Evaluating the robustness of candidate management procedures in the BC sablefish (*Anoplopoma fibria*) for 2019-2020.

# Appendices

# Appendix A: Updated operating model components

## Updated ageing error matrix

## Trawl Age-Length Key

We defined an empirical age-length key to convert commercial trawl length compositions to age compositions. The reason for this was to effectively increase the sample size of commercial trawl age composition data and improve estimates of selectivity for the commercial trawl fleet.

## Comparison of 2016 fit to 2018 fit

Table 1: A comparison of operating model posterior mean (standard deviation) biological parameter and reference point estimates from the conditioning process in the 2016 MSE cycle (fitYr = 2016), and the 2019 MSE cycle (fitYr = 2018).

|  |  |  |
| --- | --- | --- |
|  | 2016 | 2018 |
|  | 57 (1.3) | 54.1 (3.3) |
|  | 0.0411 (0.00027) | 0.0421 (0.0026) |
|  | 0.0788 (0.0014) | 0.0877 (0.0025) |
|  | 0.556 (0.064) | 0.617 (0.062) |
|  | 10.9 (1.2) | 12.5 (1.4) |
|  |  | 16.3 (2) |
|  | 23.4 (0.96) | 20.4 (1.7) |
|  | 0.0433 (0.0062) | 0.0734 (0.01) |
| Legal | 0.0423 (0.006) | 0.0773 (0.011) |
|  | 2.79 (0.27) | 4.37 (0.45) |
|  | 0.191 (0.018) | 0.231 (0.021) |
|  |  | 0.301 (0.032) |
|  | 0.467 (0.049) | 0.613 (0.065) |
|  |  | 0.8 (0.096) |

# Appendix B: New Management Procedures

## Empirical MP

We developed a new empirical MP to test for estimating sablefish stock status and determing TACs. This MP was based on comparing two consecutive 3-year moving averages of the stratified random survey (StRS), and calculating the proportional difference between those two smoothed estimates. So, for a given year , we calculated

where is the moving 3 year moving average of the StRS index, and is the proportional change between two consecutive moving averages.

This proportional change was then used to adjust the relative harvest rate in the most recent year of fishing. The relative harvest rate was calculated as the TAC in year divided by the moving average of the index in the final year,

The adjustment to the relative harvest rate was dependent on the direction of the proportional change. For increases in the moving average index, the relative harvest rate was increased at the rate , up to a maximum increase of 20% in the relative harvest rate; for decreases in the moving average index, the relative harvest rate was decreased at the rate , down to a floor of a 0% removal rate when . This rule gives the piecewise continuous function $11$).

Finally, the target harvest rate was calculated as the average of the adjusted relative harvest rate, and an overall target harvest rate scaled by a tuning scalar . This was then multipled by the final year’s moving average index to provide a TAC.

Averaging the relative harvest rate and the scaled target rate is meant to stop the harvest rate dropping to zero in response to a large negative change in observations, which could be caused by a large negative observation error. The scalar is meant to tune the target absolute harvest rate to a relative harvest rate.

This MP has multiple options for tuning parameters. First, the number of points used in the moving average could be used to reduce the influence of year to year noise. Second, the , , and parameters in the harvest control rule can be used to adjust the rate at which harvest rates are changed and the scale of the target harvest rate. Finally, the value of the target harvest rate can be changed to increase or decrease the level of precaution in the MP.

We used tuning parameters , , and , corresponding to a slow-up and fast down MP, with set close to the posterior mean value of the StRS catchability parameter . We then chose as the target absolute harvest rate.

## Delay Difference Assessment Model

We defined a delay-difference stock assessment model to use in candidate management procedures for BC Sablefish. The equilibrium equations for the delay difference model are given in Table A1, and the stock assessment model is shown in Table A2. This model increases the realism of the management procedure’s assessment component, with the added benefit of having yield curves and reference points that are closer in shape and value to the operating model’s than the existing surplus production model procedure.

Table 2: Unfished and fished equilibrium quantities for the delay-difference population dynamics.

|  |  |
| --- | --- |
| Description | Equation |
| Survivorship |  |
| Average Weight |  |
| Unfished Numbers |  |
| Unfished Recruitment |  |
| Stock-Recruit | , |
| Biomass |  |
| Recruitment |  |
| Yield |  |

Table 3: Process and observation model components of the delay difference stock assessment model used in BC Sablefish management procedures. Initialisation values for biomass, numbers, and recruitment are equilibrium unfished values from Table 2.

|  |  |
| --- | --- |
| No. | Equation |
| A2.1 | . |
| A2.2 |  |
| A2.3 |  |
| A2.4 |  |
| A2.5 |  |
| A2.6 |  |
| A2.7 |  |
| A2.8 |  |
| A2.9 |  |
| A2.10 |  |
| A2.11 |  |
| A2.12 |  |
| A2.13 |  |
| A2.14 |  |
| A2.15 |  |