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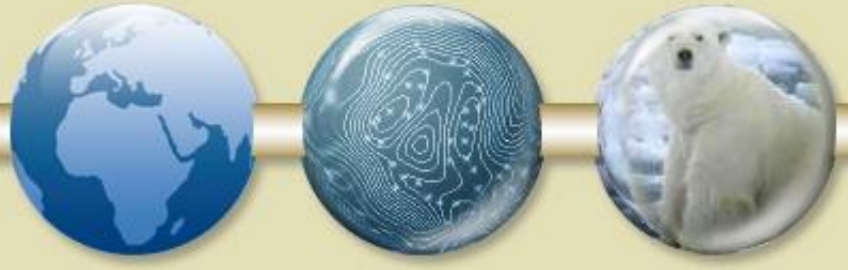

An overview of the Behavioral Response Research Evaluation Workshop (BRREW) project

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Aims of BRREW

The goal of the review was to:

- assess the current state of knowledge of the topic in order to evaluate the return on investment of current research programs (funded by US Navy).
- identify the data needs and the contributions of current research programs and methodological approaches to meeting data needs, and the ability to meet outstanding data needs given the current state of technology.
- support the long-term goal of understanding research progress and needs for future research by providing a comprehensive critique of the state of the art in marine mammal behavioral response research.
- formulate recommendations for future behavioral response research.

Major research approaches

1. Controlled exposure experiments (CEEs) on captive animals using simulated sources of Navy sonar

2. Controlled exposure experiments (CEEs) on free-ranging animals using simulated Navy sources or real, but scaled, Navy sources on research vessels

3. Controlled exposure experiments (CEEs) on free-ranging animals using real Navy sources deployed by Navy vessels

4. Observational studies (primarily using tags, PAM and visual observation) in relation to exposure to real Navy sources and Navy vessels

5. Predator playback studies

The workshop

- April 2015
- Hopkins Marine Lab, Monterey, California
- Attendees
  - 2 project PIs
  - 3 external experts *(Professor Vincent Janik [University of St Andrews], Dr Hans Slabbekoorn [University of Leiden], Professor Douglas Wartzok [Florida International University])*
  - 11 key representatives of Navy-funded behavioral response studies
  - sponsor representatives

Post-workshop activities

- The external experts each provided an independent evaluation of the research conducted to date and recommendations for future research efforts
- The three independent reviews were synthesized into a project report
- All recommendations for future research were extracted and tabulated (there were 31).
- Experts were asked, independently, to provide a priority score for each recommendation: 1 (20%) ,2 (70%) or 3 (10%). (Note, even category 3 is a recommended research priority.)
- The synthesis was approved by the experts prior to publication

SUMMARY OF FINDINGS AND RECOMMENDATIONS

Current status of research

- External experts all agreed that
  - excellent progress has been made
  - each of the research approaches has contributed to our understanding of cetacean responses to naval sonar

Future Research Recommendations
Overview

- External experts
  - 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.
  - 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.
  - Emphasized the importance of baseline studies and longer-term monitoring of animals before and after exposure.
  - Ranked beaked whales highest in terms of research priority.
  - Highlighted further development of tag technology 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.

Species priorities

Species/species group	Priority score
Beaked whales	1
ESA listed baleen whales	2
Sperm whales	
Harbour porpoise	
Small delphinids	

Future Research Recommendations

ID	Recommendation	Approach	Priority score	Note
4	Increase collection of baseline data (improve both spatial and temporal extent of data)	Free-ranging CEEs and observational with sat tags	1-1-1	
10	Conducting CEEs with real Navy vessels and sources to generate dose-response functions for real sonar sources	Free-ranging CEEs with real sources	1-1-2	Requires adequate replication and appropriate sampling design
11	Investigate the relationship between source-whale distance and received level	Free-ranging CEEs with real sources		Logistically difficult, although not as difficult as two sources or repeated multiple days
18	Development of a medium-long term Fastloc GPS tag that can measure sound exposure	Technology		
19	Development of attachment mechanism to fit GPS tag (described in 15 and 16) to porpoises and small delphinids	Technology		
20	Development of long-term tag attachment mechanism for large species that cannot be captured for attachment.	Technology		
25	Improve understanding of link between dose and severity of response to better understand consequences	Observational and free-ranging CEE		With an emphasis on understanding consequences

