Some Further Runs of ASPM/SCAA for Gulf of Maine Cod

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As suggested in discussions, the ASPM/SCAA assessment approach for Gulf of Maine cod has been rerun commencing in 1964 when the survey time series commence. In addition, the implications of increasing M from the conventional 0.2 to 0.3 are explored. Commencement in 1964 requires the specification of starting conditions, which have been set as θ=0.5 (reflecting the B^{sp}/K ratio at that time) and ζ=0.4 (the addition to M made to provide a starting age structure). Sensitivities are investigated for the alternatives of Ricker *vs* Beverton-Holt stock-recruitment relations and of fully estimated *vs* asymptotically flat selectivity functions (the commercial selectivity functions are fully estimable throughout). In other respects the specifications of the 2007 Reference Case of Butterworth and Rademeyer (2008) have been retained.

Results are provided in Table 1, and in Fig. 1 for estimated spawning biomass trajectories and Fig. 2 for stock-recruitment plots.

The most important result is that increasing M to 0.3 would seem to provide a resolution of the earlier difficulty of needing a domed shaped selectivity function to achieve a satisfactory fit to the proportions at age data. Note that for M=0.3 and a Ricker stock recruitment function, although a better fit to the data is achieved when estimating the survey selectivity function values at larger ages (see $-\ln L$ values), allowing for the estimated decrease in selectivity at these ages would not be justified in AIC terms. These new runs also indicate clear preferences in likelihood terms for M=0.3 over M=0.2 (thus also achieving greater consistency with the results from tag recapture analyses of Hart and Miller (2008)), and for the Ricker over the Beverton-Holt stock-recruitment functional form.

Increasing M to 0.3 (with the assessment commencing in 1964) would thus seem to provide a way forward towards achieving consensus regarding this assessment. There are nevertheless further aspects that need to be investigated:

- Earlier sensitivity runs to the 2007 Reference Case (Butterworth and Rademeyer, 2008) indicated insensitivity of Reference Point estimates to the starting specifications (values of θ and ζ), but this needs to be rechecked for this revised assessment configuration.
- Those sensitivity runs also indicated little difference between Pope and Baranov formulations of the catch equation, but this needs rechecking given that some higher mortality values are now implied.
- Fit diagnostics need to be checked.
- Further alternatives to the Beverton-Holt and Ricker stock recruitment relationships need to be explored. Note that the relatively high values of F_{MSY} and low values of B^{sp}_{MSY} below are consequences of the Beverton-Holt form fits opting for steepness estimates at their upper bound (here 0.98), and of the relatively fast drop of recruitment with B^{sp} for the Ricker form. An option here might be the generalised Ricker form of Butterworth and Rademeyer (2008) for which low values of γ might both avoid the steep slope at the origin that the Beverton-Holt fits, seek while also falling off less rapidly as B^{sp} increases than does the standard Ricker form.

REFERENCES

Butterworth, DS and Rademeyer, RA. 2008. Updated SCAA/ASPM Assessment of Gulf of Maine cod. GARM-III Working paper 4.F.1.

Hart, D and Miller, T. 2008. Analyses of tagging data for evidence of decreased fishing mortality for large Gulf of Maine cod, *Gadus morhua*. GARM-III BRP TOR 4.7.

Table 1: Penalised maximum likelihood estimates of key management quantities for the 2007 Reference Case and sensitivities thereto, all starting in 1964, with θ=0.5 and ζ=0.4. Biomass units are thousand tons. The estimates given for quantities such as B^{sp}_{MSY} refer to the commercial selectivity function from 1992+. The *slope* statistic is $-\ln(S_8/S_7)$. Values shown in bold are fixed on input. Values in parenthesis are Hessian-based CV's. Note that the –ln*L* value for the 2007 Reference Case is not comparable to the others shown.

