

## Consideration of a revision to the 2020 directed sardine TAC

C.L. de Moor\*

Correspondence email: [carryn.demoor@uct.ac.za](mailto:carryn.demoor@uct.ac.za)

*Three alternative proposals are made for a revision to the 2020 directed sardine TAC, based on the quantitative analyses of de Moor (2020c).*

I have been asked to submit my “thoughts” regarding whether the 2020 directed sardine Total Allowable Catch (TAC) (of 9000t west of Cape Agulhas and 13 000t east of Cape Agulhas) should be increased from that recommended in April 2020, given the June 2020 survey estimate of recruitment, and if so, what the TAC should be increased to. I have briefly separated this into three alternative proposals below.

Firstly, readers are reminded that the sardine west component biomass has been estimated to be very low in recent years (Figure 1), and current short-term projections (de Moor 2020a) do not indicate an immediate change to the situation experienced since 2013 by November 2020. The west component effective<sup>1</sup> spawning biomass has been estimated to be below the risk threshold adopted for OMP-18 of the 2007 effective spawning biomass (de Moor 2018) in both November 2018 and 2019 (Figure 2), with a substantial part of the effective spawning biomass consisting of south component spawning biomass (Figure 3). While the contribution of some south component spawning biomass to west component recruitment (the proportion of which will be re-evaluated during 2021) is a “bonus”, one does not wish for a situation in which the west component spawning biomass is depleted to such an extent that recruitment becomes almost completely dependent on the south component.

### Proposal 1

The first proposal would be for **no change to the 2020 directed sardine TAC**. This takes into consideration the non-negligible possibility of the west component biomass decreasing from November 2019 to 2020. Ideally, we’d not want the population to decrease below the November 2019 level (and then distribute any increase (‘surplus biomass’) between growth in the population and catch). Any realised recruitment during the course of this year that may be higher than that previously assumed would benefit the population (both west and south components), the fishery<sup>2</sup> and the ecosystem through a higher biomass in November 2020. The April 2020 recommendation was already heavily influenced by “pressing socio-economic circumstances” (SWG-PEL TG 2020) and this proposal may therefore allow for some balance towards growth in the population instead.

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\* MARAM (Marine Resource Assessment and Management Group), Department of Mathematics and Applied Mathematics, University of Cape Town, Rondebosch, 7701, South Africa.

<sup>1</sup> The ‘effective’ spawning biomass is taken to consist of all the west component spawning biomass and 8% of the south component spawning biomass.

<sup>2</sup> If catch quotas are assumed to increase with increasing total biomass.

The directed sardine TAC has not standardly been increased mid-year over the past three decades<sup>3</sup>. The primary reason for this is because the directed >14cm catches should mostly consist of fish already surveyed as part of the adult biomass in the previous November (i.e. “1+ fish” during the year in which they are caught). The only new fishery-independent information available during the course of the year is the recruit survey estimate, and higher or lower recruitment should not influence the biomass from which the current year’s TAC is taken.

The short-term projections of de Moor (2020b,c) do, however, assume some 0-year olds are taken as part of the >14cm catch and the recruits of the year influence the total biomass at the end of the year (i.e. November 2019 recruits, surveyed in June 2020, will contribute to the November 2020 biomass as 1-year-olds).

The second two proposals revisit the same method used to recommend the sardine TAC/Bs in April 2020, but now under different west component November 2019 recruitment assumptions. In April, the recommendations were based on short-term projections which randomly sampled November 2019 west component recruitment from the most recent five years (de Moor 2020b).

There have been some suggestions within the SWG-PEL TG that any increase in TAC would need to be equally split between coasts. The below proposals assume this position and thus focus on Tables 5a and 5b of de Moor (2020c) in preference to Tables 2 to 4 of de Moor (2020c).

#### Proposal 2a

This proposal is based on a June 2020 survey estimate of sardine recruitment west of Cape Infanta of **7.01 billion fish** and would be for an **increase of 1000t in the 2020 directed sardine TAC for each coast** (i.e. from 9 000t to 10000t on the west coast and from 13 000t to 14 000t on the south coast). This takes into consideration:

