Huynh 2020 Interim Analysis Code

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Purpose

This document explains what the Huynh et al (2020) code (code link) is doing and how it relates to the paper so that we can make sure we understand how their analysis works and replicate their results.

Basic structure of the study and code files

The main code to run the analysis is in a file `run_script.R`. It intalls modified versions of the `DLMtool` and `MSEtool` packages from files included with the code (`DLMtool_5.3.1.tar.gz` and `MSEtool_1.4.1.tar.gz`). The main script `run_script.R` is actually pretty brief (105 lines) and relies heavily on the `DLMtool` and `MSEtool` packages. It seems like most of the novel coding that went into this project is in `iMP.R` in the `fn` folder. It's also not a very long script (267 lines) and mostly defines MPs and accessory functions.

The authors developed inputs for operating models (OM) based on three species:

1. Capelin (`capelin`)
2. Vermilion Snapper (`vs`)
3. Pacific Ocean Perch (`POP`)

The OM files are in the OM folder (`capelin_OM.rds, POP_OM.rds, vs_OM.rds`)

The authors ran six scenarios for each OM:

1. Base (`base`)
2. Hyperstable (`hs`)
3. Hyperdeplete (`hd`)
4. Depleted (`dep`)
5. Lighly fished (`lf`)
6. Episodic M (`epiM`)

They ran 250 simulations for each species-scenario combination, and saved results in 18 files in the `MSE_obj` folder (e.g. `capelin_base.rds, capelin_dep.rds, vs_base.rds, vs_dep.rds`). These resulting data files (.rds) provide results for 15 management procedures (MP), although only nine were used in the Huynh et al. (2020) paper. MPs that were not used are in gray text below. Descriptions of the MPs below are from the `DLMTool` Help and comments in the `iMP.R` script:

1. `NFref`: A reference MP that sets annual catch to almost zero (0.01)
2. `FMSYref75`: A reference FMSY method that fishes at 75% of FMSY
3. `FMSYref`: A reference FMSY method that fishes at FMSY
4. `curE`: Set effort to 100% of that in final year of historical simulations.

5. `SQ`: ??? (I can't find any documentation for this MP)
6. `AvC`: A simple average catch MP that is included to demonstrate a 'status quo' management option
7. `SCA_1`: Statistical catch-at-age model run every 1 year (i.e. Annual assessment)
8. `SCA_5`: Statistical catch-at-age model run every 5 years (i.e. Fixed TAC (5))
9. `SCA_10`: Statistical catch-at-age model run every 10 years (i.e. Fixed TAC (10))
10. `iMP_5`: Averaged Index with assessments run every 5 years (i.e. `iMP_avg_5`)
11. `iMP_10`: Averaged Index with assessments run every 10 years (i.e. `iMP_avg_10`, Averaged Index (10))
12. `buffer_iMP_5`: Buffered Index MP, with assessments run every 5 years (i.e. Buffered Index (5))
13. `buffer_iMP_10`: Buffered Index MP, with assessments run every 10 years (i.e. Buffered Index (10))
14. `pMP_5`: Projection MP with assessments run every 5 years (i.e. Projection (5))
15. `pMP_10`: Projection MP with assessments run every 10 years (i.e. Projection (10))

Unfortunately, the authors didn't include any plotting scripts or any other way to display the results with the code. The results files (e.g. `capelin_base_rds`) contain raw results

Connecting code to results from the paper

Length, maturity, and vulnerability (selectivity) at-age vectors associated with each operating model (species) are plotted in Figure 1.

Time series of mean relative spawning biomass (B^S/B^S_{MSY}) and mean relative yield (C/MSY), of 250 simulations, are plotted in Figures 2 and 3 for four MPs [Annual assessment, Averaged Index (10), Buffered Index (10), and Fixed TAC (10)], for each species.

Dot-and-whisker plots of the coefficient of variation of time series of spawning stock biomass ($CV(B^S) = CVB$) and geometric mean of relative yield ($geomean(C/MSY) = GMRY$) for 250 simulations, are plotted in Figures 4 and 5, for nine MPs [Annual assessment, Averaged Index (10), Buffered Index (10), and Fixed TAC(10)], Averaged Index (5), Buffered Index (5), and Fixed TAC (5)]) for each species.

Time series of mean relative spawning biomass (B^S/B^S_{MSY}) and mean relative yield (C/MSY), of 250 simulations, are plotted in Figures 6 and 7, for three MPs [Averaged Index (10), Buffered Index (10), and Projection (10)], for each species.

