U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Detection and Perception of Sound by Eagles and Surrogate Raptors

M22 DE-EE0007881

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FY17-FY18 Wind Office Project Organization

"Enabling Wind Energy Options Nationwide"

Technology Development	Market Acceleration & Deployment
Atmosphere to Electrons	Stakeholder Engagement, Workforce Development, and Human Use Considerations
Offshore Wind	Environmental Research
Distributed Wind	Grid Integration
Testing Infrastructure	Regulatory and Siting
Standards Support and International Engagement	
Advanced Components, Reliability, and Manufacturing	

Analysis and Modeling (cross-cutting)

Project Overview

M22: Detection and Perception of Sound by Eagles and Surrogate Raptors

Technology Summary: Sound-based deterrents are one category of possible deterrents to reduce eagle mortality at wind energy facilities.

Period of Performance: June 2017 to October 2018

Technology Impact: Project focused on mapping the hearing capabilities of bald eagles, golden eagles, and red-tailed hawks. Research is needed by deterrent technology developers since hearing abilities of these bird species were previously unknown.

Project Goals:

- Provide robust audiograms for bald eagle, golden eagle, and red-tailed hawk.
- Record and analyze bald eagle vocalizations
- Quantify behavioral response of bald eagles to several auditory stimuli in controlled lab setting.

Partners:

- UMN Raptor Center, UMN Center for Center for Applied and Translational Sensory Science
- **Sia: the Comanche nation ethno-ornithological initiative** provide volunteer assistance
- 9 volunteer judges evaluated behavior response

Technical Merit and Relevance

Project Motivation

- Wind energy generation must co-exist within habitats of birds, bats, humans and other animals.
- Focus here is on raptors – bald and golden eagle and rapid development of technologies to minimize adverse impacts to the birds.
- Auditory deterrents (sound emitted at sites to alert and deter birds).
- What sounds are effective for these species?

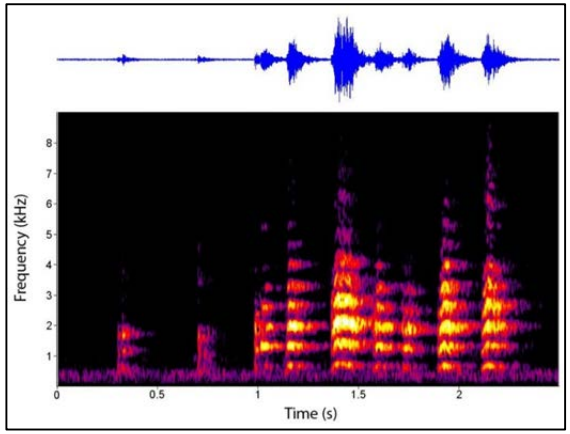
Research Target/Goal

1. Identify, with certainty, the hearing abilities of bald and golden eagles to help optimize deterrent design.
2. Test most promising acoustic deterrents on bald eagles and evaluate response.
3. Transfer findings to technology developers.

Approach and Methodologies

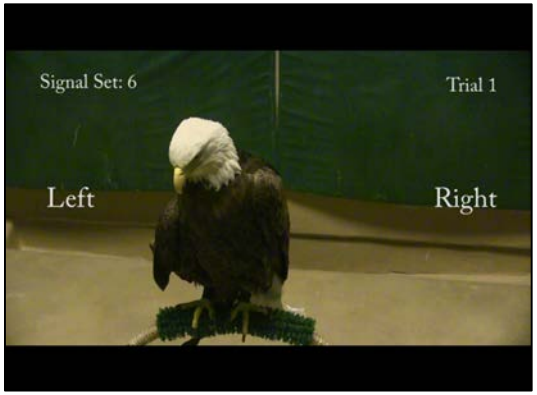
Measuring eagle hearing abilities

- Standard techniques used to map hearing thresholds in animals. Auditory brainstem response (ABR)
- Measure timing of amplitude of response to stimulus.



Vocal recordings and analysis

- Recorded >350 calls from captive eagles and hawks.
- Measure frequencies in a variety of calls.
- Used to design behavior tests.