- Revisiting the April 2020 recommendation of the SWG-PEL in the light of a revised understanding of the west component November 2019 recruitment. The November 2019 west component recruitment is updated from randomly sampling from the last 5 years, to randomly sampling from the three highest of these 5 years (see “Recruitment in November 2019” of de Moor (2020c) for reasoning).
- The statistics in the “Three highest” block are therefore compared to that which was considered to be ‘acceptable’ in April 2020. (The same conclusion is, however, reached if only using the  $N_{w,0,2014,0}^S = 11.5$  block)
- The same method is now followed as was followed by the SWG-PEL in April 2020. This is consistent with the approach used for anchovy (de Moor 2020d, DEFF 2020). In brief, this involves finding the catch quota which corresponds with a 20%ile in the multiplicative change in effective west component spawning biomass relative to that under a no catch scenario (“Relative Multiplicative  $\Delta$ ”) of 0.90 (or higher) and an additive change in west component biomass (“Additive  $\Delta$  in B”) of -46, -20 and 6 thousand tons at the 5%ile, 20%ile and 50%ile, respectively (further detail provided in de Moor (2020c)) (Table 1). The latter

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<sup>3</sup> Under OMP-08 and OMP-14 different HCRs were used which did allow for a mid-year increase in the TAC based on the survey estimate of sardine recruitment, but this applied only in cases where the TAC awarded at the beginning of the year was conservatively set at 50% of that initially calculated (de Moor and Butterworth 2008, de Moor 2014).

comparison, however, does not allow for any potential improvement in the biomass to be afforded to population growth, but rather, only to the fishery.

- The option of a total catch of 37 050t (an increase of 1 000t in the directed sardine TAC for each coast) provides the best match of the “Additive  $\Delta$  in B” and “Relative Multiplicative  $\Delta$ ” statistics under the “Three highest” recruitment scenario, to the values corresponding to the SWG-PEL April 2020 recommendation under the “Random” recruitment scenario (Table 1). This option does, however, result in a greater impact on the south component than that considered ‘acceptable’ by the SWG-PEL in April 2020: a “Relative Multiplicative  $\Delta$ ” of 0.94 instead of 0.95. Personally, I would be comfortable with this change given that the south component biomass is predicted to increase substantially more than predicted under the “Random” recruitment scenario, but I am concerned about maintaining the same precedent throughout<sup>4</sup>.

### Proposal 2b

This proposal is based on a June 2020 survey estimate of sardine recruitment west of Cape Infanta of **11.78 billion fish** and would be for an **increase of 3 000t in the 2020 directed sardine TAC for each coast** (i.e. from 9 000t to 12000t on the west coast and from 13 000t to 16 000t on the south coast). This takes into consideration:

- Revisiting the April 2020 recommendation of the SWG-PEL in the light of a revised understanding of the west component November 2019 recruitment. The November 2019 west component recruitment is updated from randomly sampling from the last 5 years, to considering only the highest of these 5 years (see “Addendum: Updated survey estimate of recruitment” of de Moor 2020c for reasoning).

- The statistics in the  $N_{w,0,2018,0}^S = 14.14$  block are therefore compared to that which was considered to be ‘acceptable’ in April 2020.

- The same method is now followed as was followed by the SWG-PEL in April 2020. This is consistent with the approach used for anchovy (de Moor 2020d, DEFF 2020). In brief, this involves finding the catch quota which corresponds with a 20%ile in the multiplicative change in effective west component spawning biomass relative to that under a no catch scenario (“Relative Multiplicative  $\Delta$ ”) of 0.90 (or higher) and an additive change in west component biomass (“Additive  $\Delta$  in B”) of -46, -20 and 6 thousand tons at the 5%ile, 20%ile and 50%ile, respectively (further detail provided in de Moor (2020c)) (Table 1). The latter comparison, however, does not allow for any potential improvement in the biomass to be afforded to population growth, but rather, only to the fishery.

- The option of a total catch of 41 050t<sup>5</sup> (an increase of 3 000t in the directed sardine TAC for each coast) provides the best match of the “Additive  $\Delta$  in B” and “Relative Multiplicative  $\Delta$ ” statistics under the  $N_{w,0,2018,0}^S = 14.14$  recruitment scenario, to the values corresponding to the SWG-PEL April 2020 recommendation under the “Random” recruitment scenario (Table 1). Of the 4 to 6 000t ‘improvement’ in the “Additive  $\Delta$  in B” under a no catch scenario from the “Random” to the  $N_{w,0,2018,0}^S = 14.14$  recruitment scenario, 50 to 75% is allocated to the fishery, with 25 to 50% to population growth (Table 1). Table A.2 of de Moor (2020c) additionally shows how the change in biomass under a higher total catch of 43 050t and assuming a  $N_{w,0,2018,0}^S = 14.14$  recruitment scenario would result in a greater probability of a decrease in west component biomass from

<sup>4</sup> If one allows arguments for a higher risk to the south component than agreed in April 2020, then one needs to additionally allow arguments for a lower risk to the west component than agreed in April 2020.

