5th Working Group Meeting on the Multi-study OCean acoustics Human effects Analysis (MOCHA)

Hosted by Cascadia Research Collective, Olympia, Washington

17-19 March 2014

1. Summary

This document briefly reports on the fifth meeting of the US Office of Naval Research sponsored MOCHA working group, held on 17-19 March 2014 and hosted by the Cascadia Research Collective in Olympia, Washington. The overall aim of the group is to develop and implement innovative statistical methodologies for the analysis of behavioral response study (BRS) data. In this fifth meeting we focused on baleen whales, and the related analyses that the MOCHA team and BRS project teams have been working on thus far.

2. Background and objectives of working group

The background to the work and the objectives of the working group are described in full in the report of the 1st Working Group Meeting and in the project proposal. Both of these documents are available for download from http://www.creem.st-and.ac.uk/mocha/

The specific objective of the 5th Working Group Meeting was to focus on analysis carried out by BRS project teams and the MOCHA team on the baleen whales, to discuss priorities for development of analysis tools for these species, and to plan ahead for the final workshop and final year of the project.

3. Summary of fifth working group meeting

The format of this working group meeting was different from previous meetings and built on the small technical group format, which was trialled and found to be popular at the 4th working group meeting. By this point in the MOCHA project it was felt that there was a good awareness of the data held by each project team and the analysis each has been conducting. Therefore there were no presentations made over the first two days of the meeting. Instead, in advance of the meeting we had asked people to propose research questions and come to the meeting equipped with ready-prepared datasets. The first two days of the meeting were structured into multiple small working group sessions, which allowed time for significant development of a number of research questions and analyses. The following were the primary groupings over the two days, with brief descriptions of what each group achieved:

Johnson and Thomas – investigated development of a Bayesian version of the state-based hidden Markov model developed for the SOCAL blue whale dive dataset. They formulated some sensible restrictions that could be placed on the prior distributions of the parameters for assessing deviations in behaviour post exposure and started work on the MCMC algorithm.

Sadykova and Bowers – implemented a dive-by-dive state-based model for pilot whale data. A hidden Markov model (HMM) framework was used to define behavioural states and to understand how those states depend on received levels. The HMM was constructed based on the assumption that there were 2-3 underlying behavioural states and that the observations were conditionally independent given the state. The playback received level was included as a covariate in the transition probability matrix. Input data for the model included dive duration, surface duration, maximum depth, buzzes, median minimum specific acceleration and variation in heading.

McClintock, Wensveen, Calambokidis, Southall, Tyack, Miller, Noad and Gailey – held a discussion about how to define, and identify, an avoidance response in horizontal movement (i.e. from a centre of repulsion). The goal was to investigate how horizontal avoidance can be modelled within a state-based movement model framework. McClintock led a brainstorm session in which the group discussed possible models, the general level of model complexity, and what defines avoidance responses in baleen whales. Discussion focussed on the movements of humpback whales and blue whales as 3S, SOCAL and BRAHSS have large data sets for these species. The group decided that the initial model should include: 2-dimensional movement (horizontal plane only), 3-4 behavioural states (forage, travel with/without avoidance), no measurement error, and include both the stationary source and moving source. The group thought avoidance was defined by: an initial change in the direction of movement, movement directly away (stationary source) or at 90 degrees relative to the projected source track, a potential increase in directionality, and a potential increase in speed. The output of the discussion was values of input parameters for avoidance speed and optimal escape angles from both stationary and moving sources.

Thomas and Wensveen – simulated from a horizontal movement model with avoidance. Following the discussion session described above, Thomas and Wensveen implemented a movement model and simulated tracks from this model for the stationary and moving source cases with and without avoidance (Figure 1).

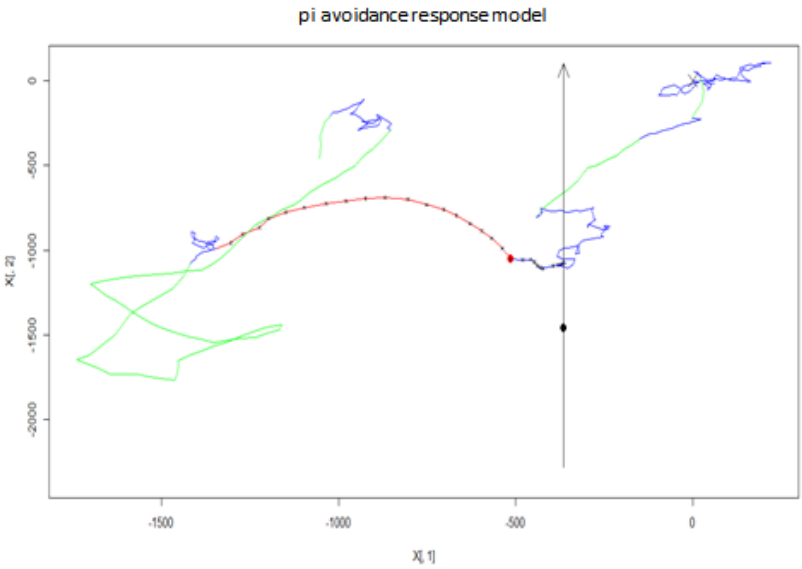

Figure 1: Example output from the simulation of horizontal avoidance. Green represents travelling, blue represents foraging, red represents the period of horizontal avoidance, the black line and arrow represent the

source and the direction of travel, the black circle represents the start of the exposure session, and the red circle represents the start of the avoidance response.

