



## **Embracing the Latest Version of Stock Synthesis beyond 3.30.14**

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## Summary

The 2022 stock assessment for Pacific bluefin tuna, which was an update to the 2020 benchmark assessment, used Stock Synthesis SS3.30.14. However, as of November 2023, SS3.30.14 has become significantly outdated, lagging eight iterations behind the latest version, SS3.30.22. The primary objective is to transition to the latest SS version, comparing results among different versions and addressing any discrepancies. Challenges arise from version discrepancies, with the 2022 assessment in later SS versions showing poorer fits to certain data, leading to different estimates for spawning stock biomass. This is primarily related to selectivity estimates, where a narrower parameter bound for F23 resulted in better-aligned likelihood estimates. Jitter analyses assessing convergence toward a global minimum revealed evidence of local minimums for both the original and modified models, with more runs resembling the best-fitting model for the modified version. This work demonstrates a smooth transition to the latest SS version.

## Introduction

The 2022 stock assessment for Pacific bluefin tuna was an update to the 2020 benchmark stock assessment. Both assessments, conducted in 2020 and 2022, relied on Stock Synthesis SS3.30.14, which was the latest available version at the time of the 2020 assessment. However, as of November 2023, SS3.30.14 lags 8 iterations behind the latest version SS3.30.22.

Since 2022, SS3.30.20 has incorporated and complied with ADMB 13.0, bringing significant improvements in algorithms, console output, and bug fixes when compared to the previous ADMB 12.0, which SS3.30.14 adhered to, albeit 4 iterations behind. For detailed account of these changes, please refer to the ADMB change log, accessible at <https://github.com/admb-project/admb/blob/admb-13.0/CHANGES.md>. Developers consistently recommend that users stay up to date with the latest version to benefit from new features, enhancements, and bug fixes as a best practice.

The primary objective of this effort is to transition to the latest SS version, with a twofold approach: 1) comparing results among different versions, and 2) identifying and addressing any discrepancies in results that may arise.

## Challenges stemming from version discrepancies and their solutions

The 2022 stock assessment was then run using various SS versions, including SS3.30.16, SS3.30.17, SS3.30.18, SS3.30.19, SS3.30.21, and SS3.30.22. These later versions showed identical likelihood values (Table 1). However, they exhibited a poorer fit to the CPUE indices and size composition data compared to SS3.30.14, resulting in a total likelihood degradation of 54 points, which, in turn, produced different estimates for spawning stock biomass (Figure 1). As the estimates were the same for these later versions, I use SS3.30.22 for demonstration and all other later versions can apply a similar approach.

Upon comparing parameters between SS3.30.14 and SS3.30.22, the majority of differences were related to selectivity estimates (“2022SA\_SS3.30.14” vs “2022SA\_SS3.30.22” in Table 2). Among these differences, the most notable was observed in the length-based selectivity for F23 (Table 2, Figure 2), resulting in a 40 unit degradation in likelihood. It appears that the estimation search may converge to a local solution.

When a narrower bound for the peak parameter for F23JLL was specified as 100 cm instead of 21.2 cm for the lower bound using SS3.30.22, the likelihood and likelihood components showed no significant difference from the 2022 stock assessment using SS3.30.14 (“2022SA\_SS3.30.22\_mod” in Table 1). Estimated parameters and SSB were also very close to those using SS3.30.14 (Table 2, Figure 3). This suggests that using a more constrained bound resulted in better alignment of the likelihood estimates.

To evaluate convergence towards a global minimum for this modified model, we conducted 30 jitter analyses for both models (“2022SA\_SS3.30.22” vs “2022SA\_SS3.30.22\_mod”), which we randomly perturb the initial values of all parameters by 10% and subsequently re-running the model. This process ensures that the best-fitting model had the lowest total negative log-likelihood (NLLs) and a positive-definite Hessian matrix (Figure 4). Based on the results from the 30 model runs with the random perturbations of initial values, there was evidence for local minimums around the best fitting model for both models. Both analyses showed similar NLL for the best-fitting model (1652.41 and 1648.36 for 2022SA\_SS3.30.22 and 2022SA\_SS3.30.22\_mod, respectively). However, more runs were similar to the best-fitting model for 2022SA\_SS3.30.22\_mod compared to 2022SA\_SS3.30.22.

The final gradient of the best-fitting model was 0.0002 and 0.0034 for 2022SA\_SS3.30.22 and 2022SA\_SS3.30.22\_mod, respectively, compared to 0.0012 in the 2022 assessment. Both best-fitting models’ hessian were positive-definite, and the variance-covariance matrix could be estimated. The best-fitting models are likely converged to a global minimum as there was no evidence of further improvements in the total likelihood.

## Conclusions

The 2022 stock assessment conducted using various versions of the Stock Synthesis (SS) model highlighted identical likelihood values for later versions, yet they exhibited a diminished fit to critical data compared to SS3.30.14. Adjusting the peak parameter bound for F23JLL in SS3.30.22 demonstrated that a more constrained bound improved alignment with SS3.30.14, emphasizing the importance of parameter specifications. The subsequent evaluation of convergence towards a global minimum through jitter analyses revealed evidence of local minimums for both the original and modified models in the latest version. However, the modified model (2022SA\_SS3.30.22\_mod) demonstrated greater consistency with the best-fitting model across multiple runs, indicating a more stable solution. Overall, these findings underscore the importance of careful parameter specification in achieving robust stock assessment results. This

work exemplified a seamless transition of the 2022 stock assessment to the recent SS version with the proposed modification, offering insights into refining modeling approaches.

## References

ISC 2022. Stock Assessment of Pacific Bluefin Tuna in the Pacific Ocean in 2022. Annex 13 22<sup>nd</sup> Meeting of the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean. Available at [https://isc.fra.go.jp/pdf/ISC22/ISC22\\_ANNEX13\\_Stock\\_Assessment\\_for\\_Pacific\\_Bluefin\\_Tuna.pdf](https://isc.fra.go.jp/pdf/ISC22/ISC22_ANNEX13_Stock_Assessment_for_Pacific_Bluefin_Tuna.pdf)

