Is the Sardine Population Now Outside the Range Tested for OMP-04, and if so, What are the Implications for the Basis for Recommending a 2007 Directed Sardine TAC?

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The below average recruitment to the sardine population in 2004 and 2005 has sparked concern as to whether this has taken the population outside the range projected when OMP-04 was tested. OMP-04 (Cunningham and Butterworth 2005) was developed on the basis of assessments taking data up to November 2003 into account, a period ending when the sardine biomass was at a peak (Cunningham and Butterworth 2004).

The distribution of sardine biomass in November 2005 and 2006 predicted during the testing of OMP-04 is shown in Figure 1. The biomass observed in November 2005 is clearly outside the range of that predicted by base case projections in the testing of OMP-04. The difference is primarily due to recent recruitments being low compared to the stock-recruitment curve used during the testing of OMP-04 (even when taking the assumed level of variation about this curve into account). The sensitivity test (which adjusted data weighting parameters to provide a better fit to recent recruitments) for the rough update to the sardine assessment in Cunningham and Butterworth (2006) provided a best estimate for the predicted November 2006 spawner biomass survey result of around 1.17 million tonnes (Figure 2). The associated distribution for this prediction hardly overlaps the range predicted when testing OMP-04 (Figure 1).

From the above it seems reasonable to suggest that the current situation is outside the range considered during OMP testing, so that additional consideration is necessary rather than trusting the application of the current OMP formulae alone.

The Potential Problem

Figure 3 shows the directed sardine TAC in 2007 that will result under the application of OMP-04, as a function of the sardine abundance estimate from the November 2006 survey. Also shown is the relationship that would result were it not for the 15% constraint on inter-annual TAC reduction, unless the survey results fall below the exceptional circumstances threshold of 250 thousand tonnes. Note that

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under OMP-04, the TAC remains at the same value of 173 thousand tonnes over a large resource abundance range from 1183 down to 250 thousand tonnes.

The potential problem becomes evident from close inspection of the lower plots in Figure 3. Because of the 15% constraint, the catch/biomass ratio for 2007 could rise as high as almost 70% towards the lower end of this range, rather than only to a maximum of some 30% that would apply in the absence of this constraint.

Note that proportional harvests of over about 35% occur only for survey results less than some 500 thousand tonnes, an eventuality Figure 2 suggests is very unlikely. However, there is the concern associated with that evaluation of a possible overestimation of the number of 4- and 5-year-old sardine still contributing to the November 2006 spawner biomass. Thus though this circumstance of a survey result less than 500 thousand tonnes is very unlikely, it does seem desirable to **pre**-agree a revised rule to apply should this eventuate.

A Suggested Approach

Figure 4 illustrates a suggested approach to address the above. For November 2006 survey results below B^* (Figure 4 illustrates the case of $B^* = 500$ thousand tonnes), but above the exceptional circumstances threshold of 250 thousand tonnes, there is a linear transformation from the relation with the 15% constraint and the one without. Note from the plots shown, this effectively limits the maximum (apparent) harvest proportion to about 35%.

The appropriate choice for B^* cannot, however, be satisfactorily "guessed" on such a basis. Rather some simulations are needed to check the medium term risks associated with different choices. Given the short time for such evaluations (which need to be conducted and evaluated, with a choice for B^* made, **before** the November cruise result becomes known), we suggest a simple set of tests for this modification of OMP-04 as follows.

Operating Model

The assessment sensitivity test of Cunningham and Butterworth (2006) will be used to define starting values of numbers-at-age at the beginning of 2007 for projections (note that this sensitivity is more conservative than the base case, giving greater weight to fitting recent low recruitment survey results. Estimates of numbers-at-age for ages 2 and above will be treated deterministically, but the 1-year-olds at the end of 2006 (i.e. this year's recruits) will be reflected as a distribution to capture this key uncertainty, using the approach of Cunningham and Butterworth (2006). (If time permits, some improvements to these somewhat coarse specifications may be attempted.)

