LIVING MARINE RESOURCES PROJECT 42

ACCURATE ACoustic CUe RATEs for Passive Acoustics Density Estimation

NEED

Marine mammal density estimates are a critical input for the Navy's acoustic effects modeling. While ship or aerial visual surveys are standard methodologies for estimating marine mammal density, they can be very expensive to conduct, are limited both in their spatial and temporal coverage, and are not effective at documenting cryptic species (species that are difficult to see). Estimating density using fixed-passive acoustic monitoring (PAM) has the potential to increase the amount of density data that can be used in the Navy's acoustic effects modeling. In some PAM-based density estimation (PAM-DE) methods, the "cue rate" or the marine mammal sound production rate is an important multiplier to get to a final density estimate. Cue rates can vary in marine mammals as a function of multiple factors, including time of day, year, group size, age, sex, behavioral state, season, bottom depth and location. Also cue rates often are determined from limited data sets and assumed to be representative for the species. The Navy needs recommendations of the most appropriate species for which to collect cue rate data and the appropriate cue rates to use in density estimates.

Tagged sperm whale.

Rune Roland Hansen, Norwegian Animal Research Authority permit 2015/223222

SOLUTION

The ACCURATE project is designed to deliver a comprehensive, quantitative synthesis of the current state of knowledge on acoustic cue rates and cue rate stability for marine mammal density estimation from passive acoustics. The ultimate project goal is to determine the most appropriate cue rates to use in different contextual settings. The project will produce a comprehensive set of recommendations of the most appropriate means by which to advance this field to meet Navy needs. This information will be made publicly available to the wider scientific community involved in estimating density from passive acoustics.

METHODOLOGY

The project team will:

- Identify, review, compile and provide open access to all data available on cue rates (and their variability) across deep-diving and baleen whale species
- Develop methods to estimate cue rates from different data types (e.g. time-depth data) and for different taxa

- Apply these methods to species of interest for the Navy
- Explore the factors that determine cue rate variability over time and space
- Evaluate impacts of cue rate variability on density estimates from cue-based methods.

The project will begin with an extensive bibliographic search for peer reviewed papers and grey literature reports as well as contacting researchers involved in PAM work to understand existing but unpublished data sources. The project team will investigate different methods that could be used to estimate cue rates, and if different types of cues exist, what might be the optimal choice of cue for each species (e.g. regular clicks vs. buzzes, social vs feeding sounds, etc.). The outcome will be a user-friendly data repository that enables Navy users to find the most appropriate cue rate to select in PAM-DE efforts for a given priority species and area.

The team will work with other researchers to process and analyze existing acoustic tag data to estimate cue rates for selected species. These will include at least Cuvier's beaked whale, Blainville's beaked whale and sperm whale. All cues and cue types from each tag will be counted to obtain a cue rate per tag. The estimated cue rate per tag will be combined into a simple cue rate per species.

Based on the initial project efforts, the team will explicitly assess how the cue rates change over time and space, in particular to understand the main drivers of cue rate variability for considered species and cues. A variety of factors might affect cue rates—time of day, sex, season, depth, species, population, sub-population, behavioral state and density itself. One objective is to define easy-to-measure covariates that can be used to predict cue rate. The project team will then build models predicting cue rate as a function of possible factors of interest, providing a framework to estimate cue rate for other times and places based on available covariates.

As information is collected, a series of case-study investigations will be considered to highlight specific scenarios of Navy interest. Examples include:

1. **Evaluating methods for cue rate estimation in baleen whales.**
   The team will work to identify call signatures in different data streams and generate methods to assign cues to a tagged animal.
2. **Estimating cue rate from proxy data when acoustic data are not available.**
   Hidden Markov models (HMMs) could be one approach that could support estimating the most likely, yet unobserved (i.e. hidden), behavioral state (e.g. feeding).
3. **Investigating cue rate variability of deep divers due to geographic region, behavioral state and group size and composition.**
   This work will focus on sperm whales, which have highly detectable echolocation clicks.
4. **Investigating inter click interval (ICI) patterns for deep divers.**
   The ICI patterns can feed directly into evaluating factors driving cue rates such as time of day, season, geographic location, population or behavioral state.
5. **Estimating cue rates when the automatic detector/classifier system influences the cue definition**
   This will use a combination of empirical and simulated data to investigate which 'cue' is the most stable for deep diving animals.

As a final step, the project team will conduct a simulation exercise to evaluate the potential consequences of using biased cue rates. The project will also identify the potential effects of using different cues (with different characteristics) in cue-based density estimation exercises. This will provide guidance on interpreting the density estimates derived using cue rates from times and places other than the original PAM survey.

SCHEDULE

Efforts during 2020 will focus on identifying and compiling existing information on cue rates, as well as extracting and analyzing existing tag data to estimate cue rates for selected deep-diving species. Tasks to analyze cue rate variability and stability will occur primarily during 2021 and simulation exercises will be initiated during 2022 and continue into 2023. If the information and funding indicate that they would be beneficial, the specific case study investigations will be implemented throughout the project period, 2020 to 2023. Reports and presentations will be provided throughout the project, with final reporting by the close of 2023.

NAVY BENEFITS

Marine mammal density estimates are a critical element of the Navy's acoustic effects modeling, which supports environmental compliance. Passive acoustic monitoring potentially offers a cost-effective method to generate density estimates for a wide range of species across Navy priority areas. By addressing a fundamental aspect of PAM-DE—understanding cue rates and cue rate stability—this project will advance the practical application of PAM–DE for Navy purposes. The resulting repository of synthesized data will support future density estimation from passive acoustic monitoring.

TRANSITION

Results will be provided through regular project reports as well as manuscripts that will be submitted to peer-reviewed journals. Presentations, and potentially a workshop, at marine mammal conferences will also disseminate information. Cue rates compiled and estimated throughout the project will be organized and available in a publically available database.

ABOUT THE PRINCIPAL INVESTIGATOR

Tiago Marques is a senior research fellow at the Centre for Research into Ecological and Environmental Modelling (CREEM), University of St Andrews, UK. Dr. Marques has been involved in a large number of projects related to different aspects of statistical ecology, mostly with an emphasis on estimating animal abundance considering a large variety of methods and taxa and with passive acoustic data in particular. He earned his Ph.D. in Statistics from the University of St Andrews, UK.

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About the LMR Program

The Living Marine Resources (LMR) program seeks to develop, demonstrate, and assess data and technology solutions to protect living marine resources by minimizing the environmental risks of Navy at-sea training and testing activities while preserving core Navy readiness capabilities. For more information, contact the LMR program manager at exwc_lmr_program@navy.mil or visit www.navfac.navy.mil/lmr.