# Updated performance statistics for the existing OMP and modified tunings thereof for the west coast rock lobster resource

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## Summary

Performance statistics for the current OMP, as adopted in 2003, are recomputed using an operating model that incorporates a reassessment including data that have become available since that time. The OMP is retuned to give the same median biomass increase target over 2003 to 2013 as was the case for the 2003 analyses. The same OMP approach is applied to data and assessments for super-area Area 8.

## Introduction

This document reports performance statistics for the current west coast rock lobster OMP using the newly updated assessment model. Of interest is to see how the current OMP is expected to perform based upon this update.

The current OMP is then re-tuned for the updated area-aggregated model to give similar biomass ($B75$) recovery ($B(13/03)$) performance as the 2003 OMP predicted.

Note that here we use the actual TAC values for seasons 2003, 2004 and 2005, with projections beginning in 2006 (recall that 2003 reflects the 2003/04 season).

We report results of the current OMP for the west coast area-aggregated scenario, as well as results where we apply the current OMP to some of the super-areas for the area-disaggregated approach.

The TAC values reported in this document are what are called “global” TACs – that is they include commercial TACs and recreational takes.

The 2005 updated assessment includes data that have become available since the 2003 assessment. The table below provides a brief summary of the data available for the 2003 and 2005 assessments.

| Data series | 2003 assessment | 2005 assessment |
|---|---|---|
| Catch | 2002 | 2005 |
| CPUE (commercial trap, hoop and FIMS) | 2001 | 2004 |
| Commercial catch-at-length | 1998 | 2004 |
| FIMS catch-at-length | 2001 | 2004 |
| Somatic growth | 2001 | 2004 |

## Methods

At a MCM Rock Lobster Working Group meeting in 2003 it was decided that a sensible way to take account of various uncertainties regarding the resource (particularly those concerning future somatic growth rate and future recruitment) was for performance statistics to be produced using an integrated-weighting procedure. The following weights were assigned to various assessment and projection model assumption options to provide a reference set spanning what appeared to be the major uncertainties. Note that the "future somatic growth" now refers to 2005+ (i.e. the model uses the observed values up to and including 2004).

| | | |
|---|---|---|
| **Assessment model (historic recruitment)** | **RC1** | 0.80 |
| | **RC2** | 0.20 |
| **Future somatic growth** | **L (89-01 ave)** | 0.50 |
| | **I10 (incr to 68-01 ave over 10 years)** | 0.35 |
| | **I3 (incr to 68-01 ave over 3 years)** | 0.15 |
| **Future recruitment** | **L (lowest over 75-95)** | 0.10 |
| | **M (ave over 75-90)** | 0.60 |
| | **H (highest over 75-95)** | 0.30 |

***Implementation***

These options in combination give a total of 18 scenarios. Each of the OMP candidates considered are run (stochastically) for each of these scenarios, and the results combined according to the weighting scheme above, except that RC1 and RC2 results are presented separately, rather than formally combined, because predicted abundance estimates have different implications for these two scenarios as they reflect very different current resource status relative to pristine.

To recap:
The following nine scenarios are thus identified for RC1 and RC2:

Scenario 1:**Low** somatic growth; **Low** recruitment
Scenario 2: **Low** somatic growth; **Med** recruitment
Scenario 3: **Low** somatic growth; **High** recruitment
Scenario 4:**I10** somatic growth; **Low** recruitment
Scenario 5: **I10** somatic growth; **Med** recruitment
Scenario 6: **I10** somatic growth; **High** recruitment
Scenario 7:**I3** somatic growth; **Low** recruitment
Scenario 8: **I3** somatic growth; **Med** recruitment
Scenario 9: **I3** somatic growth; **High** recruitment

Fifty stochastic simulations are run for each OMP candidate for all nine scenarios (separately for RC1 and RC2). For each output statistic there are thus 50 x 9 values. These 450 values are then ordered from smallest to largest. Each of these values has a weight associated with it (as defined in the table above by the product of the weights for the two options that define the scenario). The cumulative weights going down an ordered column of results are examined, and the values corresponding to 5, 25.5 and 46 of the cumulative weight column are reported as reflecting the median and the 80% probability interval of the distribution concerned.

Although results are presented using this integration by weights method, results are also presented for the individual scenarios, so that the reader can get a feel for how the performance statistics for each scenario on its own compare with the overall weighted statistics.

