

## **Behavioral Response Research Evaluation Workshop (BRREW)**

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### **LONG-TERM GOALS**

The behavioral response of marine mammals to Navy sonar exposure has been a research area funded by the US Navy for a decade or more. The BRREW project aims to provide a synthesis of the current state of knowledge and potential future research directions, focusing on controlled exposure experiments (captive and free-ranging animals) and observational studies.

### **OBJECTIVES**

The overall objective is to review the status and future of research into behavioral responses of marine mammals to naval sonar exposure in order to evaluate the return on investment of current US Navy funded programs, identify the data needs and the contributions of current research programs to meeting data needs, and determine the ability to meet outstanding data needs given the current state of technology.

Specifically the objectives are to:

1. undertake a science-based synthesis of the current state of knowledge on the behavioral response of marine mammals to Navy sonar exposure in key areas including controlled exposure experiments (captive and free-ranging animals) and observational studies on real Navy exercises;
2. critically evaluate on-going research efforts, pinpointing strengths and weaknesses; and
3. identify future research directions based on current knowledge and its potential for advancement using available research methods. Identify new research capabilities needed to meet requirements for future research.

## APPROACH

The following outlines the planned approach, in four stages:

*1: Identify and recruit external experts.*

A short list of key active researchers on behavioral response of marine mammals to sound exposure will be created, including both foreign and domestic, based on the applicability of each individual's contributions to research in behavioral response of marine mammals to sonar exposure. We will recruit three experts, with complementary skills and experience.

*2. Obtain information on current state of knowledge.*

The project PIs will undertake a literature review, in collaboration with the steering committee and in consultation with behavioral response study (BRS) PIs. In addition, we will circulate a questionnaire to BRS PIs and other relevant researchers, selected in consultation with the steering committee, with questions tailored to elicit an assessment of the current state of knowledge in key areas (see below), the research gaps, and suggested pathways to fill knowledge gaps. Lastly, we will hold focused tele-meetings with the external experts and sub-groups of the BRS PIs to ensure a complete picture of the current state of knowledge.

*3. Discuss and synthesize during face-to-face research workshop.*

We will hold a research workshop of 2.5 days in length, with the aim of discussing and assessing current studies and their findings, synthesizing, and examining possible future research directions. Invited attendees will include the external experts and representatives of each of the Navy-sponsored behavioral response study research programs. Key topics of discussion will include response to simulated sources of Navy sonar (BRS and captive studies), response to real Navy sources (BRS studies, M3R), incidental response to Navy sonar exposure, context of responses (i.e., diving behavior, prey density), and analysis of response. Additional workshop discussion topics may include technological needs, analytical needs, and experimental design. The final half-day will be spent discussing and structuring an article for peer-review.

*4. Complete synthesis; produce report and manuscript.*

After the workshop, the external experts will work with the PIs to produce the workshop report. The scientific manuscript will be led by the project PIs, with input from all those who have provided input into the project and who wish to be active participants. The goal will be to produce a landmark assessment of the current and future state of the science on behavioral response of marine mammals to sonar.

## WORK COMPLETED

We approached three active researchers to act as external experts in the review. Specifically Dr. Hans Slabbekoorn (University of Leiden), Professor Vincent Janik (University of St Andrews) and Professor Douglas Wartzok (Florida International University) agreed to serve. The external experts were then provided with relevant literature to familiarize themselves with prior to the workshop, and focused tele-meetings were held with the external experts and sub-groups of the BRS PIs to ensure a complete picture of the current state of knowledge. Additionally a questionnaire was circulated prior to the workshop to canvass the opinions of members of the scientific community (primarily workshop participants exclusive of the external reviewers) with respect to each of the different research

approaches being reviewed. The external experts were provided with a synthesized and anonymized version of the questionnaire responses.

The primary component of the review was the workshop, which was held at Hopkins Marine Lab, Monterey, California. The invited workshop participants were key representatives of each of the Navy-sponsored research programs plus the three external experts. The structure of the questionnaire and the collated responses formed the structure of the workshop, which consisted of a series of discussion sessions. After the workshop, the external reviewers each provided an independent evaluation of the research conducted to date and recommendations for future research efforts, using as source material the supporting literature, pre-workshop presentations provided by a representative of each research approach, the questionnaire responses and the content of the workshop discussion sessions.

