# OMP-18 Baseline Sardine Operating Model Proposal

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Having further considered the implications of weighting across alternative Operating Models, it is proposed that OMP-18 be finalised based on the Operating Model assuming $p = 0.08$ and MoveD.

## Introduction

de Moor (2018) considered Candidate Management Procedures (CMPs) tuned to two different sardine Operating Models (OMs): one assuming a proportion ($p$) of 0.08 of the south component spawning biomass contributing to west component effective spawning biomass, and the other assuming $p = 0.6$. Both these OMs assumed that future movement of sardine from the west to the south component is randomly selected from that estimated in recent years (MoveR, e.g. de Moor 2017).

de Moor (2018) also showed the results from simulating the implementation of these CMPs under alternative OMs. These alternative OMs included values of $p = 0.0$ and $p = 0.2$ and a density-dependent hypothesis of future movement of sardine from the west to the south component being dependent on the west component total biomass (MoveD, de Moor et al. 2018).

Thus far only four members and one observer of the Small Pelagic Scientific Working Group (SPSWG) have provided their preferred weightings between the 8 alternative OMs. The SPSWG requested that CMPs be tuned to a reference set of the 8 OMs that result from i) an average of the weightings provided by Carl, Janet and Carryn and ii) an average of the weightings provided by Doug and Mike. Should such CMPs not differ drastically, there would be little need to open the debate regarding the weightings of the 8 OMs to form a reference set.

This document presents the requested further analyses, together with an OMP Task Team recommendation following consideration of these results.

## Method

CMP1 and CMP2 were tuned using the leftward shift method on OM1 and OM2, respectively (de Moor 2018). OM-CCJ and OM-MD are the reference set OMs resulting from taking the average weighting across all OMs by Carl, Carryn and Janet and by Mike and Doug, respectively. The CMP tuned using the leftward shift approach to OM-CCJ is called CMP-A and the CMP tuned using the leftward shift approach to OM-MD is called CMP-B.

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**Results**

Tables 1 and 2 show that by weighting over all the OMs (and in particular, but including $p = 0.0$ and MoveD) CMP-A and CMP-B have $\beta$ control parameters and sardine risk (the probability of west component effective spawning biomass falling below the 2007 level during the projection period) that are further apart than those of CMP1 and CMP2.

**Recommendation**

Having considered these results further, together with the possible implications of requesting other SPSWG members (and possibly observers) to debate the weightings across the alternative OMs, the OMP Task Team recommends that OMP-18 be finalised based on the OM assuming 8% of south component spawning biomass contributes to the effective west component spawning biomass.

Furthermore, given the general consensus among Task Team members that MoveD is somewhat preferred to MoveR, the OMP Task Team recommends that OMP-18 be finalised based on the OM assuming movement of sardine from the west component to the south component is related to the west component biomass (density dependence). The performance statistics associated with a CMP tuned to this "OM3" (with $p = 0.08$ and MoveD) are shown in Table 3.

**References**

de Moor CL. 2017. A summary of the operating models being used to simulation test OMP-18 for South African sardine and anchovy. MARAM International Stock Assessment Workshop, December 2017, Cape Town. Document MARAM/IWS/2017/Sardine/P6.

de Moor CL. 2018. Multiple sardine Operating Models and associated risk. DAFF: Branch Fisheries Document FISHERIES/2018/AUG/SWG-PEL/19.

de Moor CL, Bergh M, Butterworth DS, Coetzee JC and van der Lingen CD. 2018. Density dependent movement of South African sardine. DAFF: Branch Fisheries Document FISHERIES/2018/MAR/SWG-PEL/02.

