitat and activities using radio telemetry, and gathered photos from park visitors. Support from WNPA allowed us to continue our research program while developing strong educational and Citizen Science components. After organizing the literally hundreds of photos taken by park visitors since 2008, we created a program where high school students help us to use the photos to identify Gila monsters using the beaded and colored skin pattern that is unique to each individual. Park visitors are now able to easily upload photos of Gila monsters from their smart phones through the iNaturalist phone app, as well as view existing data and learn more about Gila monsters in Saguaro National Park. In addition, we continued to radio-track several Gila monsters during 2015-2016, collecting and analyzing data, including DNA, for individual animals. We also developed social media content about Gila monsters; gave interpretive programs at the park's Visitor Center and in the community; assisted in training park staff and Junior Rangers about Gila monsters; and taught a wide variety of audiences to radio track Gila monsters in the field. We helped develop a high-quality video on this project for the park's visitor center, and wrote a peer-reviewed paper about Gila monster genetics based on data collected during this study.

## **Introduction**

The University of Arizona, Saguaro National Park, and Friends of Saguaro National Park initiated a research and citizen science program on the Gila monster (*Heloderma suspectum*) in 2008. Gila monsters are one of the most recognizable animals in the park, and for many of our visitors it is the thrill of a lifetime to see this elusive, large, and venomous lizard. Yet the life history, ecology, and genetics of Gila monsters are poorly understood because of their reclusive nature and tendency to spend long periods in underground burrows (Beck 2005). For example, when researchers saw a pair breeding in the park in 2014, it was the first time this behavior had ever been recorded in the wild (Zylstra et al. 2015).

Saguaro National Park is an ideal location to study Gila monsters because the species is relatively common at the park, and the park has the capacity to support long-term research and monitoring. In addition, using sound science to preserve natural resources for long-term conservation is essential to Saguaro's mission. The major goal of our Gila monster research partnership is to develop a comprehensive understanding of this species. We have accomplished this so far by collecting, over the course of seven years, a substantial amount of data on habitat use, home range, conservation genetics, movement patterns, recruitment, and survival. Since 2009 we have published several technical reports (Park and Bonine 2012, Bonine and Swann 2013) and a peer-reviewed paper on Gila monster genetic tools (Hess et al. 2013).

Gila monsters elicit tremendous interest from the public, who are fascinated by these colorful, enigmatic, venomous lizards. The state of Arizona afforded legal protection to Gila monsters in 1952 and made it illegal to collect, kill, harass or sell them. From the beginning of this project we have taken advantage of park visitors' interest in this species by asking them to send us photos of Gila monsters they encounter while hiking, biking, or driving in the park. Since 2008, we have received literally hundreds of these photos. Gila monster skin has a colorful beaded

pattern that is unique to each individual and does not change over time in adults. These photos form the basis of a rich dataset that allow us to follow individuals over space and time; however, they had not been systematically organized prior to this year.

The purpose of this WNPA project was to support genetic and other research for one year, while providing visitors the opportunity to explore the data in a meaningful way. Our goal was to fully engage park visitors in both collection and analysis of scientific data, contributing to a peer-reviewed article on the natural history and demographics of this species.

## **Methods**

We collected data on Gila monsters at Saguaro National Park throughout 2015-2016. We conducted systematic searches, captured and processed animals, collected DNA samples, and tracked animals using radio telemetry. We focused systematic searches during the spring (April-June) and the summer (July-September) seasons because Gila monster observations are very infrequent during the late fall and winter (Beck 2005). Because previous park-wide searches have revealed an important center of Gila monster activity in the RMD, search efforts were focused in this district. We photographed each individual captured, collected tissue samples through minimally invasive mouth swabs (Figure 1; Goldberg et al. 2003), and implanted PIT tags (passive integrated transponders) to verify the identification of each individual animal.

We analyzed genetic samples from 100 individuals collected in the park during 2011-2015. We used 18 microsatellite markers and sequenced 1,195 base pairs of the mitochondrial DNA 12S locus to examine genetic diversity, estimate effective population size, and assess demographic history of the population. We performed a mark-recapture analysis of population size and estimated effective population size using the linkage disequilibrium method in NeEstimator.

In a subset of animals we implanted small radio transmitters ( $\leq 13$ g) and tracked them using radio telemetry (Beck and Jennings 2003) during 2015-2016. We typically tracked every 1-2 weeks in winter and weekly during April-November, recording habitat information and location using GPS. All field activities were conducted under research permits approved by Saguaro National Park, Arizona Game and Fish Department, and University of Arizona (IUCUC).

