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Informing stock depletion from expert knowledge using limited data

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Summary
Data-poor fisheries are a major challenge for stock assessment experts in cases where traditional analytical approaches cannot be implemented. Recent development in data-poor methods has improved the situation, but further research is needed. Existing approaches that are based on stock reduction analysis and its extensions offer simple ways to handle low data availability, but are particularly sensitive to assumptions regarding stock depletion. In this study, we imitated a data-poor stock assessment and developed a tool for eliciting expert judgments to inform the depletion prior required in data-poor methods. We compared expert opinions to stock depletion derived with analytical data-rich approaches and evaluated how experts with different levels of expertise in stock assessment performed relative to each other. Experience in stock assessment proved valuable in defining an appropriate prior for depletion whilst unexperienced experts had the least success in meeting the data-rich estimates. All experts, regardless of their expertise level, appeared to be risk neutral in the central tendency of stock status. We concluded that due to the sensitivity of these methods in depletion misspecification, caution is required when inadequately trained scientific personnel use these approaches for management purposes.

Introduction
Data-poor stock assessment has been an area of rapid development in the recent years. Different approaches have emerged utilizing life-history traits, length compositions and exploitation patterns. Some of these approaches (Dick and MacCall 2011; Cope 2013; Martell and Froese 2014) use modified versions of the classic stock reduction analysis (Kimura and Tagart 1982; Kimura et al. 1984) as the basis for estimating harvest levels. The emerged approaches require time-series of catches, information regarding stock depletion in the form of a prior distribution along with additional information on life history. Even though time-series of catches are fairly unbiased and easy to obtain for most exploited stocks, information regarding stock depletion is rarely available. Simulation testing of the aforementioned approaches has shown that the estimated harvest level is sensitive to depletion misspecification which could potentially lead to overfishing (Wetzel and Punt 2011; Carruthers et al. 2014). When only limited data is available, assessment authors are faced with the challenge of having to define stock depletion in order to apply these methods. In this work, we tried to imitate data-poor stock assessment and elicited expert knowledge to define stock depletion prior given limited information. We explored how experts perceive the given data, how expert opinions compare to "best available science" and how/if additional data improves expert performance. The ultimate goal of this work was to investigate, to what extend subjectivity can affect the estimation procedure and if subjectivity should be taken into consideration when harvest levels are defined based on data-poor models.

Materials and Methods
Data from 18 data-rich stocks from the Pacific Fishery Management Council (PFMC) and Alaska Fisheries Science Center (AFSC) formed the basis for this analysis. Experts were provided with data on catch history, fishery length compositions and additional information on life-history and

management in four different data combinations (From data-poorest to more data-rich). In addition, two simulated stocks were used for expert calibration purpose. Six experts with knowledge on west coast groundfishes and different background in stock assessment (experienced, novice, and unexperienced) were chosen for the elicitation process. A novel web application that is user friendly, easy, and fast to access and use was developed for eliciting expert judgements using the 'Shiny' package (Rstudio 2014).

Results and Discussion

Experts experienced in stock assessment appeared to have the lowest relative errors (REs) in stock depletion in relation to depletion values obtained from the official assessments. Novice experts in stock assessment performed similar to experienced ones. High uncertainty regarding the depletion is observed with both experienced and novice experts probably as a result of the precautionary approach that fisheries scientists are trained to follow. Moreover, it was observed that additional data does not seem to decrease uncertainty but it provides further information for updating expert beliefs. On the other hand, experts unexperienced in stock assessment scored the highest REs but appeared more certain in their depletion beliefs. Additional data seems to help unexperienced experts in decreasing uncertainty and updating their previous beliefs. For all experts, regardless of their experience level, higher variability in the REs and larger degree of uncertainty in the beliefs exists in the beginning of the elicitation process but progressively expert beliefs became more smooth and closer to the "true" values, as experts gained confidence and experience from the elicitation procedure. Furthermore, it was observed that the status of species with depletion between 0.2-0.5 is most likely to be overestimated, the status of species with depletion between 0.7-0.9 is most likely to be underestimated and the status of species with depletion between 0.5-0-9 is most likely to have lower REs. These results indicated that experts consider themselves as risk neutral in the central tendency of stock status. Experience in stock assessment proved to be valuable for defining stock status and even limited data can contain enough information to obtain a reasonable prior for stock depletion required as an input in data-poor methods. In countries where the number of experienced scientific personnel conducting stock assessments is low, care should be taken when these models and outputs are used for management purposes, as unexperienced experts seem to perform poorer in "correctly" defining stock depletion.

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