Additional information

OM files

The operating model files (e.g. `vs_OM.rds`) contain 107 slots in a list-like S4 object, with the following slot names: 1. Name, 2. Agency, 3. Region, 4. Sponsor, 5. Latitude, 6. Longitude, 7. nsim, 8. proyears, 9. interval, 10. pstar, 11. maxF, 12. reps, 13. cpars, 14. seed, 15. Source, 16. Common_Name, 17. Species, 18. maxage, 19. R0, 20. M, 21. M2, 22. Mexp, 23. Msd, 24. Mgrad, 25. h, 26. SRrel, 27. Perr, 28. AC, 29. Period, 30. Amplitude, 31. Linf, 32. K, 33. t0, 34. LenCV, 35. Ksd, 36. Kgrad, 37. Linfsd, 38. Linfgrad, 39. L50, 40. L50_95, 41. D, 42. a, 43. b, 44. Size_area_1, 45. Frac_area_1, 46. Prob_staying, 47. Fdisc, 48. nyears, 49. Spat_targ, 50. EffYears, 51. EffLower, 52. EffUpper, 53. Esd, 54. qinc, 55. qcv, 56. L5, 57. LFS, 58. Vmaxlen, 59. isRel, 60. LR5, 61. LFR, 62. Rmaxlen, 63. DR, 64. SelYears, 65. AbsSelYears, 66. L5Lower, 67. L5Upper, 68. LFSLower, 69. LFSUpper, 70. VmaxLower, 71. VmaxUpper, 72. CurrentYr, 73. MPA, 74. Cobs, 75. Cbiascv, 76. CAA_nsamp, 77. CAA_ESS, 78. CAL_nsamp, 79. CAL_ESS, 80. Iobs, 81. Ibiascv, 82. Btobs, 83. Btbiascv, 84. beta, 85. LenMbiascv, 86. Mbiascv, 87. Kbiascv, 88. t0biascv, 89. Linfbiascv, 90. LFCbiascv, 91. LFSbiascv, 92. FMSYbiascv, 93. FMSY_Mbiascv, 94. BMSY_B0biascv, 95. Irefbiascv, 96. Brefbiascv, 97. Crefbiascv, 98. Dbiascv, 99. Dobs, 100. hbiascv, 101. Recbiascv, 102. TACFrac, 103. TACSD, 104. TAEFrac, 105. TAESD, 106. SizeLimFrac, 107. SizeLimSD.

Results files

The results files (e.g. `vs_base.rds`) contain 25 slots in a list-like S4 object, with the following slot names: 1. Name, 2. nyears, 3. proyears, 4. nMPs, 5. MPs, 6. nsim, 7. OM, 8. Obs, 9. B_BMSY, 10. F_FMSY, 11. B, 12. SSB, 13. VB, 14. FM, 15. C, 16. TAC, 17. SSB_hist, 18. CB_hist, 19. FM_hist, 20. Effort, 21. PAA, 22. CAA, 23. CAL, 24. CALbins, 25. Misc.

Some of these slots are more or less self explanatory. Many (all?) of them are explained in documentation for `DLMtool` (DLMtool.pdf link) `MSEtool` (MSEtool.pdf link). However, you have to search the documents for the slot names to find what you're looking for, and it's a bit of a chore figuring out what's in the output.

