

## Accomplishments

### 1. What were the major goals of this project?

The major goals of this project are to understand the sensory and sensorimotor processes that enable agile, high-speed maneuvering and complex spatial navigation in echolocating bats and dolphins. The goals for this project would comprise two phases: a field phase investigating swarming acoustics in Mexican (Brazilian) free-tailed bats, and a laboratory phase investigating adaptations to jamming signals in individual bottlenose dolphins. This was broken into three objectives:

**Objective 1:** Investigate adaptive time-frequency signatures and waveform diversity in echolocation signals for different flight behaviors.

**Objective 2:** Investigate how bats address Doppler compensation of echolocation signals when returning from high-speed flight.

**Objective 3:** Investigate how bats and dolphins overcome mutual-interference.

### 2. What was accomplished towards achieving these goals?

#### Major Activities:

The main accomplishment in year two of the grant was the development of our UAV recording platform, and creation and implementation of an algorithm to quantify the FM shape of bat echolocation calls. This year also resulted in five publications for the PI, with three more publications under review/in preparation. In the summer of year two the PI traveled with one student and one post-doc to the main field site, a lava tube bat cave in New Mexico. At the cave, we (“we,” as follows, refers to the PI as the lead and additional members as support) recorded synchronized ultrasonic and video recordings of the bats during cave emergence and re-entry. From these recordings and recordings collected in year one, we continue to address objectives 1 and 2. This is further elaborated below with specific objectives, significant results, and key outcomes clarified under each topic, and relevant figures in the attachment.

1) From the acoustic recordings collected in year one, and motivated by the pilot FM shape analysis conducted by the two undergraduates in year one, the postdoc developed a new algorithm to isolate, track and discriminate the time-frequency components of bat calls. This technique allows us to quantify differences in FM shape between bat calls and cluster groups of calls based on time frequency characteristics. This work was presented at one conference and published in *The Journal of the Acoustical Society of America*. This algorithm is the first important step to accomplishing Objective 1.

2) A research technician was hired starting in year two of the grant. This technician was a recent undergraduate alumna of the PI's lab, and applied the skills she learned under the PI's mentorship as she transitioned to a STEM professional. The technician assisted the PI with acoustic and video analysis to support objectives 1 and 2 of the grant. Furthermore, the technician undertook an independent project to analyze the acoustic and flight adaptations made by bats during high-speed re-entry. This included an analysis of how bats address Doppler compensation of echolocation signals when returning from high-speed flight (Objective 2). She analyzed the dataset recorded by the PI and two undergraduates in year one of the grant, and her manuscript is currently under review at JASA-EL.

**REPORT DOCUMENTATION PAGE**

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<b>4. TITLE AND SUBTITLE</b> Biologically Inspired Approaches to Overcome Mutual-Interference by Active Sensor Systems	<b>5a. CONTRACT NUMBER</b>
	<b>5b. GRANT NUMBER</b> N000-14-16-1-2478
	<b>5c. PROGRAM ELEMENT NUMBER</b>

<b>6. AUTHOR(S)</b> Kloepper, Laura N., Ph.D.	<b>5d. PROJECT NUMBER</b>
	<b>5e. TASK NUMBER</b>
	<b>5f. WORK UNIT NUMBER</b>

<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> Saint Mary's College, 130 Le Mans Hall, Notre Dame, Indiana 46556-5001	<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>
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<b>9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> Office of Naval Research, ONR REG Office Chicago, 230 South Dearborn, Chicago, IL 60604-1595	<b>10. SPONSOR/MONITOR'S ACRONYM(S)</b> ONR REG
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NA

**14. ABSTRACT**  
The main accomplishment in year two of the grant was the development of our UAV recording platform, and creation and implementation of an algorithm to quantify the FM shape of bat echolocation calls. This year also resulted in five publications for the PI, with three more publications under review/in preparation. In the summer of year two the PI traveled with one student and one post-doc to the main field site, a lava tube bat cave in New Mexico. At the cave, we recorded synchronized ultrasonic and video recordings of the bats during cave emergence and re-entry. The PI also completed the dolphin project in January 2018 in a consultation agreement with National Marine Mammal Foundation.

