

## **ADDENDUM**

# Updated SCAA/ASPM Assessment of Gulf of Maine cod

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### **VPA ASSESSMENTS - ABSTRACT**

The Alt-VPA methodology of Butterworth and Rademeyer (2008a) is applied to updated data for the Gulf of Maine cod population for the period 1982-2006 for which catch-at-age data are available. The fits of the models show a preference for domed over asymptotically flat selectivity. However, the narrow range of estimates of  $B^{sp}$  values virtually precludes fits of different stock-recruitment curves from being able to distinguish between options as different as Ricker and Beverton-Holt (from which also very different estimates of Reference Points follow). Because of the clearly high variance that would accompany Reference Points inferred from this analysis, they are not advanced, with a preference for approaches that can accommodate a wider range of data and hence achieve reasonable precision being expressed.

### **INTRODUCTION**

This Addendum reports the results of the application of the Alt-VPA methodology of Butterworth and Rademeyer (2008a – see their Appendix 1) to the updated data for the Gulf of Maine cod, which for VPA application then covers the period 1982-2006 for which catch at age data are available. As for the ASPM assessments, the plus group is now extended from age 7 to age 8. The formulation of what is termed the 2007 RC-VPA assessment is the same as for the corresponding 2005 RC-VPA in Butterworth and Rademeyer (2008a); thus for example, here again  $M=0.2 \text{ yr}^{-1}$ .

### **RESULTS**

Two implementations of Alt-VPA are run, one with asymptotically flat selectivity ( $\alpha=1$ ), and the other allowing  $\alpha$  to be estimated in the model fit ( $\alpha=\text{est}$ ) which hence admits the possibility of selectivity trending up or down at large ages. The resultant spawning biomass and recruitment estimate pairs are then fit externally to both the Ricker and the Beverton-Holt stock recruitment functions.

Results are listed in Table Add.1, which includes comparable results for the 2005 RC-VPA (except that then the plus-group age was 7 rather than the current 8). Spawning biomass trends for the two implementations (and the corresponding plots for 2005 RC-VPA) are shown in Fig. Add.1, together

with the estimated commercial selectivity-at-age. Stock-recruitment data plots, together with fitted Ricker and Beverton-Holt stock-recruitment curves, are shown in Fig. Add.2 for both  $\alpha$  implementations.

## DISCUSSION

From Fig. Add.1 it is evident that even when  $\alpha=1$ , the estimated commercial selectivity curve shows a dome; this dome becomes more marked when  $\alpha$  is estimated as the data prefer a downward slope in selectivity at larger ages. Estimating  $\alpha$  leads to larger biomasses in absolute terms.

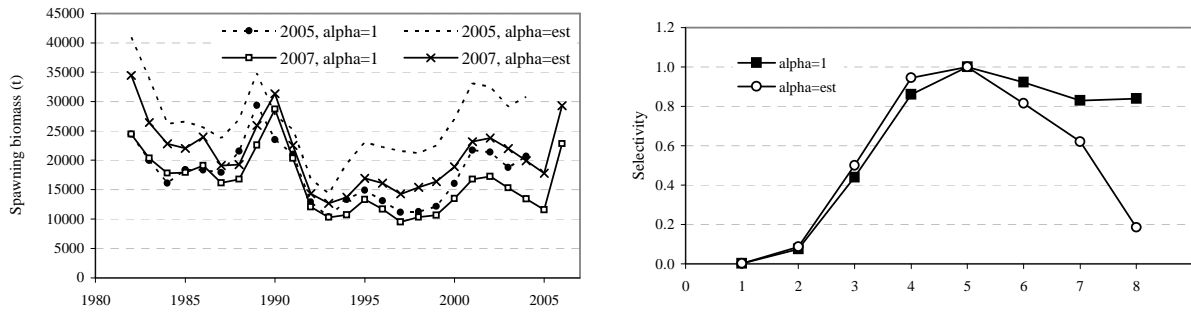
Table Add.1 provides reference points such as  $B^{sp}_{MSY}$  values. These differ markedly for the Ricker and Beverton-Holt stock-recruitment forms, though the corresponding SS objective function values are virtually identical (the  $-\ln L$  difference is a mere 0.04 for either  $\alpha$  value). The reason for this is immediately evident from inspection of Fig. Add.2: with the VPA restricted to years for which commercial catch-at-age data are available, the range of  $B^{sp}$  values covered by the data is simply too narrow to introduce the contrast needed to render reasonably precise MSYL estimation possible. In these circumstances, selecting Reference Point values from such an analysis is hardly defensible – the results would be much too imprecise. This points to the need to consider a wider biomass range, as possible under the ASPM/SCAA approach which can consider a longer time series of data to achieve the necessary contrast because it does not require catch-at-age data for every year.