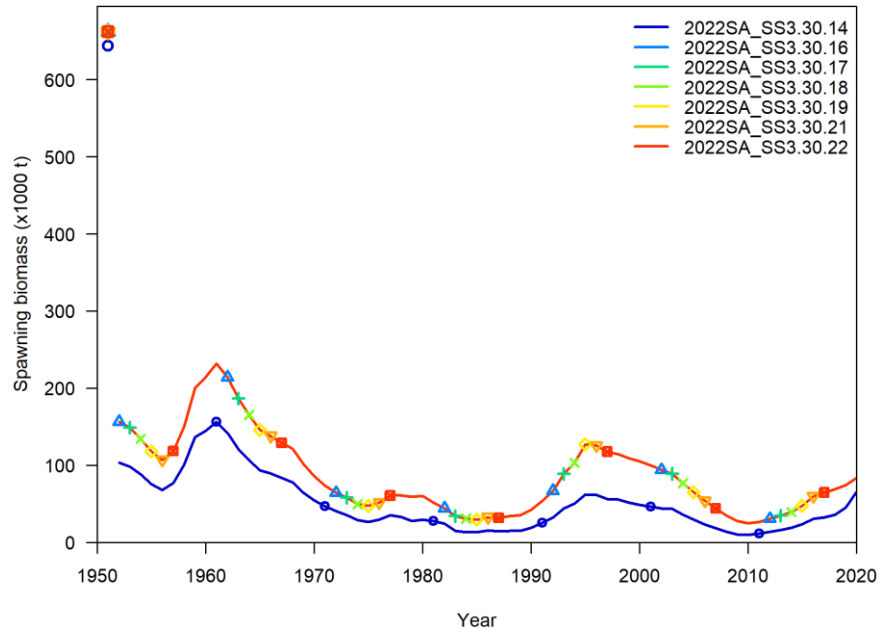


Figure 1. Spawning stock biomass estimates from the 2022 stock assessment model using various versions (SS3.30.14, SS3.30.16, SS3.30.17, SS3.30.18, SS3.30.19, SS3.30.21 and, SS3.30.22).

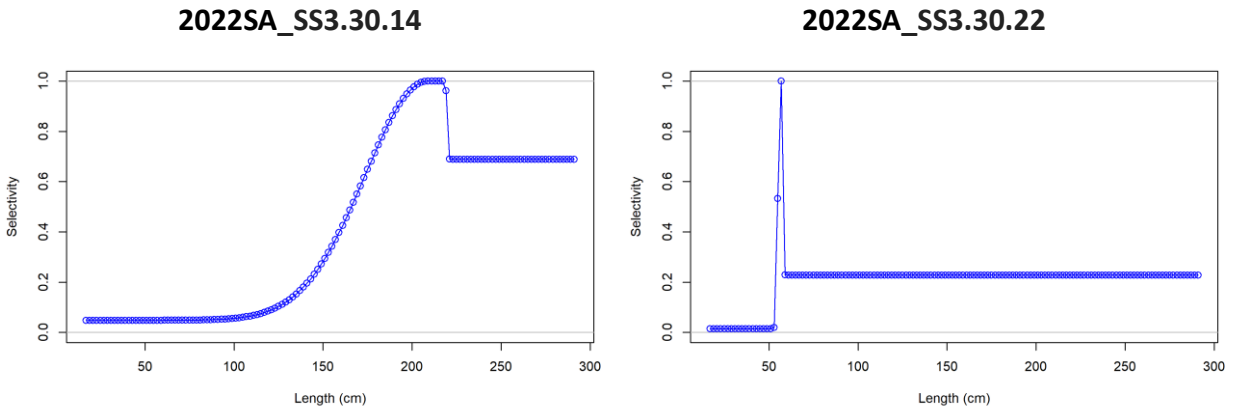


Figure 2. Estimated length-based selectivity for F23 in the 2022 stock assessment using SS3.30.14 (left panel) and SS3.30.22 (right panel).

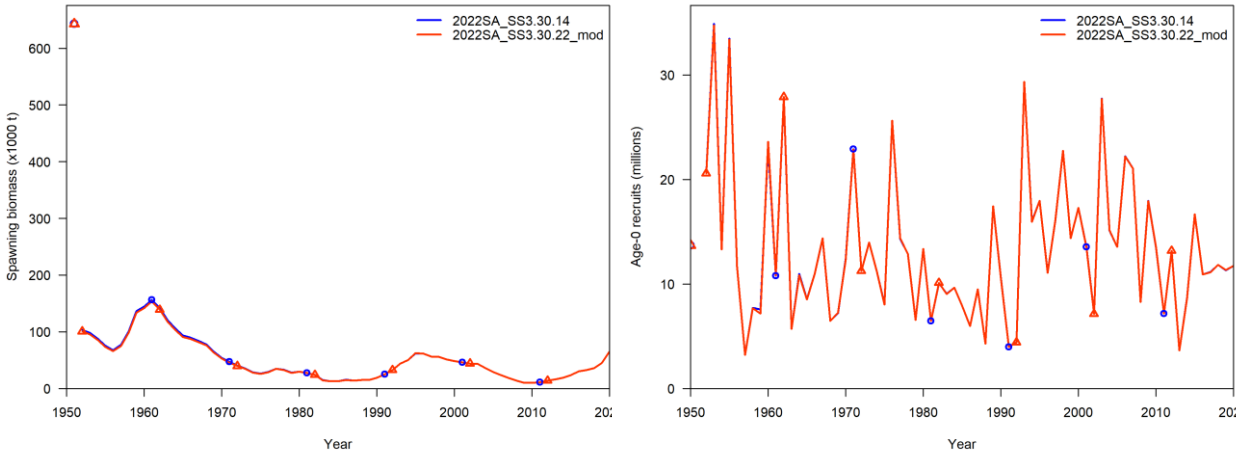


Figure 3. Estimated spawning stock biomass (left panel) and recruitment (right panel) from the 2022 stock assessment model using various versions (SS3.30.14 and, SS3.30.22 with modification).

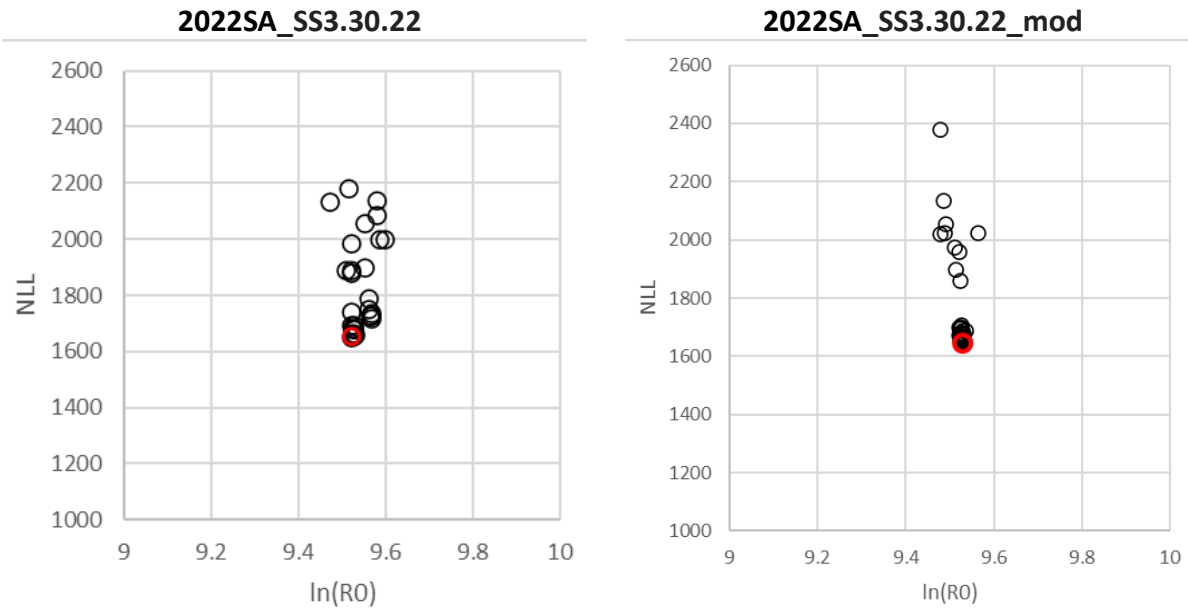


Figure 4. 30 jitter runs were conducted using the models in SS3.30.22, where the y-axis shows the total negative log-likelihood (NLL) and the x-axis shows  $\ln(R_0)$  values. Dots represent runs with positive-definite Hessian matrices. Red circle indicates the best-fitting run with the lowest total NLL and positive-definite Hessian matrices.