**15. SUBJECT TERMS**  
Major goals, accomplishments, opportunities for training and professional development, dissemination to communities of interest, research and publication plans for next reporting period, honors, participants, students, products (publications, conference papers, website, other products).

<b>16. SECURITY CLASSIFICATION OF:</b>			<b>17. LIMITATION OF ABSTRACT</b>	<b>18. NUMBER OF PAGES</b>	<b>19a. NAME OF RESPONSIBLE PERSON</b>	
<b>a. REPORT</b>	<b>b. ABSTRACT</b>	<b>c. THIS PAGE</b>			Laura Kloepper	
U	U	U	SAR	13	<b>19b. TELEPHONE NUMBER (Include area code)</b> 352-598-0689	

3) During the summer period of year two of the grant, we successfully flew and acquired video and acoustic data from our UAV, which we piloted inside the swarm of bats during high-speed re-entry. We had no collisions with the bats during this time period and recorded high signal to noise ratio signals from bats at all flight altitudes. The data acquired from this project was published in two high-profile peer-reviewed journals, and both publications included an undergraduate female student as coauthor.

4) During the summer period of year two of the grant, the PI also collected additional flight and acoustic adaptations during re-entry via ground-based equipment. This was collected in collaboration with mathematical biologists from the University of Oxford. The data was collected with synchronized 3D video and acoustic recordings in the summer of 2017, and was analyzed when the PI traveled to Oxford in the spring of 2018. The PI will continue to collect additional data for this project in the summer of 2018 with a manuscript submission expected in the fall of 2018. This paper will also support Objective 2.

5) During the summer period of year two of the grant, the PI also developed a new method to record the sound field from inside the bat swarm. We created a zip line that allowed us to deploy acoustic units that matched the speed of the bats. We collected pilot data from this project, which will ultimately allow us to characterize the sound field an individual bat experiences inside the swarm. We are continuing this project in the summer of year 3 of the grant, adding silicone models of actual bat ears, to investigate how the ear shape may aid in self-recognition of echoes while flying inside the swarm.

6) During the summer period of year two of the grant, the PI also successfully flew her trained Harris' Hawk inside the swarm of bats. The hawk carried a custom designed (in collaboration with the Electrical Engineering department at the University of Notre Dame (NDEE)) ultrasonic microphone and video unit to record bats from inside the emerging stream. We tested our proof of concept, collected pilot data, and refined our unit for deployment in the summer of year three of the grant. This will allow us to get on-axis recordings from bats during emergence, observe their flight behavior head-on, and obtain opportunistic anti-predator adaptations during flight. Three falcon biologists from Oxford University will join us in the field this summer to include the hawk behavior as part of their ongoing research.

7) One graduate student from NDEE was funded to work on a project for video tracking and analysis of bat swarming flight. This student met weekly with the PI and the NDEE mentor to assess weekly progress. The output from this student was used in synchrony with the acoustic recordings to support the analysis of adaptive time-frequency signatures and waveform diversity in echolocation signals for different flight behaviors (Objective 1). This work was presented at the North American Joint Bat Working Group Meeting.

8) The PI traveled to SPAWAR to conduct an experiment on how dolphins adapt their sonar when in jamming scenarios. In partnership with the National Marine Mammal Foundation, the PI recorded the echolocation signals of two bottlenose dolphins while playing jamming stimuli (dolphin clicks) at different click repetition rates and azimuth to the animal. The results have been analyzed and we are finalizing a manuscript based on this project for submission to the Journal of the Acoustical Society of America. This paper supports Objective 3.

9) Four senior undergraduate female students conducted 18-month long independent research related to this project as part of their undergraduate senior comprehensives. These women presented their work at our institution's poster and presentation day, and also presented their work at a national conference. One student won best overall student poster, beating out graduate students, with her poster titled "The effect of altitude on frequency, duration, and bandwidth of echolocation calls of *Tadarida brasiliensis* recorded with an unmanned aerial vehicle."

10) To continue to aid the PI and research technician's work, we have enlisted the help of 4 first-year undergraduate (all female) students and one high school student who are processing the data from the summer of 2017. The students are conducting video and acoustic analyses from bats in different group sizes. This helps us cut down dramatically on processing time and helps engage these young women and men in an active and vibrant laboratory.