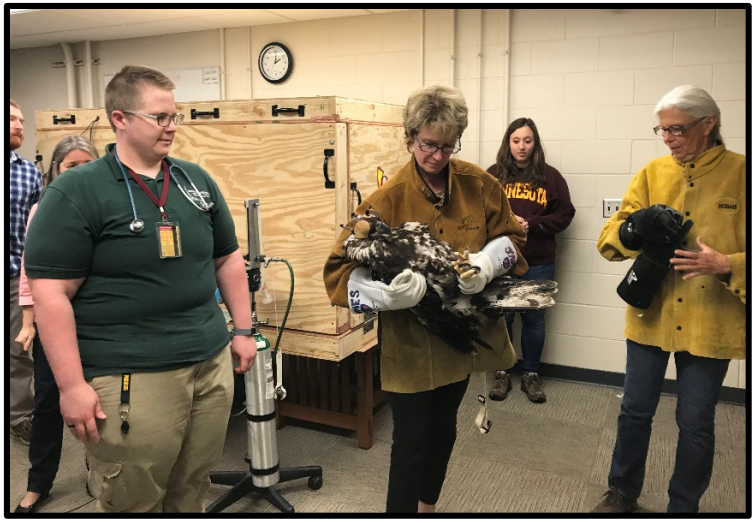


Behavior response to acoustic stimuli

- Protocols adopted from other examples of behavior response research.
- Responses reviewed and evaluated by independent judges.

Accomplishments and Progress

Measuring Auditory Brainstem Response (ABR)



Bald Eagles & Red-tailed Hawks

Location: U. Minn., Dept. Speech, Lang. & Hearing Science.;

- Large, double-walled, electrically-shielded, acoustic foam-lined booth.
- 9 bald eagles & 7 Red-tailed hawks
- October – December 2017