Table 1. Likelihood estimates from various stock synthesis versions.

	2022SA_ SS3.30.14	2022SA_ SS3.30.16, SS3.30.17, SS3.30.18, SS3.30.19, SS3.30.21, SS3.30.22	2022SA_ SS3.30.16_mod, SS3.30.17_mod, SS3.30.18_mod, SS3.30.19_mod, SS3.30.21_mod, SS3.30.22_mod
TOTAL	1652.68	1706.78	1652.66
Catch	0.45	0.17	0.47
Indices	-116.61	-106.67	-116.44
SizeFreq	1746.36	1789.54	1745.92
Recruitment	-1.67	-1.46	-1.60

Table 2. Parameter estimates from various stock synthesis versions. Yellow highlights are the difference of estimates from the 2022 stock assessment model (2022SA) that is greater than or equal to 2.

Parameters	2022SA_ SS3.30.14	2022SA_ SS3.30.22	2022SA_ SS3.30.22_ modified
SR_LN(R0)	9.53	9.55	9.52
SR_regime_BLK5add_1951	0.02	0.03	0.02
InitF_seas_1_ft_1F1JLL	0.61	0.31	0.63
InitF_seas_1_ft_8F8JSN(S1-3)	4.44	4.01	4.48
Size_DbIn_peak_F1JLL(1)	197.60	196.19	197.69
Size_DbIn_top_logit_F1JLL(1)	-8.39	-8.25	-8.39
Size_DbIn_ascend_se_F1JLL(1)	6.75	6.74	6.75
Size_DbIn_descend_se_F1JLL(1)	5.84	5.93	5.83
Size_DbIn_end_logit_F1JLL(1)	-3.75	-3.95	-3.74
Size_DbIn_peak_F2JSPPS(S1,3,4)(2)	48.83	48.82	48.83
Size_DbIn_top_logit_F2JSPPS(S1,3,4)(2)	-13.04	-13.05	-13.04
Size_DbIn_ascend_se_F2JSPPS(S1,3,4)(2)	3.12	3.12	3.12
Size_DbIn_descend_se_F2JSPPS(S1,3,4)(2)	3.76	3.76	3.76
Size_DbIn_end_logit_F2JSPPS(S1,3,4)(2)	-3.10	-3.12	-3.10
Size_inflection_F3KOLPS(3)	43.82	43.84	43.82
Size_95%width_F3KOLPS(3)	9.16	9.18	9.16
Size_inflection_F4TPSJS(4)	114.59	115.03	114.74
Size_95%width_F4TPSJS(4)	7.29	7.38	7.32
Size_inflection_F5TPSPO(5)	51.34	51.36	51.34
Size_95%width_F5TPSPO(5)	4.01	4.04	4.01
Size_DbIn_peak_F6JTroll(S2-4)(6)	53.74	53.33	53.73
Size_DbIn_ascend_se_F6JTroll(S2-4)(6)	4.33	4.30	4.33
Size_DbIn_descend_se_F6JTroll(S2-4)(6)	3.78	3.92	3.78
Size_DbIn_start_logit_F6JTroll(S2-4)(6)	-3.99	-3.94	-3.99
Size_DbIn_end_logit_F6JTroll(S2-4)(6)	-3.62	-4.02	-3.62
Size_inflection_F8JSN(S1-3)(8)	25.61	25.70	25.61
Size_95%width_F8JSN(S1-3)(8)	5.82	5.89	5.82
Size_inflection_F9JSN(S4)(9)	51.56	51.56	51.56
Size_95%width_F9JSN(S4)(9)	4.71	4.71	4.71
Size_inflection_F10JSN(HK_AM)(10)	56.77	57.10	56.77
Size_95%width_F10JSN(HK_AM)(10)	16.82	16.88	16.82
Size_inflection_F12TWLLSouth(12)	207.51	203.71	207.51
Size_95%width_F12TWLLSouth(12)	15.50	13.95	15.50
Size_DbIn_peak_F13USCOMM(-2001)(13)	65.40	65.40	65.45
Size_DbIn_ascend_se_F13USCOMM(-2001)(13)	3.26	3.28	3.28
Size_DbIn_descend_se_F13USCOMM(-2001)(13)	6.97	6.84	6.98
Size_DbIn_peak_F14MEXCOMM(2002-)(14)	84.91	84.95	84.90
Size_DbIn_ascend_se_F14MEXCOMM(2002-)(14)	3.98	3.99	3.98
Size_DbIn_descend_se_F14MEXCOMM(2002-)(14)	8.02	7.83	8.03
Size_DbIn_peak_F15EPOSports(15)	85.41	85.22	85.41