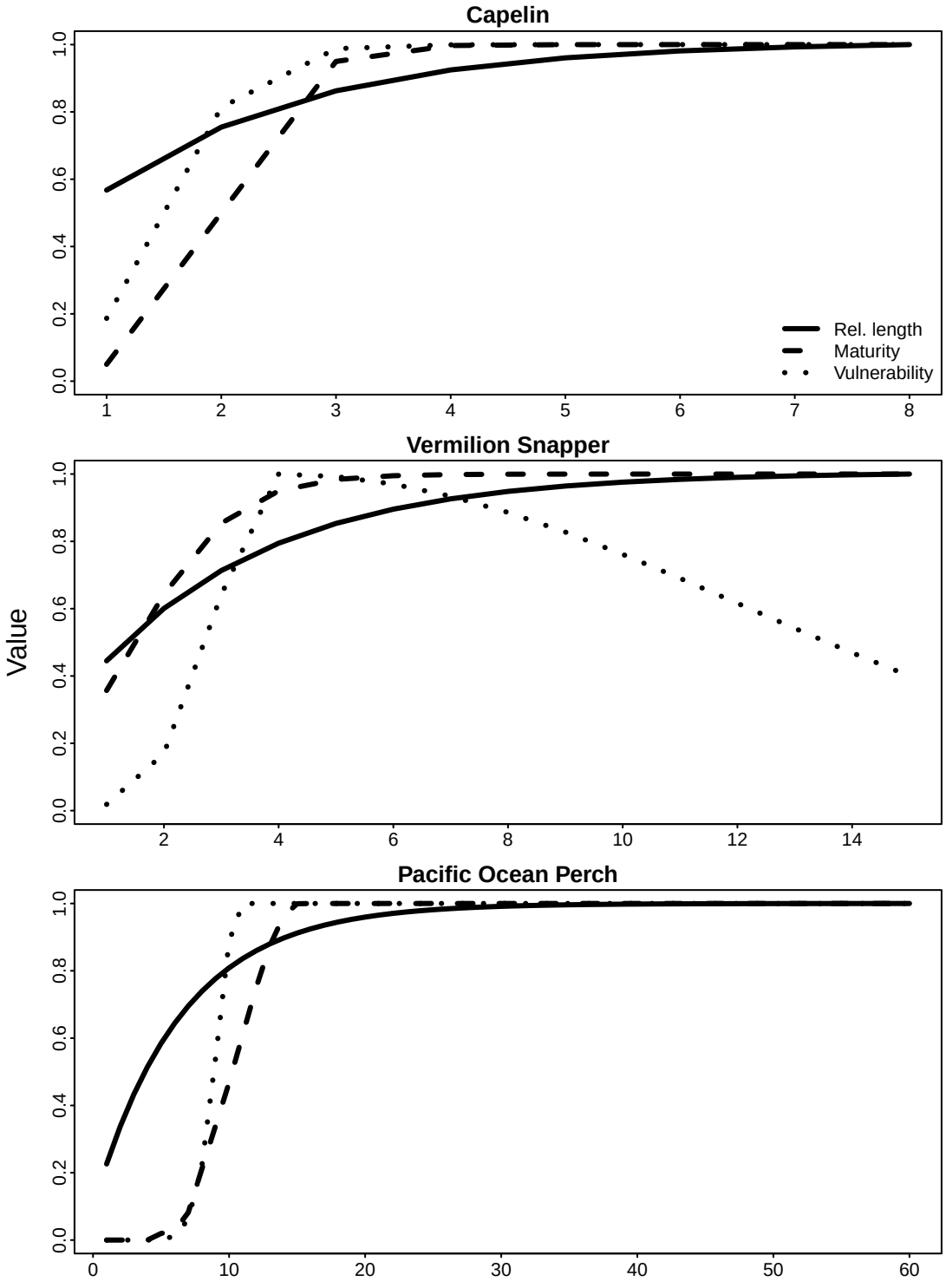

Figure 1: Life history (growth and maturity) and vulnerability schedules at age used in the operating models for Capelin, Vermilion Snapper and POP. Growth is expressed as mean length-at-age relative to that at the maximum age. Compare with Huynh et al (2020) Figure 1.

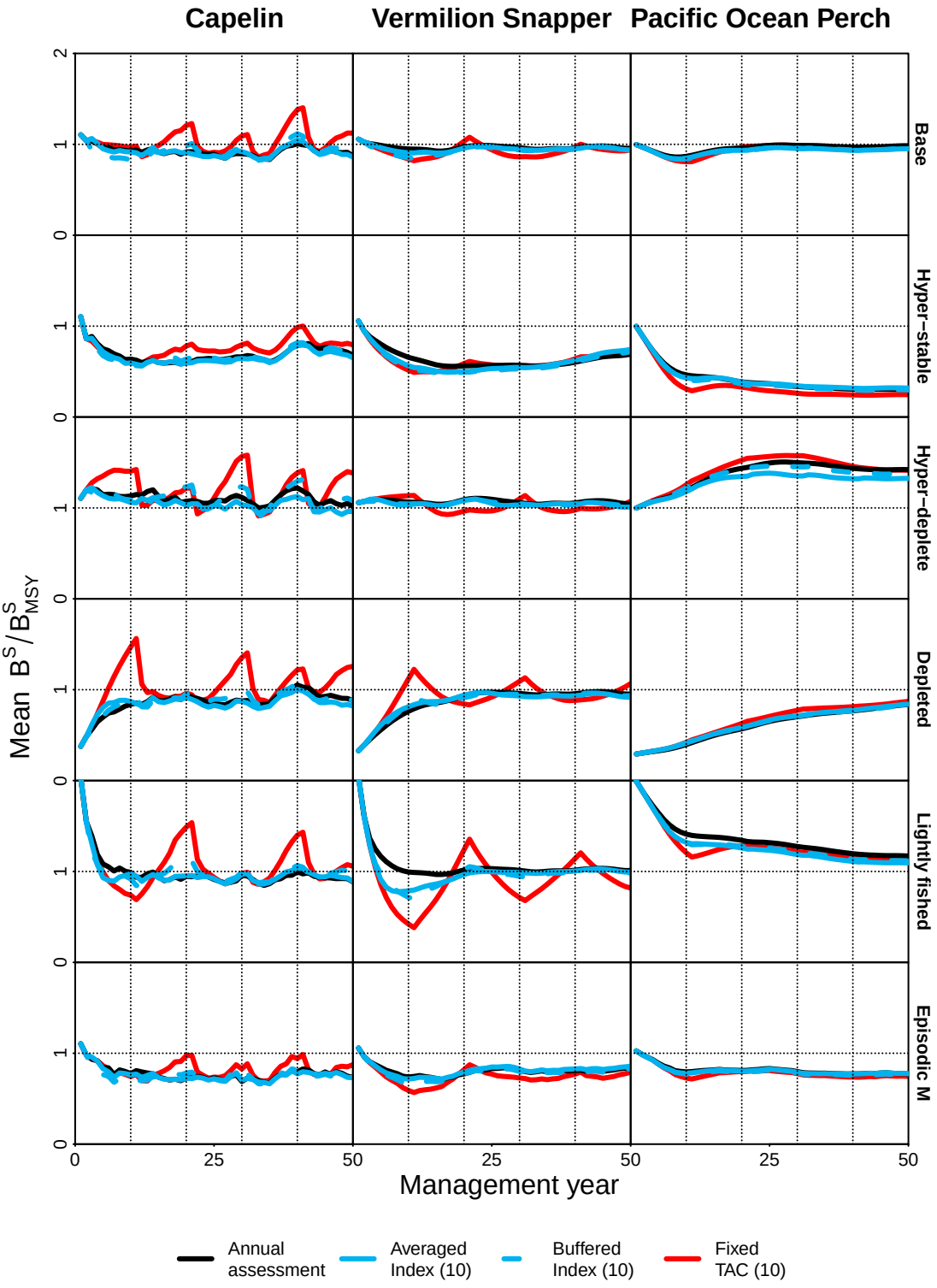

Figure 2: Annual mean B^S/B^S_{MSY} from 250 simulations for each species (columns) and scenario (rows). Coloured lines correspond to the four MPs. Note that B^S = SSB. Compare with Huynh et al (2020) Figure 2.