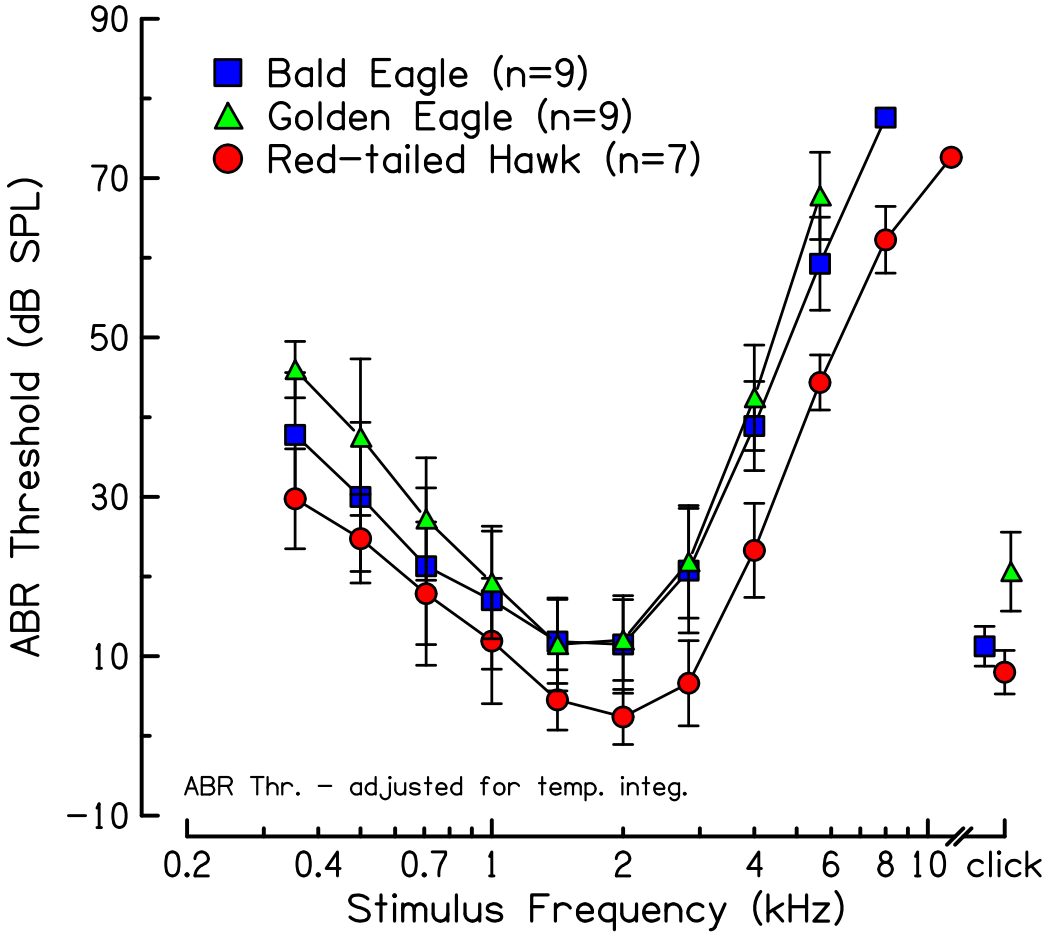
Golden Eagles

Location: Sia, Comanche Nation Ethno-Ornithological Initiative;

- Custom-built, double-walled, electrically-shielded, acoustic foam-lined box.