The role of the project PIs has been to synthesize the three independent reviews and ensure all views are represented in the project report, which contains a synthesis of the evaluations and recommendations. The project report was submitted to the sponsors (ONR, LMR and NOAA) on 12 August 2015.

In addition a scientific manuscript is being led by the project PIs, with input from all those workshop attendees who have expressed a wish to be active participants in the manuscript. A manuscript outline was developed during the last session of the workshop.

## **RESULTS**

The external experts all agreed that excellent progress has been made on the topic and that each of the research approaches has contributed to our understanding of cetacean responses to naval sonar. The report submitted to the sponsors includes specific comments and recommendations of the external experts relevant to each approach, but also includes suggestions for priority species and a comprehensive list of recommendations for the future of BRS research in general. In summary it was recommended that BRS research be continued and extended to increase sample sizes and experimental replication, and temporal duration and spatial scale including more research in areas where the animals are presumably more naïve than on the naval ranges. It was noted that future investigations would benefit from combining experimentation and observation to enable linkage of short-term behavioral response to long-term fitness consequences of repeated exposure. Beaked whales were the species group ranked highest in terms of research priority. The importance of baseline studies and longer-term monitoring of animals before and after exposure is emphasized throughout the report. Further development of tag technology was also highlighted as a priority to support the goal of monitoring animals over longer time periods and also provide the capability to monitor a wider range of species.

## **IMPACT/APPLICATIONS**

As part of rule-making under the US Marine Mammal Protection Act, the Navy has committed to an Integrated Comprehensive Monitoring Program with the following objectives: monitor and assess the effects of Navy activities on protected marine species; ensure that data collected at multiple locations is collected in a manner that allows comparison between and among different geographic locations; assess the efficacy and practicality of the monitoring and mitigation techniques; add to the overall knowledge base of protected marine species and the effects of Navy activities on these species (Stone 2009). As part of its environmental compliance, the Navy must attempt to quantify the effect of sonar

operations on marine mammals in all of its operating areas. This requires research to enhance our understanding of the behavioral responses of marine mammals to sonar exposure and to allow the estimation of the relationship between acoustic dosage and other factors with behavioral responses. This project will provide a synthesis of the current state of knowledge in this subject area, enabling the Navy to evaluate the return on investment of current US Navy funded programs. The project will also highlight current data needs and the ability to meet outstanding data needs given the current state of technology. This review will help identify new research capabilities needed to meet requirements for future research. The workshop report will provide a synthesis of the current state of behavioral response research for academia, government, industry, and interested member of the public.

## RELATED PROJECTS

The BRS approaches being reviewed and evaluated have involved many projects. The key projects within each approach are listed below with links to websites where more information can be obtained.

Controlled exposure experiments:

- Captive studies: <http://www.nmmf.org/>
- BRS Bahamas (AUTEC): <http://www.nmfs.noaa.gov/pr/acoustics/behavior.htm>
- SOCAL BRS: <http://sea-inc.net/socal-brs/>
- 3S: <http://soi.st-andrews.ac.uk/documents/424.pdf>
- 3S2: <http://www.ffi.no/no/Rapporter/11-01289.pdf>
- Cape Hatteras: <http://www.serdp.org/Program-Areas/Resource-Conservation-and-Climate-Change/Natural-Resources/Living-Marine-Resources-Ecology-and-Management/RC-2154/RC-2154>
- MOCHA: <http://www.creem.st-and.ac.uk/mocha/>

Observational studies:

- Marine Mammal Studies at the Southern California Offshore Range (SCORE): <http://www.cascadiaresearch.org/SCORE/SCORMain.htm>
- PAM methods:
  - M3R program
  - HARPS [http://cetus.ucsd.edu/technologies\\_AutonomousRecorders.html](http://cetus.ucsd.edu/technologies_AutonomousRecorders.html)
- Photo-identification studies:
  - <http://www.bahamaswhales.org/research/index.html>

## REFERENCES

Stone VF. 2009. United States Navy Integrated Comprehensive Monitoring Program. Available at [http://www.nmfs.noaa.gov/pr/pdfs/permits/socal\\_hrc\\_icmp.pdf](http://www.nmfs.noaa.gov/pr/pdfs/permits/socal_hrc_icmp.pdf)

## PUBLICATIONS

Harris C.M., Thomas, L. 2015. Report on the current status and future of behavioral response research.