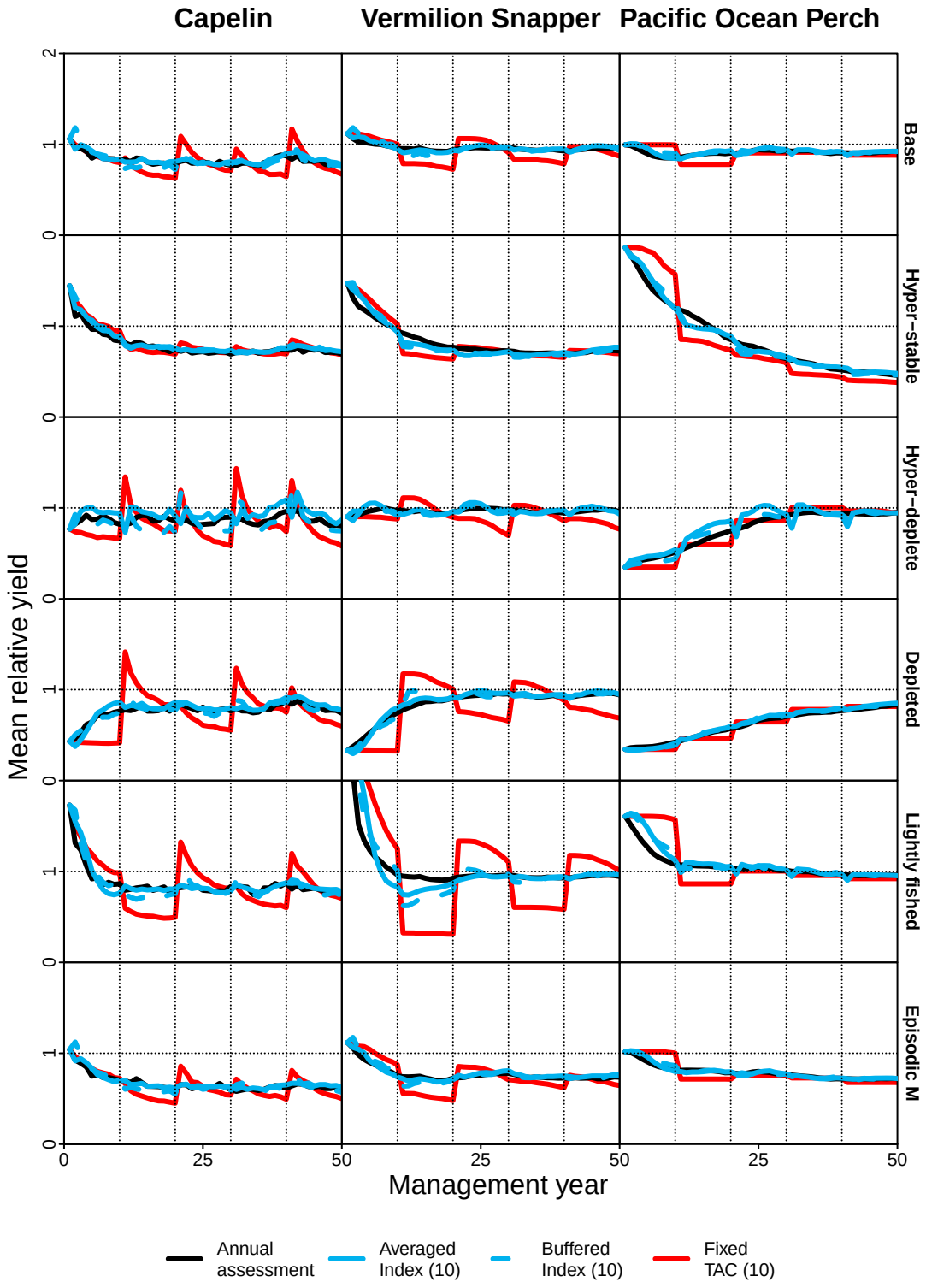

Figure 3: Annual mean relative yield from 250 simulations for each species (columns) and scenario (rows). Coloured lines correspond to the four MPs. Compare with Huynh et al (2020) Figure 3.