**Table 1.** Key summary performance statistics for CMP1, CMP2 and the CMPs (CMP-A and CMP-B) tuned to the two alternatively weighted reference set OMs. Where appropriate, medians and 90%iles are provided, and for some statistics the means are provided additionally and shown in **bold**. All biomasses are given in thousands of tons.

| | | OM1 | OM-CCJ | | OM-MD | | OM2 |
|---|---|---|---|---|---|---|---|
| | | CMP1 | No Catch | CMP-A | No Catch | CMP-B | CMP2 |
| Risk statistics | $\beta$ | 0.174 | - | 0.157 | - | 0.214 | 0.208 |
| | $Risk_S$ | 0.200 | 0.071 | 0.199 | 0.074 | 0.256 | 0.320[1] |
| | p(TAC$^S$<20) | 0.02 | - | 0.02 | - | 0.01 | 0.01 |
| Biomass statistics | $B^S_{tot,2036}$ | **274** 213<br>[85,623] | **420** 367<br>[175,841] | **284** 239<br>[88,638] | **422** 374<br>[174,829] | **273** 228<br>[77,629] | **281** 229<br>[90,657] |
| | $B^S_{west,2036}$ | **120** 82<br>[14,362] | **182** 142<br>[29,463] | **124** 88<br>[14,345] | **180** 144<br>[27,445] | **119** 89<br>[13,331] | **125** 84<br>[15,378] |
| | $B^S_{south,2036}$ | **154** 131<br>[44,334] | **238** 207<br>[87,477] | **160** 136<br>[44,345] | **242** 214<br>[91,481] | **154** 126<br>[37,358] | **156** 130<br>[42,353] |
| | $B^S_{tot,2036}/B^S_{tot,2015}$ | 2.7<br>[0.8,14.4] | 4.5<br>[1.5.22.4] | 2.9<br>[0.8,15.1] | 4.5<br>[1.5,25.0] | 2.8<br>[0.7,16.8] | 2.8<br>[0.8,15.0] |
| | $B^S_{west,2036}/B^S_{west,2015}$ | 1.8<br>[0.3,12.9] | 3.1<br>[0.5,20.6] | 2.0<br>[0.3,13.8] | 3.1<br>[0.5,23.6] | 1.9<br>[0.3,15.8] | 1.9<br>[0.3,14.2] |
| | $B^S_{south,2036}/B^S_{south,2015}$ | 0.7 [0.2,1.9] | 1.1 [0.5,2.7] | 0.7 [0.2,1.9] | 1.2 [0.5,2.8] | 0.7 [0.2,2.0] | 0.7 [0.2,1.9] |
| | $B^S_{tot,min}$ | 102 [40,186] | 177<br>[113,258] | 107 [45,192] | 180<br>[116,263] | 100 [41,187] | 100 [43,186] |
| | $B^S_{west,min}$ | 16 [3,48] | 28 [6,72] | 16 [3,50] | 28 [5,69] | 16 [2,45] | 17 [4,48] |
| | $B^S_{south,min}$ | 53 [15,108] | 96 [50,154] | 53 [17,108] | 93 [50,154] | 44 [11,99] | 50 [15,108] |
