Fisheries New Zealand
Tini a Tangaroa

Updated harvest control rule for SBW 6B to allow for years with no acoustic surveys

New Zealand Fisheries Assessment Report 2023/38

I.J. Doonan

ISSN 1179-5352 (online)
ISBN 978-1-991087-40-9 (online)

August 2023

Te Kāwanatanga o Aotearoa
New Zealand Government

Disclaimer

Requests for further copies should be directed to:

Fisheries Science Editor
Fisheries New Zealand
Ministry for Primary Industries
PO Box 2526
Wellington 6140
NEW ZEALAND

Email: Fisheries-Science.Editor@mpi.govt.nz
Telephone: 0800 00 83 33

This publication is also available on the Ministry for Primary Industries websites at:
http://www.mpi.govt.nz/news-and-resources/publications
http://fs.fish.govt.nz go to Document library/Research reports

Please cite this report as:

Doonan, I.J. (2023). Updated harvest control rule for SBW 6B to allow for years with no acoustic surveys. *New Zealand Fisheries Assessment Report 2023/38.* 5 p.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Doonan, I.J.[1] (2023). Updated harvest control rule for SBW 6B to allow for years with no acoustic surveys.

***New Zealand Fisheries Assessment Report 2023/38.* 5 p.**

Southern blue whiting (*Micromesistius australis*, SBW) on the New Zealand Bounty Plateau (SBW 6B) is managed by using a harvest control rule (HCR) to set the Total Allowable Commercial Catch (TACC). The HCR actually sets the Total Allowable Catch (TAC) which is then adjusted by subtracting catch from other processes to give the TACC. The HCR was developed in 2016 and first used in 2017 (denoted HCR_{2017}). The HCR_{2017} depended on an industry acoustic spawning biomass survey conducted in the year before its use. The HCR_{2017} has been used twice (2017 and 2018), but since then no surveys have been conducted (including 2022).

In this report, a new HCR was developed that adapts to years with missing surveys. The HCR was estimated from model simulations, and, apart from survey gaps, these followed the methods and parameterisation used for deriving HCR_{2017}. The new HCR_{2022} recommended that if future gaps in surveys occurred, the future TAC should be reduced each year by a scalar (denoted *D*), which was estimated to be between 0.87 and 0.83. Note that the HCR assumes that the calculated catch is fully caught.

[1] National Institute of Water and Atmospheric Research (NIWA), New Zealand

1. INTRODUCTION

Southern blue whiting (*Micromesistius australis*, SBW) on the New Zealand Bounty Plateau (SBW 6B) is managed by a harvest control rule (HCR) to set the Total Allowable Commercial Catch (TACC). The HCR was developed in 2016 (Doonan 2017) and first used in 2017 (denoted HCR_{2017}) (Fisheries New Zealand 2022). The HCR_{2017} depended on an industry acoustic survey in the year before its use. The HCR_{2017} was based on simulations in which the key assumption was that the catchability (Q) distribution for the acoustic survey was known, i.e., the real Q was within this assumed distribution, although the true Q was unknown (Doonan 2017). The Q distribution was assumed to have a mean of 0.54, and this was applied to the simulated acoustic survey biomass in the simulations. The simulations assumed that Q was 0.54 in HCR_{2017} and estimated the risk associated with the true Q value lying elsewhere in the distribution. The HCR_{2017} had an absolute biomass estimate incorporating both sampling error and process error (from the Q distribution), meaning it was assumed the current biomass was known with error.

The HCR_{2017} was used twice, in 2017 and 2018 (Fisheries New Zealand 2022), but since then no surveys have been available (including 2022). A HCR_{2022} was developed using the same structure as Doonan (2017) but allowing for periods of consecutive years with no surveys. The HCR_{2022} used as its base the HCR_{2017} calculated catch for the year after an acoustic survey, but it cumulatively 'discounted' this catch for each consecutive year with no survey.

This report fulfils the reporting requirements for Objective 1 of Fisheries New Zealand research project SEA2021-09.