Parameters	2022SA_ SS3.30.14	2022SA_ SS3.30.22	2022SA_ SS3.30.22_ modified
Size_DblN_top_logit_F15EPOSports(15)	-4.91	-6.17	-4.91
Size_DblN_ascend_se_F15EPOSports(15)	-0.74	-2.33	-0.74
Size_DblN_descend_se_F15EPOSports(15)	2.98	3.30	2.98
Size_DblN_start_logit_F15EPOSports(15)	-2.83	-2.99	-2.83
Size_DblN_end_logit_F15EPOSports(15)	-2.67	-3.03	-2.67
Size_DblN_peak_F17TWLLNorth(17)	240.10	229.09	240.11
Size_DblN_top_logit_F17TWLLNorth(17)	1.81	1.53	1.81
Size_DblN_ascend_se_F17TWLLNorth(17)	6.62	6.36	6.62
Size_DblN_descend_se_F17TWLLNorth(17)	2.57	2.67	2.57
Size_DblN_peak_F18JSPPS(S2)(18)	69.94	70.14	70.09
Size_DblN_top_logit_F18JSPPS(S2)(18)	-8.77	-8.82	-8.81
Size_DblN_ascend_se_F18JSPPS(S2)(18)	5.36	5.36	5.36
Size_DblN_descend_se_F18JSPPS(S2)(18)	4.05	3.99	4.01
Size_DblN_peak_F19JTroll(S1)(19)	22.05	22.05	22.05
Size_DblN_ascend_se_F19JTroll(S1)(19)	1.80	1.80	1.80
Size_DblN_descend_se_F19JTroll(S1)(19)	7.04	7.01	7.04
Size_DblN_peak_F23JLL(1993-S1-3)(28)	208.62	56.09	208.62
Size_DblN_top_logit_F23JLL(1993-S1-3)(28)	-2.16	-6.82	-2.16
Size_DblN_ascend_se_F23JLL(1993-S1-3)(28)	7.81	0.62	7.81
Size_DblN_descend_se_F23JLL(1993-S1-3)(28)	-0.08	-2.88	-0.08
Size_DblN_start_logit_F23JLL(1993-S1-3)(28)	-2.99	-4.25	-2.98
Size_DblN_end_logit_F23JLL(1993-S1-3)(28)	0.79	-1.22	0.80
AgeSel_P2_F3KOLPS(3)	-0.45	-0.50	-0.45
AgeSel_P3_F3KOLPS(3)	-0.22	-0.34	-0.22
AgeSel_P4_F3KOLPS(3)	-0.96	-1.16	-0.97
AgeSel_P5_F3KOLPS(3)	-0.05	-0.28	-0.04
AgeSel_P4_F4TPSJS(4)	-2.41	-2.68	-2.47
AgeSel_P5_F4TPSJS(4)	0.92	0.85	0.92
AgeSel_P6_F4TPSJS(4)	-0.14	-0.24	-0.14
AgeSel_P7_F4TPSJS(4)	-0.57	-0.69	-0.57
AgeSel_P8_F4TPSJS(4)	0.72	0.75	0.72
AgeSel_P9_F4TPSJS(4)	-4.95	-4.93	-4.96
AgeSel_P10_F4TPSJS(4)	4.68	4.36	4.69
AgeSel_P2_F5TPSPO(5)	1.42	1.21	1.43
AgeSel_P3_F5TPSPO(5)	2.57	2.43	2.57
AgeSel_P4_F5TPSPO(5)	-2.04	-1.92	-2.01
AgeSel_P5_F5TPSPO(5)	0.59	0.19	0.52
AgeSel_P6_F5TPSPO(5)	0.70	1.25	0.79
AgeSel_P7_F5TPSPO(5)	0.87	-0.22	0.80
AgeSel_P8_F5TPSPO(5)	-11.39	-10.16	-11.35
AgeSel_P9_F5TPSPO(5)	8.25	8.28	8.26
AgeSel_P10_F5TPSPO(5)	-1.21	-2.11	-1.24
AgeSel_P11_F5TPSPO(5)	-0.07	0.73	-0.03
AgeSel_P2_F8JSN(S1-3)(8)	1.47	1.39	1.47

Parameters	2022SA_ SS3.30.14	2022SA_ SS3.30.22	2022SA_ SS3.30.22_ modified
AgeSel_P3_F8JSN(S1-3)(8)	-1.35	-1.50	-1.35
AgeSel_P4_F8JSN(S1-3)(8)	-1.16	-1.40	-1.16
AgeSel_P5_F8JSN(S1-3)(8)	-0.54	-0.42	-0.53
AgeSel_P2_F9JSN(S4)(9)	0.32	0.22	0.32
AgeSel_P3_F9JSN(S4)(9)	0.15	0.01	0.15
AgeSel_P4_F9JSN(S4)(9)	-0.31	-0.45	-0.32
AgeSel_P5_F9JSN(S4)(9)	-0.43	-0.55	-0.43
AgeSel_P6_F9JSN(S4)(9)	-0.93	-0.91	-0.92
AgeSel_P2_F10JSN(HK_AM)(10)	1.03	0.90	1.03
AgeSel_P3_F10JSN(HK_AM)(10)	-0.64	-0.80	-0.64
AgeSel_P4_F10JSN(HK_AM)(10)	0.06	-0.03	0.06
AgeSel_P5_F10JSN(HK_AM)(10)	-3.85	-3.66	-3.88
AgeSel_P6_F10JSN(HK_AM)(10)	1.13	1.63	1.34
AgeSel_P7_F10JSN(HK_AM)(10)	-1.18	-0.27	-1.15
AgeSel_P2_F18JSPPS(S2)(18)	-0.56	-0.70	-0.57
Size_DbIN_peak_F1JLL(1)_BLK1repl_1993	183.12	181.16	183.10
Size_DbIN_top_logit_F1JLL(1)_BLK1repl_1993	-1.14	-1.34	-1.14
Size_DbIN_ascend_se_F1JLL(1)_BLK1repl_1993	5.14	5.00	5.13
Size_DbIN_descend_se_F1JLL(1)_BLK1repl_1993	6.86	6.69	6.86
Size_DbIN_end_logit_F1JLL(1)_BLK1repl_1993	-0.15	-1.48	-0.15
Size_DbIN_peak_F13USCOMM(-2001)(13)_BLK2repl_1954	63.14	63.14	63.13
Size_DbIN_peak_F13USCOMM(-2001)(13)_BLK2repl_1955	80.34	80.29	80.34
Size_DbIN_peak_F13USCOMM(-2001)(13)_BLK2repl_1956	65.95	65.84	65.96
Size_DbIN_peak_F13USCOMM(-2001)(13)_BLK2repl_1958	86.99	86.93	87.00
Size_DbIN_peak_F13USCOMM(-2001)(13)_BLK2repl_1959	85.21	84.79	85.23
Size_DbIN_peak_F13USCOMM(-2001)(13)_BLK2repl_1960	60.98	60.97	61.06
Size_DbIN_peak_F13USCOMM(-2001)(13)_BLK2repl_1961	67.43	67.21	67.36
Size_DbIN_peak_F13USCOMM(-2001)(13)_BLK2repl_1963	59.08	59.07	59.08
Size_DbIN_peak_F13USCOMM(-2001)(13)_BLK2repl_1965	62.83	62.77	62.83
Size_DbIN_peak_F13USCOMM(-2001)(13)_BLK2repl_1979	74.27	74.45	74.27
Size_DbIN_ascend_se_F13USCOMM(-2001)(13)_BLK2repl_1954	2.32	2.31	2.32
Size_DbIN_ascend_se_F13USCOMM(-2001)(13)_BLK2repl_1955	2.37	2.35	2.37
Size_DbIN_ascend_se_F13USCOMM(-2001)(13)_BLK2repl_1956	2.52	2.49	2.53
Size_DbIN_ascend_se_F13USCOMM(-2001)(13)_BLK2repl_1958	5.55	5.56	5.55
Size_DbIN_ascend_se_F13USCOMM(-2001)(13)_BLK2repl_1959	5.10	5.11	5.10
Size_DbIN_ascend_se_F13USCOMM(-2001)(13)_BLK2repl_1960	-8.61	-8.44	-5.19
Size_DbIN_ascend_se_F13USCOMM(-2001)(13)_BLK2repl_1961	3.79	3.72	3.75
Size_DbIN_ascend_se_F13USCOMM(-2001)(13)_BLK2repl_1963	1.21	1.19	1.20
Size_DbIN_ascend_se_F13USCOMM(-2001)(13)_BLK2repl_1965	2.50	2.48	2.50
Size_DbIN_ascend_se_F13USCOMM(-2001)(13)_BLK2repl_1979	2.65	2.68	2.65
Size_DbIN_descend_se_F13USCOM(-2001)(13)_BLK2repl_1954	8.14	8.09	8.15
Size_DbIN_descend_se_F13USCOM(-2001)(13)_BLK2repl_1955	4.64	4.64	4.64
Size_DbIN_descend_se_F13USCOM(-2001)(13)_BLK2repl_1956	6.66	6.61	6.66
Size_DbIN_descend_se_F13USCOM(-2001)(13)_BLK2repl_1958	3.14	3.16	3.14