Given concerns that sardine of 4- and 5-years-of-age by November 2006 are estimated in Cunningham and Butterworth (2006) to be contributing about two-thirds of the biomass at that time, and that this biomass could be an overestimate as a result, perhaps, of setting natural mortality M for older ages too low, a robustness test will also be run. In this test, the biomass of all age-groups of age 2 and above will be decreased by a factor of two-thirds.

Projections

The stock-recruitment relation to be used for projections will be deliberately conservatively chosen by treating the three highest model predicted recent sardine recruitments (for the years of May 2000 to 2002) as "anomalies", and ignoring them in a fit of a hockey-stick relationship to the assessment's estimates (see Figure 5). This fit will also provide the estimate for the variance of recruitment about this curve, with auto-correlation ignored for the purposes of this simple exercise.

Performance criteria

Projections will carried out for 5 years only, and under OMP-04 as it stands, and as modified in the manner described above. Risk will be evaluated in relation to the same criterion as used in OMP-04 testing, namely the probability that adult spawning biomass falls below the average adult sardine biomass over November 1991 to November 1994 (an average of 600 thousand tonnes under the sensitivity test from Cunningham and Butterworth (2006)) at least once during the projection period, which on this occasion will be five rather then 20 years because of the immediate particular importance of short term concerns, and also the rapidity of recovery should this 600 thousand ton threshold be breached. The objective will be to examine how these change as the value of B^* in the modified control rule illustrated in Figure 3 is altered.

References

Cunningham, C.L., and Butterworth, D.S. 2004. Base Case Bayesian Assessment of the South African Sardine Resource. MCM Document WG/PEL/APR04/02. 22pp.

Cunningham, C.L., and Butterworth, D.S. 2005. Re-Revised OMP-04. MCM Document SWG/DEC2005/PEL/05. 14pp

Cunningham, C.L., and Butterworth, D.S. 2006. Update regarding Potential Directed Sardine TAC for 2007. MCM Document SWG/AUG2006/PEL/09. 7pp.

**Distribution of Projected November Biomass Under OMP-04
(given data up to November 2003)**

962 observed in Nov 2005
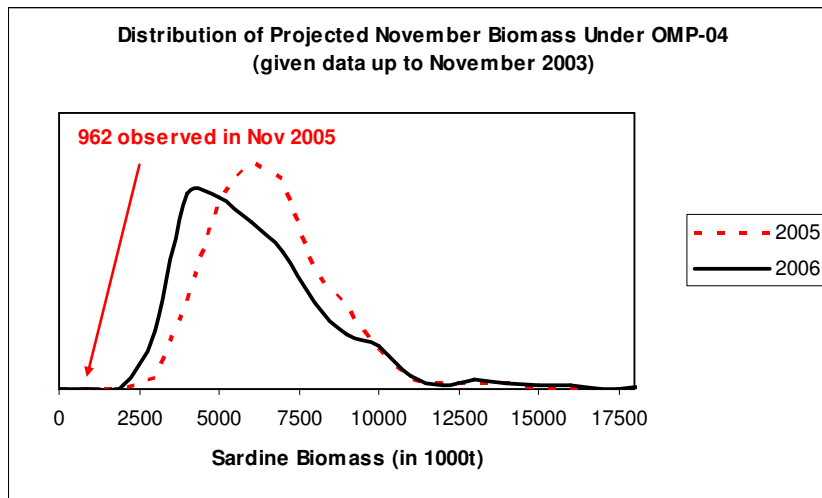
2005
2006

Sardine Biomass (in 1000t)