- 9 golden eagles
- January 2018

Accomplishments and Progress

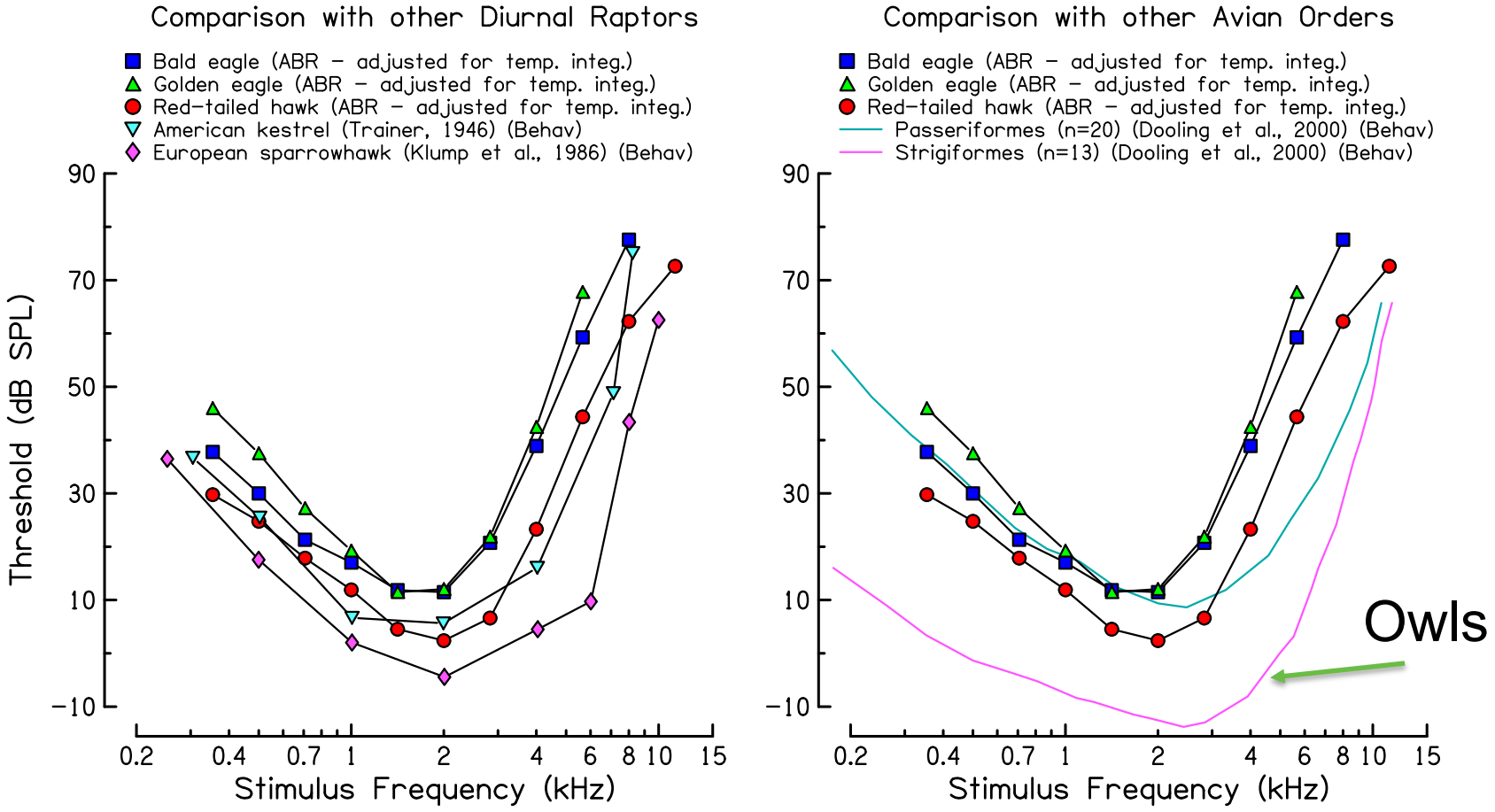
Measuring Auditory Brainstem Response (ABR)