Parameters	2022SA_ SS3.30.14	2022SA_ SS3.30.22	2022SA_ SS3.30.22_ modified
Size_DbIN_descend_se_F13USCOM(-2001)(13)_BLK2repl_1959	6.74	6.71	6.75
Size_DbIN_descend_se_F13USCOM(-2001)(13)_BLK2repl_1960	7.95	7.87	7.94
Size_DbIN_descend_se_F13USCOM(-2001)(13)_BLK2repl_1961	5.74	5.59	5.67
Size_DbIN_descend_se_F13USCOM(-2001)(13)_BLK2repl_1963	7.19	7.15	7.20
Size_DbIN_descend_se_F13USCOM(-2001)(13)_BLK2repl_1965	5.85	5.84	5.85
Size_DbIN_descend_se_F13USCOM(-2001)(13)_BLK2repl_1976	8.72	8.64	8.71
Size_DbIN_descend_se_F13USCOM(-2001)(13)_BLK2repl_1979	4.45	4.51	4.45
Size_DbIN_peak_F14MEXCOMM(2002-)(14)_BLK3repl_2006	90.67	90.68	90.67
Size_DbIN_peak_F14MEXCOMM(2002-)(14)_BLK3repl_2008	57.22	57.22	57.22
Size_DbIN_peak_F14MEXCOMM(2002-)(14)_BLK3repl_2009	85.10	87.11	85.10
Size_DbIN_peak_F14MEXCOMM(2002-)(14)_BLK3repl_2010	84.12	83.27	84.12
Size_DbIN_peak_F14MEXCOMM(2002-)(14)_BLK3repl_2011	65.39	64.59	65.39
Size_DbIN_peak_F14MEXCOMM(2002-)(14)_BLK3repl_2012	83.60	83.45	83.60
Size_DbIN_peak_F14MEXCOMM(2002-)(14)_BLK3repl_2013	85.93	85.41	85.93
Size_DbIN_peak_F14MEXCOMM(2002-)(14)_BLK3repl_2014	105.13	105.12	105.13
Size_DbIN_peak_F14MEXCOMM(2002-)(14)_BLK3repl_2016	128.41	127.54	128.41
Size_DbIN_peak_F14MEXCOMM(2002-)(14)_BLK3repl_2017	153.44	149.92	153.43
Size_DbIN_peak_F14MEXCOMM(2002-)(14)_BLK3repl_2019	104.35	96.93	104.32
Size_DbIN_peak_F14MEXCOMM(2002-)(14)_BLK3repl_2020	166.82	154.60	166.81
Size_DbIN_ascend_se_F14MEXCOM(2002-)(14)_BLK3repl_2006	5.08	5.07	5.08
Size_DbIN_ascend_se_F14MEXCOM(2002-)(14)_BLK3repl_2008	-3.69	-3.74	-3.70
Size_DbIN_ascend_se_F14MEXCOM(2002-)(14)_BLK3repl_2009	4.41	5.37	4.41
Size_DbIN_ascend_se_F14MEXCOM(2002-)(14)_BLK3repl_2010	4.31	3.85	4.32
Size_DbIN_ascend_se_F14MEXCOM(2002-)(14)_BLK3repl_2011	2.65	2.33	2.65
Size_DbIN_ascend_se_F14MEXCOM(2002-)(14)_BLK3repl_2012	2.76	2.32	2.76
Size_DbIN_ascend_se_F14MEXCOM(2002-)(14)_BLK3repl_2013	4.23	4.19	4.22
Size_DbIN_ascend_se_F14MEXCOM(2002-)(14)_BLK3repl_2014	-4.47	-4.51	-4.47
Size_DbIN_ascend_se_F14MEXCOM(2002-)(14)_BLK3repl_2016	5.45	5.46	5.45
Size_DbIN_ascend_se_F14MEXCOM(2002-)(14)_BLK3repl_2017	6.77	6.88	6.77
Size_DbIN_ascend_se_F14MEXCOM(2002-)(14)_BLK3repl_2019	5.65	5.17	5.65
Size_DbIN_ascend_se_F14MEXCOM(2002-)(14)_BLK3repl_2020	7.65	7.57	7.65
Size_DbIN_descend_se_F14MEXCOM(2002-)(14)_BLK3repl_2006	-4.25	-4.28	-4.24
Size_DbIN_descend_se_F14MEXCOM(2002-)(14)_BLK3repl_2010	3.06	2.92	3.06
Size_DbIN_descend_se_F14MEXCOM(2002-)(14)_BLK3repl_2011	8.70	8.57	8.70
Size_DbIN_descend_se_F14MEXCOM(2002-)(14)_BLK3repl_2012	3.06	2.70	3.06
Size_DbIN_descend_se_F14MEXCOM(2002-)(14)_BLK3repl_2013	8.37	8.26	8.37
Size_DbIN_descend_se_F14MEXCOM(2002-)(14)_BLK3repl_2014	6.24	6.13	6.24
Size_DbIN_descend_se_F14MEXCOM(2002-)(14)_BLK3repl_2016	7.13	7.04	7.13
Size_DbIN_descend_se_F14MEXCOM(2002-)(14)_BLK3repl_2017	6.19	6.37	6.19
Size_DbIN_descend_se_F14MEXCOM(2002-)(14)_BLK3repl_2019	9.27	8.47	9.27
Size_DbIN_descend_se_F14MEXCOM(2002-)(14)_BLK3repl_2020	5.28	6.02	5.28
Size_DbIN_peak_F15EPOSports(15)_BLK6repl_2015	67.00	67.00	67.00
Size_DbIN_peak_F15EPOSports(15)_BLK6repl_2016	104.11	102.87	104.11
Size_DbIN_peak_F15EPOSports(15)_BLK6repl_2017	67.01	67.02	67.01