We urged visitors to send us their photographs of Gila monsters from in and near the park, or post them to iNaturalist (Figure 2) advertising with flyers posted at the Visitor Center and other locations. We organized all photos from 2008-2016 using Photo Mechanic, a software program that adds metadata such as GPS coordinates, date, time, and individual identification to each photo so they can be quickly sorted, viewed, and mapped. We created a photo database of individual Gila monsters and their locations over time. Finally, we created and tested a citizen science program with high school and middle school students that facilitates matching of photos and identification of individuals so that we can populate and vet the database and use the data for long-term analysis.

## **Results**

Field data. We spent approximately 120 hours searching for Gila monsters in the Rincon Mountain District during the active season (March-October) of 2015. We made 20 captures of

Gila monsters; of these individuals, 8 were re-captures from previous years, and 1 was a recapture from 2015.

Using genetic data from 100 individuals, we observed high genetic diversity with uninhibited gene flow within the study population (Farrar et al. in review). From field capture-recapture analysis we estimated 731 individual Gila monsters within a 42 km<sup>2</sup> subset of the approximately 82 km<sup>2</sup> total study sample area. We estimated effective population size (Ne) to be 94 individuals (80.7-111.2, 95% confidence interval).

We radio tracked 3 Gila monsters during 2015-2016, and summarized the results of a total of 8 individuals tracked during 2011-2016 (Figure 3). Mean within-home range size (minimum convex polygon, MCP) within years was 10.6 ha (51 acres); 13.6 ha for males and 8.3 ha for females. Combining all locations for all years for each individual tracked, mean MCP home range size for Gila monsters was 26.5 ha (65.5 acres).

Citizen science. Visitors and park staff documented >40 sightings of Gila monsters in and near Saguaro National Park in 2015. We refined our process for uploading photos directing to iNaturalist, and 29 of these records were uploaded directly by visitors to this phone app. Analysis of >350 photos from citizen scientists (n=176) and researchers indicated that >224 photos are of individual Gila monsters that were photographed more than once. We identified 153 unique individuals. The longest interval between the first and last photos was 12 years, an individual photographed in 2001 and 2013. The most photographs of a single individual was 8. We created a GIS map of all photographs in the park, and then wrote a protocol that provides step-by-step instructions for citizen scientist volunteer groups to systematically match photographs of Gila monsters with photos in the same vicinity to identify individuals based on their skin pattern.

We tested this protocol first with inexperienced park interns, then with a small class of high school students from Arizona College Prep Academy, a diverse local high school that does service learning projects at the park (Figure 4). The protocol was successfully used to match photographs. We tested the program with the park's advanced Cactus Rangers in 2016 and our Environmental Education staff used it to develop a similar program for elementary school students that they tested in spring 2016.

Interpretive component. We accomplished a large number of educational objectives and continued to integrate our research with the park's interpretive program through staff and volunteer training. Our interpretive efforts included the following:

1. Worked closely with videographer Dan Bell to produce a video for the Visitor Center on Gila monsters at Saguaro National Park. The video (Figure 1) features principle investigator Kevin Bonine, primary field intern Darren Anderson, and interns Kitra Henker and Corina Yeh and focuses on Gila monsters and the goals, methods, and results of the research project, and acknowledges WNPA and FOSNP. It can be viewed at the Visitor Center or on-line: <https://vimeo.com/139102554>.

2. Worked with park staff to develop video social media posts “Myths about the Gila Monster.” These short videos (Figure 5) were translated into Spanish and both language versions had literally thousands of views. See examples:  
<https://www.facebook.com/saguaronationalpark/videos>.
3. Provided a large number of outreach events to the public and volunteers at Saguaro National Park. These included informal, impromptu presentations at the Visitor Center with captured Gila monsters. Examples of formal programs included:
  - a. SNP interns, donors, and docents (January 2015)
  - a. UA Environmental journalism class (May 2015)
  - b. Cub scout group (May 2015)
  - c. SNP summer interns (June 2015)
  - d. Outreach field class for college students (July 2015)
  - e. Ecology club at Desert Sky Middle School (October 2015)
  - f. General public at Tucson Book Fair (March 2016)
4. Provided hands-on field experiences with radio telemetry to more than 10 groups of 1-5 individuals from The Friends of Saguaro National Park, interns, volunteers; and others.
5. Achieved media coverage on a variety of web-based outlets and developed a published “Resource Brief” explaining the project to park visitors.
6. Developed photo booklet on Gila monsters that is featured in the Rincon Mountain Visitor Center “science corner.”
7. Developed a web page (<https://www.nps.gov/sagu/getinvolved/gila-monster-project.htm>) and iNaturalist page (<http://www.inaturalist.org/projects/gila-monsters-at-saguaro-national-park>) on the project for citizen scientists and the public.