***OMP variants considered***

The 2003 OMP is described more fully in RLWS/DEC05/MAN/8/1/1. The TAC setting formula is as follows:

$$TAC_y = wTAC_{y-1} + (1-w)\alpha\left(1+\lambda(\beta_t^m - \overline{\beta}^m)\right)\frac{\hat{B}_y}{\hat{B}_{1992}}\left[\left(\frac{CPUE_{y-3,y-2,y-1}}{CPUE_{93,94,95}}\right)^{0.25}\left(\frac{FIMS_{y-3,y-2,y-1}}{FIMS_{92,93,94,95}}\right)^{0.75}\right]^2$$

where the *w* value is fixed at 0.50 for all years (in the 2003 OMP development stage, options were presented where the *w* value could vary over time). Recall that $B_t^m$ refers to somatic growth and $\hat{B}_y$ to a simple production model fit to past abundance, CPUE and somatic growth indices. For all OMPs considered here, the following apply:

10% maximum inter-annual TAC increase and decrease constraints, and
$p = 2$.

Note that the reason for introducing the *p* factor and the term in the formula involving CPUE and FIMS was to attempt to render the OMPs more responsive (in TAC terms) to circumstances of either high or low future recruitment, which become manifest in the monitoring data only towards the end of the projection period.

The tuning parameter which is altered to give different levels of biomass recovery is the $\alpha$ value. The current area-aggregated OMP sets $\alpha$ = 920. For the 2003 assessment model this gave, for RC1, a median *B*(13/03) = 1.15, i.e. a 15% biomass increase over the 2003-2013 period. When this OMP is used in conjunction with the updated 2005 area-aggregated RC1 model, this median *B*(13/03) value turns out to be 1.36 (see Table 1a). The authors have thus "re-tuned" the area-aggregated OMP in conjunction with the 2005 assessment model so that the median *B*(13/03) is once again 1.15.

***Area 8***

Area-disaggregated OMPs have yet to be explored. The authors have, for initial illustrative purposes, taken the existing 2003 area-aggregated OMP and applied it to Area 8. For projections, the same assumptions about the nature of future somatic growth and recruitment, and the same level of data variability as for the area-aggregated reference case, have been assumed pending future in-depth discussion. The resulting median B(13/03) was 0.94 (see Table 2a). Although the Working Group have yet to discuss management objective for individual areas, the authors have "re-tuned" the OMP for Area 8 so that the median B(13/03) would be approximately 1.00, i.e. the authors assume a management target for Area 8 could be so keep the biomass above 75mm constant.

***OMPs run with "real" data***

As in the 2003 OMP development, the OMPs considered here are tested with the latest available somatic growth, FIMS and CPUE data. Thus the OMP now uses real data up to 2004, whereas tests in 2003 used model-generated data over the 2002+ period. Naturally model generated data remains used for the 2005+ period. The observed FIMS and CPUE data were re-scaled so that the average values were consistent with the average values of the model generated data for the same historic periods to avoid any unrealistic "jump" at the time the actual data ends and the model generated data begins.

***Summary statistics***

Tables 1 and 2 report a number of summary statistics (median and 80% probability intervals). Some of these summary statistics have been retained from the previous OMP development process ($B$(13/03), $C_{ave}$(03..12), AAV(03..12)) in order to make some comparisons with the current OMP. A range of "updated" summary statistic are also reported. Thus overall:

| | |
|---|---|
| $B$(13/03) | the biomass above 75mm at the start of 2013 relative to that at the start of 2003 |
| $B$(16/06) | the biomass above 75mm at the start of 2016 relative to that at the start of 2006, i.e. how does the biomass change after a 10 year projection period |
| $B$(26/06) | the biomass above 75mm at the start of 2026 relative to that at the start of 2006, i.e. how does the biomass change after a 20 year projection period. |
| $C_{ave}$(03..12) | the average catch for the 2003-2012 period (assumes the OMP operates only from 2006, and the 2003-2005 catches are from the current OMP) |
| $C_{ave}$(06..15) | the average catch for the 2006-2015 period (five year period) |
| $C_{ave}$(06..25) | the average catch for the 2006-2025 period (20 year period) |
| $C_{ave}$(06..10) | the average catch for the 2006-2010 period (five year period) |
| AAV(03..12) | the average inter-annual catch variation for the 2003-2012 period |
| AAV(06..15) | the average inter-annual catch variation for the 2006-2015 period |
| AAV(06..25) | the average inter-annual catch variation for the 2006-2025 period |
| AAV(06..10) | the average inter-annual catch variation for the 2006-2010 period |
| FE(15/06) | fishing effort in 2-15 relative to that in 2006 |
| $E$_trap(16/06) | ratio of the biomass above 350g in 2015 relative to that ratio in 2006 for lobster caught by traps |
| $E$_hoop(16/06) | ratio of the biomass above 350g in 2015 relative to that ratio in 2006 for lobster caught by hoops |
| TAC($t$) | the TAC for season $t$ (note that this is the combined commercial TAC and recreational amount) |

