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PCoD Lite - Using an Interim PCoD Protocol to Assess the Effects of Disturbance Associated with US Navy Exercises on Marine Mammal Populations

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LONG-TERM GOALS

The approach is being developed in this project has the potential for operational use by the US Navy as part of its environmental impact assessments. In future, these assessments will likely be required to

provide information on the potential population-level consequences of exposure to anthropogenic noise from Navy activities as well as the number of animals that are exposed. In order to issue an incidental harassment authorization to the US Navy under the Marine Mammal Protection Act (MMPA), the Office of Protected Resources must ensure that "the specified activity …cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival". Under the Endangered Species Act (ESA), jeopardy decisions are made where "jeopardy occurs when an action is reasonably expected, directly or indirectly, to diminish a species' numbers, reproduction, or distribution so that the likelihood of survival and recovery in the wild is appreciably reduced." We have recently developed an interim protocol (Harwood et al. 2014; King, et al. 2015) that can be used to implement the framework for assessing the population consequences of acoustic disturbance for marine mammals originally developed by a panel appointed by the US National Research Council (NRC 2005). Here, we provide an insight into how the Interim PCoD approach (Harwood et al. 2014, King et al. 2015) might be used to inform the science that underpins Navy Environmental Impact Statements.

OBJECTIVES

The main objective of the project was to illustrate how the interim PCoD protocol can be used to inform the process of determining whether or not Navy activities are likely to have an impact on populations of two priority species at two different Navy ranges within the regulatory frameworks associated with the Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA). For this project, we adapted the protocol so that it could be used to forecast the potential effects of disturbance associated with Navy exercises on populations of Blainville's beaked whale *Mesoplodon densirostris* (covered under the MMPA) and ESA-listed sperm whale *Physeter macrocephalus* at the Atlantic Undersea Test and Evaluation Center (AUTEC), Bahamas, and at the Pacific Missile Range Facility (PMRF), Hawaii (Blainville's only).

APPROACH

The project was overseen by a Steering Committee comprised of members of the US Navy, National Oceanographic and Atmospheric Administration (NOAA), and the Marine Mammal Commission (MMC). This ensured a broad review and steer on the project and its objectives. The Steering Committee helped to determine the scope of the project (e.g. which species should be investigated and which study sites should be included) and provided input on the composition of a wider stakeholder group consisting of representatives of other organizations likely to be interested in the project.

We conducted a series of expert elicitation workshops, to which a list of experts on beaked whales and sperm whales, compiled with assistance from the Steering Committee, were invited. Each expert was supplied with an electronic questionnaire allowing them to provide the information required to parameterize the relationships shown in Fig. 1. A similar questionnaire had been used successfully during the development of the interim PCoD protocol (see Appendix 1 of Harwood et al. 2014). This questionnaire uses the 4-step approach developed by Spiers-Bridge et al. (2010) to provide robust information on the uncertainty associated with each expert's opinions. Following this initial online elicitation, workshops for beaked whales were held in Washington, DC (November 2014) and St Andrews (January 2015), and a workshop for sperm whales was held in Washington, DC (April 2015). The relationship shown in Fig. 1 was modified to that shown in Fig. 2, based on feedback from experts during the workshops