	1		M=0.2								M=0.3							
			Ricker				Beverton-Holt				Ricker				Beverton-Holt			
	2007 Reference Case		estimated sel		flat survey sel		estimated sel		flat survey sel		estimated sel		flat survey sel		estimated sel		flat survey sel	
-lnL	8.34		35.69		56.08		52.55		153.89		30.35		32.69		40.68		58.96	
M	**0.20**	-	**0.20**	-	**0.20**	-	**0.20**	-	**0.20**	-	**0.30**	-	**0.30**	-	**0.30**	-	**0.30**	-
h	1.34	(0.15)	2.21	(0.20)	4.75	(0.14)	0.98	(0.00)	0.98	(0.00)	1.54	(0.16)	1.84	(0.14)	0.98	(0.00)	0.98	(0.00)
γ	**1.00**	-	**1.00**	-	**1.00**	-	**1.00**	-	**1.00**	-	**1.00**	-	**1.00**	-	**1.00**	-	**1.00**	-
K^{sp}	147.31	(0.10)	84.36	(0.15)	47.21	(0.05)	182.93	(0.08)	107.20	(0.08)	65.83	(0.11)	56.41	(0.06)	108.13	(0.08)	86.08	(0.07)
B^{sp}_{2004}	34.49	(0.14)	29.34	(0.15)	19.42	(0.09)	45.43	(0.13)	28.58	(0.13)	26.52	(0.12)	23.89	(0.10)	32.61	(0.12)	26.68	(0.12)
B^{sp}_{2006}	42.87	(0.15)	37.14	(0.15)	25.54	(0.11)	52.11	(0.13)	32.09	(0.15)	33.04	(0.13)	30.21	(0.12)	37.40	(0.13)	30.34	(0.13)
B^{sp}_{2004}/K	0.23	(0.13)	0.35	(0.11)	0.41	(0.08)	0.25	(0.10)	0.27	(0.10)	0.40	(0.11)	0.42	(0.10)	0.30	(0.10)	0.31	(0.09)
B^{sp}_{2006}/K	0.29	(0.15)	0.44	(0.13)	0.54	(0.10)	0.28	(0.11)	0.30	(0.12)	0.50	(0.13)	0.54	(0.12)	0.35	(0.11)	0.35	(0.11)
B^{sp}_{MSY}	53.05	(0.09)	28.28	(0.10)	18.11	(0.06)	24.12	(0.11)	16.94	(0.11)	24.48	(0.09)	21.00	(0.09)	18.10	(0.09)	15.79	(0.08)
$B^{sp}_{2004}/B^{sp}_{MSY}$	0.65	(0.15)	1.04	(0.14)	1.07	(0.09)	1.88	(0.13)	1.69	(0.11)	1.08	(0.13)	1.14	(0.12)	1.80	(0.11)	1.69	(0.11)
$B^{sp}_{2006}/B^{sp}_{MSY}$	0.81	(0.15)	1.31	(0.14)	1.41	(0.10)	2.16	(0.13)	1.89	(0.13)	1.35	(0.13)	1.44	(0.12)	2.07	(0.12)	1.92	(0.12)
B^{sp}_{MSY}/K	0.36	(0.13)	0.34	(0.15)	0.38	(0.07)	0.13	(0.07)	0.16	(0.05)	0.37	(0.13)	0.37	(0.11)	0.17	(0.04)	0.18	(0.04)
MSY	12.54	(0.06)	11.23	(0.08)	11.18	(0.05)	9.09	(0.07)	5.67	(0.07)	11.02	(0.08)	10.99	(0.08)	9.49	(0.07)	7.65	(0.07)
F_{MSY}	0.46	-	0.77	-	1.20	-	0.82	-	0.63	-	0.82	-	1.03	-	1.11	-	0.91	-
$F_{2004/2006}$	0.17	(0.15)	0.20	(0.15)	0.24	(0.12)	0.19	(0.14)	0.24	(0.15)	0.20	(0.14)	0.21	(0.14)	0.20	(0.14)	0.22	(0.15)
Comm *slope*	0.57	(0.18)	0.50	(0.21)	0.30	(0.28)	0.66	(0.15)	0.47	(0.22)	0.30	(0.36)	0.23	(0.44)	0.43	(0.25)	0.33	(0.32)
NEFSC *slope*	0.47	(0.10)	0.37	(0.15)	**0.00**	-	0.50	(0.10)	**0.00**	-	0.13	(0.46)	**0.00**	-	0.26	(0.17)	**0.00**	-