<sup>5</sup> Both 39 050t and 41 050t have a “Relative Multiplicative  $\Delta$ ” of 0.90, but the “Additive  $\Delta$  in B” is closer to that considered ‘acceptable’ in April 2020 for 41 050t than 39 050t.

that accepted in April 2020<sup>6</sup>. This option does, however, result in a greater impact on the south component than that considered ‘acceptable’ by the SWG-PEL in April 2020: a “Relative Multiplicative  $\Delta$ ” of 0.94 instead of 0.95. Personally, I would be comfortable with this change given that the south component biomass is predicted to increase substantially more than predicted under the “Random” recruitment scenario, but I am concerned about maintaining the same precedent throughout<sup>7</sup>.

In summary, the short-term projections indicate that under these additional directed sardine TAC proposals, the effective west component spawning biomass will increase from November 2019 to 2020, with this change being 90% of that expected under a no catch scenario. However there is a 41-44% chance that the west component biomass will decrease.

Please note:

- The above proposals assume that the  $\leq 14$ cm sardine TABs totaling 10 400t will not be exceeded during 2020. Should there be any possibility that this allowance will hamper the anchovy fishery (especially given the recent revision to the June 2020 survey estimate of recruitment) and an increase would be required, that increase would need to be considered now. If an increase in sardine TAC is recommended, no further increases in sardine TAB can be entertained during 2020.
- The above proposals have been made considering the baseline model only. Some sensitivity tests produce more optimistic, and some more pessimistic projections. In particular, results are sensitive to the proportion of west component sardine that will move to the south component at the end of this year (de Moor 2020b).
- During the course of making its recommendation in April 2020, the SWG-PEL and its TG chose to prefer the statistic “Relative Multiplicative  $\Delta$ ” over “Multiplicative  $\Delta$  in effSSB” and “Additive  $\Delta$  in effSSB”, consistent with its decision in 2019. The latter two statistics were left in the tables for interest purposes: for information on the calculation of the relative statistic (as it is derived directly from “Multiplicative  $\Delta$  in effSSB”) and for comparison against the additive change in total biomass, partially reflecting the influence of south spawning biomass on the west effective spawning biomass. Unlike for effective spawning biomass, a relative statistic was not considered for total biomass due to the decrease in biomass predicted for some scenarios, and thus the “Additive  $\Delta$  in B” was the preferred total biomass statistic.
- Methods that consider weighting all four statistics from the tables in de Moor (2020c) thus not only double count the multiplicative change in effective spawning biomass, but consider effective spawning biomass three times more than total biomass. This is contrary to what the SWG-PEL considered in April 2020.

## References

de Moor CL. 2014. OMP-14. DAFF: Branch Fisheries Document FISHERIES/2014/DEC/SWG-PEL/60.

de Moor CL. 2018. The 2018 Operational Management Procedure for the South African sardine and anchovy resources.

DAFF: Branch Fisheries Document FISHERIES/2018/DEC/SWG-PEL/37.

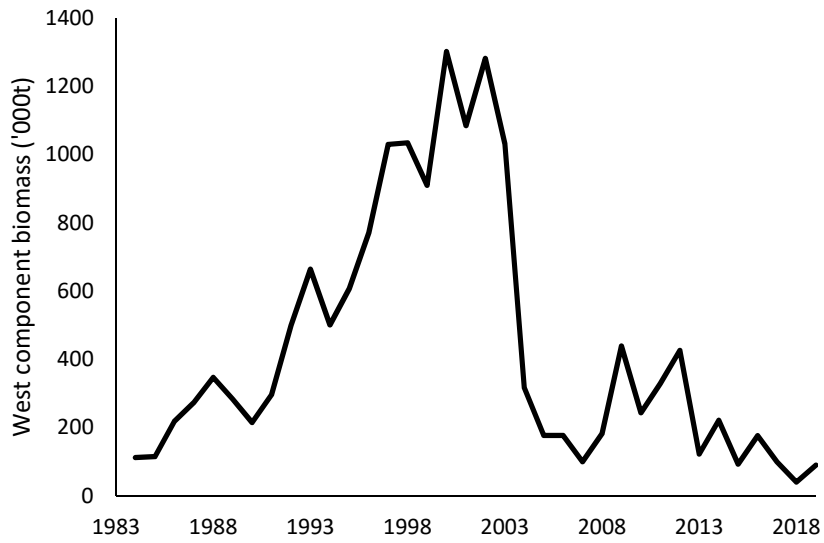
<sup>6</sup> If one considers the difference in west component biomass from a no catch scenario (Table A.2 of de Moor (2020c)), no increase in total catch could be supported.

