Issues with the assessment of the quillback stock off California that need to be address before it is used for management advice

Mark Maunder

(No official affiliation)

Introduction

The quillback stock off California is data poor in the sense that it has no reliable index of relative abundance, which is typically considered the most important data type in contemporary stock assessments. In addition, there is very little age information. The assessment therefore relies on length composition data to inform estimates of absolute abundance and depletion levels. Using length composition data to inform absolute abundance and depletion has several issues as explained by Maunder and Piner (2015). The information content of the length composition data is conditional on growth (and variation of length-at-age), natural mortality, selectivity (particularly the assumption of asymptotic selectivity), and possibly trends in recruitment and/or the stock-recruitment relationship. Therefore, these quantities need to be known reasonably well to provide a reliable estimate of absolute abundance, trends in abundance, and depletion.

The assessment authors use an integrated age-structured stock assessment model (Stock Synthesis) fit to the length composition data “conditioned” on the catch. This is the most appropriate approach since it makes all the assumptions explicit, allows the inclusion of other data, and can easily be used to investigate alternative assumptions. The assessment authors also conduct many sensitivity analyses and diagnostics to evaluate the model assumptions, including requests from the SSC. The analysis is very comprehensive.

The assessment for this stock will be uncertain due to the lack of a reliable index of relative abundance, lack of information on growth, natural mortality, steepness of the stock-recruitment relationship, and the form of selectivity and how it changes over time. In addition, there are some issues with the current assessment that should be further investigated, which may have consequences for management advice.

The assessment advice is based on conservative assumptions about all the models fixed parameters compared to that supported by the data, and assumes that the selectivity is asymptotic for the whole time period for both the commercial and recreational fisheries.

Fixed Parameters

All the likelihood profiles suggest a less depleted stock than under the base assumptions (steepness of the stock-recruitment relationship = 1, higher M = 0.12, lower Linf = 42, lower K = 0.13, lower CV at maximum length = 0.08). The values of these parameters should be re-evaluated. The value of K and asymptotic length influence the depletion level obtained, while M and steepness influence the rate of rebuilding, and these findings might help identify the misspecification in future analyses.

Steepness

The prior (fixed value) for steepness comes from a meta-analysis endorsed by the SSC, but the approach has been subsequently rejected. It was rejected because re-analysis with more recent data produced values that were high and presumably considered unreasonable by the SSC. Therefore, the same approach, but applied to an older data set and was endorsed by the SSC, was used. Obviously, this is dubious logic and subjective. Both commercial and recreation length composition data support a steepness of 1. However, there is substantial evidence that estimating steepness is problematic and can be biased by regime-shifts, model misspecification, and other factors. Therefore, estimates from within the assessment can be unreliable, as are estimates used in met-analysis. Steepness has a double impact on management advice since lower steepness generally increases the depletion level (B/B_0, because virgin biomass is higher as the virgin recruitment is higher) and, at the same time, generally increases the biomass reference point (B_{MSY}/B_0). The proxy reference point already accounts for a conservative value for steepness, so it is unclear if it should also be accounted for in the estimation. Using a default steepness = 1 during estimation has recently been recommended (Brooks 2024). Since a total catch history approach is used and length composition data is only available for the latter part of the time series, steepness can be influential in the estimation of both depletion level and absolute abundance.

Natural mortality

The base value of M = 0.57 is based on a maximum age of 95 years for a female. The fit to the data supports a higher value of M. Commercial length composition data support M = 0.12. Recreational length composition data support a M = 0.06. Yamanako and Lacko (2001) state "Quillback rockfish range to 76 and 95 years for males and females, respectively." but their report is for stocks on the Pacific coast of British Columbia and it is not clear where the maximum ages come from. The maximum ages in the data use in the assessments for the US stocks were 73, 70, and 69 and these were from the Washington stock not the Californian stock. The maximum age used can make a big different in the estimated natural mortality (see Table 1) and the consequent management implications. It is not clear if the maximum age used represents the California component of the population. It also might be appropriate to make natural mortality a function of length which would increase the level for smaller fish, but since full selectivity occurs around the age where growth essentially stops, it is not clear how this would influence the results.

Table 1. Estimates of natural mortality from different values of maximum age.

Max age	M
95	0.057
76	0.071
73	0.074

Asymptotic length (or L2)

The data used to create the growth curve used in the assessment were mainly from Oregon and Washington. The coastwide fishery independent data had limited observations above 40 years of age and none from California above 40. The CA data not used in the assessment supported the Linf used possibly a slightly higher one.