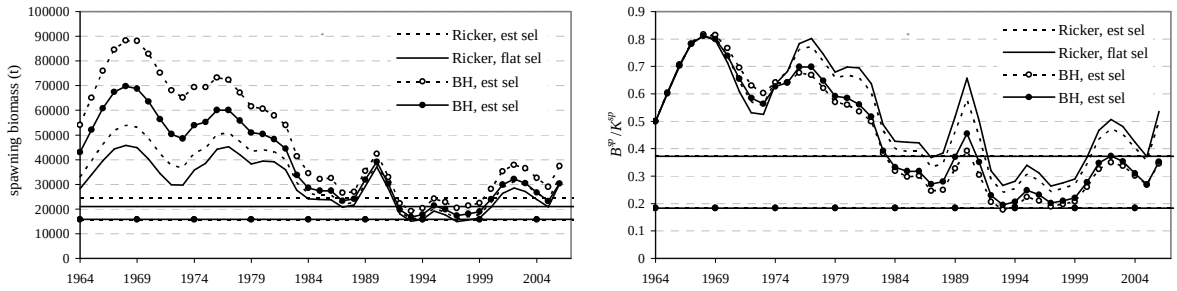

Fig. 1: Spawning biomass trajectories (in absolute terms and in terms of pre-exploitation level). The estimated B_{MSY}^{sp} and *MSYL* are also shown. These results are for the *M*=0.3 cases.

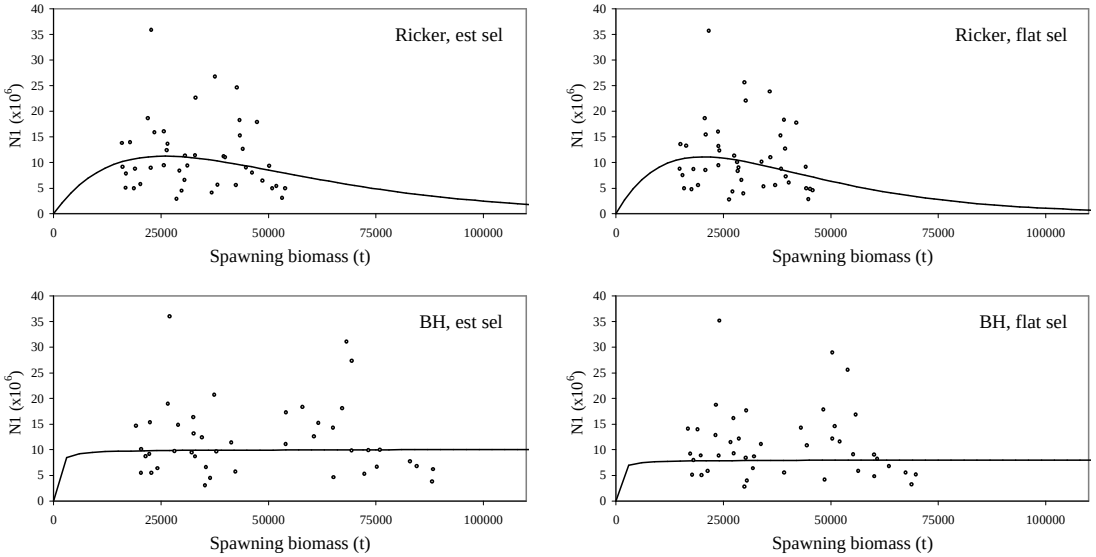

Fig. 2: The estimated stock-recruitment curve and estimated recruitments each year over the period 1964-2006. These results are for the *M*=0.3 cases.