## **Conclusion**

The Gila monster research project at Saguaro National Park is a unique long-term partnership that includes not only scientists from the University of Arizona and the National Park Service, but also student interns and park visitors. The project has now engaged several “generations” of interns, mostly undergraduates from the University of Arizona. Some of these interns have become leaders in the project, teaching new interns how to safely process Gila monsters. In 2015-2016, as in previous years, these interns have in turn also taught park staff and volunteers about Gila monsters through radio telemetry in the field. By engaging a cross-section of park visitors, local high school students, and others, our goal has been to create a greater understanding of this unique Sonoran Desert species through hands-on discovery.

Support from WNPA allowed us to make a major step forward in this project. While continuing field activities, we worked to consolidate the data we had already collected, particularly the citizen science photos, and reach out in new ways to the public. We are particularly excited about the new Gila monster video in the Visitor Center, as well as the social media videos, which are simple in form and content but reach large numbers of people and completely new audiences. Although we did organize a huge number of citizen science photos, we did not achieve our

original goal of “matching” all of them. Instead, we decided it would be more fun and educational to have students do the matching for us. We created a successful process for doing this, and plan to continue to pursue this in the future.

We wrote in our proposal that “in 2014, few visitors want to be talked to and “educated” by park interpreters; they want to learn by seeing, experiencing, and sharing their observations of the world with others. We feel that by encouraging these activities we can better understand how we can work with the public to achieve the conservation of these resources – so that, in 50 or 100 years, visitors will continue to have the thrilling opportunity to see a Gila monster in the wild. ” Major threats to Gila monsters may be harder to determine than threats to other high-profile wildlife species, since Gila monsters spend so much of their time underground, out of sight of humans. These threats are probably more subtle as well, and may include long-term changes in habitat due to invasive plants, changing fire regimes, and increasing temperatures and aridity due to climate change. Understanding how they may affect Gila monsters requires more than just a 2-3 year graduate study, rather the accumulation of data on individuals on a scale that is more appropriate for a species that may live for several decades. We have already matched some photos of Gila monsters at the park separated by more than 10 years; citizen scientist photographs should continue to allow us to gather these data relatively inexpensively over a much longer period of time while engaging and informing a broad audience in the process.

### **Literature Cited**

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Figure 1. Intern Corina Yeh collects a DNA sample (mouth swab) from a Gila monster, June 2015. This year we completed a major DNA study of this species and prepared a scientific paper on the results. Photo from video by Dan Bell.