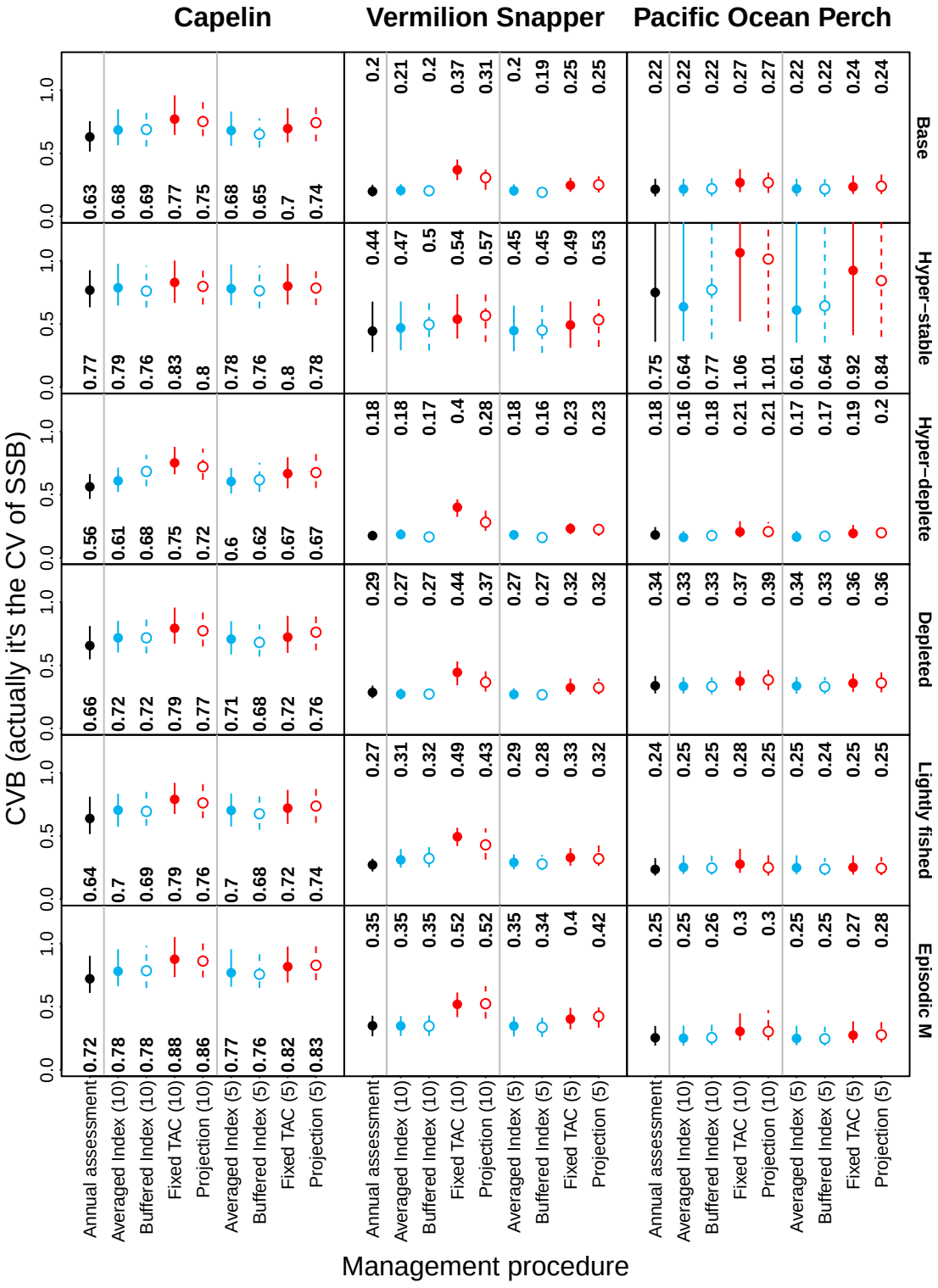

Figure 4: Dot-and-whisker plots of CVB (coefficient of variation in spawning stock biomass) for each species (columns) and scenario (rows). For each MP, dots and numbers indicate the median from 250 simulations, and whiskers span the interquartile range. Compare with Huynh et al (2020) Figure 4.