Figure 1. The distribution of sardine biomass in November 2005 and 2006 as projected from the base case operating model during the testing of OMP-04, based upon data up to November 2003.
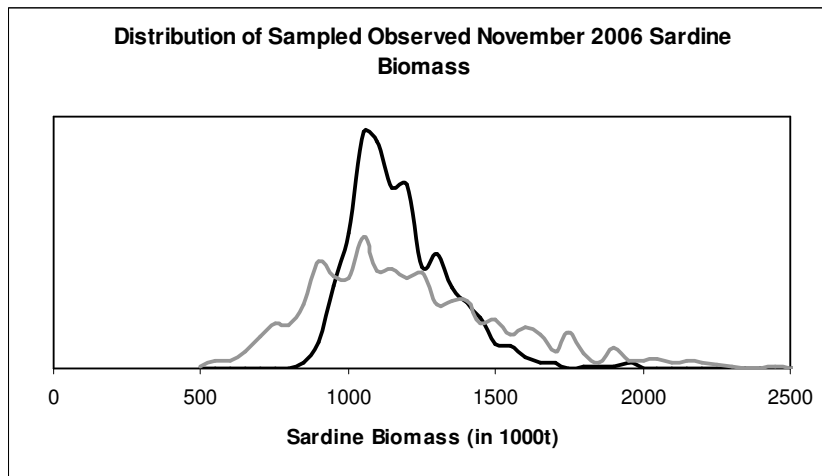
**Distribution of Sampled Observed November 2006 Sardine
Biomass**

Sardine Biomass (in 1000t)

Figure 2. The distribution of predicted sardine biomass in November 2006 (black line) and as may be observed taking a survey sampling CV of 0.24 into account (grey line), generated using a roughly updated sardine assessment based upon data up to and including the May 2006 survey and the commercial catch to June 2006 (from Cunningham and Butterworth 2006).
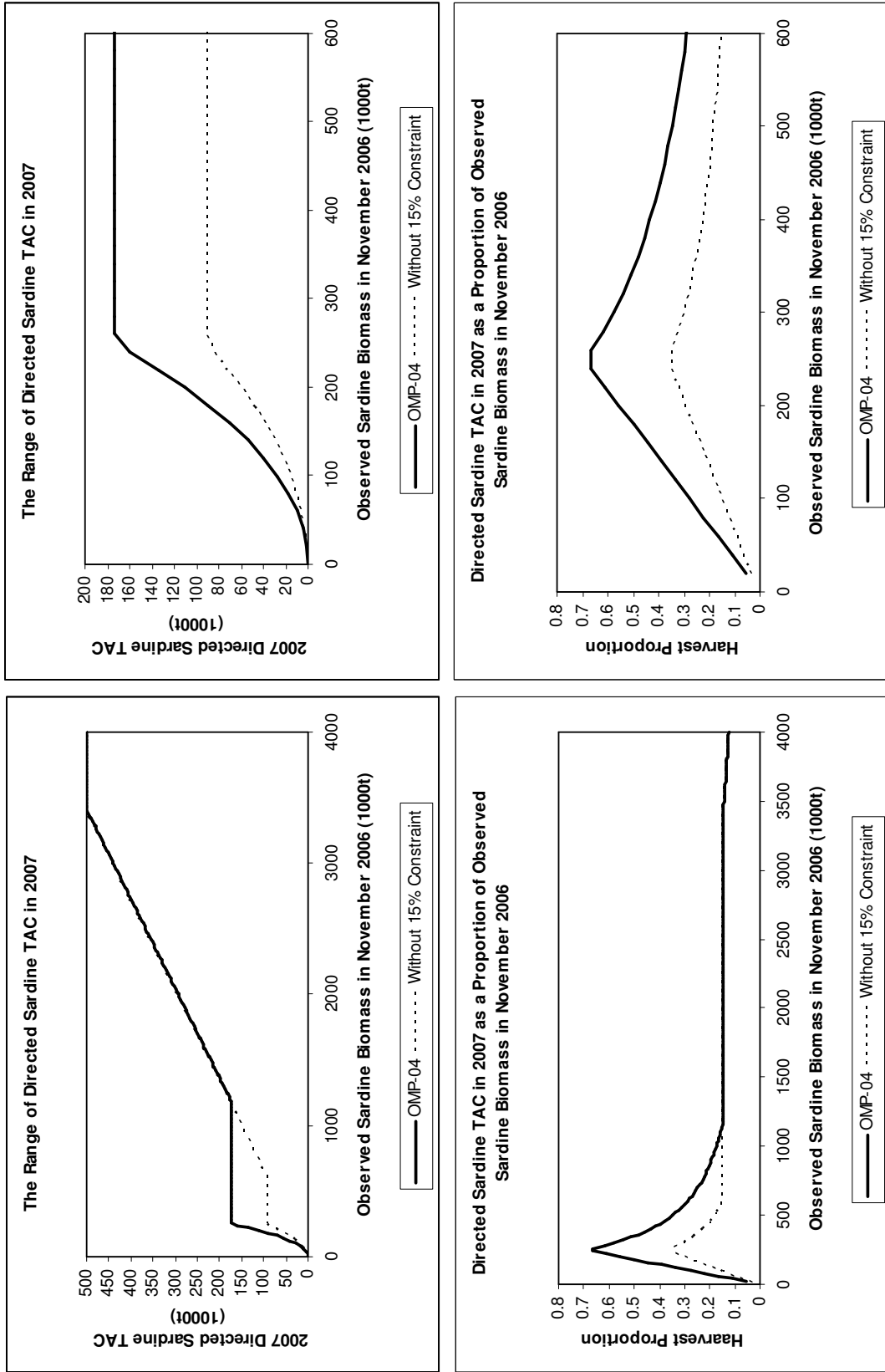
SWG/OCT2006/PEL/05

