Response to king threadfin external review

General comments

We are very appreciative that the reviewer broadly endorses the assessment and expresses confidence in the model outputs (review page 13, section 2.3.2).

All extra modelling and other analysis suggested by the external reviewer has been deferred for consideration in the next assessment, provisionally planned for completion in the first half of 2023.

We believe that none of the suggested extra work would make any significant difference to the estimates of population status, with the possible exception of the suggestion to explore lower values of the q_{inc} parameter in AR2 and potentially other Queensland East Coast Assessment Regions (page 11 of the review). Lower q_{inc} values may produce biomass ratio estimates well above 60%, but such estimates would be subject to high uncertainty. Even if they were adopted, they would have only a small effect on the operation of the fishery, as the current estimates are already around 60%.

More important updates to the results could come from ageing data from the 1990s in the Gulf of Carpentaria, which we believe will be available for the next assessment.

Recommended additional work from the review

Page 6: *The information given in the assessment report regarding the biological spatial structure of the stock is very brief, and I sought additional information from Moore et al. (2011) and Moore et al. (2017). More detail on this should be given in the report because this spatial structure is crucial for understanding of the spatial structure assumed by the assessment.* **Change to report text:** We have expanded the report's Introduction and included a new section on stock structure.

Page 7: *To fully evaluate the [catch rate] standardisations, more documentation is required including model diagnostics such as plots to justify distribution assumptions, presentation of the procedure used for choice of optimal models, and presentation and evaluation of results for fitted factors or variables and their significance.* **Response:** This would be straightforward but time-consuming and would add a lot of volume to the report. We presume that the main diagnostics would be plots of residuals against fitted values, tables of the coefficients that come out of the GLMs, and records of terms that were not statistically significant and hence were excluded from the GLMs. We did examine all of these things and the most consequential were presented to and discussed by the king threadfin Project Team.

Page 7: *Make use of catch-rate time series that were not included in this assessment*. **Response:** These series are shown in Appendix C of the report, so were available to the reviewer. Using them would require major changes to the methodology of the population model. As we did in the Gulf, we would have to fix M instead of q_{inc}, and fit multiple q_{inc} parameter values to the different catch rate series within each Assessment Region. The time commitment would be similar to that for a whole new assessment. **Change to report text:** We have clarified our method of choosing representative catch-rate time series. Our principle was to use the catch-rate regions with the most data, and not use those with less data.

Page 10: *Demonstrate that CPUE trends for AR3 (including those not used) are implausible:* **Response:** It is common in stock assessment that increasing catch-rate time series produce extremely large estimates of population size, on which fishing has no noticeable effect. We observed this for the CPUE series that we used, although those results do not appear in the report. We have not checked that the CPUE series that we didn't use also produce extremely large population-size estimates. It would be time-consuming to do, and in our opinion would only advance our understanding of stock status if coupled with additional data sources that we currently do not have.

Page 10: *Alternative methods for handling the catchability change for king threadfin need to be explored and presented (beyond alternative values for q_{inc}), at least as sensitivity analyses.* **Response:** We take this to mean trying stepped changes to catchability instead of a constant annual rate of increase. We don't expect the results to show significantly greater uncertainty than we have already produced by

varying the q_{inc} parameter. We would have to implement the stepped changes by fixing M instead of q_{inc}, and estimating a separate value of q for each time period. The time commitment would be similar to that for a new assessment. Again, this is something that we believe could be of value if combined with the additional data but at this time would be unlikely to reduce uncertainty or increase precision.

Page 10: *I had questions for the lead assessment author regarding ... minimum length binning.* **Response:** No suggestion for additional work on length binning was made by the reviewer, but he did point out an oversight that should be corrected in the next assessment. The model length bins were accidentally set equal to the data length bins, whereas for this species the minimum model bin should have been set lower than the minimum data bin. We do not believe that this error made any significant difference to the results of the assessment, because our minimum length bin was well below any minimum legal size, so fish from the minimum bin would not be seen in fishery-dependent data. **Change to report text:** Note in the Methods section that we omitted from the Fishery Monitoring data any fish whose lengths were lower than 1.5 cm below the prevailing minimum legal size.

