Pella-Tomlinson in WinBUGS

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Introduction

These are the results of the Bayesian state-space models for for Albacore, Hake and rock lobster. Data are from Polacheck et al. (1993). Four models were run: Schaefer, Schaefer with starting biomass estimated, Pella-Thomlinson and Pella-Thomlinson with initial biomass estimated. The state-space models were implemented in WinBUGS (version 1.4.3, Lunn et al. 2000) via the R2WinBUGS package (Sturtz et al. 2005) in the statistical programming environment R (R Development Core Team 2008). WinBUGS uses a Markov Chain Monte Carlo (MCMC) approach to estimate the joint posterior distribution of the model parameters. Marginal posterior distributions of model parameters and unobserved states were based on 500 000 iterations of two chains after discarding the first 460 000 iterations (burn-in). These 40 000 iterations were reduced to 2 000 by sampling every 20$^{\text{th}}$ value to reduce sample autocorrelation. Models were considered to have converged when the potential scale reduction factor $\hat{R}$ was < 1.2 for all parameters (Brooks and Gelman 1998). All models passed this convergence diagnostic.

First, I re-ran the model code from Meyer and Millar (1999) to ensure results were similar to the publication. I then removed the informative priors to make generic code that could be used for all three stocks. Priors used in Meyer and Millar (1999) and the flat priors used here are desctibed in Table 1.

Table 1. Summary of specified priors for Bayesian state-space models

Parameter	Meyer & Millar (1990)	Flat priors
r (intrinsic growth rate)	lognormal(5.042905,3.7603664)I(10,1000)	uniform(0,2)
K (carrying capacity; tons)	lognormal(-1.38,3.845)I(0.01,1.2)	exp(uniform(1,20))
σ^2 (Process error variance)	gamma(3.785518,0.010223)	gamma(0.001, 0.001)
τ^2 (Observation error variance)	gamma(1.708603,0.008613854)	gamma(0.001, 0.001)
a (B_{init}/K)	NA	exp(uniform(0.01,3)
q (Catchability coefficient)	gamma(0.001,0.001)I(0.5,100)	uniform(0,1)
p (Pella-Thomlinson parameters)	NA	exp(uniform(0.01,20))

Comparison with results published by Meyer & Millar (1999)

Table 2. Results from Meyer & Millar (1999), Schaefer model. Values are means of posteriors.

Parameter	Observation error model	Process error model	Statespace model
r	0.33	0.62	0.29
K (1000s t)	239.6	153.4	279.8
$q \times 10^4$	26.71	43.72	23.89
B_{1990}	75.51	50.04	83.97
MSP (1000's t)	19.65	23.78	19.26

Below are the results of the model run with the informative priors. Differences between the state-space results in Table 2 are relativel small.

Table 3. WinBUGS state-space model output foralbacore. Parameter estimates use the same priors as found in Meyer & Millar (1999). File name:schaefer.alb.paperpriors.out

Parameter	mean	median	mode
r	0.305	0.300	0.302
K	270.633	261.700	247.155
q	0.248	0.244	0.242
σ (Process variance)	0.003	0.003	0.002
τ (Obs. variance)	0.012	0.011	0.010
B_{init}	275.325	266.500	249.258
B_{current}	88.263	84.670	75.276
Depletion	0.321	0.318	0.302
a (B_{init}/K)	1.017	1.018	1.008
p (Pella)			

Albacore

The results of the albacore models are as follows:

Table 4. WinBUGS state-space model output for albacore. Model uses the flat priors found in Table 1. File name:schaefer.alb.out

Parameter	mean	median	mode
r	0.317	0.310	0.307
K	300.465	260.650	234.746
q	0.246	0.241	0.225
σ (Process variance)	0.006	0.003	0.002
τ (Obs. variance)	0.013	0.013	0.012
B_{init}	308.225	266.450	228.768
B_{current}	102.059	86.835	71.634
Depletion	0.331	0.326	0.313
a (B_{init}/K)	1.026	1.022	0.975
p (Pella)			

Table 5. WinBUGS state-space model output for albacore. Model uses the flat priors found in Table 1. File name:schaefer.init.alb.out

Parameter	mean	median	mode
r	0.273	0.264	0.229
K	341.770	297.300	243.200
q	0.194	0.186	0.152
σ (Process variance)	0.006	0.003	0.001
τ (Obs. variance)	0.014	0.013	0.012
B_{init}	491.496	373.900	271.153
B_{current}	156.462	115.900	81.928
Depletion	0.318	0.310	0.302
a (B_{init}/K)	1.438	1.258	1.115
p (Pella)			

Table 6. WinBUGS state-space model output for albacore. Model uses the flat priors found in Table 1. File name:pella.alb.out

Parameter	mean	median	mode
r	0.723	0.592	0.212
K	318.923	262.950	228.963
q	0.246	0.242	0.234
σ (Process variance)	0.006	0.003	0.001
τ (Obs. variance)	0.013	0.012	0.012
B_{init}	324.237	266.900	228.168
B_{current}	107.976	86.950	72.308
Depletion	0.333	0.326	0.317
a (B_{init}/K)	1.017	1.015	0.997
p (Pella)	1.087	0.471	0.252

Table 7. WinBUGS state-space model output for albacore. Model uses the flat priors found in Table 1. File name:pella.init.alb.out