In the prior year reporting for this grant, the PI explained that she did not achieve a desirable number of publications due to the time demands of postdoc and student training. Year two of the grant was much more productive, with 5 published papers and three more under review/in preparation. Additionally, the PI directly presented her work at 5 different conferences and was a coauthor on 10 postdoc/student conference presentations. The PI also presented her research, including communicating the importance of DoD funding for basic sciences, through two major media presentations: a guest in a live (studio audience, 1500 in-person audience members, 1.8 million radio listeners each week) Science Friday radio show episode, and through a TEDxUND talk, which is archived on YouTube.

### **3. What opportunities for training and professional development did this project provide?**

During year two of the grant, this project has provided training and professional development for 18 individuals in addition to the PI. First, under this project the PI directly mentored the postdoc and 15 undergraduate female students and supervised one NDEE graduate student. Through the mentoring of the students, the PI assists them with learning about acoustics, bat behavior, field methods, video analysis, and computer programming. The PI also worked closely with the postdoc. With this mentorship the PI trained the postdoc how to adapt methodology for the lab, think of creative solutions to experimental challenges, and develop quantitative techniques for analyzing bat calls. Additionally, under this project the PI mentors the research technician. This technician learns fundamental research techniques and bioacoustics principles. The technician learns data processing, data analysis, figure construction, and manuscript preparation. The technician desires to attend graduate school, so the primary authorship on one paper (under review) and co-authorship on another paper (in preparation) provides important skills she will need for her career in research and academia. The technician is directly responsible for the mentoring and training of 6 students and is learning how to teach advanced acoustic methods to students with little to no acoustics background. Furthermore, the technician assists with guest teaching classes when the PI must travel to present work at conferences.

#### **4. How were these results disseminated to communities of interest?**

The dissemination of results from this project can be divided into two broad categories: to a technical audience and to a non-technical audience

To a technical audience:

We have published five papers in peer-reviewed journals (see products) and have one more paper under review and another in preparation. We presented a total of 15 talks at five different conferences in year two. The conferences attended in year two were the Acoustical Society of America, the International Symposium on Acoustic Communication by Animals, the XXVI International Bioacoustics Council Meeting, the North American Society for Bat Research Annual Meeting, and the North American Joint Bat Working Group meeting. She also gave an invited research seminar at Oxford University

To a non-technical audience

In November 2017, the PI was a guest on Public Radio International's Science Friday, a science radio show that has 1.8 million weekly visitors (<https://www.sciencefriday.com/segments/to-the-bat-cave/>). In April the PI was a featured speaker on TEDxUND with her talk "Dare to navigate your complex world" (<https://www.youtube.com/watch?v=e7mrEB4RB3Q>). Additionally, the PI communicates her work on an ongoing basis through her lab's blog ([smcbellebats.wordpress.com](http://smcbellebats.wordpress.com)) and through her Twitter (@ProfLKloepper).

#### **5. Plans: What are your research and publication plans during the next reporting period to further progress towards achieving the goals?**

The next reporting period will begin with a month-long field work with the PI and collaborators. We will be building on our zip line and trained hawk method to record the flight and acoustic behavior from inside the bat swarm during emergence and collecting more 3D flight trajectory and acoustic recordings from bats returning to the roost at high speed flight. We will apply the FM shape analysis and classification algorithm the postdoc developed in year one to quantify differences in call structure, investigate the variability in call structure for different group sizes, and compare FM shape for emerging bats and re-entering bats. With supplemental ONR funds (N00014-18-1-2522) we will fund one year of a NDEE Ph.D. student, who will focus his efforts on creating an algorithm for source separation of overlapping FM calls from the swarm. With his output, we will be able to separate individual bat echolocation calls, analyze the FM shape with the algorithm developed in year one, and investigate how shape variation changes across bat swarm density, which will address objective 3 in this project.