Page 11: *Results for sensitivities such as q_{inc} 0.02 in AR2 that produce an overall lower –lnL than the base case require further examination of fits to particular data series to refine the rule used for model rejection.* **Response:** It is not clear what benefits this would provide. It would not affect the fishery management outcomes, as all of the East Coast stocks are already estimated as being around the target level of B_{60}. **Change to report text:** Further emphasise our model selection method in the Results section. Our goal was to produce similar values of the natural mortality rate M across regions.

Other comments on the review

Page 6: Borrowing parameters from different regions: *A feature of independent area assessments is the ability to borrow population characteristics for the data-poor areas from the more data-rich ones where required, which has been done in this assessment to some extent.* **Response:** This actually appears to be an argument for a multi-region population model. Such a model could analyse all regions simultaneously while maintaining the assumption that they constitute separate stocks, and decide for itself on parameters to borrow, without subjective human intervention. It would probably make little difference to the actual results, but would make the assessment more objective and defensible. It would also produce better diagnostics; for example, comparison of overall negative log-likelihood values when varying the natural mortality parameter M, and a histogram of credible values of M from Markov chain Monte Carlo (MCMC). The Project Team decided that the methodology of running a separate model for each Assessment Region was adequate for this assessment, bearing in mind that it is the first fully quantitative assessment of king threadfin.

Pages 9–10: Option 3, density-dependent catchability: **Response:** Dependence of catchability on population density might appear to happen in the Gulf if no data were available from the East Coast. On the East Coast, however, density dependence is obviously not the mechanism that has caused the increase in catchability, because the density has not changed much. It would be difficult to justify making catchability density-dependent in the Gulf but driven by something else on the East Coast.

We believe that catchability will remain high if the Gulf stock recovers in the future, due to improvements in fishers' ability to target king threadfin. Assuming density dependence would force the estimated catchability down again as the stock level increases, resulting in substantial overestimates of the biomass in future stock assessments.

Page 9: Option 4, random walk process for catchability: **Response:** We believe that this would be over-parameterised and that its parameters could not be estimated sufficiently accurately.

Pages 9–10: Option 5, stepped changes to catchability: **Response:** These would require the years in which the steps took place to be specified, which would add an additional level of subjective human judgement to the assessment. If more than one step were required, this option would also add more parameters to the model. Again it is doubtful that these parameters could be estimated sufficiently accurately.

We agree that stepped changes could be tried as sensitivity analyses (see above).

Change to report text: We have recommended a research project to identify factors that caused the catchability increases, and the times at which the increases occurred. Such a research project could also investigate what king threadfin do in times of drought: whether they move somewhere else or slow down their metabolism.

Page 10: *A more compelling justification* [for the use of a constant annual rate of catchability increase, q_{inc}, as opposed to alternative parameterisations of catchability increase,] *is required that includes interaction with other influential parameters such as M.* **Response:** Interaction of parameters q_{inc} and M is already an integral part of the assessment. Estimators of these two parameters are very highly correlated and move in opposite directions. In the East Coast regions, M was estimated and q_{inc} took various values that were fixed for each model run. We have taken on board the suggestion to try some alternative parameterisations of catchability increase in future assessments, and we have proposed a research project to try to document the ways in which catchability of king threadfin has changed over the years.

Page 11: *Suspiciously precise estimate of B_0 and therefore the whole modelled biomass series in the Gulf*: **Response:** The upper and lower confidence limits of the biomass ratio B / B_0, from the early 1990s to present, still differ by a factor of about three. We believe that this level of precision is reasonable, and the precision of B / B_0 has not been greatly exaggerated. This ratio is the quantity that really matters for fishery management. The high apparent precision of R_0 and B_0 is a result mainly of the harvest-size history and the model's need for the population to stay positive. **Change to report text:** We have included these points in the Results section.