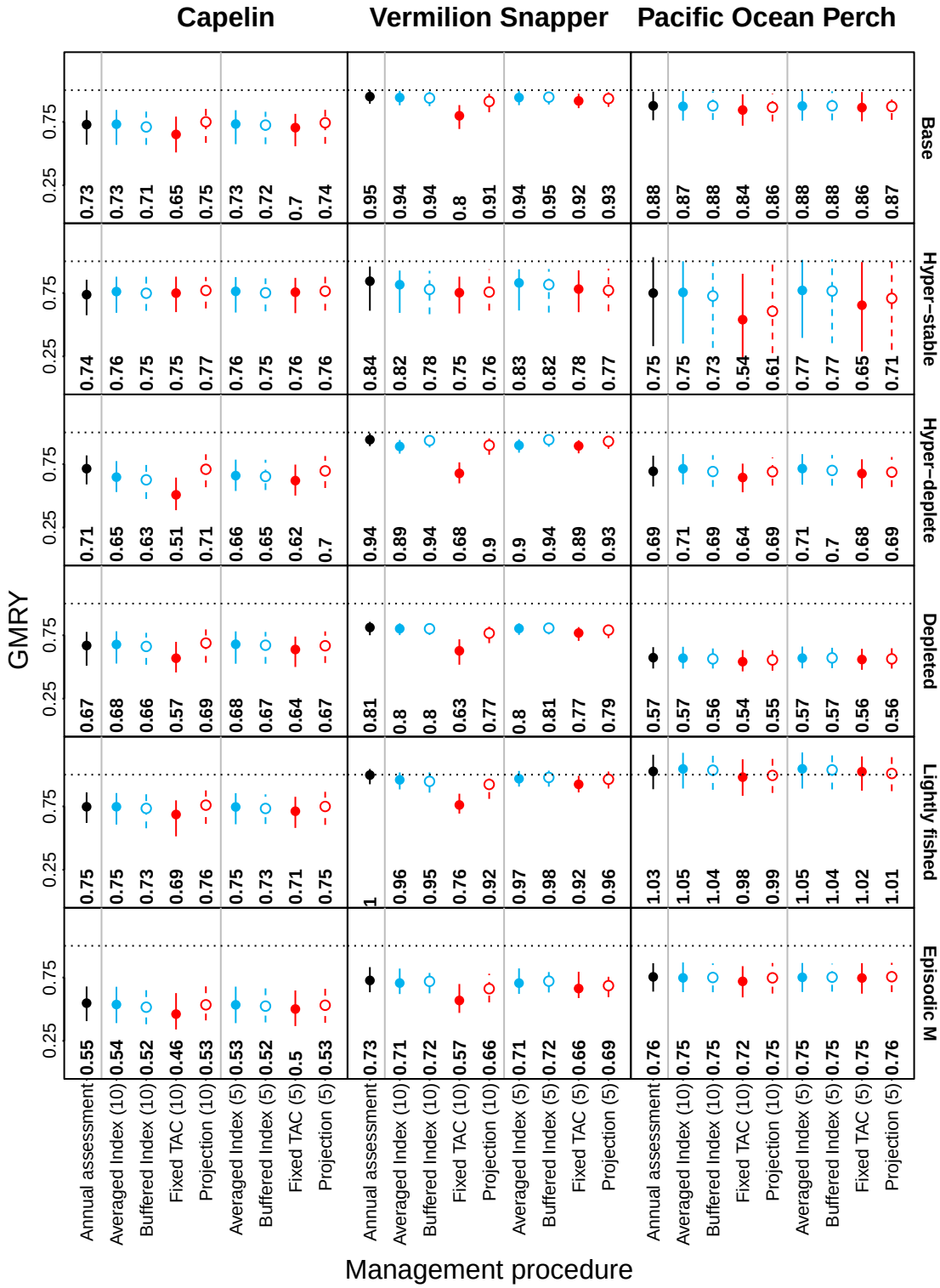

Figure 5: Dot-and-whisker plots of GMRY (geometric mean of relative yield) for each species (columns) and scenario (rows). For each MP,dots and numbers indicate the median from 250 simulations, and whiskers span the interquartile range. Dotted, horizontal lines indicate a value of 1. Compare with Huynh et al (2020) Figure 4.