Parameters	2022SA_ SS3.30.14	2022SA_ SS3.30.22	2022SA_ SS3.30.22_ modified
Size_DbIN_peak_F15EPOSports(15)_BLK6repl_2018	180.46	180.48	180.46
Size_DbIN_peak_F15EPOSports(15)_BLK6repl_2019	74.34	73.98	74.33
Size_DbIN_peak_F15EPOSports(15)_BLK6repl_2020	84.99	84.42	84.99
Size_DbIN_top_logit_F15EPOSports(15)_BLK6repl_2015	-2.57	-2.64	-2.57
Size_DbIN_top_logit_F15EPOSports(15)_BLK6repl_2016	-7.62	-7.98	-7.62
Size_DbIN_top_logit_F15EPOSports(15)_BLK6repl_2018	-8.19	-7.50	-8.19
Size_DbIN_top_logit_F15EPOSports(15)_BLK6repl_2019	-2.00	-1.98	-2.00
Size_DbIN_top_logit_F15EPOSports(15)_BLK6repl_2020	-8.66	-8.69	-8.66
Size_DbIN_ascend_se_F15EPOSports(15)_BLK6repl_2015	0.99	1.06	0.99
Size_DbIN_ascend_se_F15EPOSports(15)_BLK6repl_2016	6.12	6.24	6.12
Size_DbIN_ascend_se_F15EPOSports(15)_BLK6repl_2017	1.36	1.64	1.36
Size_DbIN_ascend_se_F15EPOSports(15)_BLK6repl_2018	7.75	9.00	7.75
Size_DbIN_ascend_se_F15EPOSports(15)_BLK6repl_2019	3.56	3.61	3.56
Size_DbIN_ascend_se_F15EPOSports(15)_BLK6repl_2020	5.56	5.56	5.56
Size_DbIN_descend_se_F15EPOSports(15)_BLK6repl_2015	6.23	6.28	6.23
Size_DbIN_descend_se_F15EPOSports(15)_BLK6repl_2016	7.61	7.46	7.61
Size_DbIN_descend_se_F15EPOSports(15)_BLK6repl_2017	2.43	3.52	2.43
Size_DbIN_descend_se_F15EPOSports(15)_BLK6repl_2019	0.79	0.66	0.79
Size_DbIN_descend_se_F15EPOSports(15)_BLK6repl_2020	4.35	4.97	4.36
Size_DbIN_end_logit_F15EPOSports(15)_BLK6repl_2015	-2.40	-2.79	-2.41
Size_DbIN_end_logit_F15EPOSports(15)_BLK6repl_2016	-7.59	-7.77	-7.59
Size_DbIN_end_logit_F15EPOSports(15)_BLK6repl_2017	-2.24	-3.07	-2.24
Size_DbIN_end_logit_F15EPOSports(15)_BLK6repl_2018	-3.33	-3.28	-3.33
Size_DbIN_end_logit_F15EPOSports(15)_BLK6repl_2019	-2.04	-2.70	-2.04
Size_DbIN_end_logit_F15EPOSports(15)_BLK6repl_2020	-2.22	-2.94	-2.22
AgeSel_P2_F5TPSPO(5)_BLK4repl_2004	-2.64	-2.46	-2.65
AgeSel_P2_F5TPSPO(5)_BLK4repl_2011	5.22	5.16	5.23
AgeSel_P2_F5TPSPO(5)_BLK4repl_2015	6.10	6.11	6.11
AgeSel_P5_F5TPSPO(5)_BLK4repl_2004	0.69	0.28	0.66
AgeSel_P5_F5TPSPO(5)_BLK4repl_2011	5.99	5.68	5.97
AgeSel_P5_F5TPSPO(5)_BLK4repl_2015	4.65	4.00	4.62
AgeSel_P6_F5TPSPO(5)_BLK4repl_2004	1.61	1.41	1.62
AgeSel_P6_F5TPSPO(5)_BLK4repl_2011	-4.86	-7.19	-4.85
AgeSel_P6_F5TPSPO(5)_BLK4repl_2015	2.68	2.52	2.68
AgeSel_P7_F5TPSPO(5)_BLK4repl_2004	-1.12	-1.09	-1.13
AgeSel_P7_F5TPSPO(5)_BLK4repl_2011	4.56	6.66	4.55
AgeSel_P7_F5TPSPO(5)_BLK4repl_2015	0.47	0.27	0.47
AgeSel_P8_F5TPSPO(5)_BLK4repl_2004	-6.67	-6.83	-6.65
AgeSel_P8_F5TPSPO(5)_BLK4repl_2011	-8.39	-7.50	-8.40
AgeSel_P8_F5TPSPO(5)_BLK4repl_2015	-8.14	-8.22	-8.14
AgeSel_P2_F10JSN(HK_AM)(10)_BLK7repl_2004	4.49	4.62	4.50
AgeSel_P2_F10JSN(HK_AM)(10)_BLK7repl_2014	6.93	6.14	6.93
AgeSel_P5_F10JSN(HK_AM)(10)_BLK7repl_2004	1.45	1.33	1.45
AgeSel_P5_F10JSN(HK_AM)(10)_BLK7repl_2014	-0.69	-0.96	-0.69