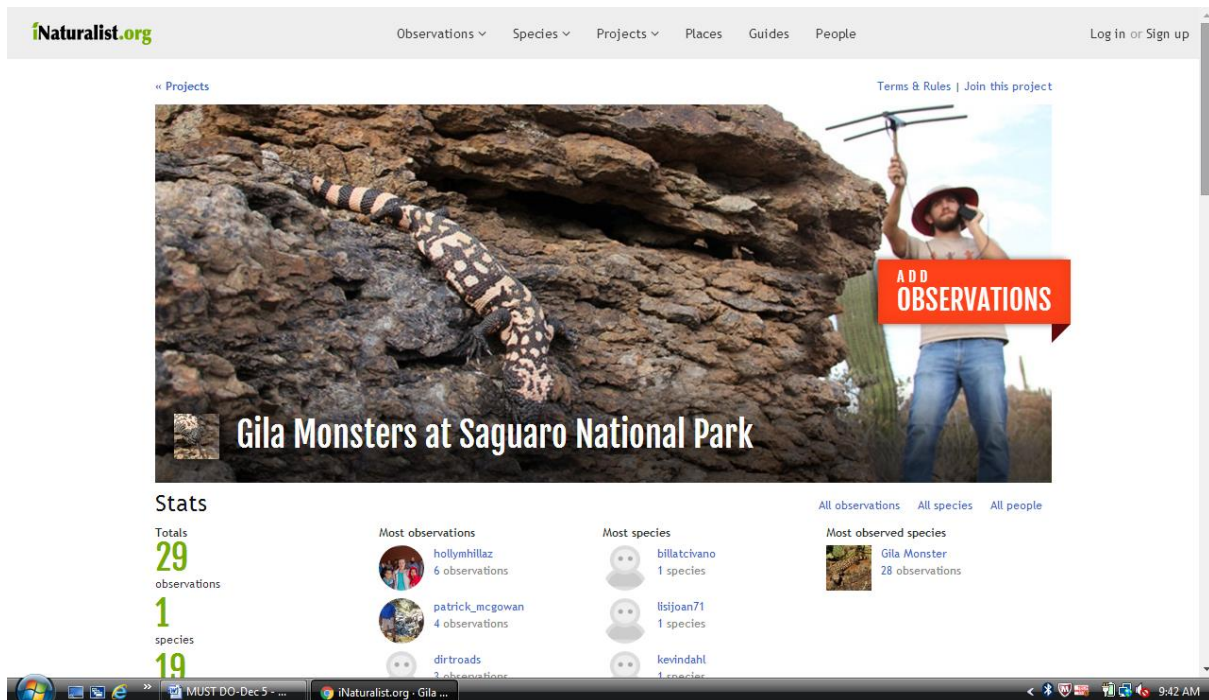


Figure 2. iNaturalist page where park visitors can upload their photographs of Gila monsters in the park. 29 observations were uploaded by citizen scientists to iNaturalist in 2015, and about the same number were emailed to UA and park staff.

Figure 3. Minimum convex polygon home range maps of Gila monsters radio tracked in Saguaro National Park, Rincon Mountain District.

# JOIN US!

## Gila Monster Photo Matching Day!



Saguaro National Park and The University of Arizona have been studying Gila monster since 2008. We now have over 350 photos of monsters that have been seen in the park. Some of the monsters have been captured by researchers and photographed at all angles. In this project we also incorporate visitor photos into the data base. We are able to do this because Gila monsters each have a unique pattern that can be used to identify individuals, much like a fingerprint! We need your help matching these photos to individuals the researchers have captured!

There are many photographs in many different areas of the park. The way we will be matching is by taking one section of the park at the time. It is possible that a photo that has been sent to us by a visitor is of

one that the researchers have not captured. In this case this monster will get a unique identifier that includes a name. You as a group will also have the opportunity to name some of the unique Gila monsters you find. This name will follow this Gila monster if it is ever caught or photographed again.

This activity would take about 2 hours to complete. To be able to do this you just have to know how to match patterns. There will also be a short introduction and training before we begin matching. It will give you the chance to get your hands on an actual research project being done. By helping match the photos of the Gila monsters you are helping to eventually advance our knowledge about these fascinating animals!

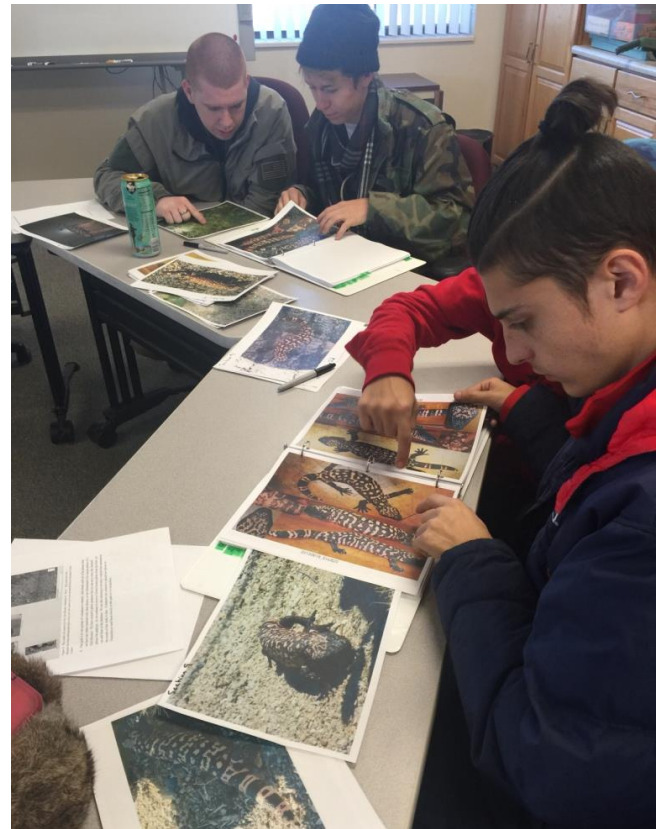


Figure 4a (left). Flyer for Gila monster photo matching activity. Figure 4b (right). Students from Arizona College Prep Academy help match Citizen Science photos of Gila monsters to identify individuals as part of long-term monitoring. Gila monsters have unique color patterns in their beaded skin that do not change over the life of the animal once it becomes an adult.