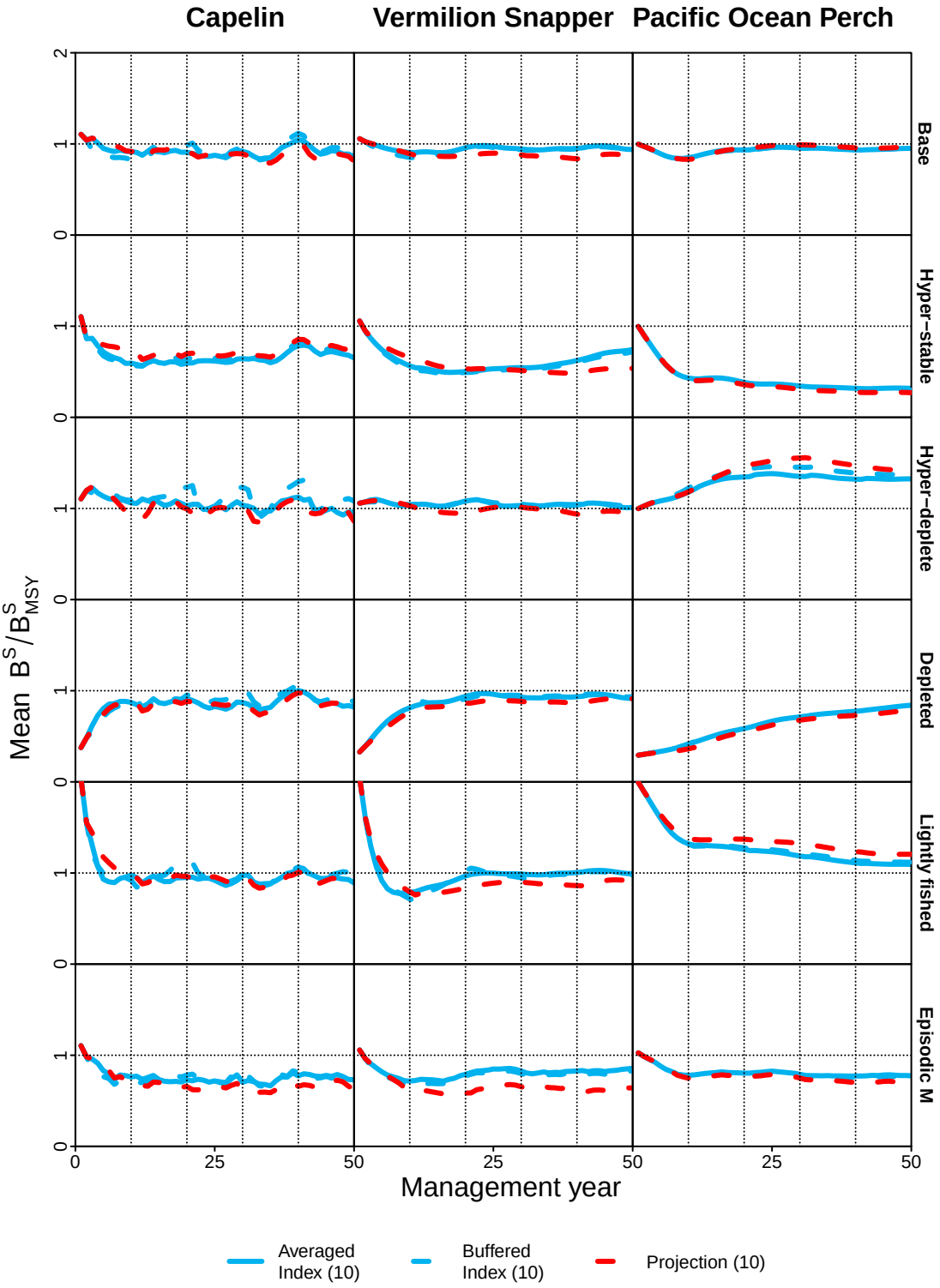

Figure 6: Annual mean B^S/B^S_{MSY} from 250 simulations for each species (columns) and scenario (rows) comparing the Averaged Index, Buffered Index and Projection MPs. Coloured lines correspond to the three MPs. Compare with Huynh et al (2020) Figure 6.

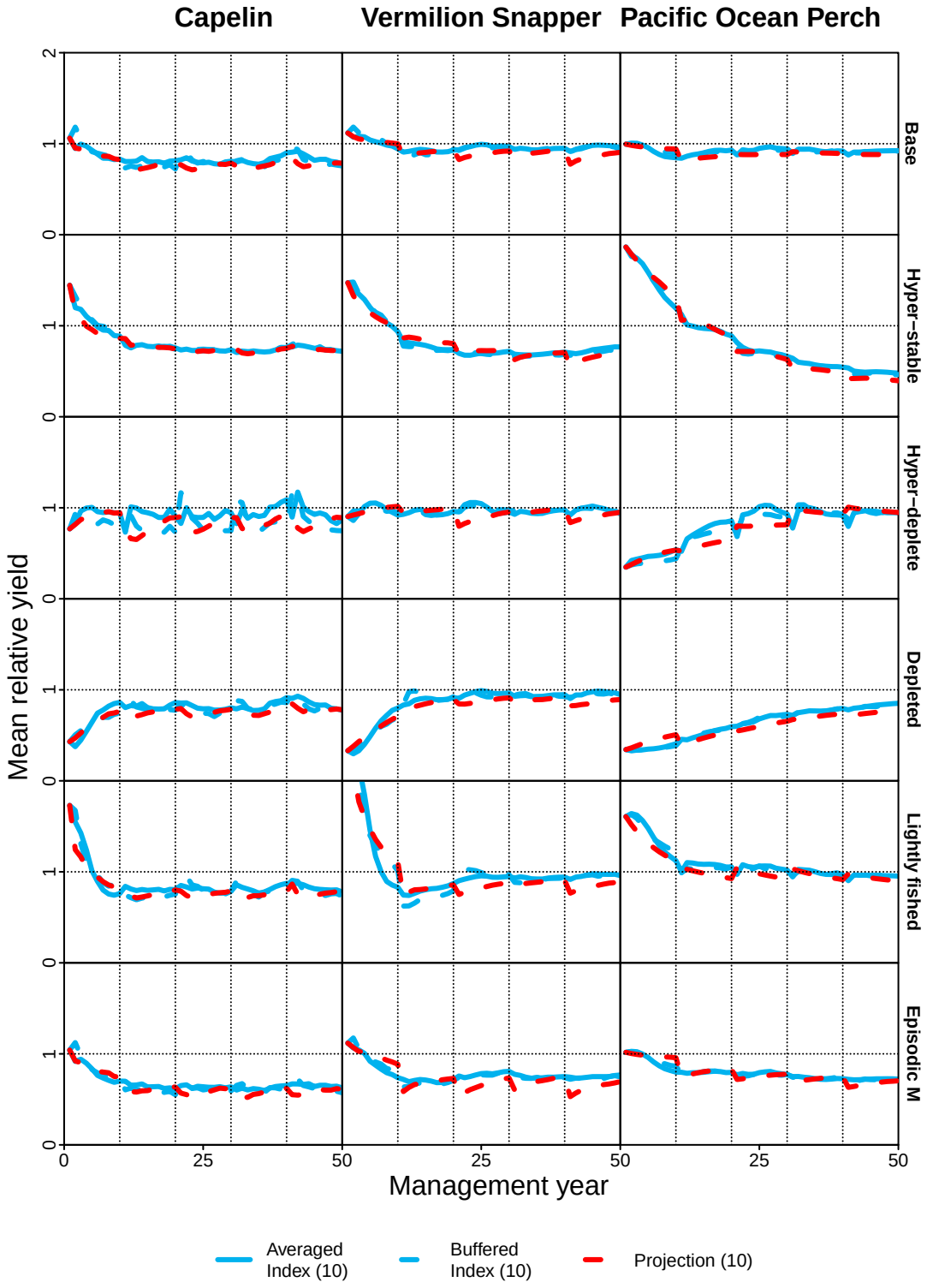

Figure 7: Annual mean relative yield from 250 simulations for each species (columns) and scenario (rows) comparing the Averaged Index, Buffered Index and Projection MPs. Coloured lines correspond to the three MPs. Compare with Huynh et al (2020) Figure 7.

