Yellowfin Tuna Assessment Review

Outline of Issues & Work Plan

Arni Magnusson
25 Feb 2022

I. Background summary

The most recent stock assessment of yellowfin tuna in the western and central Pacific was presented to the WCPFC Scientific Committee in 2020 (Vincent et al. 2020). The length-based, age-structured model is implemented in Multifan-CL (Fournier et al. 1998) and has a spatial structure of 9 regions. The data consist of catches, effort, length and weight frequencies, as well as tag recoveries. A quarterly time step is used in the model, starting in 1962 and ending in 2018, with fish aged 0 to 10 years old. The data are structured in 32 extraction fisheries and 9 index longline fisheries, standardized using VAST spatio-temporal analysis (Thorson 2019).

New features in the 2020 assessment compared to the 2017 assessment include:

- incorporation of growth data from both otoliths and tag recaptures,
- Richards growth model,
- updated reproductive potential based on maturity at length,
- 'index fishery' approach with a geostatistical standardized CPUE series in each region,
- 'pseudo catch conditioned' estimation of F,
- increased maximum age from 7 to 10 years old, and
- ungrouping of selectivity parameters between regions to better fit the data.

A structural uncertainty grid of 72 models were run to capture the uncertainty about the stock status:

Axis	Levels	Option
Steepness	3	0.65, 0.80*, 0.95
Growth	3	Modal estimate, External otolith, Conditional age-at-length*
Size frequency weighting	4	Sample sizes divided by 20, 60*, 200, 500
Tag mixing	2	1 quarter, 2 quarters*

The overall conclusions from the 2020 assessment were:

- Stock status was relatively stable until the early 1970s, after which time there was a notable decline across the remaining time series.

- The estimated stock status was more optimistic than from the 2017 assessment, which is especially linked to the incorporation of new growth data.
- All models in the structural uncertainty grid estimate the stock status to be above $20\%SB_{F=0}$, which is consistent with the previous assessment. Median terminal depletion ($SB_{recent}/SB_{F=0}$) was 0.58.
- Depletion is notably greater in the tropical regions (3, 4, 7 and 8) and in region 5 (southwest temperate), influenced by stronger declining CPUE signals in those regions. In all regions, the current stock status was estimated above $20\%SB_{F=0}$.
- Average F for juveniles and adults has increased steadily since the 1970s. Juvenile F reached a plateau by the early 2000s, but adult F has continued to increase since then.
- All models in the structural uncertainty grid estimated F to be below F_{MSY}. Median F_{recent}/F_{MSY} was 0.36.

When the 2020 assessment was presented to the WCPFC Scientific Committee, there was a general concern that this assessment gave a considerably more optimistic view of the stock status than the 2011, 2014, and 2017 assessments, without apparent positive signals in the recent years of data. One recommendation was to explore the possibility of simplifying the model, in terms of structure and the number of estimated parameters.

II. List of issues

1. Model inputs, commenting on the adequacy and appropriateness of data sources and data inputs to the stock assessment, with particular attention to:

    a. Growth: review the approach to estimation of growth parameters and consider the implications of potential regional variations in growth.

    b. Tagging data: review the approach used to treat tagging data as model inputs, and how the tagging data are used within the modelling.

    c. Size composition: review the approach for pre-treatment of size composition data (comparing the approaches of Peatman and Maunder et al.) and how size composition is weighted for the likelihood function.

    d. CPUE: review potential issues regarding hyperstability and technological creep.

    e. Natural mortality: review the approach used to determine M-at-age and implications of alternative M assumptions.

    f. Steepness: review the choice of steepness values used in the assessment.

    g. Data inputs: identify and provide recommendations on the key areas for improvement in data collection (both fishery data and biological information).

2. Model configuration, assumptions and settings, with particular attention to:

   a. Model complexity: review the appropriateness of the model complexity, including spatial and fishery structure and time-varying processes, in relation to data inputs and other available information.

   b. Selectivity: review selectivity assumptions and settings, based on the fit to data.

   c. Uncertainty: review the approach used to represent uncertainty (comparing YFT and SWO assessments) in model-derived management quantities, considering structural, model and input data uncertainty, and how this uncertainty is incorporated in current management.