## Results and Discussion

Table 1 compares the OMP 2003 predicted TACs for 2003, 2004 and 2005, with the actual TACs which were calculated when the OMP was applied to observed data each year. The 2003 actual TAC (3206 MT) was identical to "predictions", as the actual data input were all already taken into account as known and fixed in the simulations. The actual 2004 TAC (3527 MT) is equivalent to both the predicted median and the upper 80% probability bound for that year. Finally, the actual TAC for 2005 (3174 MT) was below the predicted median, but above the lower 80% probability bound. These values are illustrated in Figure 1.

Tables 2a and b report the RC1 and RC2 integrated-by-weights output statistics for various area-aggregated OMPs with the medians and 80% probability intervals provided. Here, the first column reports the current 2003 OMP with some predicted statistics as estimated using the 2003 assessment model. This OMP was tuned so that the median $B$(13/03) was 1.15. The middle column reports results for this same 2003 OMP, but in conjunction with the updated 2005 assessment model. Here we see the median $B$(13/03) value is estimated to be rather higher – 1.36. The final column is a re-tuning of the OMP in conjunction with the 2005 assessment model, so that the median $B$(13/03) value is once again 1.15. Table 2b reports the RC2 output statistics for the same three OMP scenarios.

Table 4a reports the results (medians) for each of the nine individual scenarios for the same re-tuned area-aggregated OMP.

The 2003 OMP was for the area-aggregated resource only – no OMPs have been developed yet for individual areas. Table 3 shows results of what happens if one takes the newly re-tuned area-aggregated OMP and applies it to Area 8. The first column of Table 3 reports these results. The median $B$(13/03) is 0.94. Although the MCM Rock Lobster Working Group has yet to discuss management objectives for the individual areas, the authors have re-tuned the OMP here to give a median $B$(13/03) of approximated 1.0 (reported in the second column of Table 3). Table 4b reports the results (medians) for each of the nine individual scenarios for this Area 8 re-tuned OMP. Table 4b shows a very large range in median $B$(13/03) values across the 9 future scenarios. These range from 0.03 (Scenario 1 = low growth and low recruitment), to 3.74 (Scenario 6 = high growth and high recruitment).

Figure 2 plots the performance statistics for the 2003 OMP, the 2003 OMP applied to the 2005 assessment model, and then a retuned OMP which gives the same median recovery as did the 2003 OMP when applied to the 2005 assessment model. The two "new" sets of results do not differ greatly in terms of variability of the extent of resource recovery, so that one hesitates to advocate an adoption of any retuning when the further data now available are unlikely to have significantly changed the previous assessment of the resource abundance and productivity – if these are a little better, put the "bonus" into the "bank" (resource), rather than increase likely catches perhaps? However, in this case, the appreciably better average catch performance likely under the retuning does argue for implementing that retuning, given no obvious indication of high additional risk to the resource.

Figure 3 plots the performance statistics of the two OMPs applied to Area 8, as well as the re-tuned area-disaggregated OMP for comparison. The average catches for Area 8 are less than for the resource as a whole, as would be expected. However, a concern is that for Area 8 the resource could be driven further below its initial level (see lower probability intervals in Figure 3) than in the area-aggregated case.

Table 1: Comparisons of OMP 2003 predicted TACs for 2003, 2004, and 2005 (for RC1 and RC2), and the actual TAC values produced by the OMP when actual data became available each year. The predicted values are the median and the 80% probability intervals. TAC(2003) was known at the stage of OMP selection as the input data to compute it were available at that time.

| | **OMP predicted (RC1)** | **OMP predicted (RC2)** | **Actual TAC** |
|---|---|---|---|
| **TAC(2003)** | 3206 | 3206 | 3206 |
| **TAC(2004)** | 3527 [3243, 3527] | 3527 [3225, 3527] | 3527 |
| **TAC(2005)** | 3850 [3052,3879] | 3781 [3028, 3880] | 3174 |

Figure 1: Comparisons of OMP 2003 predicted TACs for 2003, 2004, and 2005 (for RC1 and RC2), and the actual TAC values produced by the OMP (shown as open circles) when actual data became available each year. The line joins the median projections for the OMP with the error bars reflecting the 80% probability intervals.