Mackenzie and Dunlop – implemented a multivariate Generalised Estimating Equation (GEE) to identify responses of migrating humpback whales to playbacks. Following a discussion about how to include received level (RL) as a covariate and how to combine RL with other relevant dose metrics, such as distance to source, Mackenzie and Dunlop worked on the development of an interaction surface between two dose metrics (RL and distance). This 2D interaction surface was then used as a predictor variable in a multivariate GEE model looking at a number of different response variables (e.g. change of course relative to 180 degrees and speed of southward movement).

DeRuiter, Stimpert and Falcone – implemented fin whale call rate analysis based on DTAG and focal follow data to determine behavioural context of calls and any effect of controlled exposure to sonar. The initial data set was binned into 1-minute intervals and included call count as the response variable and mean whale depth, mean body pitch, group size, group dispersion, source-whale range, and CEE received level. They worked in parallel on preparation of the full SOCAL fin whale dataset (approximately 6-10 whales) and development of the modelling framework using pilot data from one whale; work will continue to fit the model to the full data set.

Harris, Miller, Southall and Tyack – reviewed dose-intensity modelling methods for severity scored data. Prior to the meeting, the MOCHA project had been working on methods to model the relationship between dose and responses of differing intensity (as measured on the Southall et al. (2007) severity scale). A couple of different model options had been investigated and Harris put forward a proposal at the meeting to move forward with the marginal stratified Cox proportional hazards method for recurrent events. The assumptions of the marginal approach, whereby responses of any severity have an equal probability of occurring at any time point, was felt to be more appropriate than the assumptions of the conditional approach. However, it was agreed that the input data be modified to reflect the belief that if a moderate response is observed, then all responses at least as severe have also occurred. This results in a dataset where low severity scores do not occur at higher SELs then high severity scores within one exposure session. There was agreement within the group that we can move forward with this method and look at different dose metrics (e.g. SPL, proximity to source), as well as different covariates (e.g. behavioural state at the start of exposure).

Sadykova and Dunlop –implemented a hidden Markov model (HMM) for humpback whale focal follow data. Using multiple response variables in a behavioural response study analysis can be complicated, and results can be difficult to interpret in the context of being biologically meaningful. Defining behavioural states in an objective way may be one solution. A hidden Markov model (HMM) was used as the framework to define behavioural states in migrating humpback whales. The baseline data set (when there was no source vessel in the area) was used as the test set. This data was land-based focal follow data of about 80 migrating groups. Variables included in the model were continuous measures of course and speed, rates of surface active behaviours, and dive time and categorical measures of social context (group composition and group social behaviour).

Mackenzie and Bowers – implemented change-point methods with spatially-adaptive smoothing. The aim was to identify change points in the DTAG data (ODBA, heading, and depth), where the "changes" last for differing amounts of time. They created a piecewise linear regression model for spline-smoothed data with an adaptive knot selection algorithm (SALSA) that determines both the number and location for "knots". These knots represent a change point and the distance between knots would represent the duration of this altered state.

The focus of the last morning of the meeting was meta-analysis across projects and species. The MOCHA project is entering its final year of funding, and as such, we are keen to extend some of our analysis methods to include data from more species and projects. It was agreed that each project will aim to publish their individual data and results first before any publication uses the data for meta-analysis. Each project will supply data to allow MOCHA to progress with analysis development but will place a realistic embargo date on its publication. From the MOCHA perspective the primary options for meta-analysis include exposure-response/exposure-intensity modelling, event rate analysis (e.g. baleen whale lunge rate analysis), and state-based modelling. There was interest in all of these ideas with the priority being the exposure-response/exposure-intensity models. Currently there is a reliance on expert scoring to obtain more data for the exposure-response/exposure-intensity modelling. Expert scored data are expected to be received from 3S2, SOCAL and AUTEC in the next six months, allowing the current models to be substantially extended.

Finally we discussed the venue, date and format of the final MOCHA working group meeting. It had already been agreed to hold the meeting in St Andrews towards the end of 2014, but exact dates were still to be decided. It was felt that a four day meeting will allow for two days of presentations on MOCHA outputs with external reviewers present, and two days of technical meetings with project partners. It was agreed to hold the review meeting prior to the technical meeting.

4. Acknowledgements

We would like to acknowledge that, although the MOCHA project itself is funded by the US Office of Naval Research, we rely on the participation of the working group members whose time and efforts are kindly supported by a wide range of institutes and funders.

Appendix 1 – 5th working group meeting attendees

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