| Catch statistics | $C^S_{tot}$ | **103**<br>92 [31,200] | **2**<br>0 [0,31] | **99**<br>85 [31,200] | **2**<br>0 [0,31] | **117**<br>104 [31,200] | **116**<br>103 [31,200] |
| | Med $C^S_{tot}$[2] | 94 [65,139] | 0 [0,0] | 87 [65,127] | 0 [0,0] | 107 [70,169] | 106 [71,168] |
| | $C^S_{west}$ | **68**<br>58 [19,154] | **1**<br>0 [0,26] | **67**<br>57 [20,152] | **1**<br>0 [0,26] | **74**<br>65 [21,160] | **74**<br>64 [22,161] |
| | $C^S_{south}$ | **36**<br>26 [3,104] | **0**<br>0 [0,5] | **32**<br>22 [3,96] | **0**<br>0 [0,5] | **43**<br>32 [4,118] | **42**<br>32 [4,116] |
| | $C^S_{west}/C^S_{tot}$ | 0.72<br>[0.31,0.94] | 0.00<br>[0.00,0.82] | 0.74<br>[0.32,0.95] | 0.00<br>[0.00,0.82] | 0.70<br>[0.28,0.93] | 0.69<br>[0.30,0.93] |
| | $ByC^S_{tot}$ | **20.5** 11.2<br>[1.4,70.7] | **0.3** 0.0<br>[0.0,5.2] | **20.6** 11.3<br>[1.3,71.2] | **0.3** 0.0<br>[0.0,5.2] | **21.0** 11.6<br>[1.4,71.9] | **21.2** 11.8<br>[1.4,72.5] |
| | $ByC^S_{west}$ | **20.5** 11.1<br>[1.3,70.7] | **0.3** 0.0<br>[0.0,5.2] | **20.6** 11.3<br>[1.3,71.2] | **0.3** 0.0<br>[0.0,5.2] | **21.0** 11.6<br>[1.4,71.9] | **21.2** 11.8<br>[1.4,72.5] |
| | $ByC^S_{south}$ | **0.0** 0.0<br>[0.0,0.1] | **0.0** 0.0<br>[0.0,0.0] | **0.0** 0.0<br>[0.0,0.0] | **0.0** 0.0<br>[0.0,0.0] | **0.0** 0.0<br>[0.0,0.1] | **0.0** 0.0<br>[0.0,0.1] |
| | $MAV^S_{tot}$[3] | 0.50<br>[0.26,0.50] | - | 0.49<br>[0.26,0.50] | - | 0.48<br>[0.23,0.50] | 0.48<br>[0.23,0.50] |
| | $MAV^S_{west}$ | 0.38<br>[0.24,0.54] | - | 0.38<br>[0.24,0.54] | - | 0.39<br>[0.23,0.57] | 0.38<br>[0.23,0.54] |
| | $MAV^S_{south}$ | 0.72<br>[0.51,0.91] | - | 0.73<br>[0.51,0.93] | - | 0.71<br>[0.49,0.90] | 0.71<br>[0.48,0.88] |
| Critical Biomass statistics | $p(B^{Sobs}_y < B^S_{crit}, B_y < B^S_{crit}/k^S_N)$ | 0.10 | - | 0.09 | - | 0.09 | 0.09 |
| | $p(B^{Sobs}_y < B^S_{crit}, B_y \geq B^S_{crit}/k^S_N)$ | 0.16 | - | 0.16 | - | 0.16 | 0.16 |
| | $p(B^{Sobs}_y \geq B^S_{crit}, B_y < B^S_{crit}/k^S_N)$ | 0.06 | - | 0.06 | - | 0.06 | 0.06 |
| | $p(B^{Sobs}_y \geq B^S_{crit}, B_y \geq B^S_{crit}/k^S_N)$ | 0.68 | - | 0.69 | - | 0.69 | 0.69 |