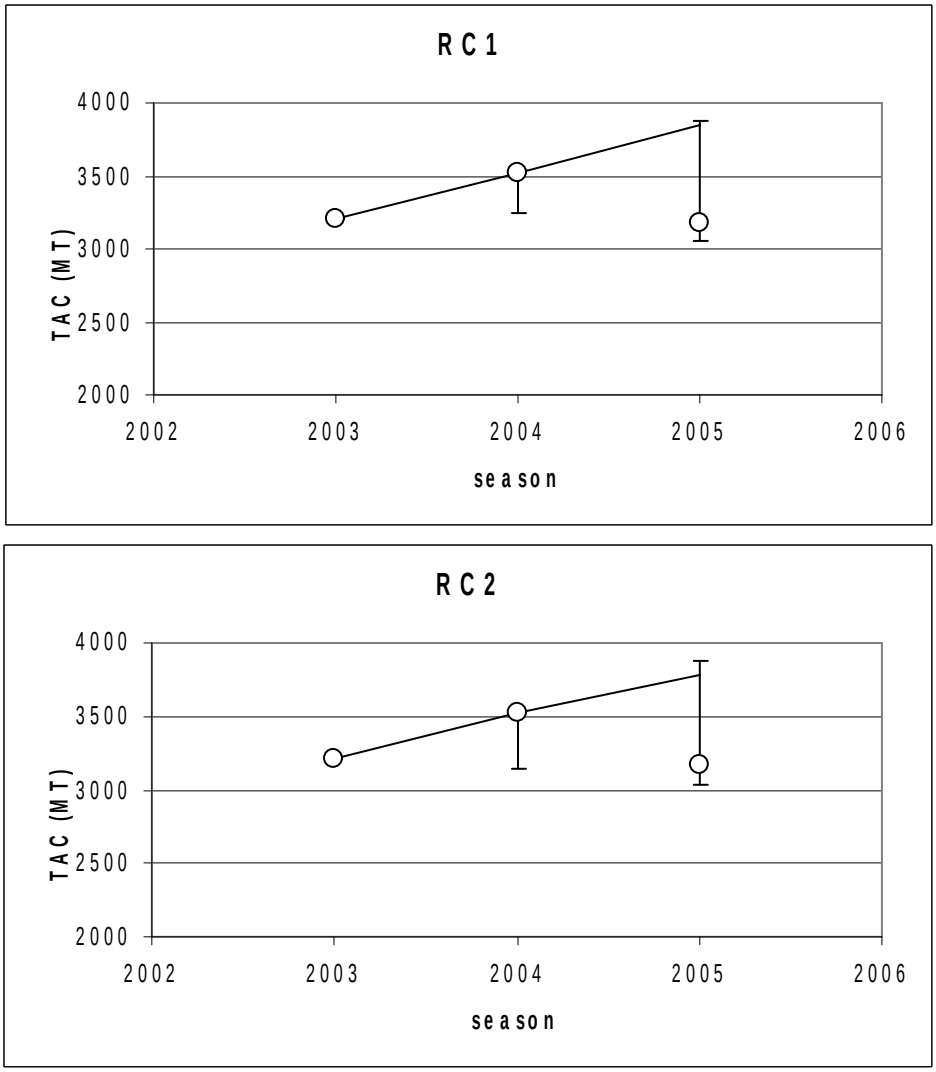

Table 2a: Integrated-by-weights performance statistics for the area –aggregated model for **RC1**. Medians and 80% probability intervals are shown.