Parameters	2022SA_ SS3.30.14	2022SA_ SS3.30.22	2022SA_ SS3.30.22_ modified
AgeSel_P6_F10JSN(HK_AM)(10)_BLK7repl_2004	-0.71	-1.05	-0.72
AgeSel_P6_F10JSN(HK_AM)(10)_BLK7repl_2014	0.66	-0.16	0.64
AgeSel_P2_F3KOLPS(3)_DEVadd_2007	1.20	1.24	1.20
AgeSel_P2_F3KOLPS(3)_DEVadd_2008	0.48	0.44	0.48
AgeSel_P2_F3KOLPS(3)_DEVadd_2009	-0.42	-0.43	-0.42
AgeSel_P2_F3KOLPS(3)_DEVadd_2010	-0.60	-0.69	-0.60
AgeSel_P2_F3KOLPS(3)_DEVadd_2011	-0.23	-0.23	-0.23
AgeSel_P2_F3KOLPS(3)_DEVadd_2012	-0.69	-0.71	-0.69
AgeSel_P2_F3KOLPS(3)_DEVadd_2013	0.05	0.00	0.04
AgeSel_P2_F3KOLPS(3)_DEVadd_2014	-0.56	-0.57	-0.56
AgeSel_P2_F3KOLPS(3)_DEVadd_2015	0.53	0.47	0.53
AgeSel_P2_F3KOLPS(3)_DEVadd_2016	0.56	0.45	0.56
AgeSel_P2_F3KOLPS(3)_DEVadd_2017	1.26	1.21	1.26
AgeSel_P2_F3KOLPS(3)_DEVadd_2018	0.70	0.69	0.70
AgeSel_P2_F3KOLPS(3)_DEVadd_2019	0.31	0.32	0.31
AgeSel_P2_F3KOLPS(3)_DEVadd_2020	0.58	0.73	0.58
AgeSel_P3_F3KOLPS(3)_DEVadd_2007	0.25	0.37	0.25
AgeSel_P3_F3KOLPS(3)_DEVadd_2008	0.19	0.26	0.19
AgeSel_P3_F3KOLPS(3)_DEVadd_2009	0.40	0.36	0.40
AgeSel_P3_F3KOLPS(3)_DEVadd_2010	-0.23	-0.26	-0.23
AgeSel_P3_F3KOLPS(3)_DEVadd_2011	0.15	0.10	0.15
AgeSel_P3_F3KOLPS(3)_DEVadd_2012	-0.23	-0.23	-0.23
AgeSel_P3_F3KOLPS(3)_DEVadd_2013	-0.58	-0.59	-0.58
AgeSel_P3_F3KOLPS(3)_DEVadd_2014	-0.46	-0.45	-0.46
AgeSel_P3_F3KOLPS(3)_DEVadd_2015	0.13	0.16	0.13
AgeSel_P3_F3KOLPS(3)_DEVadd_2016	-0.06	-0.11	-0.06
AgeSel_P3_F3KOLPS(3)_DEVadd_2017	0.53	0.43	0.53
AgeSel_P3_F3KOLPS(3)_DEVadd_2018	0.85	0.78	0.85
AgeSel_P3_F3KOLPS(3)_DEVadd_2019	0.36	0.35	0.36
AgeSel_P3_F3KOLPS(3)_DEVadd_2020	-0.09	-0.03	-0.09
AgeSel_P4_F4TPSJS(4)_DEVadd_2000	0.21	0.21	0.22
AgeSel_P4_F4TPSJS(4)_DEVadd_2001	0.08	0.08	0.08
AgeSel_P4_F4TPSJS(4)_DEVadd_2002	0.01	0.00	0.01
AgeSel_P4_F4TPSJS(4)_DEVadd_2003	0.49	0.48	0.49
AgeSel_P4_F4TPSJS(4)_DEVadd_2004	-1.22	-1.23	-1.23
AgeSel_P4_F4TPSJS(4)_DEVadd_2005	0.72	0.73	0.72
AgeSel_P4_F4TPSJS(4)_DEVadd_2006	0.97	1.00	0.97
AgeSel_P4_F4TPSJS(4)_DEVadd_2007	-0.01	0.14	-0.06
AgeSel_P4_F4TPSJS(4)_DEVadd_2008	0.49	0.65	0.51
AgeSel_P4_F4TPSJS(4)_DEVadd_2009	1.24	1.33	1.25
AgeSel_P4_F4TPSJS(4)_DEVadd_2010	-1.28	-1.25	-1.28
AgeSel_P4_F4TPSJS(4)_DEVadd_2011	-0.98	-1.28	-1.01
AgeSel_P4_F4TPSJS(4)_DEVadd_2012	0.66	0.65	0.66
AgeSel_P4_F4TPSJS(4)_DEVadd_2013	-1.23	-1.21	-1.23

Parameters	2022SA_ SS3.30.14	2022SA_ SS3.30.22	2022SA_ SS3.30.22_ modified
AgeSel_P4_F4TPSJS(4)_DEVadd_2014	0.76	0.75	0.77
AgeSel_P4_F4TPSJS(4)_DEVadd_2015	0.58	0.54	0.58
AgeSel_P4_F4TPSJS(4)_DEVadd_2016	0.24	0.24	0.24
AgeSel_P4_F4TPSJS(4)_DEVadd_2017	0.46	0.43	0.46
AgeSel_P4_F4TPSJS(4)_DEVadd_2018	-0.92	-1.09	-0.92
AgeSel_P4_F4TPSJS(4)_DEVadd_2019	-1.60	-1.75	-1.59
AgeSel_P4_F4TPSJS(4)_DEVadd_2020	-0.86	-0.99	-0.85
AgeSel_P5_F4TPSJS(4)_DEVadd_2000	0.37	0.37	0.37
AgeSel_P5_F4TPSJS(4)_DEVadd_2001	0.29	0.27	0.29
AgeSel_P5_F4TPSJS(4)_DEVadd_2002	0.10	0.09	0.10
AgeSel_P5_F4TPSJS(4)_DEVadd_2003	-0.23	-0.24	-0.23
AgeSel_P5_F4TPSJS(4)_DEVadd_2004	-0.33	-0.39	-0.33
AgeSel_P5_F4TPSJS(4)_DEVadd_2005	0.43	0.39	0.43
AgeSel_P5_F4TPSJS(4)_DEVadd_2006	0.99	0.96	0.99
AgeSel_P5_F4TPSJS(4)_DEVadd_2007	-1.21	-1.22	-1.22
AgeSel_P5_F4TPSJS(4)_DEVadd_2008	-0.54	-0.48	-0.54
AgeSel_P5_F4TPSJS(4)_DEVadd_2009	-0.57	-0.52	-0.57
AgeSel_P5_F4TPSJS(4)_DEVadd_2010	-0.21	-0.14	-0.21
AgeSel_P5_F4TPSJS(4)_DEVadd_2011	-0.25	-0.20	-0.24
AgeSel_P5_F4TPSJS(4)_DEVadd_2012	0.74	0.73	0.74
AgeSel_P5_F4TPSJS(4)_DEVadd_2013	-0.51	-0.53	-0.51
AgeSel_P5_F4TPSJS(4)_DEVadd_2014	-1.68	-1.63	-1.69
AgeSel_P5_F4TPSJS(4)_DEVadd_2015	-0.59	-0.64	-0.59
AgeSel_P5_F4TPSJS(4)_DEVadd_2016	-0.41	-0.47	-0.41
AgeSel_P5_F4TPSJS(4)_DEVadd_2017	0.78	0.73	0.78
AgeSel_P5_F4TPSJS(4)_DEVadd_2018	-0.71	-0.82	-0.70
AgeSel_P5_F4TPSJS(4)_DEVadd_2019	0.30	0.08	0.30
AgeSel_P5_F4TPSJS(4)_DEVadd_2020	0.35	0.13	0.35
AgeSel_P6_F4TPSJS(4)_DEVadd_2000	0.86	0.91	0.86
AgeSel_P6_F4TPSJS(4)_DEVadd_2001	0.50	0.49	0.49
AgeSel_P6_F4TPSJS(4)_DEVadd_2002	0.45	0.43	0.45
AgeSel_P6_F4TPSJS(4)_DEVadd_2003	-0.47	-0.50	-0.48
AgeSel_P6_F4TPSJS(4)_DEVadd_2004	-0.19	-0.16	-0.19
AgeSel_P6_F4TPSJS(4)_DEVadd_2005	-0.90	-1.01	-0.90
AgeSel_P6_F4TPSJS(4)_DEVadd_2006	0.45	0.34	0.45
AgeSel_P6_F4TPSJS(4)_DEVadd_2007	-0.18	-0.25	-0.18
AgeSel_P6_F4TPSJS(4)_DEVadd_2008	-0.85	-0.93	-0.86
AgeSel_P6_F4TPSJS(4)_DEVadd_2009	-0.28	-0.29	-0.28
AgeSel_P6_F4TPSJS(4)_DEVadd_2010	-0.02	0.03	-0.02
AgeSel_P6_F4TPSJS(4)_DEVadd_2011	-0.58	-0.50	-0.58
AgeSel_P6_F4TPSJS(4)_DEVadd_2012	-0.12	-0.07	-0.12
AgeSel_P6_F4TPSJS(4)_DEVadd_2013	-0.14	-0.10	-0.14
AgeSel_P6_F4TPSJS(4)_DEVadd_2014	-0.50	-0.51	-0.50