[1] The 2007 risk threshold corresponds to the lowest historical spawning biomass level for OM1, with $p = 0.08$, but not for OM2 with $p = 0.6$.

[2] This gives the median and 90%ile of the 1000 median (over 20 years for each simulation) catches.

[3] Median and 90%ile of $AAV^b_y = \left|C^{S,b}_{tot,y} - C^{S,b}_{tot,y-1}\right| / C^{S,b}_{tot,y-1}$

**Table 1 (continued).**

| | | OM1 | OM-CCJ | | OM-MD | | OM2 |
|---|---|---|---|---|---|---|---|
| | | CMP1 | No Catch | CMP-A | No Catch | CMP-A | CMP2 |
| Risk statistics | $\alpha$ | 1.379 | - | 1.379 | - | 1.379 | 1.379 |
| | $Risk_A$ | 0.109 | 0.026 | 0.109 | 0.026 | 0.109 | 0.109 |
| Biomass statistics | $B^A_{2036}$ | **723** 310 [18,2807] | **1333** 960 [70,3678] | **722** 312 [18,2807] | **1333** 960 [70,3678] | **723** 312 [18,2807] | **723** 312 [18,2807] |
| | $B^A_{2036}/B^A_{2015}$ | 0.2 [0.0,2.0] | 0.7 [0.1,2.7] | 0.2 [0.0,2.0] | 0.7 [0.1,2.7] | 0.2 [0.0,2.0] | 0.2 [0.0,2.0] |
| | $B^A_{min}$ | 138 [15,677] | 447 [51,1130] | 138 [15,677] | 447 [51,1130] | 138 [15,679] | 138 [15,679] |
| Catch statistics | $C^A$ | **237** 303 [0,350] | **11** 0 [0,217] | **237** 303 [0,350] | **11** 0 [0,217] | **237** 303 [0,350] | **237** 302 [0,350] |
| | Med $C^A$ | 306 [2,350] | 0 [0,0] | 306 [2,350] | 0 [0,0] | 306 [2,350] | 305 [2,350] |
| | $MAV^A$ | 0.14 [0.00,0.78]] | - | 0.14 [0.00,0.78]] | - | 0.14 [0.00,0.78] | 0.14 [0.00,0.78] |
| Critical Biomass statistics | $p(B^{Aobs}_y < B^A_{crit}, B_y < B^A_{crit}/k^A_N)$ | 0.33 | - | 0.33 | - | 0.33 | 0.33 |
| | $p(B^{Aobs}_y < B^A_{crit}, B_y \geq B^A_{crit}/k^A_N)$ | 0.02 | - | 0.02 | - | 0.02 | 0.02 |
| | $p(B^{Aobs}_y \geq B^A_{crit}, B_y < B^A_{crit}/k^A_N)$ | 0.02 | - | 0.02 | - | 0.02 | 0.02 |
| | $p(B^{Aobs}_y \geq B^A_{crit}, B_y \geq B^A_{crit}/k^A_N)$ | 0.63 | - | 0.63 | - | 0.63 | 0.63 |

**Table 2.** Key summary performance statistics for CMP1, and CMPs tuned to a sardine risk of <0.2 under OM-CCJ, OM-MD and OM2. Where appropriate, medians and 90%iles are provided, and for some statistics the means are provided additionally and shown in **bold**. All biomasses are given in thousands of tons.