| | **Current OMP; 2003 assessment** | **Current OMP; 2005 assessment** | **Current OMP re-tuned using the updated 2005 assessment** |
|---|---|---|---|
| | **RC1** | **RC1** | **RC1** |
| ***B*(13/03)** | 1.15 [0.67, 2.50] | 1.36 [0.65, 2.69] | 1.15 [0.65, 2.60] |
| ***B*(16/06)** | | 1.82 [0.76, 3.57] | 1.78 [1.04, 3.37] |
| ***B*(26/06)** | | 2.50 [1.02, 5.37] | 2.06 [0.69, 6.54] |
| $C_{ave}$**(03..12)** | 3754 [2651, 5100] | 2634 [2634, 3351] | 3511 [2636, 4284] |
| $C_{ave}$**(06..15)** | | 1873 [1873, 3210] | 3251 [1901, 4247] |
| $C_{ave}$**(06..25)** | | 1445 [1263, 5525] | 2860 [1583, 3889] |
| $C_{ave}$**(06..10)** | | 2355 [2355, 2650] | 2978 [2355 ,3511] |
| ***AAV*(03..12)** | 9.36 [7.89,10.0] | 10.46 [9.64, 10.46] | 10.45 [9.60, 10.45] |
| ***AAV*(06..15)** | | 10.0 [0.02, 10.0] | 10.0 [9.07, 10.0] |
| ***AAV*(06..25)** | | 10.0 [8.97, 10.0] | 10.0 [9.29, 10.0] |
| ***AAV*(06..10)** | | 10.0 [9.18, 10.0] | 10.0 [8.88, 10.0] |
| ***FE*(15/06)** | | 0.40 [0.23, 0.80] | 0.83 [0.36, 2.14] |
| $E_{trap}$**(16/06)** | | 1.33 [1.03, 1.75] | 1.22 [0.91, 1.69] |
| $E_{hoop}$**(16/06)** | | 1.43 [1.00, 2.37] | 1.28 [0.81, 2.23] |
| **TAC(2006)** | | 2876 [2876, 2876] | 2876 [2876, 2876] |
| **TAC(2007)** | | 2588 [2588, 2588] | 2588 [2588, 3163] |
| **TAC(2008)** | | 2329 [2329, 2373] | 2847 [2329, 3480] |

Table 2b: Integrated-by-weights performance statistics for the area-aggregated model for **RC2**. Medians and 80% probability intervals are shown.

| | **Current OMP; 2003 assessment** | **Current OMP; 2005 assessment** | **Current OMP re-tuned using the updated 2005 assessment** |
|---|---|---|---|
| | **RC2** | **RC2** | **RC2** |
| ***B*(13/03)** | 0.97 [0.59, 1.94] | 1.08 [0.64, 1.61] | 0.98 [0.63, 1.52] |
| ***B*(16/06)** | | 1.46 [0.69, 2.25] | 1.22 [0.66, 2.06] |
| ***B*(26/06)** | | 1.66 [0.66, 3.61] | 1.32 [0.53, 3.51] |
| $C_{ave}$**(03..12)** | 3662 [2599, 5110] | 2633 [2633, 2861] | 3511 [2648, 4284] |
| $C_{ave}$**(06..15)** | | 1873 [1873, 2369] | 3210 [1943, 4247] |
| $C_{ave}$**(06..25)** | | 1326 [1263, 2802] | 2716 [1619, 3888] |
| $C_{ave}$**(06..10)** | | 2355 [2355, 2399] | 2978 [2455, 3511] |
| ***AAV*(03..12)** | 9.29 [7.96,10.0] | 10.46 [9.68, 10.0] | 10.45 [9.64, 10.0] |
| ***AAV*(06..15)** | | 10.0 [8.92, 10.0] | 10.0 [9.06, 10.0] |
| ***AAV*(06..25)** | | 9.77 [8.71, 10.0] | 10.0 [9.53, 10.0] |
| ***AAV*(06..10)** | | 10.0 [10.0, 10.0] | 10.0 [9.47, 10.0] |
| ***FE*(15/06)** | | 0.34 [0.21, 0.65] | 0.90 [0.39, 2.38] |
| $E_{trap}$**(16/06)** | | 1.27 [1.02, 1.73] | 1.17 [0.90, 1.61] |
| $E_{hoop}$**(16/06)** | | 1.43 [1.01, 1.73] | 1.29 [0.83, 2.22] |
| **TAC(2006)** | | 2876 [1876, 1876] | 2876 [2876, 2876] |
| **TAC(2007)** | | 2588 [2588, 2588] | 2588 [2588, 3163] |
| **Tac(2008)** | | 2329 [2329, 2329] | 2847 [2329, 3480] |