Appendix

Table 1: Slotnames of S4 operating model objects. Classes and lengths of slots and dimensions (dim) where appropriate are also provided. Previews of what is included in each slot vary by class: ≤ 3 values for vectors, ≤ 3 values in the first row for matrices, and ≤ 3 names for lists.

slotName	class	length	dim	preview
Name	character	1		REPLACED – vs
Agency	character	0		
Region	character	0		
Sponsor	character	0		
Latitude	numeric	0		
Longitude	numeric	0		
nsim	numeric	1		250
proyears	numeric	1		50
interval	numeric	1		4
pstar	numeric	1		0.5
maxF	numeric	1		3
reps	numeric	1		1
cpars	list	4		Mat_age, V, Perr , ...
seed	numeric	1		1
Source	character	1		No source provided. Author: No author provided.
Common_Name	character	0		
Species	character	0		
maxage	numeric	1		15
R0	numeric	1		1000
M	numeric	2		0.25, 0.25
M2	numeric	0		
Mexp	numeric	2		0, 0
Msd	numeric	2		0, 0
Mgrad	numeric	2		0, 0
h	numeric	2		0.6, 0.6
SRrel	integer	1		1
Perr	numeric	2		0.222377, 0.222377
AC	numeric	2		0.221849239851624, 0.221849239851624
Period	numeric	2		NaN, NaN
Amplitude	numeric	2		NaN, NaN
Linf	numeric	2		34.4, 34.4
K	numeric	2		0.3254, 0.3254
t0	numeric	2		-0.795129, -0.795129
LenCV	numeric	2		0.2535, 0.2535
Ksd	numeric	2		0, 0
Kgrad	numeric	2		0, 0
Linfsd	numeric	2		0, 0
Linfgrad	numeric	2		0, 0
L50	numeric	2		17.109529290595, 17.109529290595
L50_95	numeric	2		9.43975353297666, 9.43975353297666

Table 1: *(continued)*

slotName	class	length	dim	preview
D	numeric	2		0.3, 0.6
a	numeric	1		2.19e-05
b	numeric	1		2.916
Size_area_1	numeric	2		0.5, 0.5
Frac_area_1	numeric	2		0.5, 0.5
Prob_staying	numeric	2		0.5, 0.5
Fdisc	numeric	2		0, 0
nyears	numeric	1		65
Spat_targ	numeric	2		1, 1
EffYears	integer	65		1, 2, 3 , ...
EffLower	numeric	65		0.0370496, 0.0505344, 0.0596992 , ...
EffUpper	numeric	65		0.0555744, 0.0758015999999999, 0.0895488 , ...
Esd	numeric	2		0.1, 0.2
qinc	numeric	2		0, 0
qcv	numeric	2		0, 0
L5	numeric	2		12.1427979373047, 12.1427979373047
LFS	numeric	2		18.0991, 18.0991
Vmaxlen	numeric	2		0.4, 0.4
isRel	character	1		FALSE
LR5	numeric	2		0, 0
LFR	numeric	2		0, 0
Rmaxlen	numeric	2		1, 1
DR	numeric	0		
SelYears	numeric	0		
AbsSelYears	numeric	0		
L5Lower	numeric	0		
L5Upper	numeric	0		
LFSLower	numeric	0		
LFSUpper	numeric	0		
VmaxLower	numeric	0		
VmaxUpper	numeric	0		
CurrentYr	numeric	1		2014
MPA	matrix, array	0	0, 0	
Cobs	numeric	2		0.1, 0.2
Cbiascv	numeric	1		0.05
CAA_nsamp	numeric	2		150, 300
CAA_ESS	numeric	2		50, 100
CAL_nsamp	numeric	2		150, 300
CAL_ESS	numeric	2		50, 100
Iobs	numeric	2		0.1, 0.25

Table 1: *(continued)*

slotName	class	length	dim	preview
Ibiascv	numeric	1		0.1
Btobs	numeric	2		0.05, 0.2
Btbiascv	numeric	2		0.333, 3
beta	numeric	2		0.666, 1.5
LenMbiascv	numeric	1		0.05
Mbiascv	numeric	1		0.05
Kbiascv	numeric	1		0.05
t0biascv	numeric	1		0.05
Linfbiascv	numeric	1		0.05
LFCbiascv	numeric	1		0.05
LFSbiascv	numeric	1		0.05
FMSYbiascv	numeric	1		0.1
FMSY_Mbiascv	numeric	1		0.25
BMSY_B0biascv	numeric	1		0.1
Irefbiascv	numeric	1		0.1
Brefbiascv	numeric	1		0.1
Crefbiascv	numeric	1		0.1
Dbiascv	numeric	1		0.2
Dobs	numeric	2		0.025, 0.1
hbiascv	numeric	1		0.1
Recbiascv	numeric	2		0.05, 0.1
TACFrac	numeric	2		1, 1
TACSD	numeric	2		0, 0
TAEFrac	numeric	2		1, 1
TAESD	numeric	2		0, 0
SizeLimFrac	numeric	2		1, 1
SizeLimSD	numeric	2		0, 0