3. Model diagnostics, with particular attention to:

   a. Review the suitability of the diagnostics used and reported for the assessment: Hessian, jittering, profile likelihood, and retrospective analysis.

   b. Consider the diagnostics provided for the 2020 YFT assessment and provide guidance on follow-up work where the diagnostics suggest issues, i.e., data conflicts.

   c. Diagnose whether the combination of estimated recruitment and unconstrained migration may reflect artificial model balancing rather than signals in the data; the apparent local depletion in equatorial waters could be caused by such 'buffering', where the model moves fish into more heavily exploited regions to fit other data.

4. Recent MULTIFAN-CL model developments, with particular attention to:

   a. New MULTIFAN-CL features, such as catch-conditioned F and self-scaling multinomial sample sizes, in relation to their application to the 2023 scheduled YFT assessment.

5. Future research areas, with the identification of priorities to improve future assessments.

While these key topics will be a focus of the peer review, other aspects of the assessment and data inputs may become focus areas as the review progresses.

III. Discussion

In a February meeting, Paul and Arni considered three potential research directions that could be pursued, related to this review:

A. Examine and analyze how the estimated stock status becomes considerably more optimistic when applying the model development and new data components that differed between the 2017 and 2020 assessment. Figure A4 from the assessment report (see Section VI below) shows the overall change in the estimated stock status between assessments. Figure 14b indicates that the change was mainly caused by three steps: SelUngroup (ungrouping of selectivity parameters between regions), JPTP (incorporation of data from the Japanese Tagging Program), and CondAge (incorporation of otolith data). Evaluate whether model development steps and data incorporation should be revisited.

B. Examine and analyze whether the combination of estimated recruitment and unconstrained migration may reflect artificial model balancing rather than signals in the data; the apparent local depletion in equatorial waters could be caused by such ‘buffering’, where the model moves fish into more heavily exploited regions to fit other data. Evaluate whether estimation constraints could be applied to remedy such problems.

C. Develop and compare three models with different spatial structure: based on 1 region, 4 regions, and 9 regions. From the catch data (Figures 4 and 5) and CPUE indices (Figures 8 and 16), it seems that a 4 region model could collapse the northern regions into one, the equatorial regions into one, the southern regions into one, and keeping the Philippines/Indonesia region as is. Simplifying the spatial structure may help with model convergence and stability, as well as improving comprehension and diagnostics of the model fit, while the more complex spatial structure can be beneficial to detect local depletion and give region-specific management advice.

Based on the amount of collaborative research effort, discussions, and diagnostics that led to the development decisions and data incorporation for the 2020 assessment, ‘proposal A’ does not seem likely to lead to new significant discoveries. It was concluded that overall, ‘proposal C’ is the most likely to result in improvements for the upcoming 2023 assessment and will to some extent touch on the questions raised in ‘proposal B’.

IV. Work plan

Phase I

The March milestone will mainly focus on the incorporation of new Multifan-CL features, such as catch-conditioned F and self-scaling multinomial sample sizes.

Upcoming milestones

Phase II (June milestone) will focus on the different spatial structure options, along with modelling issues that have emerged.

The review meeting in Noumea (September milestone) will summarize and discuss the findings so far, and decide on model development direction for the upcoming 2023 assessment.

V. References

Fournier, D.A., J. Hampton, and J.R. Sibert. 1998. MULTIFAN-CL: a length-based, age-structured model for fisheries stock assessment, with application to South Pacific albacore, *Thunnus alalunga*. Can. J. Fish. Aquat. Sci. 55:2105–2116. doi:10.1139/f98-100.

Thorson, J.T. 2019. Guidance for decisions using the Vector Autoregressive Spatio-Temporal (VAST) package in stock, ecosystem, habitat and climate assessments. Fish. Res. 210:143-161. doi:10.1016/j.fishres.2018.10.013.

Vincent, M., N. Ducharme-Barth, P. Hamer, J. Hampton, P. Williams, and G. Pilling. 2020. Stock assessment of yellowfin tuna in the western and central Pacific Ocean. WCPFC-SC16-2020/SA-WP-04, Rev. 3. Available from https://meetings.wcpfc.int/node/11694.