ID	Recommendation	Approach	Priority score	Note
1	Captive choice studies to investigate: parameters (other than RL) that may modulate response, including signal characteristics; response mechanisms; tolerance, preferences and aversion to acoustic stimuli	Captive		
15	Comparison of population demographics in populations resident on naval ranges and those in areas far from naval ranges.	Observational (photo-id)		Political necessity to say something about whether the range is a sink. Replication at popn level required to prevent over-interpretation of a comparison of two populations
16	Conduct experiments in regions where animals are, and are not, likely to have previous experience of sonar exposure to understand role of experience.	Free-ranging CEE	1-2-2	Preferentially with long-term tag data on exposure history (for sonar and any other anthropogenic noise) for experimentally exposed whales
21	Conduct or observe exposures with higher received levels to better understand mechanisms underlying response	Observational near ranges, or free-ranging CEE		
24	Improve understanding of link between behaviour state and response	Observational and free-ranging CEE		
27	Improve understanding of role of prey by collecting prey data alongside tagging efforts, and looking at sonar effects on prey	Observational and free-ranging CEE		This is critical for any interpretation with PCAD-models
2	Captive studies to investigate effect of noise in undisturbed animals which are carrying out normal activities	Captive	1-2-3	Not specific to sonar, but essential to not misinterpret lack of deterrence as lack of impact; also critical for PCAD-models

ID	Recommendation	Approach	Priority score	Note
3	Test new technologies, such as physiology tags, on captive and free-ranging animals	Captive	2-2-2	"Tagnological" advancements will be critical for any major advancements in understanding impact
5	Increase collection of baseline data (improve both spatial and temporal extent of data)	Observational with PAM		
6	Increase use of individual focal follow observations	Free-ranging CEE and observational		Could be used to reduce reliance on tags + increase sample size associated with CEEs for some species.
8	Investigation of source vessel orientation and movement	Free-ranging CEEs		
9	Investigate species differences in individual variability	Free-ranging CEEs		
12	Investigate the relationship between source-whale distance and received level	Observational with sat tags		
17	Development of a medium-long term Fastloc GPS tag with dive profiler	Technology		
22	Improve understanding of possible response metrics such as sensation level vs received level	All		
26	Improve our understanding of social context by tagging multiple individuals simultaneously	Observational and free-ranging CEE		
28	Improve understanding of long-term consequences through studying stress hormones in different environments			
29	Body condition studies in relation to exposure, e.g. using metrics from Dtags			

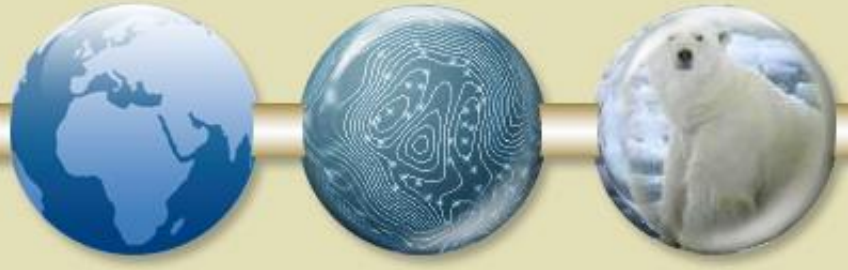
ID	Recommendation	Approach	Priority score	Note
7	Investigation of cumulative effects using two sources or repeated exposures over multiple days	Free-ranging CEEs	2-2-3	Important but exceedingly difficult. Concern that this will not become well-replicated
13	Integration of research approaches (e.g. PAM with CEEs)	All		
14	Improving interpretation of PAM data to increase potential for observing responses (i.e. move away or cease vocalisation)	PAM with tagging	2-3-3	The problem is that results cannot easily be applied to other locations and species. PAM is of limited use for looking at effects.
23	Obtain audiogram data for more species to allow investigation of sensation level as a response metric for more species			
30	Statistical review of the statistical methods developed for application to BRS			
31	Investigate the effect of ramp-up protocols	Free-ranging CEE		

Concluding comments (of the external experts)

- Baseline ecological studies of multiple species are key to our general understanding and the correct interpretation of both behavioral patterns and experimental results.
- The problem of understanding behavioral patterns and especially event-related deviations is not trivial in natural environments.
- All studies, captive and free-ranging, have shown that responses of animals are highly variable. The difficulty in drawing conclusions from data that are highly variable has required the development of new analytical techniques and the application of the latest statistical techniques to marine mammal behavioral responses.

Concluding comments (of the external experts)

- Given the variability in responses there are questions regarding the applicability of dose-response curves created with one species under one set of conditions to other species and situations.
- We still do not have sufficient data to be able to extrapolate from the current set of experimental subjects to broader conclusions about which species may be more sensitive to, or more tolerant of, sonar.
- The classification of cetaceans based on functional hearing groups according to the general hearing ranges does not appear to be appropriate for assessing sonar impacts.
- Translating the results from any of the studies conducted to free-ranging animals exposed under real exercise conditions should be carried out with caution.



Report is available online:

– http://hdl.handle.net/10023/7741

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