The depletion level is extremely sensitive to the assumption of the asymptotic length (essentially L2). A 3cm (approx. 7%) change in L2 changes depletion from about 15% to 45%. The commercial length composition data supports a lower L2 while the recreational length composition data supports a similar level to the base case.

Growth rate (K)

The growth model does not appear to fit the age-length data well. In particular, the asymptotic length appears to be too low. There is very little age-length data from California used to estimate the growth curve used in the assessment below age 10. The data for all areas, and the new data for California, supports a lower K. The literature values of K cited in the assessment report are not for the California stock. The commercial length composition data supports a lower K and the recreational length composition data is uninformative and there is suggestion that the profile is not well determined.

A more flexible growth curve is also probably warranted.

Variation of length at age

Commercial length composition data support lower variation and recreational about the same as used in the base case. Results are not very sensitive to the variation in length-at-age.

Selectivity

Much of the information about the fixed parameters (the likelihood component profiles) is related to the commercial length composition data. There have been substantial management changes (e.g. depth restrictions) that could influence the size of both the recreational and commercial effective selectivity (age/length specific availability). The commercial length composition data indicate that the selectivity differs before and after 2003, with before being dome shaped. It does not appear that any sensitivity runs were made that had a time block in commercial selectivity at 2003 and allowed the early period to be dome shaped.

The sensitivity runs were mainly done one at a time and therefore some issues or sensitivities in the assessment may have been hidden. For example, if the asymptotic commercial selectivity and/or the unmodelled difference in time blocks of commercial selectivity is controlling the fit, then dropping the early recreational composition data might not change the results. A comprehensive set of selectivity scenarios were carried out, but I don't think the authors considered one that included a) a commercial time block in 2003, b) dome shaped commercial selectivity in the early period (or both), c) a recreational time block in 1994, d) dome shape selectivity in the latter period.

These selectivity configurations and some others were run, but the results did not change substantially (Figures 1 and 2).

A model that has dome shape selectivity for the commercial fishery and a time block starting at 2003 and a time block for recreational fishery starting in 1994 with dome shape selectivity in the latter period estimates a value for natural mortality of 0.093, fitting the data with 25 negative log-likelihood units less than the original assessment, and a much less depleted stock (Figure 3). This result is very similar to that obtained by the assessment authors when they estimated natural mortality.

Other

A single composition data set can provide information on absolute abundance and depletion level given many assumptions (e.g. constant recruitment and asymptotic selectivity). Therefore, the different years of data for each gear could be evaluated independently or sub-groups of years evaluated. Of particular interest would be evaluating the recreational data for the period 1980-1990, which appears to be the gear and period most likely to have asymptotic selectivity (for example see “Only Early Rec” in Figures 1 and 2). This is very distant from the current management, and recruitment is unlikely to be constant, but may provide further insight into the model.

There is a substantial pattern in the recruitment residuals, with lower recruitment in the early period when there is no information. Therefore, using the average recruitment to estimate the unfished abundance may not be appropriate. A dynamic spawning biomass reference point might be more appropriate so that it is based on recent recruitment, adjusted by the stock-recruitment relationship.

The decline in abundance is being driven by the estimated decline in recruitment deviates from 1990-2010, some of which may be compensating for unmodelled changes in selectivity (this was somewhat investigated in the SSC requests).

Example model

The likelihood profiles presented by the assessment authors modify one fixed parameter at a time. However, several of the fixed parameters are likely misspecified. Therefore, the real consequence of the misspecification is not clear. Here we provide an example where we evaluate what we consider as more appropriate choices for some of the parameters. The approach fixes steepness at 0.95 and K at 1.5. It estimates natural mortality and profiles over L2. Variation of length-at-age is kept at the original value.

There are many alternative selectivity assumptions that could be made. In this example we assume that the commercial selectivity differs before and after 2003, with before being dome shaped. A recreational selectivity time block in 1994 with the later period being dome-shape.

The results of this model are more optimistic than the model used to provide management advice. This optimism is independent of the value assumed for asymptotic length due to the estimated M being linearly related to the L2 parameter (Figure 4). The model shows a high level of depletion in 1990s, but the population rebuilds rapidly in the 2000s (Figure 5).