Figure 3. *The directed sardine TAC in 2007 under OMP-04 with and without the constraint of a maximum interannual decrease of 15% plotted as a function of possible observed sardine biomass in November 2006. The lower panel shows the directed sardine TAC in 2007 as a proportion of possible observed sardine biomass in November 2006 (i.e. the harvest proportion), plotted as a function of the latter. The figures on the right hand side depict the same as the left hand side, only over a smaller scale of observed sardine biomass in November 2006.*
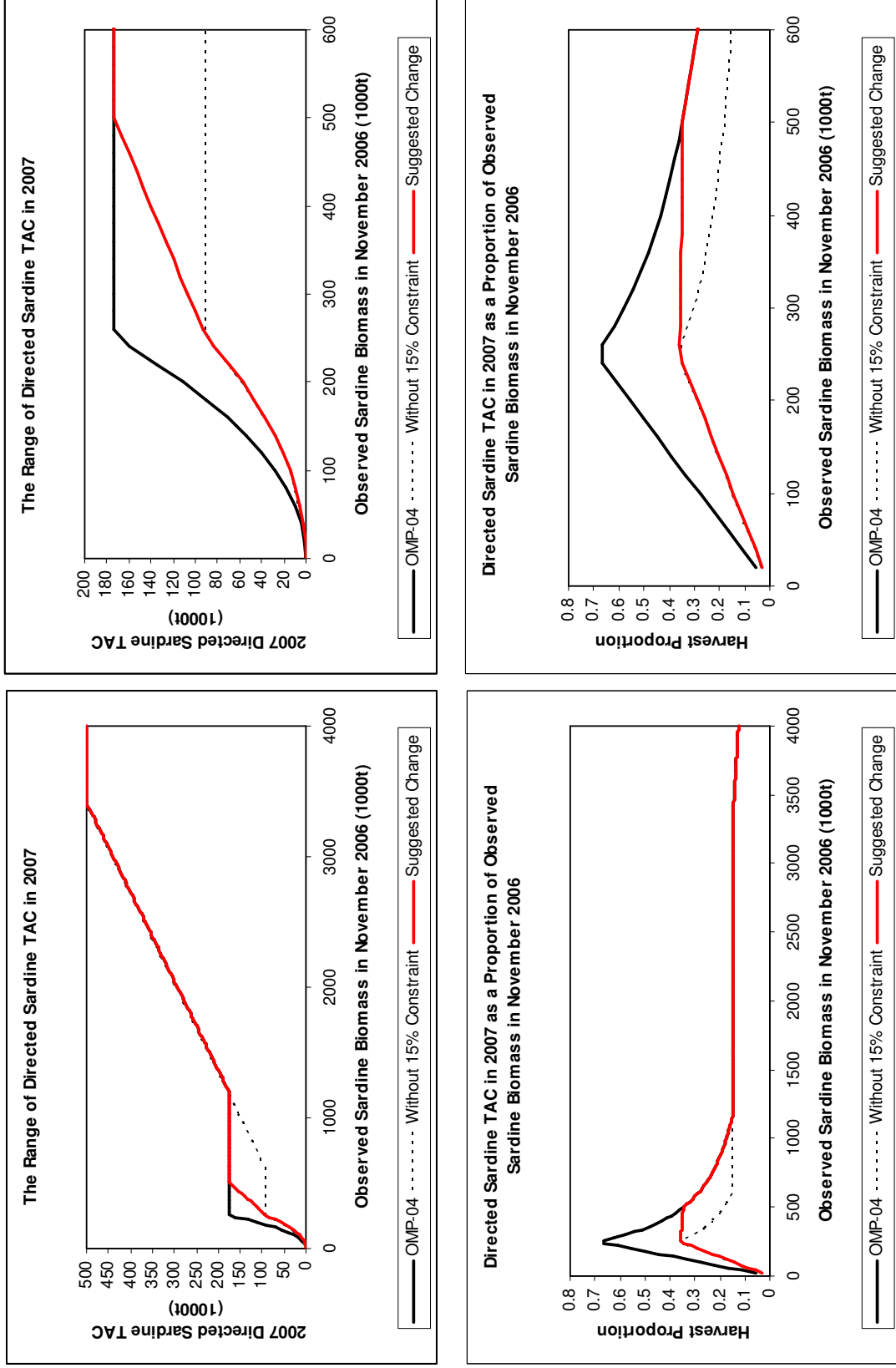
Figure 4. The directed sardine TAC in 2007 under OMP-04 with and without the constraint of a maximum interannual decrease of 15%, and also showing the effect of the proposed change to the OMP rules as described in the text, plotted as a function