VI. Selected Plots from the Assessment Report

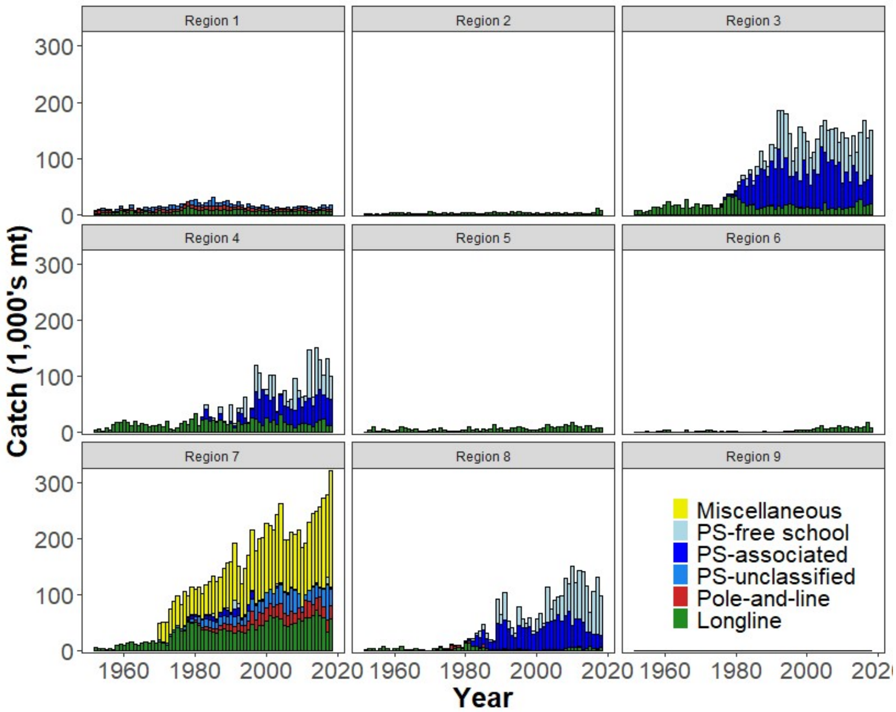

Figure 4. Catch by gear and region.

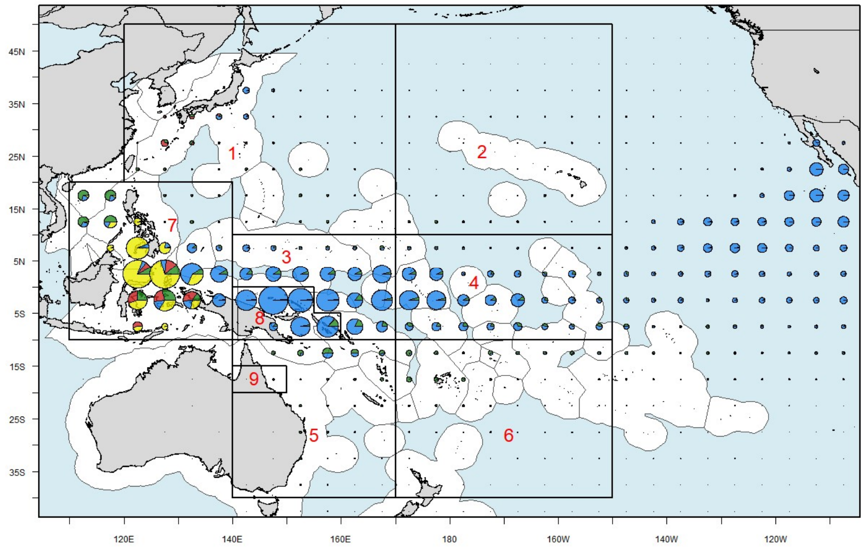

Figure 5. Spatial distribution of catches from the last 10 years in the data (2009-2018) by 5° square and fishing gear: longline (green), pole-and-line (red), purse seine (blue), and miscellaneous (yellow).