Table 3: Integrated-by-weights performance statistics for super-area A8 for **RC1**. Medians and 80% probability intervals are shown. The second column reflects results for tuning for median B(13/03) of about 1.0, i.e. "stability".

| | **Area-aggregated 2005 retuned OMP applied to Area 8** | **Current OMP re-tuned for A8 stability** |
|---|---|---|
| | **RC1** | **RC1** |
| ***B*(13/03)** | 0.94 [0.27, 2.27] | 1.02 [0.39, 2.29] |
| ***B*(16/06)** | 1.47 [0.31, 3.94] | 1.65 [0.48, 4.08] |
| ***B*(26/06)** | 2.31 [0.25, 8.74] | 2.84 [0.61, 8.83] |
| $C_{ave}$**(03..12)** | 1869 [1643, 2322] | 1668 [1643, 2014] |
| $C_{ave}$**(06..15)** | 1421 [1162, 1634] | 1219 [1163, 1721] |
| $C_{ave}$**(06..25)** | 958 [784, 2158] | 903 [784, 1698] |
| $C_{ave}$**(06..10)** | 1787 [1462, 2137] | 1469 [1462, 1851] |
| ***AAV*(03..12)** | 10.80 [9.94, 10] | 10.93 [10.03, 10.98] |
| ***AAV*(06..15)** | 9.80 [8.92, 10] | 10 [9.01, 10] |
| ***AAV*(06..25)** | 9.80 [9.17,10] | 9.95 [9.18, 10] |
| ***AAV*(06..10)** | 10 [8.19, 10] | 10 [8.37, 10] |
| ***FE*(15/06)** | 0.52 [0.14, 2.06] | 0.42 [0.13, 1.17] |
| $E_{trap}$**(16/06)** | 1.04 [0.51, 1.64] | 1.10 [0.71, 1.67] |
| $E_{hoop}$**(16/06)** | 1.10 [0.34, 2.31] | 1.17 [0.57, 2.16] |
| **TAC(2006)** | 2182 [1785, 2182] | 1785 [1785, 2182] |
| **TAC(2007)** | 1964 [1607, 2351] | 1607 [1607, 1964] |
| **TAC(2008)** | 1767 [1446, 2160] | 1446 [1446, 1767] |

Table 4a: Area-aggregated results (medians) for each of the nine individual scenarios, for the re-tuned OMP.

| **RC1** | | | | | |
|---|---|---|---|---|---|
| Scenario | Growth/Recruitment | $B$(16/06) | $C_{ave}$(06..15) | $C_{ave}$(06..10) | TAC(2006) |
| 1 | Low/Low | 0.49 | 1873 | 2355 | 2875 |
| 2 | Low/Med | 1.04 | 2121 | 2355 | 2875 |
| 3 | Low/High | 1.48 | 2331 | 2439 | 2875 |
| 4 | I10/Low | 0.95 | 3592 | 3021 | 2875 |
| 5 | I10/Med | 1.87 | 3802 | 3335 | 2875 |
| 6 | I10/High | 2.73 | 3802 | 3511 | 2875 |
| 7 | I3/Low | 0.81 | 3795 | 3290 | 2875 |
| 8 | I3/Med | 1.73 | 4213 | 3511 | 2875 |
| 9 | I3/High | 2.52 | 4233 | 3511 | 2875 |
| **RC2** | | | | | |
| 1 | Low/Low | 0.58 | 1890 | 2355 | 2875 |
| 2 | Low/Med | 0.77 | 2158 | 2366 | 2875 |
| 3 | Low/High | 0.93 | 2336 | 2439 | 2875 |
| 4 | I10/Low | 1.18 | 3653 | 3065 | 2875 |
| 5 | I10/Med | 1.56 | 3802 | 3276 | 2875 |
| 6 | I10/High | 1.92 | 3802 | 3494 | 2875 |
| 7 | I3/Low | 1.12 | 3802 | 3342 | 2875 |
| 8 | I3/Med | 1.47 | 4183 | 3511 | 2875 |
| 9 | I3/High | 1.80 | 4247 | 3511 | 2875 |

Table 4b: **Area 8** results (medians) for each of the nine individual scenarios, for the OMP re-tuned to the updated Area 8 assessment (RC1 only results are shown).