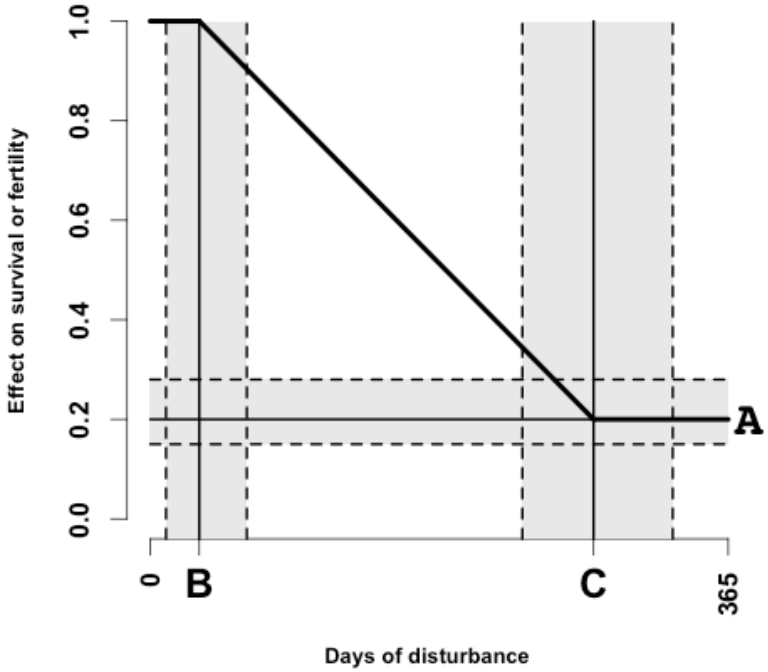

Figure 1. Hypothetical relationship between the number of days of disturbance experienced by an individual and its effect on the probability of survival or of giving birth (fertility). A is the maximum effect of disturbance, B is the number of days of disturbance an individual can tolerate before its survival or fertility is affected, and C is the number of days of disturbance required to cause the maximum effect. The shaded areas indicate the experts' estimates of the likely range around the best estimates of A, B and C.

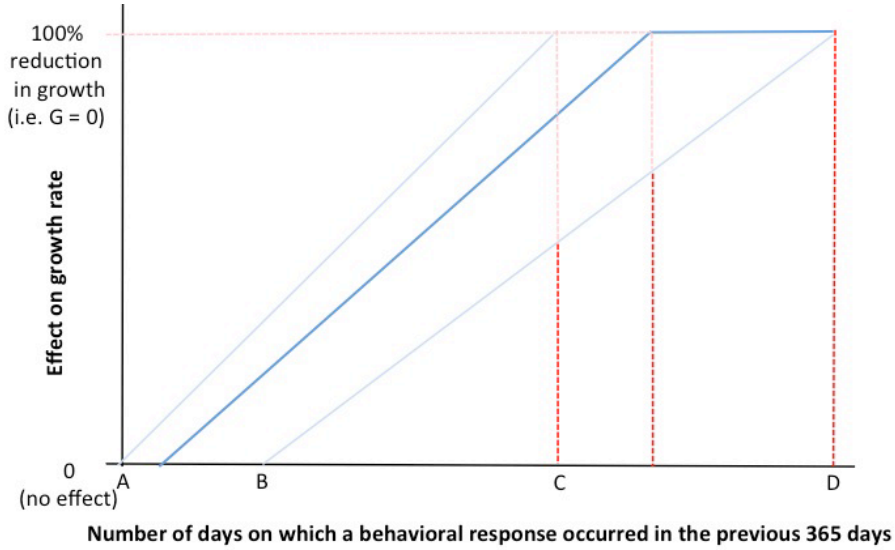

Figure 2 - Hypothetical relationship between number of days of behavioral disturbance experienced in the preceding 365 days and the growth rate of whales. A and B define plausible bounds for the number of days an individual can tolerate without any effect on its growth rate. C and D define plausible bounds for the number of days of disturbance required to reduce growth to zero.

In addition, a new application in the R package 'shiny' (Chang, et al. 2015) was developed for the sperm whale workshop that replaced the standard paper format used at previous workshops. This provide each expert with a visual representation of the effect of the parameter values they had chosen on the shape of the relationship shown in Fig. 2, and allowed the expert to choose the shape of a statistical distribution describing the uncertainty associated with these values.