<sup>7</sup> If one allows arguments for a higher risk to the south component than agreed in April 2020, then one needs to additionally allow arguments for a lower risk to the west component than agreed in April 2020.

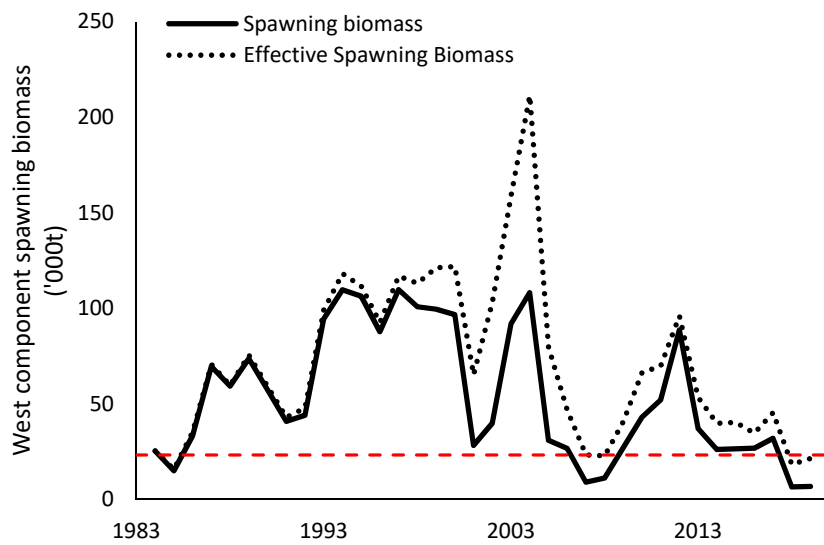
- de Moor CL. 2019. Sardine projections based on constant catch scenarios. DAFF: Branch Fisheries Document FISHERIES/2019/APR/SWG-PEL/07.
- de Moor CL. 2020a. Baseline assessment of the South African sardine resource using data from 1984-2019. DEFF: Branch Fisheries Document FISHERIES/2020/APR/SWG-PEL/30.
- de Moor CL. 2020b. Sardine projections based on constant catch scenarios. DEFF: Branch Fisheries Document FISHERIES/2020/APR/SWG-PEL/33.
- de Moor CL. 2020c. Additional sardine projections based on constant catch scenarios assuming alternative November 2019 recruitment levels. DEFF: Branch Fisheries Document FISHERIES/2020/AUG/SWG-PEL/70.
- de Moor CL. 2020d. A method to recommend the final anchovy Total Allowable Catch for 2020 based on short-term projections of the anchovy resource. DEFF: Branch Fisheries Document FISHERIES/2020/JUL/SWG-PEL/54.
- de Moor CL and Butterworth DS. 2008. OMP-08. Marine and Coastal Management Document MCM/2008/SWG-PEL/23.
- DEFF. 2020. Recommendation of the Small Pelagic Scientific Working Group for the Final Anchovy Total Allowable Catch for the 2020 Fishing Season. DEFF: Branch Fisheries Document FISHERIES/2020/JUL/SWG-PEL/66.
- SWG-PEL TG 2020. Recommendation by the SWG-PEL Task Group (SWG-PEL TG) for the sardine Total Allowable Catch and Total Allowable Bycatch for 2020. DEFF: Branch Fisheries Document FISHERIES/2020/APR/SWG-PEL/36REV.

**Table 1.** Extracts from Table 5a of de Moor (2020c) and Table 4 of de Moor (2020b). The 5%ile, 20%ile and 50%ile of the additive change in total west component biomass from November 2019 to 2020 and the 5%ile, 20%ile and 50%ile of the multiplicative change in the west component effective spawning biomass from November 2019 to 2020, relative to a no catch scenario. The top two rows give the comparative statistics under the zero catch and 2019 TAC/B as estimated by de Moor (2019) and the next four rows give the statistics considered in setting the 2020 TAC/Bs (de Moor 2020b).