2. METHODS

As for HCR_{2017}, risk for HCR_{2022} was defined as the probability of the spawning stock biomass (*SSB)* being below 20% SSB_0 (the soft limit). The target risk was 10%. The HCR_{2017} was given by Total Allowable Catch, $TAC_{t+1} = p\ (B_t - C_t/\ 2)$, where B_t is acoustic abundance, C_t is catch, and p is a fixed proportion estimated from simulations to achieve the target risk (Doonan 2017). All simulations assumed that the TAC was fully taken in each year. The HCR_{2017} depends on the values of natural mortality and Beverton-Holt recruitment steepness, and these were specified by Fisheries New Zealand to be 0.2 y^{-1} and 0.9, respectively, when applying the HCR_{2017}. However, sensitivity analyses to these assumed values were also conducted.

Assuming the last acoustic survey was completed in year t, the TAC for the following year is given by the original HCR_{2017}. However, if an acoustic survey is not completed in year t+1 (the first 'gap year') or subsequent years, the TAC for year t+2 onwards is calculated by adjusting TAC_{t+1} with a series of factors, $D1$ for the first gap year (TAC for year $t+2$), $D1 * D2$ for the second gap year to give the TAC for year $t+3$, $D1*D2*D3$ for the third gap year to give the TAC for year $t+4$, and so on. The TAC for year t+4 is $D1*D2*D3 * TAC_{t+1}$. By definition, the D factors are less than or equal to one. More formally, where gap is the length of the gap, j indexes the gap years,

$$TAC_{t+1+gap} = \left(\prod_{j=1}^{gap} D_j\right) * \ TAC_{t+1}$$

$$= \left(\prod_{j=1}^{i} D_j\right) * p(B_t - C_t/2)$$

$$= k1_{t+1+gap}(B_t - C_t/2) \quad , \tag{1}$$

where

$$k1_{t+1+gap} = p \prod_{j=1}^{gap} D_j \tag{2}$$

Because the actual gap length was not known when applying the HCR_{2022} in a particular year, the simulations were done in a nested way to maintain the risk at its target level as the gap gets bigger. For a gap size of one year, simulations were run with surveys every 2nd year so that *D1* could be established, i.e., a repetitive grid of one-year gaps. Next, simulations were run using surveys every three years (2-year gap) and using the estimated *D1* value for the first gap year to find the value of the *D2* factor. This was repeated until surveys were done every 5 years (4-year gap), to establish the value of *D4*. It was found that the *D* factors converged in value after a gap of three or more years when natural mortality and recruitment steepness were 0.2 y^{-1} and 0.9.

Apart from survey year gaps, the simulations were conducted in the same way as Doonan (2017), including using the same selected parameter sets as used in that study. Doonan (2017) used three combinations of natural mortality (M) and Beverton-Holt steepness (h): $M = 0.2$ and $h = 0.9$; $M = 0.25$ and $h = 0.9$; and $M = 0.15$ and $h = 0.85$. The coefficient of variation (CV) for process error of the acoustic survey was set to 20% since Doonan (2017) found this parameter had effect on the results, i.e., it was within simulation error of less than 0.008. Following Doonan (2017), other dynamical parameters were selected randomly including recruitment, autocorrelation of recruitment, and acoustic survey catchability. There were 1000 vectors of randomly selected parameters. Risk was evaluated over the 1000 runs by taking the number of times the *SSB* fell below 20% B_0 over all 1000 runs divided by the total number of years in the 1000 runs.

For each *M-h* combination, 1000 model runs were repeated over a grid of *D* values chosen to ensure that the risk of falling below 20% SSB_0 was both above and below 10%. The *D* value for a risk of 10% was estimated by interpolation from the nearest risk values either side of 10%.