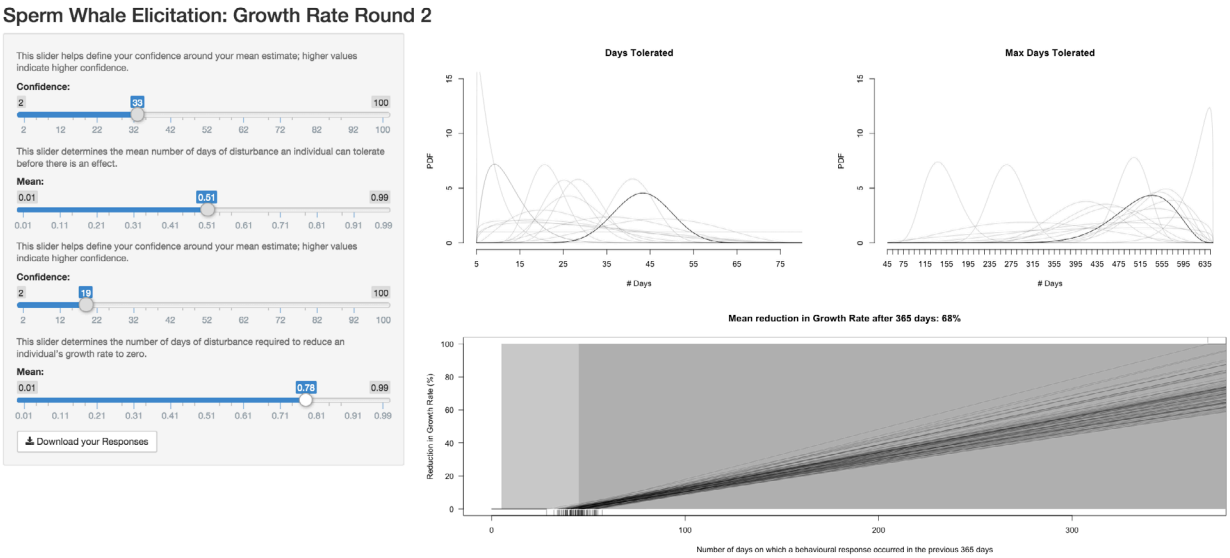

Figure 3 – Screenshot of the 'shiny' app used in the sperm whale workshop. Experts were allowed to use the sliders on the left in order to define the relationships in the right-hand windows. There results were then displayed with the uncertainty below. Expert estimates were combined to produce the heat maps described below (e.g. Figure 5).

During the workshops, we used the Delphi process (Delbecq et al. 1975, MacMillan & Marshall 2006), in which experts were asked to reconsider their opinions in the light of what other experts said. This has been shown to substantially improve the reliability of the elicitation results (Burgman et al. 2011). .

The next stage was to modify the computer code written to implement the interim PCoD protocol to account for different nature of disturbance events associated with Navy exercises and to provide metrics agreed by the Steering Committee (at a meeting in June 2015) that might be useful for assessing negligible impact and to inform jeopardy decisions An interim report describing the results of the expert elicitation and illustrating the kinds of forecasts that could be provided for the study populations was compiled and circulated to the Steering Group. The final report will include an assessment of the work that would be required to replicate this assessment for other species at different Navy ranges, and an implementation of both the beaked whale model and the sperm whale model using the results from the workshops. In addition, the report will includes a comparison of the results from the Interim PCoD model with equivalent results from an energetics-based full PCoD model for beaked whales on AUTEC being developed by D Moretti (NUWC). Once accepted by the Steering Group, this report will be published on line.

WORK COMPLETED

The project is close to completion with the final steps being the implementation of the population models described above in the R statistical computing environment. These models will use the results

of the expert elicitation for the different species/sites, and will provide illustrative examples for Blainville's beaked whale populations on AUTEC and PMRF, and for sperm whales at PMRF.

RESULTS

The workshops conducted as part of this project delivered estimates of the parameters that define the relationship between disturbance and vital rates shown in Figures 1 and 2. One take-home message is that these workshops must be conducted face-to-face to ensure that the experts understood the questions being asked and to provide an opportunity for experts to explain how they arrived at the values they chose. The 'shiny' applications developed for the sperm whale workshop resulted in a substantially improvement in the quality of the information provided by the experts and provided more realistic representations of the uncertainty that experts associated with their judgements.

Information provided at the workshops was used to derive a series of statistical density distributions that will be sampled to provide inputs for the model simulations. Example of these density surfaces are shown as heat maps in Figures 4 and 5.