Conclusion

In conclusion, even though there are many uncertainties in the assessment, there are several assumptions of the assessment leading to a more depleted stock that are not supported by the data. These should be re-evaluated and may lead to a better assessment. Further evaluation of the assessment is recommended before it is used for management advice. At a minimum, all the conservative assumptions have already been made in the stock assessment model used for management advice and no additional precautionary measures should be included in the management action.

References

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Yamanako, K.L., and Lacko, L.C. 2001. Inshore rockfish ((sebastes ruberrimus), (s. Maliger), (s. Caurinus), (s. Melanops, (s. Nigrocinctus), and (s. Nebulosus)) stock assessment for the west coast of Canada and recommendations for management. Canadian Science Advisory Secretariat, Research Document 2001/139.

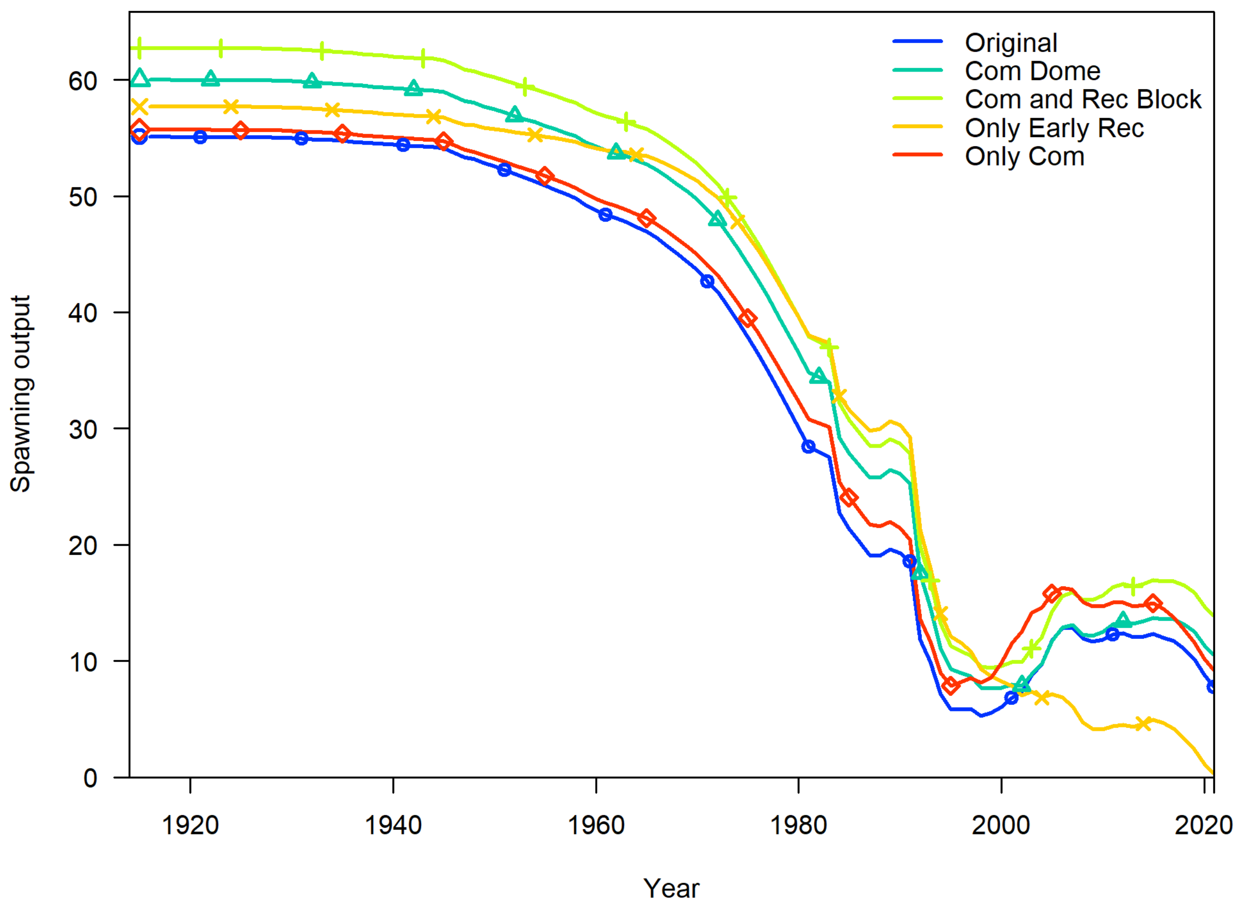

Figure 1. Spawning biomass from model runs with different assumptions about selectivity or the data fit and selectivities estimated. “Com Dome” = dome shape selectivity for the commercial fishery and a time block starting at 2003; “Com and Rec block” = dome shape selectivity for the commercial fishery and a

time block starting at 2003 and a time block for recreational fishery starting in 1994 with dome shape selectivity in the latter period; “Only Early Rec” = Only fitting to the pre 1994 recreational length comp and fixing selectivity form the commercial fishery; “Only Com” = only fitting to the commercial fishery composition data and fixing the recreational selectivity.

