4 Discussion

We used a series of three linked models to quantify the response of Blainville's beaked whales to naval training exercises involving MFAS: the first model was fitted to pre-exercise baseline data, the second was fitted to data collected when naval training exercises were ongoing but no MFAS was present, and the third model was fitted to data collected during naval training exercises that used MFAS. We found that the probability of acoustic detections of Blainville's beaked whales decreased when both naval training exercises and naval training exercises using MFAS were present.

In comparison to the risk function developed by Moretti et al. 2014 for Blainville's beaked whales at AUTEC, our risk function predicts a more intense response to naval sonar. This may be because Moretti et al. were not able to explicitly account for the effects of naval training activities that did not include MFAS. Their baseline period consisted of 19 hours of data before the onset of MFAS; as at PMRF, it is likely that training activities during this period included sound sources other than MFAS. Therefore, their risk function is probably more analagous to our expected change in the probability of a detection when MFAS is present relative to when naval training activity was present (Fig. 4).

Additionally, we used spatially-explicit methods that account for the spatial confounding of animal distribution and naval training activity. The data used in this study are from an undesigned experiment, where the spatial intensity of the treatments (naval activity and MFAS) were not applied randomly with respect to either the study area or Blainville's beaked whale presence. We did not want the spatial distribution of training exercises and MFAS to influence our understanding of the baseline spatial distribution of Blainville's beaked whales. Due to the spatial confounding of animal distribution and naval training activity at PMRF, fitting a single model to all of the data would lead to underestimates of the impact of sonar, since changes in distribution due to MFAS could be explained as spatial changes by the MRF (Appendix X). Our three-stage modelling approach addresses this issue while propagating uncertainty between the models.

The analytical approach outlined in this article could be applied to other species, regions, and types of disturbance where experimental design is not possible. The use of Markov random fields for the spatial term is useful for cases where exact distance data is not available, avoiding the use of continuous smoothers when true location data is not available. Shape-constrained smoothing is also well-suited to the kind of data we model here – ensuring that values can only stay constant or decrease over time (or any other covariate). Finally, the use of a multi-stage posterior sampling scheme extends to any situation where multiple models are fitted and the results of one part feed into another. Simulation-based approaches such as these bypass the need to derive (often complex) expressions (or shortcut them by assuming independence). We provide example code as Supplementary Material so that other researchers may apply and/or expand on these methods.

- Discuss dose-response and p(disturbance) in context of [@tyack_using_2019]
- plans to investigate what aspects of general training activity is eliciting a response.

From Liz: Then we can discuss the fact that environment/habitat (e.g. deep basin with shallow slopes all around vs deep open ocean) doesn't seem to play much of a role in Blainville's response, and the response seems to be more of an intrinsic characterisitic. Also can mention here the same effort at SCORE with Cuvier's – in light of these results we expect similar results there even though different species but similar habitat to AUTEC.