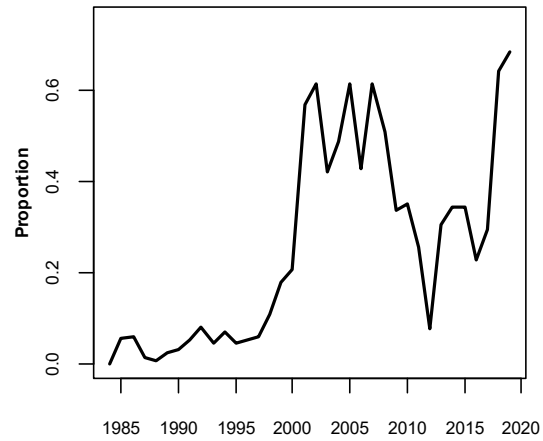
|                            | Additive $\Delta$ in B |       |       |      | Relative Multiplicative $\Delta$ |        |        |       |        |        |
|----------------------------|------------------------|-------|-------|------|----------------------------------|--------|--------|-------|--------|--------|
|                            | Total                  | West  | South | ByC  | 5%ile                            | 20%ile | 50%ile | 5%ile | 20%ile | 50%ile |
| 2019                       | 0                      | 0     | 0     | 0    |                                  |        |        |       |        |        |
|                            | 23                     | 6.5   | 7     | 9.5  |                                  |        |        | 0.86  | 0.88   | 0.90   |
| 2020                       | 0                      | 0     | 0     | 0    | -35                              | -8     | 17     | 1     | 1      | 1      |
|                            | 32.05                  | 11.65 | 13    | 7.4  | -45                              | -19    | 7      | 0.89  | 0.91   | 0.92   |
|                            | 34.05                  | 11.65 | 13    | 9.4  | -47                              | -20    | 6      | 0.88  | 0.90   | 0.92   |
|                            | 34.05                  | 13.65 | 13    | 7.4  | -46                              | -20    | 6      | 0.88  | 0.90   | 0.91   |
| Baseline                   | 0                      | 0     | 0     | 0    | -35                              | -8     | 17     | 1     | 1      | 1      |
|                            | 35.05                  | 11.65 | 13    | 10.4 | -47                              | -21    | 5      | 0.88  | 0.90   | 0.92   |
|                            | 37.05                  | 12.65 | 14    | 10.4 | -48                              | -21    | 4      | 0.87  | 0.89   | 0.91   |
|                            | 39.05                  | 13.65 | 15    | 10.4 | -48                              | -22    | 4      | 0.87  | 0.89   | 0.90   |
|                            | 41.05                  | 14.65 | 16    | 10.4 | -49                              | -22    | 3      | 0.86  | 0.88   | 0.90   |
|                            | 43.05                  | 15.65 | 17    | 10.4 | -49                              | -23    | 3      | 0.85  | 0.87   | 0.89   |
| $N_{w,0,2018,0}^S = 14.14$ | 0                      | 0     | 0     | 0    | -29                              | -4     | 21     | 1     | 1      | 1      |
|                            | 35.05                  | 11.65 | 13    | 10.4 | -41                              | -17    | 8      | 0.9   | 0.91   | 0.93   |
|                            | 37.05                  | 12.65 | 14    | 10.4 | -42                              | -17    | 8      | 0.9   | 0.91   | 0.92   |
|                            | 39.05                  | 13.65 | 15    | 10.4 | -42                              | -18    | 7      | 0.89  | 0.90   | 0.92   |
|                            | 41.05                  | 14.65 | 16    | 10.4 | -43                              | -18    | 7      | 0.89  | 0.90   | 0.91   |
|                            | 43.05                  | 15.65 | 17    | 10.4 | -43                              | -19    | 6      | 0.88  | 0.89   | 0.91   |
| Three highest              | 0                      | 0     | 0     | 0    | -6                               | 19     | 1      | 1     | 1      | 0      |
|                            | 35.05                  | 11.65 | 13    | 10.4 | -19                              | 7      | 0.89   | 0.91  | 0.92   | 0.06   |
|                            | 37.05                  | 12.65 | 14    | 10.4 | -19                              | 6      | 0.89   | 0.90  | 0.92   | 0.09   |
|                            | 39.05                  | 13.65 | 15    | 10.4 | -20                              | 5      | 0.88   | 0.90  | 0.91   | 0.11   |
|                            | 41.05                  | 14.65 | 16    | 10.4 | -20                              | 5      | 0.87   | 0.89  | 0.90   | 0.15   |
|                            | 43.05                  | 15.65 | 17    | 10.4 | -21                              | 4      | 0.87   | 0.88  | 0.90   | 0.20   |
| 45.05                      | 16.65                  | 18    | 10.4  | -21  | 4                                | 0.86   | 0.88   | 0.90  | 0.26   |        |



**Figure 1.** The deterministic time series of west component biomass (de Moor 2020a).



**Figure 2.** The deterministic time series of west component (effective) spawning biomass (de Moor 2020a). The red dashed line indicates the risk threshold of the 2007 west component effective spawning biomass.



**Figure 3.** The proportion of west component effective spawning biomass (defined as west component spawning biomass combined with 8% of south component spawning biomass) that consists of south component spawning biomass (i.e.  $SSB_{j=S,y}^S / SSB_{j=W,y}^{eff,S}$ ). Reproduced from de Moor (2020a).