| **RC1** | | | | | |
|---|---|---|---|---|---|
| Scenario | Growth/Recruitment | $B$(16/06) | $C_{ave}$(06..15) | $C_{ave}$(06..10) | TAC(2006) |
| 1 | Low/Low | 0.03 | 1421 | 1786 | 2182 |
| 2 | Low/Med | 0.66 | 1641 | 1805 | 2182 |
| 3 | Low/High | 1.14 | 1821 | 1885 | 2182 |
| 4 | I10/Low | 0.84 | 1223 | 1538 | 1878 |
| 5 | I10/Med | 2.52 | 1262 | 1587 | 1937 |
| 6 | I10/High | 3.74 | 1290 | 1662 | 1980 |
| 7 | I3/Low | 0.80 | 1282 | 1612 | 1969 |
| 8 | I3/Med | 2.38 | 1324 | 1665 | 2033 |
| 9 | I3/High | 3.57 | 1354 | 1703 | 2079 |

Figure 2: A plot comparing three performance statistics between the current OMP for the area-aggregated 2003 assessment, the current OMP for the 2005 assessment and the retuned 2005 OMP. Medians and 80% probability intervals are shown.

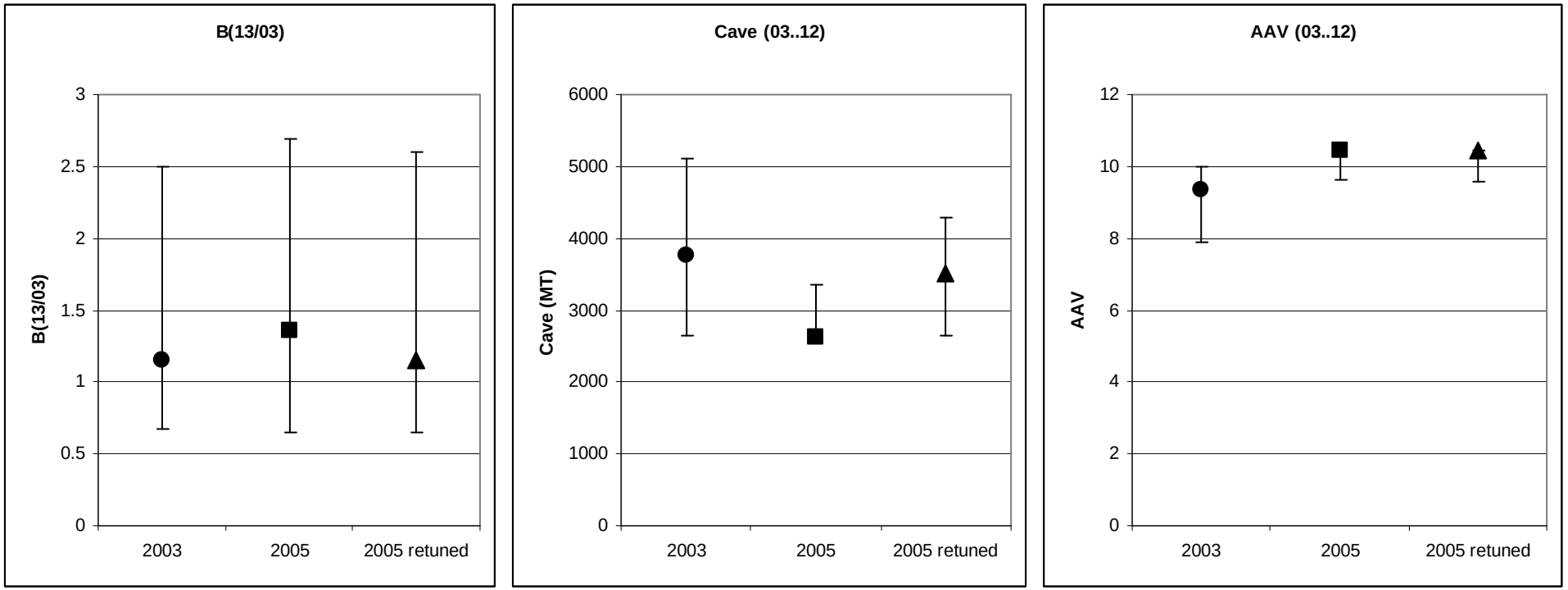

Figure 3: A plot comparing three performance statistics between the current OMP retuned for the area-aggregated scenario applied to Area 8, the current OMP retuned for Area 8 stability, and the current OMP retuned for the area-aggregated scenario (and applied to area-aggregated scenario). Medians and 80% probability intervals are shown.