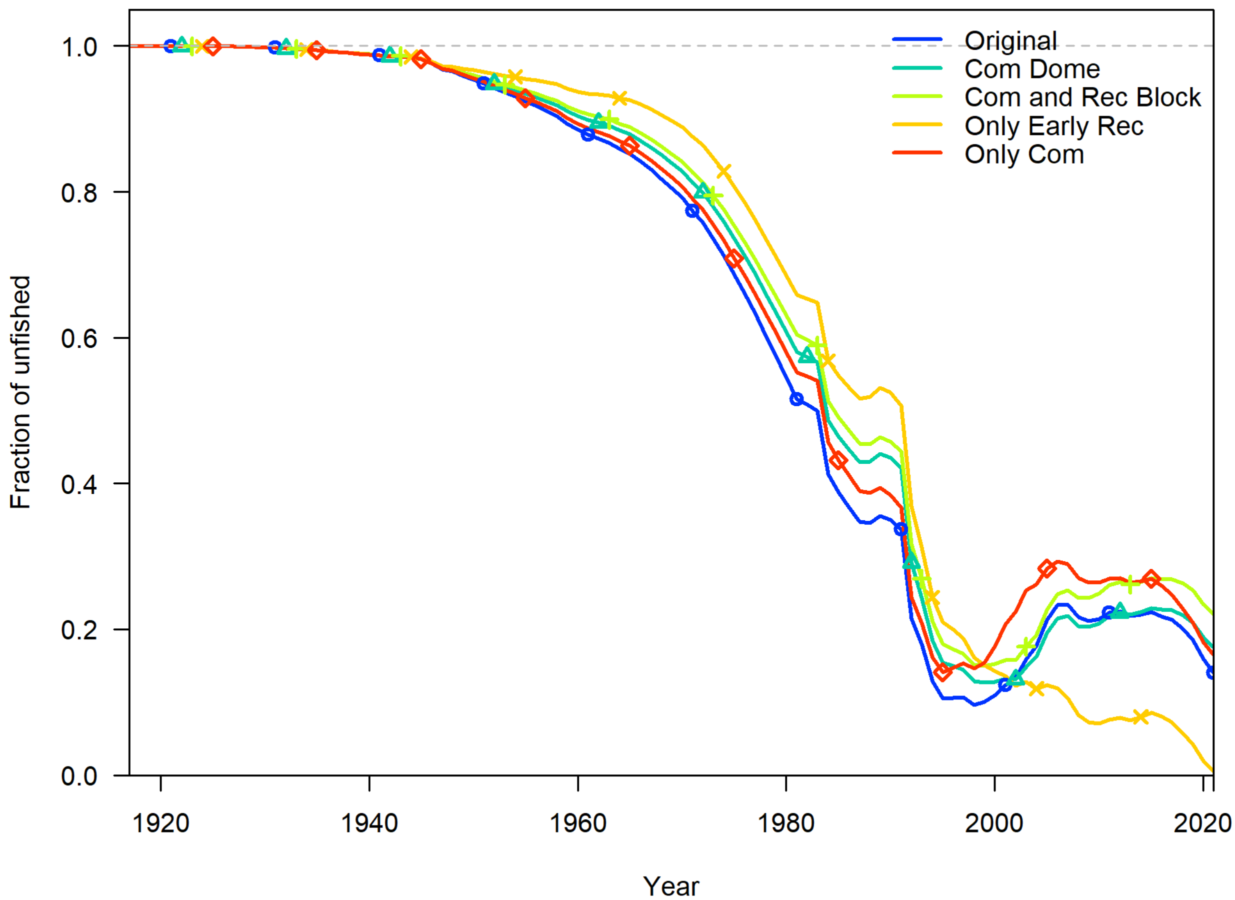

Figure 2. Depletion levels from model runs with different assumptions about selectivity or the data fit and selectivities estimated. See Figure 1 for definitions.