3. RESULTS

The estimated *D* values for the *M-h* combinations that gave a risk of 10% are shown in Table 1. For the *M-h* combinations of 0.2/0.9, the *D* value converged to 0.83; for *M-h* of 0.25/0.9, *D* converged to 0.80. For *M-h* combinations of 0.15/0.84, *D* failed to converge, and more simulations are needed if this combination were to be used for a gap between surveys of greater than 4 years.

Table 1: Discount factors (D_j) for the three combinations of *M* and *h* to apply to the TAC_{t+1} derived from the acoustic survey in year *t*, using the HCR_{2022} following 1 or more gap years (no surveys); -, no discount factor defined. Risk is 10%. Gap is the length of years with no survey, *p* is a factor for HCR_{2022}, *k* is the cumulative discount over the gap including the factor *p*.

TAC for Year	Gap	*p*	D_1	D_2	D_3	D_4	*k*
***M* = 0.2, *h* = 0.9**							
t+1	0	0.235	–	–	–	–	0.24
t+2	1	0.235	0.87	–	–	–	0.20
t+3	2	0.235	0.87	0.86	–	–	0.18
t+4	3	0.235	0.87	0.86	0.828	–	0.15
t+5	4	0.235	0.87	0.86	0.828	0.83	0.12
***M* = 0.25, *h* = 0.9**							
t+1	0	0.283	–	–	–	–	0.28
t+2	1	0.283	0.858	–	–	–	0.24
t+3	2	0.283	0.858	0.825	–	–	0.20
t+4	3	0.283	0.858	0.825	0.8	–	0.16
t+5	4	0.283	0.858	0.825	0.8	0.8	0.13
***M* = 0.15, *h* = 0.84**							
t+1	0	0.171	–	–	–	–	0.17
t+2	1	0.171	0.91	–	–	–	0.16
t+3	2	0.171	0.91	0.863	–	–	0.13
t+4	3	0.171	0.91	0.863	0.846	–	0.11
t+5	4	0.171	0.91	0.863	0.846	0.917	0.10

4. DISCUSSION

An example of how the HCR_{2022} works is given in Table 2 which shows the sequence of derived TACs from the last acoustic survey in 2017. The TAC for 2018 was derived from the HCR_{2017}, but after that *D* factors were applied cumulatively, noting that the *D* factor for the TAC calculation for 2023 relies on it converging at that point. Hence, a TAC of 3209 t for 2018 would be reduced to 1373 t in 2023.

Table 2: An example of the HCR_{2022} (*M-h* 0.2/0.9) in use over years without a survey (2018 to 2022) using the TAC for 2018, 3209 t. Note that 3209 t was the value calculated from HCR_{2017} in 2018 which was sent to the Ministry for Primary Industries (MPI), but this value was adjusted by MPI to give a TACC of 3145 t.

Year	2018	2019	2020	2021	2022	2023
Gap size at calculation time		1	2	3	4	5
TAC (t)	3 209	2 792	2 401	1 993	1 654	1 373
Dj		0.87	0.86	0.83	0.83	0.83

Note that this analysis did not address the question of under-caught quotas, and it assumed that quotas were fully caught. In the presence of a sequence of under-caught quotas, the risk of falling below 20% SSB_0 will reduce and be lower than 10%.

Adapting the HCR to allow for under-caught TACC is outside the scope of this project. Simulations would need to be done each year (after the method is accepted) since the catch would be unknown until after the previous season. The catches would have to be entered as the fraction of the calculated TACC.

5. ACKNOWLEDGEMENTS

I thank Teresa A'mar for helping with the coding of this project. This work was funded by the Fisheries New Zealand under Project SEA2021-09. Thanks to Steven Holmes for a useful review of the document.

6. REFERENCES

Doonan, I.J. (2017). Evaluation of a simple harvest control rule for the southern blue whiting Bounty management area (SBW6B). *New Zealand Fisheries Assessment Report 2017/52*. 14 p.

Fisheries New Zealand (2022). *Fisheries Assessment Plenary, May 2022: stock assessments and stock status*. Compiled by the Fisheries Science Team, Fisheries New Zealand, Wellington, New Zealand. 1886 p.