of possible observed sardine biomass in November 2006. The lower panel shows the directed sardine TAC in 2007 as a proportion of possible observed sardine biomass in November 2006 (i.e. the harvest proportion), plotted as a function of the latter. The figures on the right hand side depict the same as the left hand side, only over a smaller scale of observed sardine biomass in November 2006.
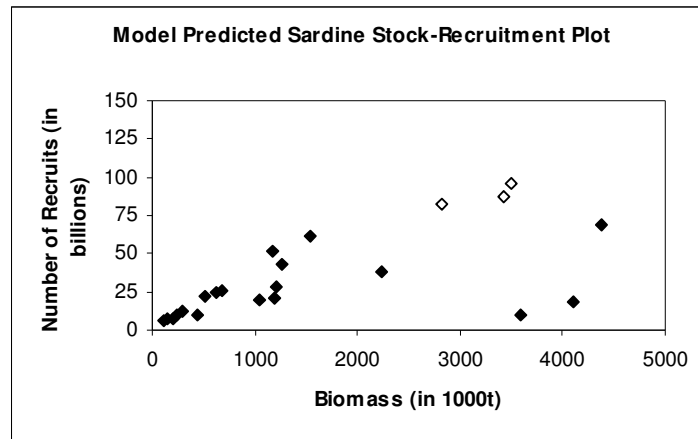
Figure 5. The model predicted sardine stock-recruitment plot from the sensitivity test assessment of Cunningham and Butterworth (2006). The open points denote the values (corresponding to November 1999 to 2001, corresponding to the highest three predicted May recruitments) that are suggested to be omitted in estimating the stock-recruitment relationship for the tests proposed for modified OMP rule.