## REFERENCE

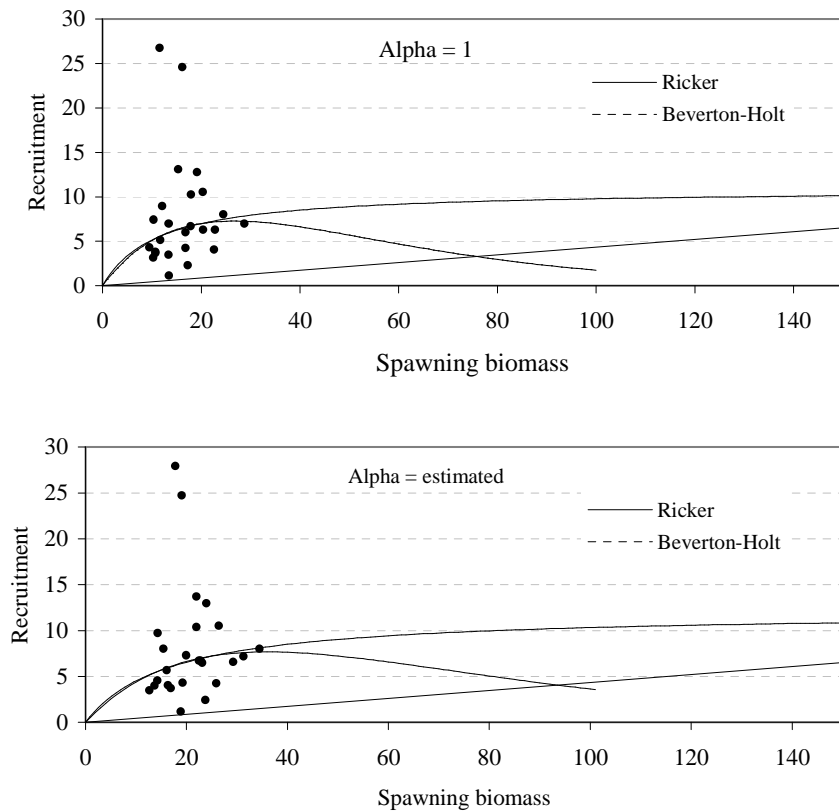
Butterworth DS and Rademeyer RA. 2008a. Statistical catch-at-age analysis vs ADAPT-VPA: the case of Gulf of Maine cod. GARM-III Working paper 2.2a.

**Table Add.1:** Estimates of key management quantities for 2007 RC-VPA assessments of the Gulf of Maine cod. Biomass units are tons. The estimates given for quantities such as  $B_{MSY}^{sp}$  refer to an average commercial selectivity function for 1992-2006, and  $MSYL = B_{MSY}^{sp} / K^{sp}$ . Fishing mortality ( $F$ ) values refer to age 5. Values shown in bold are fixed on input. Objective function ( $SS$ ) values shown in square parenthesis are not comparable to those for RC-VPA for 2005 because of data differences. For 2007 RC-VPA with  $\alpha=est$ , the value of  $\alpha$  estimated is 0.28.

	Beverton-Holt				Ricker			
	2005	2005	2007	2007	2005	2005	2007	2007
	Alt-VPA, $\alpha=1$	Alt-VPA, $\alpha=est$	Alt-VPA, $\alpha=1$	Alt-VPA, $\alpha=est$	Alt-VPA, $\alpha=1$	Alt-VPA, $\alpha=est$	Alt-VPA, $\alpha=1$	Alt-VPA, $\alpha=est$
VPA SR SS	[9.89]	[9.95]	11.20	10.86	[9.77]	[9.92]	11.16	10.82
VPA fit SS 1-7+	208.06	196.46			208.06	196.46		
VPA fit SS 1-8+			249.26	238.11			249.26	238.11
$M$	<b>0.2</b>	<b>0.2</b>	<b>0.2</b>	<b>0.2</b>	<b>0.2</b>	<b>0.2</b>	<b>0.2</b>	<b>0.2</b>
$h$	0.74	0.83	0.77	0.71	1.90	1.73	1.93	1.58
$K^{sp}$	250.5	186.2	239.1	260.8	73.2	79.0	75.7	93.5
$B_{2004}^{sp}$	20.7	30.8	13.4	19.9	20.7	30.8	13.4	19.9
$B_{2006}^{sp}$			22.8	29.3			22.8	29.3
$B_{2004}^{sp}/K^{sp}$	0.08	0.17	0.06	0.08	0.28	0.39	0.18	0.21
$B_{2006}^{sp}/K^{sp}$			0.10	0.11			0.30	0.31
$B_{MSY}^{sp}$	81.0	44.4	70.1	68.4	31.8	29.5	30.7	34.5
$B_{2004}^{sp}/B_{MSY}^{sp}$	0.25	0.69	0.19	0.29	0.65	1.04	0.44	0.58
$B_{2006}^{sp}/B_{MSY}^{sp}$			0.33	0.43			0.74	0.85
$MSYL$	0.32	0.24	0.29	0.26	0.43	0.37	0.41	0.37
$MSY$	15.8	9.9	15.4	13.0	10.8	9.6	11.7	10.9
$F_{MSY}$	0.26	0.53	0.24	0.35	0.57	0.77	0.46	0.54
$F_{2004}$	0.44	0.35	0.51	0.45	0.44	0.35	0.51	0.45
$F_{2006}$			0.31	0.27			0.31	0.27



**Fig. Add.1:** Time-series of spawning biomass estimates for RC-VPA for 2005 and for 2007, together with the commercial selectivity-at-age.



**Fig. Add.2:** Fits of the Ricker and Beverton-Holt stock-recruitment functions to the spawning biomass (in '000 tons) and recruitment (1-yr-old in  $\times 10^6$ ) values estimated for the 2007 RC-VPA. The upper panel is for the  $\alpha=1$ , and the lower for the  $\alpha=est$  implementations of RC-VPA. The straight line through the origin is the replacement line which intersects the stock-recruitment curve at a spawning biomass of  $K^{sp}$ .