Parameter	mean	median	mode
r	0.630	0.456	0.143
K	412.548	350.150	280.245
q	0.172	0.154	0.112
σ (Process variance)	0.006	0.004	0.002
τ (Obs. variance)	0.014	0.013	0.011
B_{init}	597.996	440.150	286.908
B_{current}	196.064	140.200	88.369
Depletion	0.328	0.319	0.308
a (B_{init}/K)	1.450	1.257	1.024
p (Pella)	0.955	0.446	0.216

Hake

The results of the Hake models are as follows:

Table 8. WinBUGS state-space model output for Hake. Model uses the flat priors found in Table 1. File name:schaefer.hake.out

Parameter	mean	median	mode
r	0.359	0.357	0.361
K	3480.314	3143.500	2694.223
q	0.000	0.000	0.000
σ (Process variance)	0.017	0.016	0.015
τ (Obs. variance)	0.004	0.003	0.001
B_{init}	4192.660	3836.500	3275.870
B_{current}	1619.780	1513.000	1289.856
Depletion	0.386	0.394	0.394
a (B_{init}/K)	1.205	1.220	1.216
p (Pella)			

Table 9. WinBUGS state-space model output for Hake. Model uses the flat priors found in Table 1. File name:schaefer.init.hake.out

Parameter	mean	median	mode
r	0.341	0.343	0.342
K	3364.866	3127.000	2942.530
q	0.000	0.000	0.000
σ (Process variance)	0.008	0.007	0.005
τ (Obs. variance)	0.004	0.003	0.001
B_{init}	6359.403	5671.500	5141.642
B_{current}	2279.238	2041.000	1871.581
Depletion	0.358	0.360	0.364
a (B_{init}/K)	1.890	1.814	1.747
p (Pella)			

Table 10. WinBUGS state-space model output for Hake. Model uses the flat priors found in Table 1. File name:pella.hake.out

Parameter	mean	median	mode
r	0.677	0.517	0.239
K	4010.106	3415.000	2908.251
q	0.000	0.000	0.000
σ (Process variance)	0.016	0.015	0.015
τ (Obs. variance)	0.005	0.003	0.001
B_{init}	4585.451	4031.000	3421.531
B_{current}	1776.063	1600.000	1476.331
Depletion	0.387	0.397	0.431
a (B_{init}/K)	1.143	1.180	1.177
p (Pella)	1.268	0.551	0.237

Table 11. WinBUGS state-space model output for Hake. Model uses the flat priors found in Table 1. File name:pella.init.hake.out

Parameter	mean	median	mode
r	0.735	0.589	0.375
K	3568.125	3299.500	3146.373
q	0.000	0.000	0.000
σ (Process variance)	0.009	0.008	0.008
τ (Obs. variance)	0.003	0.002	0.001
B_{init}	7217.303	6423.500	5805.101
B_{current}	2585.243	2311.500	2045.988
Depletion	0.358	0.360	0.352
a (B_{init}/K)	2.023	1.947	1.845
p (Pella)	0.656	0.519	0.266

Rock Lobster

The results of the rock lobster models are as follows:

Table 12. WinBUGS state-space model output for rock lobster. Model uses the flat priors found in Table 1. File name:schaefer.rocklob.out

Parameter	mean	median	mode
r	0.136	0.116	0.051
K	135675.575	113300.000	88907.208
q	0.000	0.000	0.000
σ (Process variance)	0.017	0.014	0.009
τ (Obs. variance)	0.018	0.018	0.018
B_{init}	138236.205	117849.989	90104.698
B_{current}	24271.516	20510.000	13831.560
Depletion	0.176	0.174	0.153
a (B_{init}/K)	1.019	1.040	1.014
p (Pella)			

Table 13. WinBUGS state-space model output for rock lobster. Model uses the flat priors found in Table 1. File name:schaefer.init.rocklob.out

Parameter	mean	median	mode
r	0.086	0.065	0.035
K	152966.255	129549.990	102312.883
q	0.000	0.000	0.000
σ (Process variance)	0.016	0.013	0.009
τ (Obs. variance)	0.019	0.018	0.018
B_{init}	207840.015	179300.000	162102.694
B_{current}	35197.640	30100.000	23584.437
Depletion	0.169	0.168	0.145
a (B_{init}/K)	1.359	1.384	1.584
p (Pella)			

Table 14. WinBUGS state-space model output for rock lobster. Model uses the flat priors found in Table 1. File name:pella.rocklob.out

Parameter	mean	median	mode
r	0.291	0.104	0.042
K	156863.115	138800.000	108762.812
q	0.000	0.000	0.000
σ (Process variance)	0.016	0.013	0.008
τ (Obs. variance)	0.019	0.018	0.017
B_{init}	158914.568	141500.000	120321.947
B_{current}	27520.156	23990.000	15479.350
Depletion	0.173	0.170	0.129
a (B_{init}/K)	1.013	1.020	1.106
p (Pella)	2.463	1.156	0.301

Table 15. WinBUGS state-space model output for rock lobster. Model uses the flat priors found in Table 1. File name:pella.init.rocklob.out

Parameter	mean	median	mode
r	0.340	0.134	0.042
K	185674.400	124400.000	100653.620
q	0.000	0.000	0.000
σ (Process variance)	0.015	0.013	0.009
τ (Obs. variance)	0.019	0.019	0.018
B_{init}	227589.895	193099.974	135710.589
B_{current}	39107.730	32670.000	21028.842
Depletion	0.172	0.169	0.155
a (B_{init}/K)	1.226	1.552	1.348
p (Pella)	1.587	0.479	0.161

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