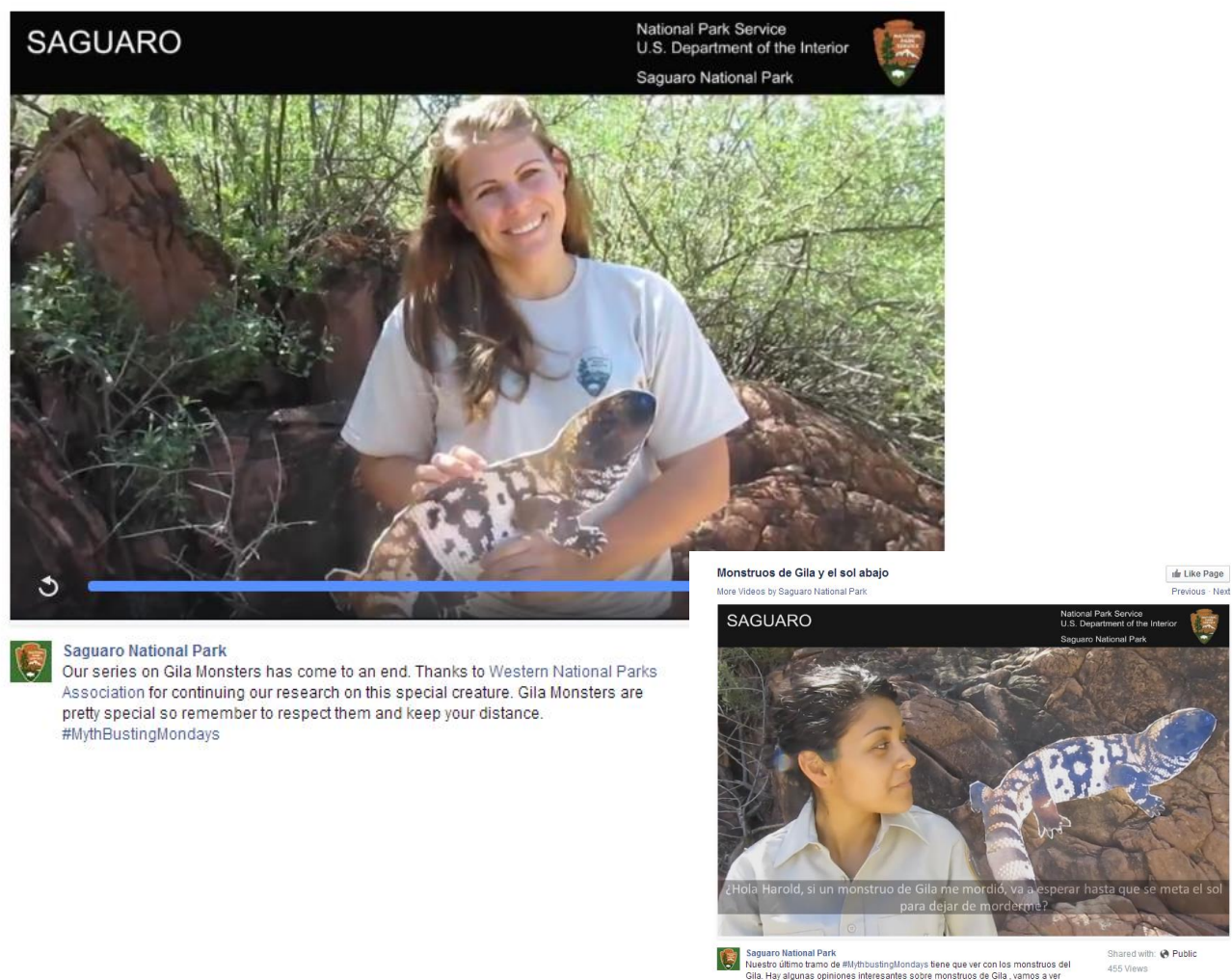


Figure 5. (Left) Carolyn Harper presents one of four “Myths about Gila monsters” videos, posted on Facebook and Instagram, about the project and its results at Saguaro National Park. (Lower right) These videos were translated into Spanish, starring Saguaro National Park intern Eesha Hernandez.



Figure 6. Darren Anderson (above) and Kit Henker (below), two interns who worked on this project, were featured along with PI Kevin Bonine in the Gila monster video about the project. This video was completed in September 2015 and is now being shown in the park's Visitor Centers.