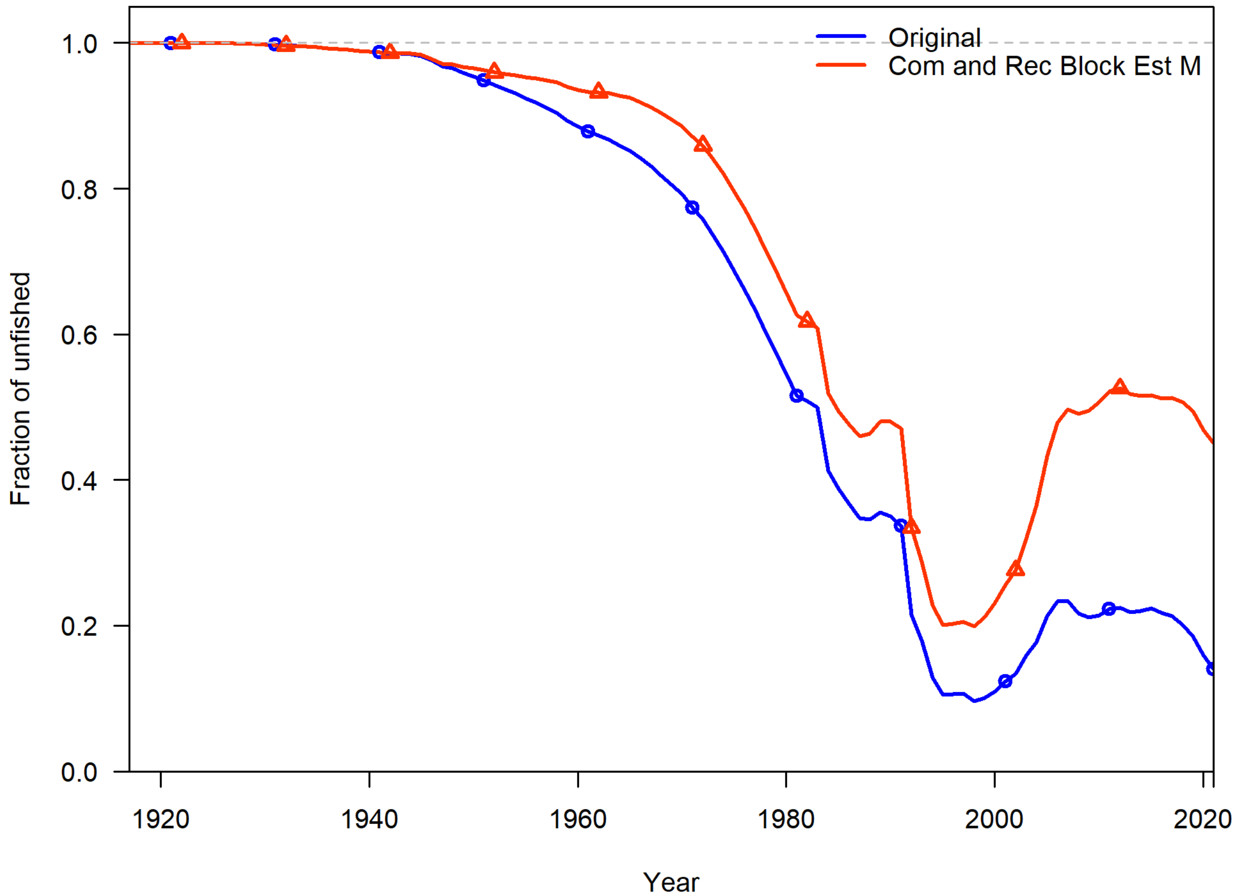

Figure 3. Depletion level from a model run that estimates natural mortality with dome shape selectivity for the commercial fishery and a time block starting at 2003 and a time block for recreational fishery starting in 1994 with dome shape selectivity in the latter period.