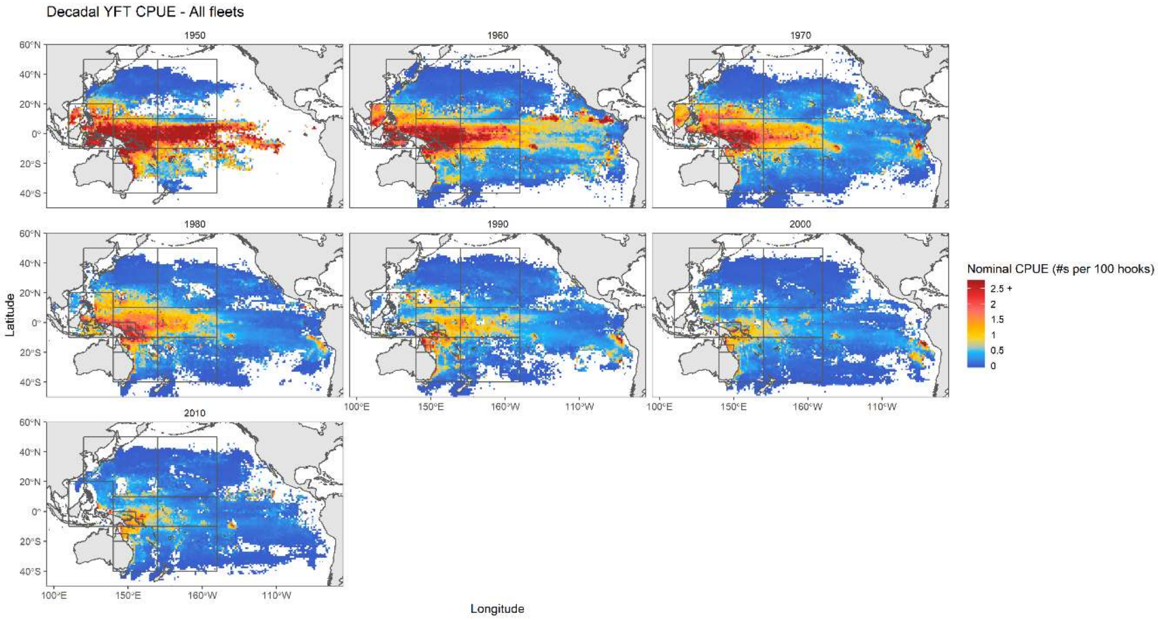

Figure 8. Spatial distribution and decadal patterns of nominal longline CPUE.

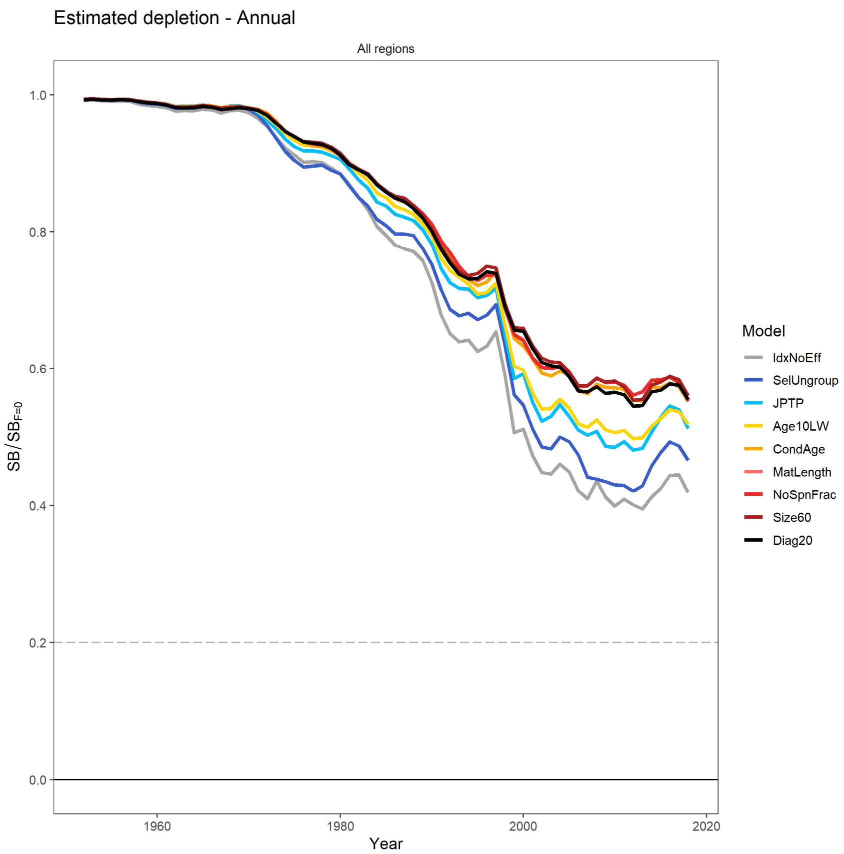

Figure 14b. Stepwise changes, showing the effect of the final steps of model development and new data components on the estimated depletion. Starting from IdxNoEff, which is close to the 2017 diagnostic model, and ending with the 2020 diagnostic model.