Parameters	2022SA_ SS3.30.14	2022SA_ SS3.30.22	2022SA_ SS3.30.22_ modified
AgeSel_P6_F4TPSJS(4)_DEVadd_2015	-0.16	-0.08	-0.16
AgeSel_P6_F4TPSJS(4)_DEVadd_2016	-0.66	-0.68	-0.66
AgeSel_P6_F4TPSJS(4)_DEVadd_2017	-0.74	-0.74	-0.74
AgeSel_P6_F4TPSJS(4)_DEVadd_2018	-0.54	-0.59	-0.53
AgeSel_P6_F4TPSJS(4)_DEVadd_2019	-0.31	-0.42	-0.31
AgeSel_P6_F4TPSJS(4)_DEVadd_2020	-0.04	-0.26	-0.04
AgeSel_P7_F4TPSJS(4)_DEVadd_2000	-0.27	-0.28	-0.27
AgeSel_P7_F4TPSJS(4)_DEVadd_2001	0.57	0.57	0.57
AgeSel_P7_F4TPSJS(4)_DEVadd_2002	0.58	0.56	0.58
AgeSel_P7_F4TPSJS(4)_DEVadd_2003	0.01	-0.04	0.01
AgeSel_P7_F4TPSJS(4)_DEVadd_2004	-0.46	-0.46	-0.46
AgeSel_P7_F4TPSJS(4)_DEVadd_2005	-0.25	-0.24	-0.24
AgeSel_P7_F4TPSJS(4)_DEVadd_2006	-0.63	-0.70	-0.63
AgeSel_P7_F4TPSJS(4)_DEVadd_2007	-0.25	-0.34	-0.25
AgeSel_P7_F4TPSJS(4)_DEVadd_2008	-0.26	-0.34	-0.26
AgeSel_P7_F4TPSJS(4)_DEVadd_2009	0.01	-0.05	0.00
AgeSel_P7_F4TPSJS(4)_DEVadd_2010	-0.13	-0.09	-0.13
AgeSel_P7_F4TPSJS(4)_DEVadd_2011	-0.13	-0.04	-0.13
AgeSel_P7_F4TPSJS(4)_DEVadd_2012	-0.23	-0.11	-0.23
AgeSel_P7_F4TPSJS(4)_DEVadd_2013	-0.39	-0.28	-0.39
AgeSel_P7_F4TPSJS(4)_DEVadd_2014	-0.31	-0.27	-0.31
AgeSel_P7_F4TPSJS(4)_DEVadd_2015	-0.51	-0.51	-0.51
AgeSel_P7_F4TPSJS(4)_DEVadd_2016	0.00	0.03	0.00
AgeSel_P7_F4TPSJS(4)_DEVadd_2017	-0.32	-0.32	-0.32
AgeSel_P7_F4TPSJS(4)_DEVadd_2018	-0.32	-0.32	-0.32
AgeSel_P7_F4TPSJS(4)_DEVadd_2019	-0.18	-0.25	-0.18
AgeSel_P7_F4TPSJS(4)_DEVadd_2020	-0.11	-0.25	-0.11
AgeSel_P8_F4TPSJS(4)_DEVadd_2000	-0.12	-0.13	-0.12
AgeSel_P8_F4TPSJS(4)_DEVadd_2001	-0.04	-0.01	-0.03
AgeSel_P8_F4TPSJS(4)_DEVadd_2002	0.61	0.59	0.61
AgeSel_P8_F4TPSJS(4)_DEVadd_2003	0.20	0.13	0.20
AgeSel_P8_F4TPSJS(4)_DEVadd_2004	-0.04	-0.10	-0.04
AgeSel_P8_F4TPSJS(4)_DEVadd_2005	-0.43	-0.45	-0.43
AgeSel_P8_F4TPSJS(4)_DEVadd_2006	-0.26	-0.30	-0.26
AgeSel_P8_F4TPSJS(4)_DEVadd_2007	-0.16	-0.21	-0.16
AgeSel_P8_F4TPSJS(4)_DEVadd_2008	-0.17	-0.25	-0.17
AgeSel_P8_F4TPSJS(4)_DEVadd_2009	0.20	0.13	0.20
AgeSel_P8_F4TPSJS(4)_DEVadd_2010	-0.15	-0.12	-0.15
AgeSel_P8_F4TPSJS(4)_DEVadd_2011	-0.13	-0.04	-0.13
AgeSel_P8_F4TPSJS(4)_DEVadd_2012	-0.09	-0.01	-0.09
AgeSel_P8_F4TPSJS(4)_DEVadd_2013	-0.28	-0.17	-0.28
AgeSel_P8_F4TPSJS(4)_DEVadd_2014	-0.21	-0.16	-0.21
AgeSel_P8_F4TPSJS(4)_DEVadd_2015	-0.38	-0.37	-0.38
AgeSel_P8_F4TPSJS(4)_DEVadd_2016	-0.20	-0.18	-0.20

Parameters	2022SA_ SS3.30.14	0	2022SA_ SS3.30.22_ modified
AgeSel_P8_F4TPSJS(4)_DEVadd_2017	-0.15	-0.15	-0.15
AgeSel_P8_F4TPSJS(4)_DEVadd_2018	-0.24	-0.24	-0.24
AgeSel_P8_F4TPSJS(4)_DEVadd_2019	-0.11	-0.14	-0.11
AgeSel_P8_F4TPSJS(4)_DEVadd_2020	-0.24	-0.35	-0.24
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2004	-1.39	-1.30	-1.50
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2005	-0.78	-0.69	-0.80
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2006	-0.69	-0.53	-0.68
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2007	0.61	0.68	0.59
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2008	0.51	0.52	0.49
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2009	-0.25	-0.24	-0.26
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2010	-0.22	-0.26	-0.22
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2011	0.52	0.57	0.51
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2012	-0.97	-0.98	-0.99
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2013	0.00	0.00	0.00
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2014	-0.23	-0.23	-0.23
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2015	0.00	0.00	0.00
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2016	0.79	0.74	0.78
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2017	0.73	0.71	0.72
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2018	0.20	0.21	0.19
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2019	0.61	0.70	0.60
AgeSel_P2_F18JSPPS(S2)(18)_DEVadd_2020	0.39	0.59	0.39