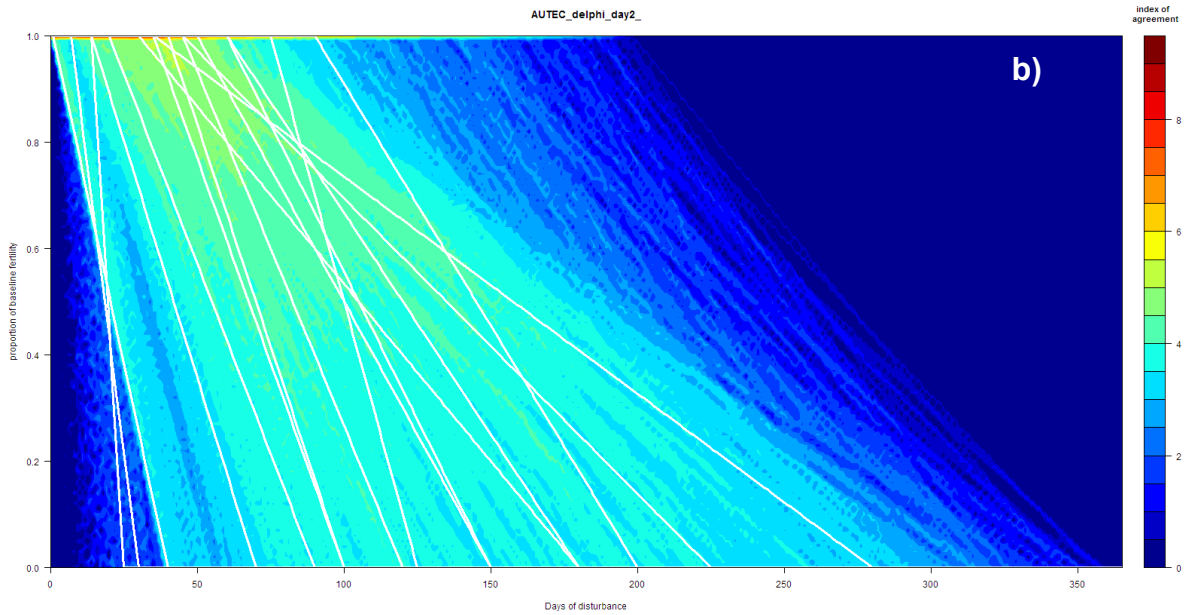

Figure 4 – Illustrative heat map showing the distribution of expert opinion on the potential effect of disturbance on fertility in Blainville's beaked whales. Hot colours indicate combinations of values for which there was strong support; cool colours indicate combinations that had little support.

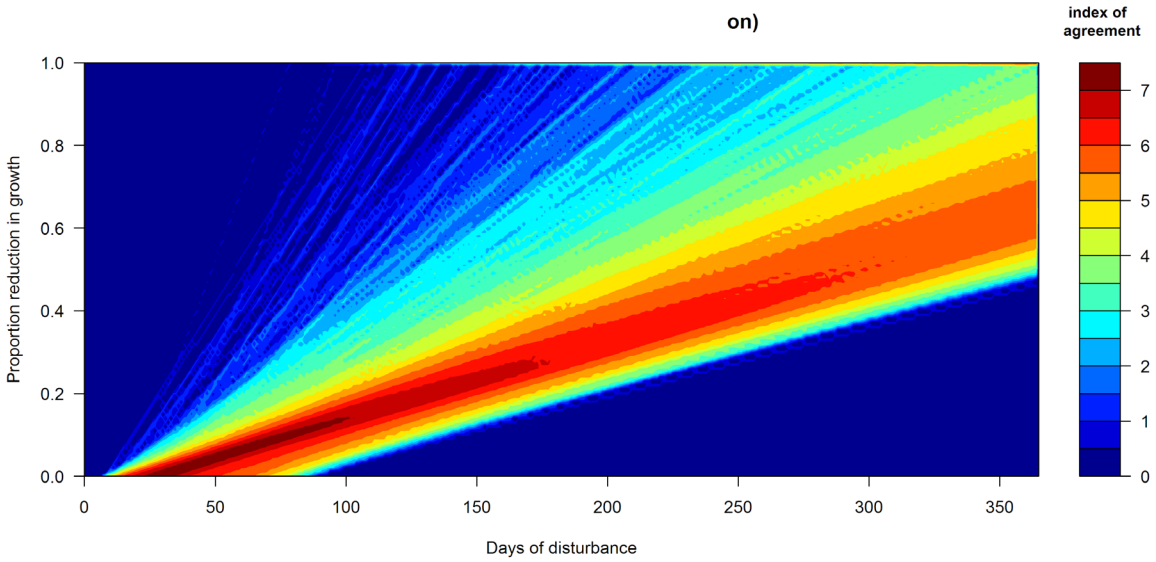

Figure 5 – Illustrative heat map showing the combined opinions from all experts of the effects of disturbance on sperm whale growth rate. Hot colours indicate combinations of values for which there was strong support; cool colours indicate combinations that had little support.

IMPACT/APPLICATIONS

As noted above, in order to issue an incidental harassment authorization to the US Navy under the Marine Mammal Protection Act (MMPA), the Office of Protected Resources (OPR) must ensure that "the specified activity …cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival". That is, it must ensure that the activity will have negligible impact. In the case of the Endangered Species Act, OPR must ensure that an exempted activity will not jeopardize the likelihood of both the survival and recovery of a listed species. The intention is to avoid "an action that reasonably would be expected, directly or indirectly, to reduce appreciably … the reproduction, numbers or distribution of that species" [50 CFR §402.02]. The interim PCoD approach is designed to provide information that can inform decision processes in situations where detailed scientific information is lacking.

Representatives of the Navy offices charged with producing environmental impact statements and of the regulatory office were included in the project steering committee to ensure that the outputs from the Interim PCoD protocol are indeed relevant to the MMPA and ESA decision processes.

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