- Hearing range determined
- Greatest sensitivity at 2 kHz
- Eagles are similar
- RT Hawk is slightly more sensitive

Accomplishments and Progress

Measuring Auditory Brainstem Response (ABR)

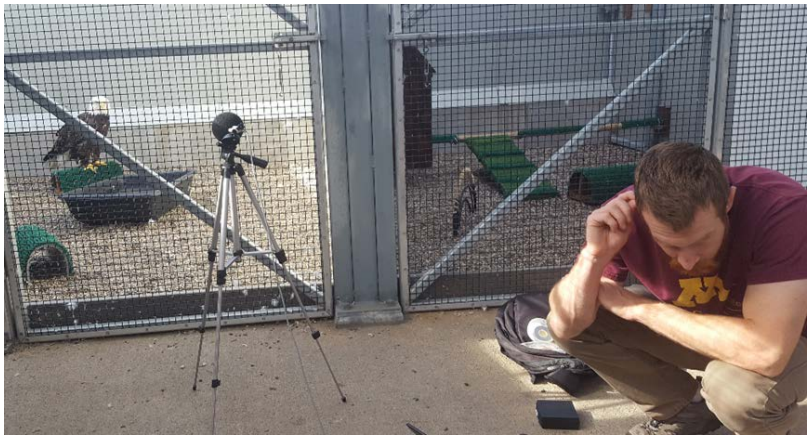


Eagles are hearing generalists – no special hearing adaptations

Accomplishments and Progress

Bald Eagle Vocalization

Goal: *Identify salient features of eagle calls that may be used in the development of acoustic deterrence protocols*

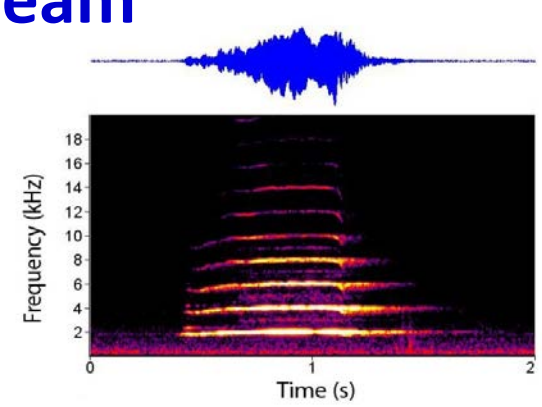


- Calls recorded from eagles housed at The Raptor Center
- Subset of birds were recorded outdoors, approximately 3 m (10 ft) from microphone
- Subset of birds were recorded indoors, approximately 4.6 m (15 ft) from microphone; some up to 18 m (~60 ft)
- ½" free-field condenser microphone (B&K 4191), frequency response of 3.15 Hz to 40 kHz, fitted with a wind screen coupled to a B&K conditioning amplifier/power supply (Nexus 2690)
- 362 artifact free calls recorded