| | | OM1 (CMP1) | OM-CCJ | OM-MD | OM2 |
|---|---|---|---|---|---|
| Risk statistics | $\beta$ | 0.174 | 0.159 | 0.097 | 0.00 |
| | $Risk_S$ | 0.200 | 0.200 | 0.200 | 0.226 |
| | p(TAC$^S$<20) | 0.02 | 0.02 | 0.02 | 0.02 |
| Biomass statistics | $B^S_{tot,2036}$ | **274** 213 [85,623] | **283** 239 [88,637] | **312** 267 [102,683] | **341** 288 [113,766] |
| | $B^S_{west,2036}$ | **120** 82 [14,362] | **124** 87 [14,345] | **131** 97 [15,351] | **146** 97 [18,435] |
| | $B^S_{south,2036}$ | **154** 131 [44,334] | **160** 136 [44,344] | **181** 155 [54,392] | **196** 168 [65,416] |
| | $B^S_{tot,2036}/B^S_{tot,2015}$ | 2.7 [0.8,14.4] | 2.9 [0.8,15.1] | 3.1 [0.9,18.0] | 3.4 [1.1,17.5] |
| | $B^S_{west,2036}/B^S_{west,2015}$ | 1.8 [0.3,12.9] | 2.0 [0.3,13.8] | 2.1 [0.3,16.8] | 2.2 [0.4,16.6] |
| | $B^S_{south,2036}/B^S_{south,2015}$ | 0.7 [0.2,1.9] | 0.7 [0.2,1.9] | 0.9 [0.3,2.2] | 0.9 [0.4,2.3] |
| | $B^S_{tot,min}$ | 102 [40,186] | 106 [45,192] | 125 [60,213] | 131 [63,218] |
| | $B^S_{west,min}$ | 16 [3,48] | 16 [3,50] | 18 [3,49] | 20 [5,56] |
| | $B^S_{south,min}$ | 53 [15,108] | 54 [17,108] | 64 [25,119] | 73 [33,134] |
| Catch statistics | $C^S_{tot}$ | **103** 92 [31,200] | **100** 86 [31,200] | **79** 65 [31,185] | **59** 65 [31,65] |
| | Med $C^S_{tot}$ | 94 [65,139] | 88 [65,128] | 65 [65,90] | 65 [65,65] |
| | $C^S_{west}$ | **68** 58 [19,154] | **67** 58 [20,153] | **59** 54 [21,127] | **47** 51 [22,63] |
| | $C^S_{south}$ | **36** 26 [3,104] | **32** 23 [3,97] | **20** 14 [2,61] | **12** 10 [1,32] |
| | $C^S_{west}/C^S_{tot}$ | 0.72 [0.31,0.94] | 0.74 [0.32,0.95] | 0.80 [0.42,0.97] | 0.82 [0.50,0.98] |
| | $ByC^S_{tot}$ | **20.5** 11.2 [1.4,70.7] | **20.6** 11.3 [1.3,71.2] | **20.7** 11.3 [1.4,71.6] | **20.7** 11.1 [1.3,71.7] |
| | $ByC^S_{west}$ | **20.5** 11.1 [1.3,70.7] | **20.6** 11.3 [1.3,71.2] | **20.7** 11.3 [1.3,71.5] | **20.7** 11.1 [1.3,71.7] |
| | $ByC^S_{south}$ | **0.0** 0.0 [0.0,0.1] | **0.0** 0.0 [0.0,0.0] | **0.0** 0.0 [0.0,0.0] | **0.0** 0.0 [0.0,0.0] |
| | $MAV^S_{tot}$ | 0.50 [0.26,0.50] | 0.49 [0.26,0.50] | 0.37 [0.12,0.50] | 0.00 [0.00,0.37] |
| | $MAV^S_{west}$ | 0.38 [0.24,0.54] | 0.38 [0.24,0.54] | 0.34 [0.19,0.50] | 0.17 [0.08,0.38] |
| | $MAV^S_{south}$ | 0.72 [0.51,0.91] | 0.72 [0.51,0.93] | 0.73 [0.48,0.94] | 0.65 [0.39,0.90] |
| Critical Biomass statistics | $p(B^{Sobs}_y < B^S_{crit}, B_y < B^S_{crit}/k^S_N)$ | 0.10 | 0.09 | 0.07 | 0.06 |
| | $p(B^{Sobs}_y < B^S_{crit}, B_y \geq B^S_{crit}/k^S_N)$ | 0.16 | 0.16 | 0.15 | 0.14 |
| | $p(B^{Sobs}_y \geq B^S_{crit}, B_y < B^S_{crit}/k^S_N)$ | 0.06 | 0.06 | 0.05 | 0.04 |
| | $p(B^{Sobs}_y \geq B^S_{crit}, B_y \geq B^S_{crit}/k^S_N)$ | 0.68 | 0.69 | 0.63 | 0.76 |

**Table 3.** Key summary performance statistics for CMP3 tuned to OM3 (with $p = 0.08$ and MoveD). Where appropriate, medians and 90%iles are provided, and for some statistics the means are provided additionally and shown in **bold**. All biomasses are given in thousands of tons.