Based on our field work, we expect to prepare the following topics for manuscript submission (some topics may be combined into manuscripts):

- 1) Source level measurements and FM shape analysis from bats flying in a group
- 2) Anti-predator flight and echolocation adaptations
- 3) Investigation of Doppler shift during high-speed re-entry
- 4) Comparison of variation in FM shape for bats flying in different group sizes and densities

- 5) Comparison of echolocation calls used during re-entry during periods of darkness and daylight

In November, the PI and one undergraduate student will present their results at the Acoustical Society of America meeting in Victoria, Canada. In March, the PI will travel with approximately 10 undergraduate students to the Midwest Bat Working Group Meeting. In May, the PI and three students will present their results at the Acoustical Society of America meeting in Louisville, KY.

**6. Honors: What honors or awards were received under this project in this reporting period?**

Saint Mary's College Women Honoring Women

Technology Transfer  
Nothing to report

Participants: None are national academy members.  
Laura Neva Kloepper, PI, 4 person months, US  
Yanqing Fu, Postdoctoral fellow, 4 person months, US  
Robert Louis Stevenson, Faculty, 1 person month, US  
Paul Domski, Consultant, 1 person month, US

Students  
Number of STEM participants: 18  
Number of participants that received a STEM degree: 4

Products

Publications

- a. Recording animal vocalizations from a UAV: bat echolocation during roost re-entry
- b. Journal: Scientific Reports
- c. Authors: Laura Kloepper, Morgan Kinniry
- d. Keywords: UAV, bats, bioacoustics
- e. Distribution statement: no restriction on distribution
- f. Publication status: published
- g. Publication identifier type DOI
- h. Publication identifier: 10.1038/s41598-018-261222-z
- i. Publication date: May 2018
- j. Volume: 8
- k. Issue: n/a
- l. First page number: 7779
- m. Publication location: <https://www.nature.com/articles/s41598-018-26122-z.pdf>
- n. Acknowledgement of federal support: yes
- o. Peer reviewed: yes

- a. Assessing bacterial communities in a bat guano cave habitat (Variation in Bat Guano Bacterial Community Composition with Depth)
- b. Journal: *Frontiers in Microbiology*
- c. Authors: Molli Newman, Laura Kloepper, Makenzie Duncan, John McInroy, and Joseph Kloepper
- d. Keywords: bats, bacteria, guano, extreme environment
- e. Distribution statement: no restriction on distribution
- f. Publication status: published
- g. Publication identifier type DOI
- h. Publication identifier: 10.3389/fmicb.2018.00914
- i. Publication date: May 2018
- j. Volume: n/a
- k. Issue: n/a
- l. First page number: n/a
- m. Publication location: <https://www.frontiersin.org/articles/10.3389/fmicb.2018.00914/full>
- n. Acknowledgement of federal support: yes
- o. Peer reviewed: yes

- a. The Chirocopter: a UAV for recording sound and video of bats at altitude
- b. Journal: *Methods in Ecology and Evolution*
- c. Authors: Yanqing Fu, Morgan Kinniry, Laura Kloepper
- d. Keywords: bats, thermal data, UAV, ultrasound
- e. Distribution statement: no restriction on distribution
- f. Publication status: published
- g. Publication identifier type DOI
- h. Publication identifier: 10.1111/2041-210X.12992
- i. Publication date: March 2018
- j. Volume: n/a
- k. Issue: n/a
- l. First page number: n/a
- m. Publication location: <https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/2041-210X.12992>
- n. Acknowledgement of federal support: yes
- o. Peer reviewed: yes

- a. Article title: A systematic method for isolating, tracking and discriminating time-frequency components of bat echolocation calls
- b. Journal: *The Journal of the Acoustical Society of America*
- c. Authors: Yanqing Fu, Laura Kloepper
- d. Keywords: echolocation, time-frequency representation, derivative dynamic time warping, agglomerative hierarchical clustering
- e. Distribution statement:
- f. Publication status: published
- g. Publication identifier type: n/a
- h. Publication identifier: n/a