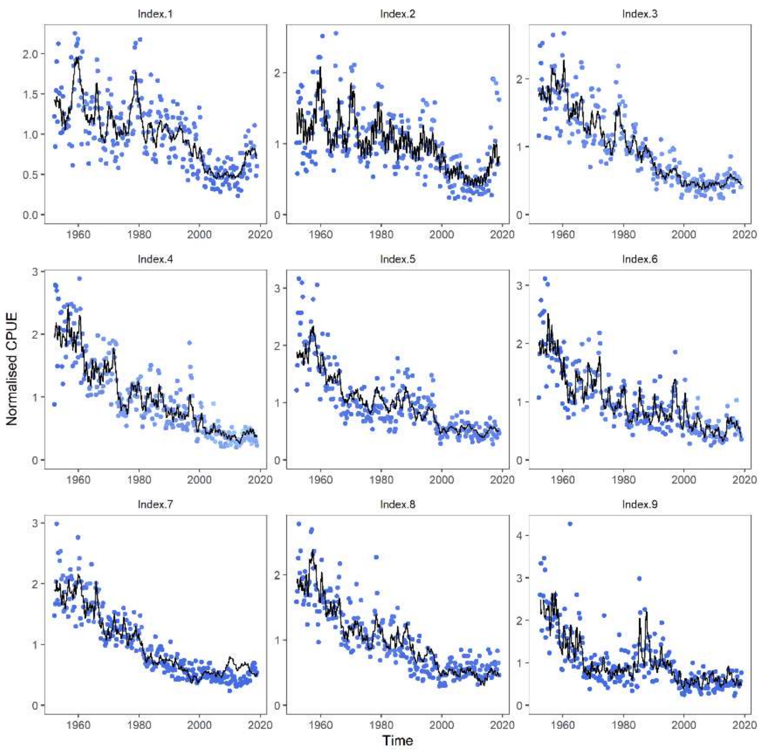

Figure 16. Observed CPUE indices from VAST (points) and model fit (line).

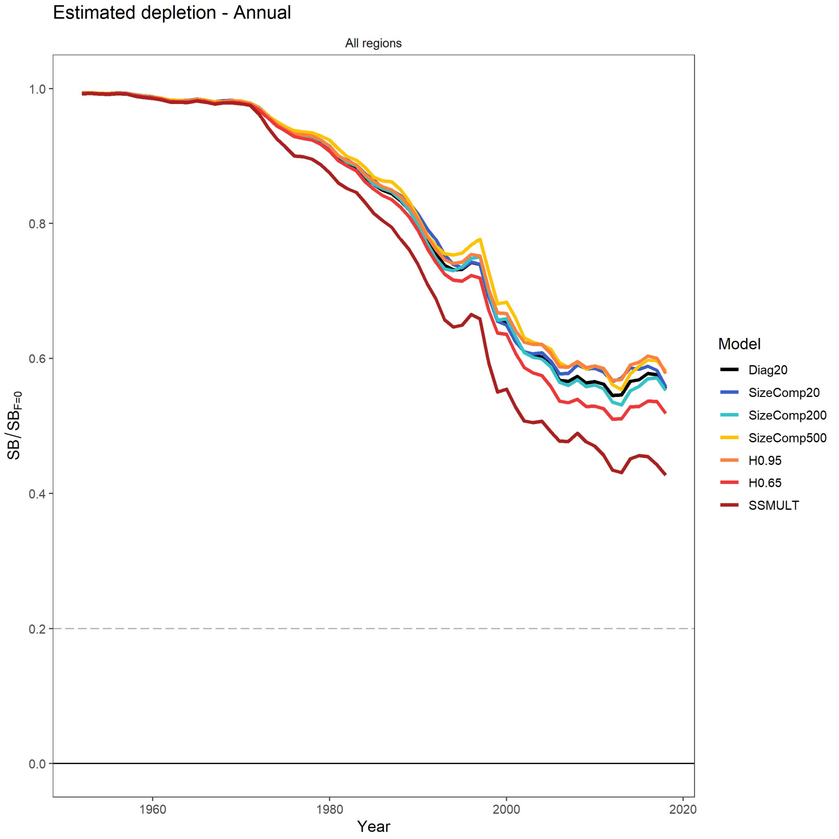

Figure 47b. Sensitivities to size composition weightings and steepness.