| | | OM3 | | | | |
|---|---|---|---|---|---|---|
| | | No Catch | CMP3 | | No Catch | CMP3 |
| Risk statistics | $\beta$ | - | 0.186 | $\alpha$ | - | 1.379 |
| | $Risk_S$ | 0.070 | 0.177 | $Risk_A$ | 0.026 | 0.109 |
| | p(TAC$^S$<20) | - | 0.02 | | | |
| Biomass statistics | $B^S_{tot,2036}$ | **416** 373 [172,821] | **274** 233 [85,610] | $B^A_{2036}$ | **1333** 960 [70,3678] | **723** 311 [18,2807] |
| | $B^S_{west,2036}$ | **178** 147 [25,438] | **120** 93 [13,316] | | | |
| | $B^S_{south,2036}$ | **238** 209 [83,477] | **154** 128 [41,355] | | | |
| | $B^S_{tot,2036}/B^S_{tot,2015}$ | 4.4 [1.5.23.4] | 2.8 [0.7,16.3] | $B^A_{2036}/B^A_{2015}$ | 0.7 [0.1,2.7] | 0.2 [0.0,2.0] |
| | $B^S_{west,2036}/B^S_{west,2015}$ | 3.0 [0.4,21.7] | 1.9 [0.2,15.6] | | | |
| | $B^S_{south,2036}/B^S_{south,2015}$ | 1.1 [0.5,2.8] | 0.7 [0.2,2.0] | | | |
| | $B^S_{tot,min}$ | 180 [115,263] | 102 [41,183] | $B^A_{min}$ | 447 [51,1130] | 138 [15,677] |
| | $B^S_{west,min}$ | 25 [5,71] | 15 [2,47] | | | |
| | $B^S_{south,min}$ | 90 [49,148] | 46 [12,98] | | | |
| Catch statistics | $C^S_{tot}$ | **2** 0 [0,31] | **108** 98 [31,200] | $C^A$ | **11** 0 [0,217] | **237** 303 [0,350] |
| | Med $C^S_{tot}$ | 0 [0,0] | 98 [65,147] | Med $C^A$ | 0 [0,0] | 306 [2,350] |
| | $C^S_{west}$ | **1** 0 [0,26] | **71** 61 [20,156] | | | |
| | $C^S_{south}$ | **0** 0 [0,5] | **37** 27 [3,108] | | | |
| | $C^S_{west}/C^S_{tot}$ | 0.00 [0.00,0.82] | 0.72 [0.30,0.94] | | | |
| | $ByC^S_{tot}$ | **0.3** 0.0 [0.0,5.2] | **20.7** 11.4 [1.4,71.0] | | | |
| | $ByC^S_{west}$ | **0.3** 0.0 [0.0,5.2] | **20.6** 11.3 [1.4,71.0] | | | |
| | $ByC^S_{south}$ | **0.0** 0.0 [0.0,0.0] | **0.0** 0.0 [0.0,0.1] | | | |
| | $MAV^S_{tot}$ | - | 0.50 [0.25,0.50] | $MAV^A$ | - | 0.14 [0.00,0.78]] |
| | $MAV^S_{west}$ | - | 0.39 [0.24,0.55] | | | |
| | $MAV^S_{south}$ | - | 0.72 [0.51,0.92] | | | |
| Critical Biomass statistics | $p(B^{Sobs}_y < B^S_{crit}, B_y < B^S_{crit}/k^S_N)$ | - | 0.10 | $p(B^{Aobs}_y < B^A_{crit}, B_y < B^A_{crit}/k^A_N)$ | - | 0.33 |
| | $p(B^{Sobs}_y < B^S_{crit}, B_y \geq B^S_{crit}/k^S_N)$ | - | 0.15 | $p(B^{Aobs}_y < B^A_{crit}, B_y \geq B^A_{crit}/k^A_N)$ | - | 0.02 |
| | $p(B^{Sobs}_y \geq B^S_{crit}, B_y < B^S_{crit}/k^S_N)$ | - | 0.06 | $p(B^{Aobs}_y \geq B^A_{crit}, B_y < B^A_{crit}/k^A_N)$ | - | 0.02 |
| | $p(B^{Sobs}_y \geq B^S_{crit}, B_y \geq B^S_{crit}/k^S_N)$ | - | 0.69 | $p(B^{Aobs}_y \geq B^A_{crit}, B_y \geq B^A_{crit}/k^A_N)$ | - | 0.63 |