- i. Publication date: February 2018
  - j. Volume: 143
  - k. Issue: n/a
  - l. First page number: 716
  - m. Publication location: <https://asa.scitation.org/doi/abs/10.1121/1.5023205>
  - n. Acknowledgement of federal support: yes
  - o. Peer reviewed: yes
- 
- a. Off-axis targets maximize bearing Fisher Information in broadband active sonar
  - b. Journal: JASA-EL
  - c. Authors: Laura Kloepper, John Buck, Yang Liu, and Paul Nachtigall
  - d. Keywords: dolphins, fisher information, biosonar, signal processing
  - e. Distribution statement: no restriction on distribution
  - f. Publication status: published
  - g. Publication identifier type DOI
  - h. Publication identifier: 10.1121/1.5021709.
  - i. Publication date: January 2018
  - j. Volume: n/a
  - k. Issue: n/a
  - l. First page number: n/a
  - m. Publication location: <https://asa.scitation.org/doi/abs/10.1121/1.5021709>
  - n. Acknowledgement of federal support: yes
  - o. Peer reviewed: yes
- 
- a. Echolocation adaptations during high-speed roost re-entry for Brazilian free-tailed bats (*Tadarida brasiliensis*)
  - b. Journal: JASA-EL
  - c. Authors: Allison Pudlo and Laura Kloepper
  - d. Keywords: bats, biosonar, high-speed, thermal data
  - e. Distribution statement: no restriction on distribution
  - f. Publication status: under review
  - g. Publication identifier type
  - h. Publication identifier:.
  - i. Publication date:
  - j. Volume: n/a
  - k. Issue: n/a
  - l. First page number: n/a
  - m. Publication location:
  - n. Acknowledgement of federal support: yes
  - o. Peer reviewed: yes
- 
- a. Diversity of echolocation behavior in drinking bats: recordings from an urban Indian swimming pool.
  - b. Journal: in preparation
  - c. Authors: Laura Kloepper, Allison Pudlo, Andrea Simmons, and James Simmons

- d. Keywords: bats, drinking, echolocation
- e. Distribution statement: no restriction on distribution
- f. Publication status: other
- g. Publication identifier type
- h. Publication identifier:
- i. Publication date:
- j. Volume: n/a
- k. Issue: n/a
- l. First page number: n/a
- m. Publication location:
- n. Acknowledgement of federal support: yes
- o. Peer reviewed: yes

- a. Dolphin jamming avoidance during echolocation
- b. Journal: JASA (proposed), in preparation
- c. Authors: Laura Kloepper and Brian Branstetter
- d. Keywords: dolphins, jamming, biosonar
- e. Distribution statement: no restriction on distribution
- f. Publication status: other
- g. Publication identifier type
- h. Publication identifier:
- i. Publication date:
- j. Volume: n/a
- k. Issue: n/a
- l. First page number: n/a
- m. Publication location:
- n. Acknowledgement of federal support: yes
- o. Peer reviewed: yes

#### Conference Paper

- a. Title: Bat population censusing with passive acoustics.
  - b. Authors: Laura Kloepper, Yanqing Fu, Joel Ralston
  - c. Conference Name: Acoustical Society of America
  - d. Conference Date: June 2017
  - e. Conference Location: Boston, MA
  - f. Publication Status: Published
  - g. Publication Date: June 2017
  - h. Publication Identifier Type: n/a or other
  - i. Publication Identifier: n/a
  - j. Acknowledgement of federal support: yes
- 
- a. Title: A systematic methodology for isolating, tracking and discriminating time-frequency components of bat echolocation calls
  - b. Authors: Yanqing Fu, Laura Kloepper
  - c. Conference Name: Acoustical Society of America
  - d. Conference Date: June 2017