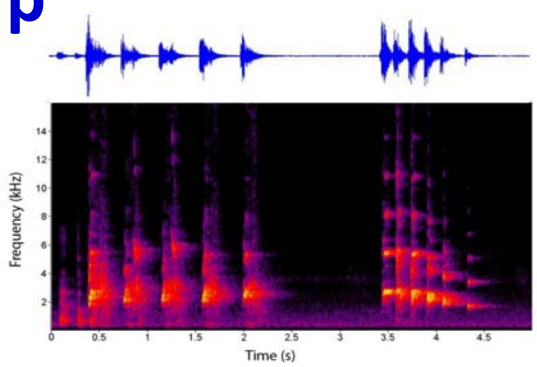
Accomplishments and Progress

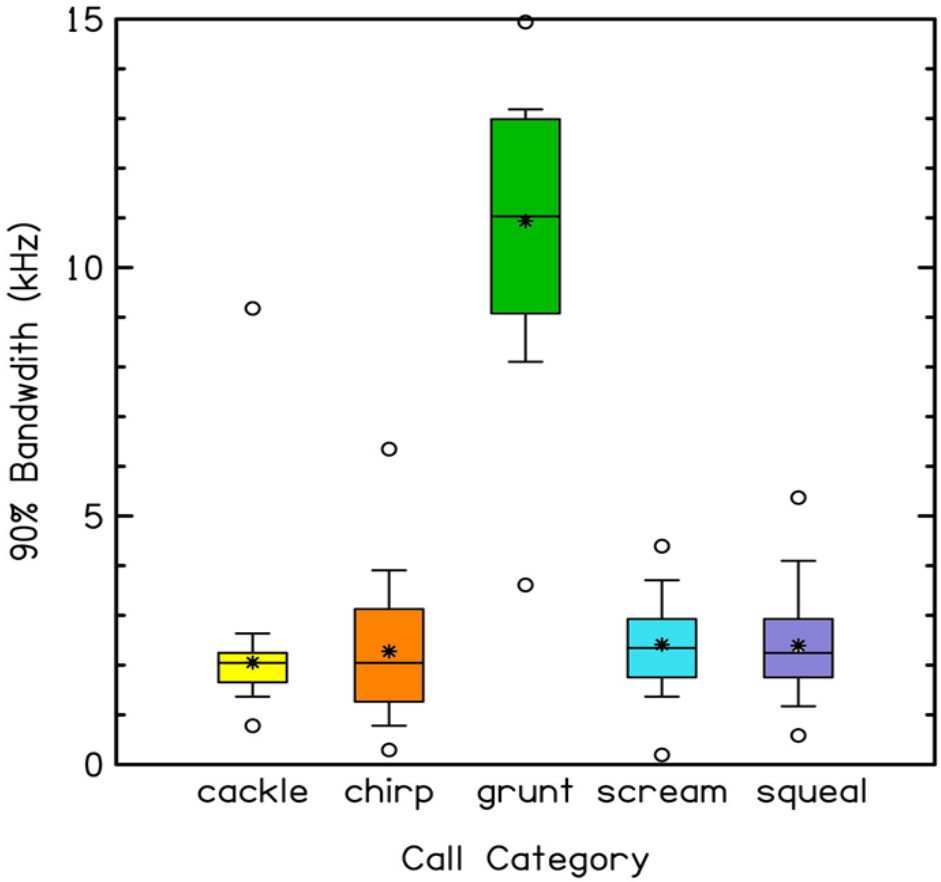
Vocalization Outcomes

scream



chirp





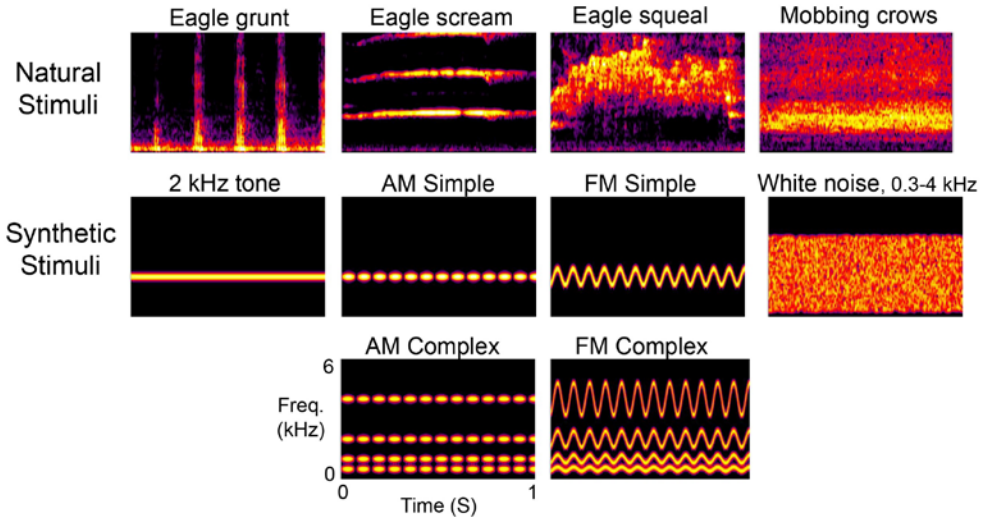
- Detailed characterization of the 5 call types
- Energy is centered around highest hearing sensitivity
- Information used to design acoustic stimuli is in last phase of project.

Accomplishments and Progress

Behavior Response: How do eagles respond?

Protocol

- 3 Bald Eagles
- 2 education birds and 1 clinic
- 10 stimuli
- Recorded response (video)
- Testing – June 2018
- Analysis – Summer/fall 2018