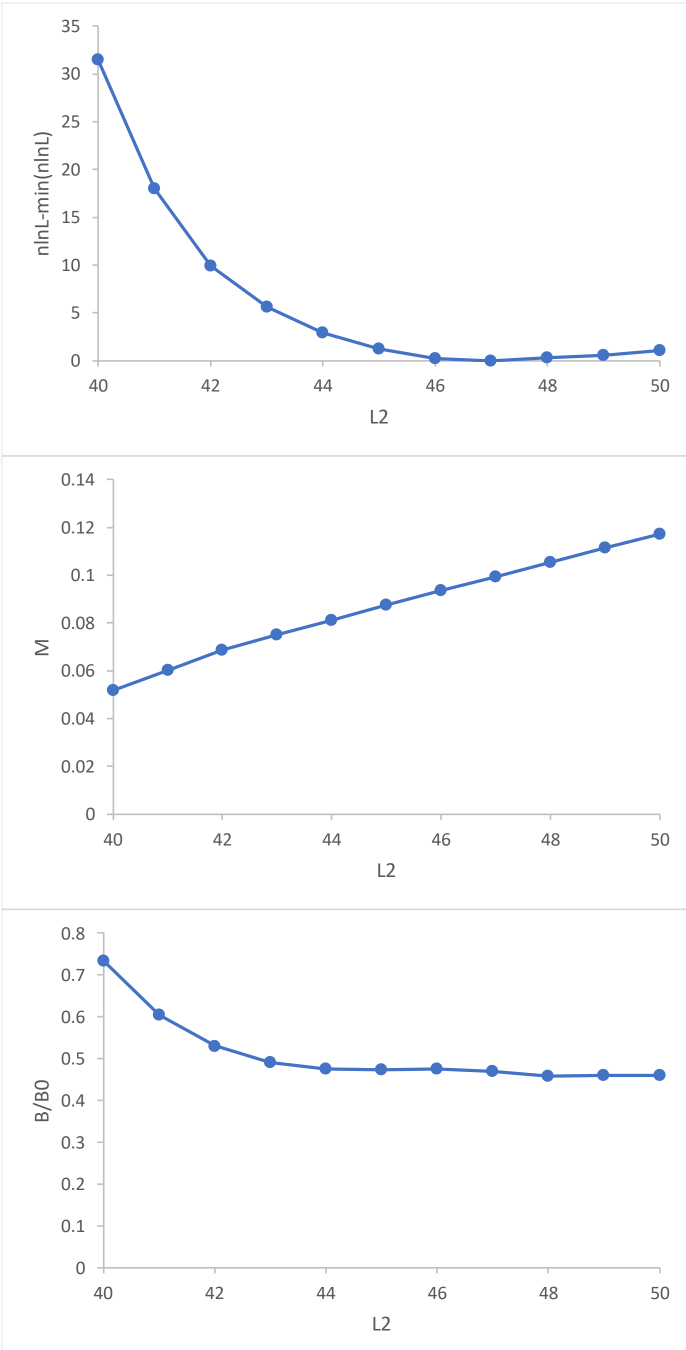

Figure 4. Likelihood profile, estimated M, and depletion level for different values of L2 for the example model (Steepness = 0.95, K = 1.5, estimated M, commercial selectivity differs before and after 2003, with before being dome shaped, recreational selectivity time block in 1994 with the later period being dome-shape)

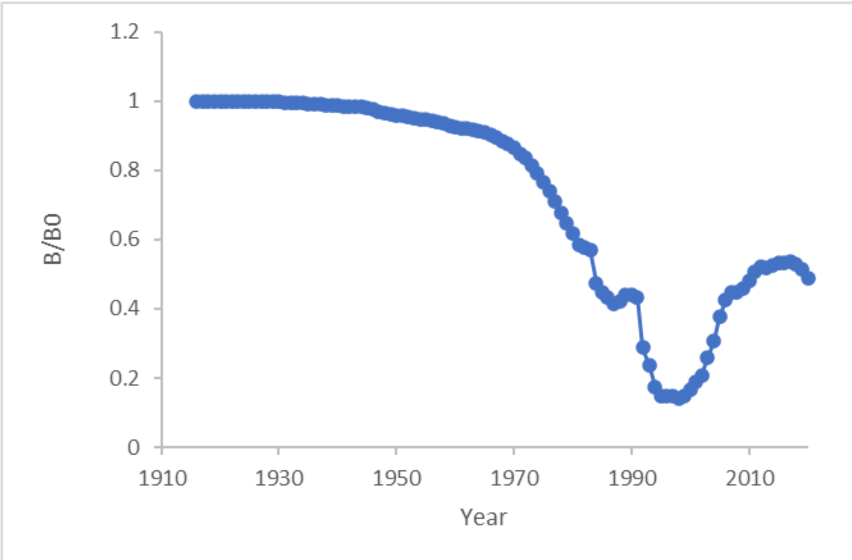

Figure 5. Depletion level time series for the example model (Steepness = 0.95, K = 1.5, estimated M, commercial selectivity differs before and after 2003, with before being dome shaped, recreational selectivity time block in 1994 with the later period being dome-shape) with L2 (47cm) that is most supported by the data.