- e. Conference Location: Boston, MA
  - f. Publication Status: Published
  - g. Publication Date: June 2017
  - h. Publication Identifier Type: n/a or other
  - i. Publication Identifier: n/a
  - j. Acknowledgement of federal support: yes
- 
- a. Title: Sounds in swarms: echolocation of Brazilian free-tailed bats in large maternal colonies.
  - b. Authors: Laura Kloepper
  - c. Conference Name: International Symposium on Acoustic Communication by Animals (Invited Speaker)
  - d. Conference Date: August 2017
  - e. Conference Location: Omaha, NE
  - f. Publication Status: Published
  - g. Publication Date: August 2017
  - h. Publication Identifier Type: n/a or other
  - i. Publication Identifier: n/a
  - j. Acknowledgement of federal support: yes
- 
- a. Title: Sensing in streams and swarms: echolocation of bats in large groups.
  - b. Authors: Kloepper, L.N., Fu, Y., Kinniry, M., Stevenson, R.L., Brighton, C.H., Domski, P., Harding, C., and Taylor, G.K.
  - c. XXVI International Bioacoustics Council Meeting
  - d. Conference Date: October 2017
  - e. Conference Location: Haridwar, India
  - f. Publication Status: Published
  - g. Publication Date: October 2017
  - h. Publication Identifier Type: n/a or other
  - i. Publication Identifier: n/a
  - j. Acknowledgement of federal support: yes
- 
- a. Title: Hawks, ziplines, and drones: new methods for recording echolocation of bats in large groups.
  - b. Authors: Kloepper, L.N., Fu, Y., Kinniry, M., Stevenson, R.L., Brighton, C.H., Domski, P., Harding, C., and Taylor, G.K.
  - c. Conference Name: North American Society for Bat Research
  - d. Conference Date: October 2017
  - e. Conference Location: Knoxville, TN
  - f. Publication Status: Published
  - g. Publication Date: October 2017
  - h. Publication Identifier Type: n/a or other
  - i. Publication Identifier: n/a
  - j. Acknowledgement of federal support: yes

- a. Title: The microbiology of fresh, surface, and deep guano samples, and the evaluation of pathogenicity
  - b. Authors: Duncan, M., Kloepper, L.N., McInroy, J., and Kloepper, J.W.
  - c. Conference Name: North American Society for Bat Research
  - d. Conference Date: October 2017
  - e. Conference Location: Knoxville, TN
  - f. Publication Status: Published
  - g. Publication Date: October 2017
  - h. Publication Identifier Type: n/a or other
  - i. Publication Identifier: n/a
  - j. Acknowledgement of federal support: yes
- 
- a. Title: Does re-entry flight behavior affect the FM calls of *Tadarida brasiliensis*?
  - b. Authors: Pudlo, A. and Kloepper, L.N.
  - c. Conference Name: North American Society for Bat Research
  - d. Conference Date: October 2017
  - e. Conference Location: Knoxville, TN
  - f. Publication Status: Published
  - g. Publication Date: October 2017
  - h. Publication Identifier Type: n/a or other
  - i. Publication Identifier: n/a
  - j. Acknowledgement of federal support: yes
- 
- a. Title: Drones for recording bats: challenges, results, and ethical considerations
  - b. Authors: Laura Kloepper and Yanqing Fu
  - c. Conference Name: North American Joint Bat Working Group Meeting
  - d. Conference Date: March 2018
  - e. Conference Location: Roanoake, VA
  - f. Publication Status: Accepted
  - g. Publication Date: n/a
  - h. Publication Identifier Type: n/a or other
  - i. Publication Identifier: n/a
  - j. Acknowledgement of federal support: yes
- 
- a. Title: The effect of altitude on frequency, duration, and bandwidth of echolocation calls of *Tadarida brasiliensis* recorded with an unmanned aerial vehicle
  - b. Authors: Morgan Kinniry and Laura Kloepper
  - c. Conference Name: North American Joint Bat Working Group Meeting
  - d. Conference Date: March 2018
  - e. Conference Location: Roanoake, VA
  - f. Publication Status: Accepted
  - g. Publication Date: n/a
  - h. Publication Identifier Type: n/a or other
  - i. Publication Identifier: n/a

- j. Acknowledgement of federal support: yes
  
- a. Title: The influence of habitat and weather parameters on bats in Northern Indiana
- b. Authors: Kaitlyn Cartone and Laura Kloepper
- c. Conference Name: North American Joint Bat Working Group Meeting
- d. Conference Date: March 2018
- e. Conference Location: Roanoake, VA
- f. Publication Status: Accepted
- g. Publication Date: n/a
- h. Publication Identifier Type: n/a or other
- i. Publication Identifier: n/a
- j. Acknowledgement of federal support: yes
  