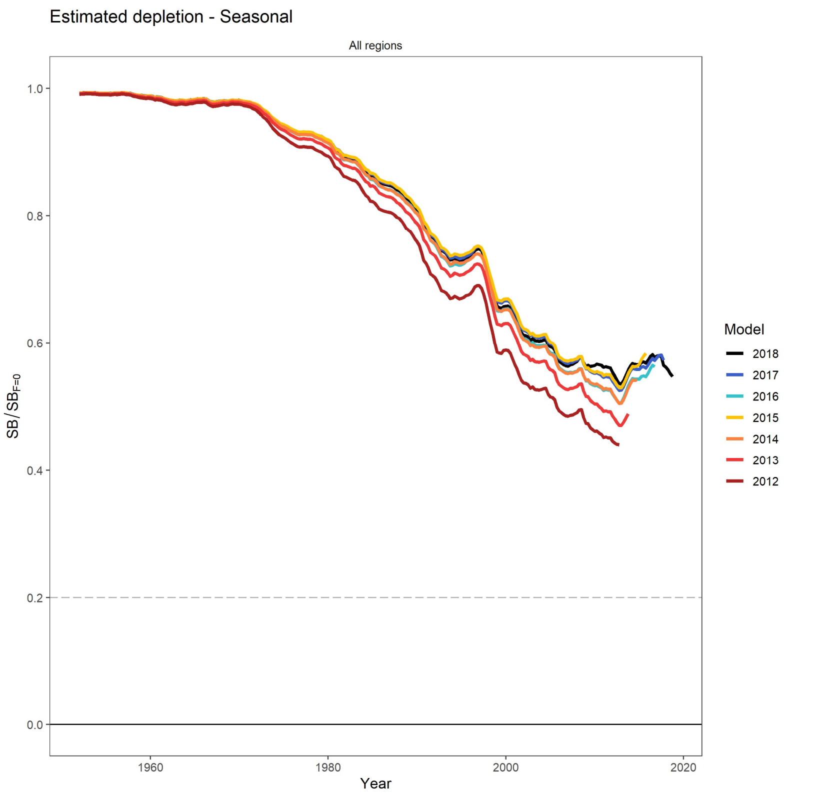

Figure A3b. Retrospective analysis of depletion.

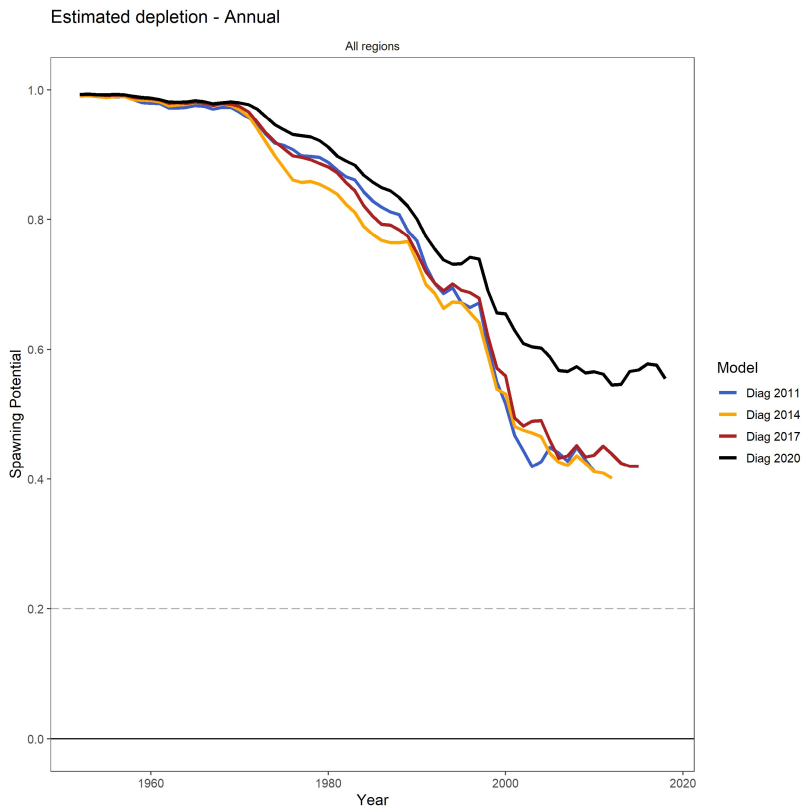

Figure A4. Estimated depletion from current and historical assessments.