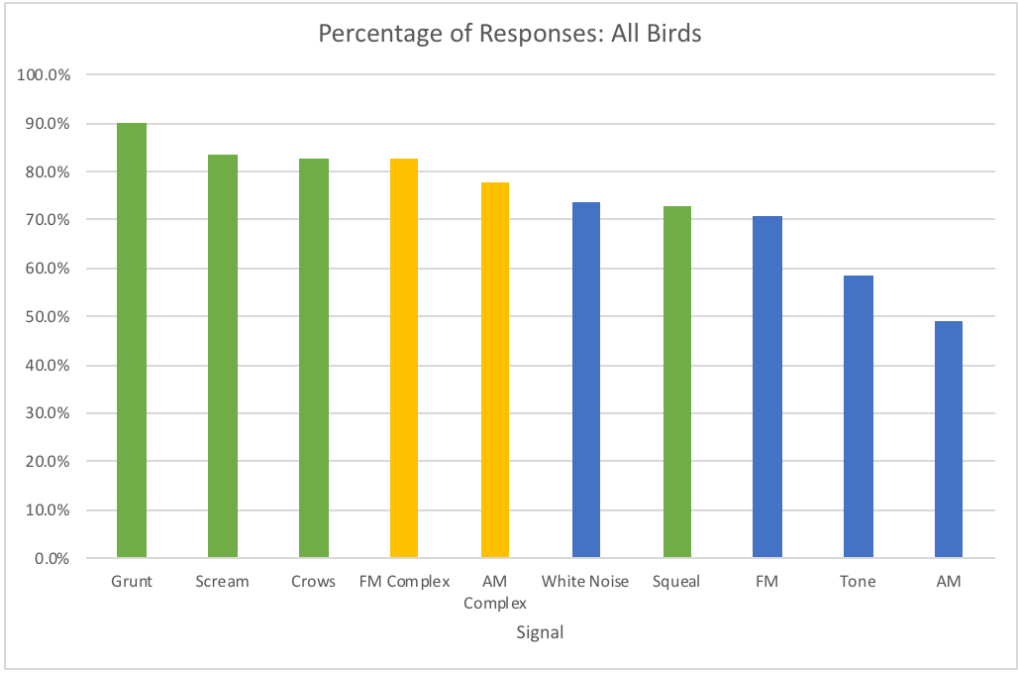
Evaluation

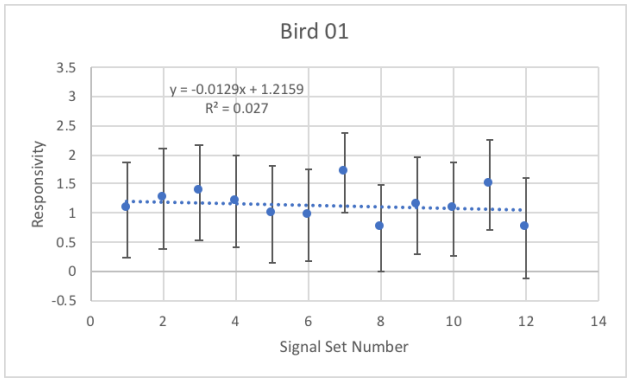
- Independent judges
- Review video and scored response
- Data synthesis

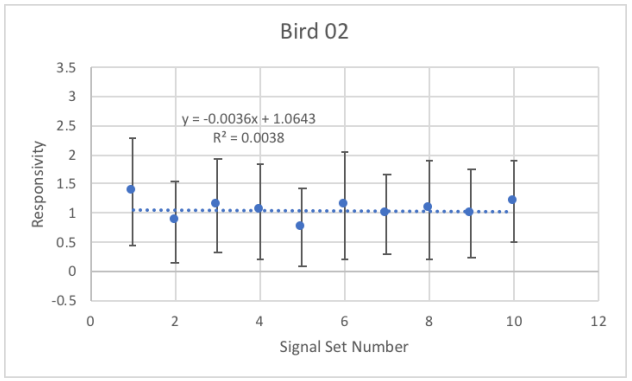
Accomplishments and Progress

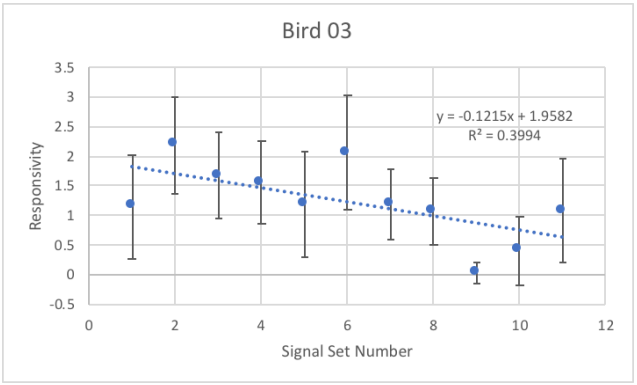
Results

- Stronger responses to more complex stimuli.
  - **Grunts** elicited the strongest response
  - **FM complex stimuli** strongest of synthetic sounds
- Habituation was observed in one of the three birds studied
- The testing protocol was successful and can be used for future behavioral studies.









Accomplishments and Progress

Summary of outcomes

- Project provided robust characterizations of hearing abilities of bald eagles, golden eagles, and red-tailed hawks. The information will allow technology developers to optimize design of acoustic stimuli. The information is also a valuable contribution to the basic sciences.

- Project developed a library of high quality recordings of eagle vocalization. Data provides important insights for acoustic deterrents and will be made available to the public.

- Project demonstrated a method for laboratory evaluation of raptors response to acoustic stimuli.

- Project identified several acoustic stimuli yielding strong response from bald eagles and minor habituation.

- Results of this work will be published in peer reviewed journal publications and technical reports.

Communication, Coordination, and Commercialization

1. **Journal papers**
   - Paper 1 focused on bald eagle hearing, submitted April 3, 2019 to *Journal of Comparative Physiology.*
   - Three additional papers in prep. Summary of vocalization; golden eagles hearing; summary paper for wind energy journal).
2. **Conferences**
   - Wind Wildlife Research Meeting, American Wind Wildlife Institute, November 2018
   - ExoticsCon 2018 - Association of Avian Veterinarians
   - Association for Research in Otolaryngology, February 2018
   - American Acoustical Society, 2017 and 2018
3. **New Proposals**
   - Wind Wildlife Research Fund through American Wind Wildlife Institute (May 2019)
   - Developing new collaborations with an acoustic technology developer and U.S. Fish and Wildlife Service
   - Exploring proposal to National Science Foundation