- a. Title: The microbiology of fresh, surface, and deep guano samples, including the detection of possible pathogens
- b. Authors: Makenzie Duncan and Laura Kloepper
- c. Conference Name: North American Joint Bat Working Group Meeting
- d. Conference Date: March 2018
- e. Conference Location: Roanoake, VA
- f. Publication Status: Accepted
- g. Publication Date: n/a
- h. Publication Identifier Type: n/a or other
- i. Publication Identifier: n/a
- j. Acknowledgement of federal support: yes
  
- a. Title: Crash into me: how Brazilian free-tailed bats avoid collisions during cave exodus
- b. Authors: Bailey Oppman and Laura Kloepper
- c. Conference Name: North American Joint Bat Working Group Meeting
- d. Conference Date: March 2018
- e. Conference Location: Roanoake, VA
- f. Publication Status: Accepted
- g. Publication Date: n/a
- h. Publication Identifier Type: n/a or other
- i. Publication Identifier: n/a
- j. Acknowledgement of federal support: yes
  
- a. Title: Welcome home: Brazilian free-tailed bats adjust their echolocation calls to detect cave opening
- b. Authors: Kathryn McGowan and Laura Kloepper
- c. Conference Name: North American Joint Bat Working Group Meeting
- d. Conference Date: March 2018
- e. Conference Location: Roanoake, VA
- f. Publication Status: Accepted
- g. Publication Date: n/a
- h. Publication Identifier Type: n/a or other
- i. Publication Identifier: n/a

- j. Acknowledgement of federal support: yes
  - a. Title: Acoustic scanning behavior in the Northern long-tailed shrew
  - b. Authors: Margaret Gleason and Laura Kloepper
  - c. Conference Name: North American Joint Bat Working Group Meeting
  - d. Conference Date: March 2018
  - e. Conference Location: Roanoake, VA
  - f. Publication Status: Accepted
  - g. Publication Date: n/a
  - h. Publication Identifier Type: n/a or other
  - i. Publication Identifier: n/a
  - j. Acknowledgement of federal support: yes
    - a. Title: Bat tracking and counting with low-cost thermal cameras
    - b. Authors: Guangyu Wu and Laura Kloepper
    - c. Conference Name: North American Joint Bat Working Group Meeting
    - d. Conference Date: March 2018
    - e. Conference Location: Roanoake, VA
    - f. Publication Status: Accepted
    - g. Publication Date: n/a
    - h. Publication Identifier Type: n/a or other
    - i. Publication Identifier: n/a
    - j. Acknowledgement of federal support: yes

Book: None

Book Chapter: None

Thesis: None

Website

- a. Title: Belle Bats: The bat bioacoustics laboratory at Saint Mary's College
- b. URL: [smcbellebats.wordpress.com](http://smcbellebats.wordpress.com)
- c. Description: This website serves as the main site for the laboratory. On this website we disseminate links to new publications, media appearances, and biographies of our lab members. More importantly, during the summers of 2016 and 2017 the students and PI maintained a blog throughout our fieldwork. This blog served as an important means for communicating our work to a non-technical audience, and we plan to continue blogging during the summer of 2018.

Other Products (Identify and explain how it is being shared):

- a. Description: Drone unit to record ultrasonic audio and thermal imagery. We spent several months conducting noise testing with various microphone arrangements and baffles in order to reach our goal of recording ultrasound vocalizations from bats aloft without interference from drone noise. Additionally, we designed and developed a method to carry a small thermal imaging system from the drone during flight. The PI and postdoc both obtained a commercial FAA UAS remote pilot license and obtained a nighttime flight

waiver in order to fly the drone at night outside the bat cave during the summer of 2017. Upon successful implementation in the field, we plan to share the results of this method in a suitable publication.

- b. Product Type: Instruments and Equipment
  - c. Other Product Type (audio or video, data and research material, educational aids or curricula, evaluation instruments, instruments or equipment, etc.).
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- a. Description: Ultrasonic microphone and HD video pack to be worn by a falcon and flown through the bats. We created, in collaboration with electrical engineers, a custom-built ultrasonic microphone and video recording equipment for a hawk to carry while it flies through the swarm of bats. We plan to share this use of falconry in scientific work in a falconry trade magazine, and share our recording unit and results in scientific publications.
  - b. Product Type: Instruments and Equipment
  - c. Other Product Type