

Supplementary materials

Fecundity trends of Chinook salmon in the Pacific Northwest

Malick et al.

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Supplemental tables

Table S1: Summary of Chinook salmon hatchery stocks. 'Number' gives the stock number used in figure 1, 'Hatchery' gives the name of the releasing hatchery, 'Region' gives the geographic region of the hatchery, 'Run' gives the run timing, 'Release' gives the predominate smolt release type, 'Years' gives the range of release years available, 'N' gives the number of years of data, and 'Length' specifies if the stock had corresponding body length data.

Number	Hatchery	Region	Run	Release	Years	N	Length
1	Solduc	Coast	Spring	Mixed	1995–2007	12	
2	Forks Creek	Coast	Fall	Sub-yearling	1995–2018	19	y
3	Humptulips	Coast	Fall	Sub-yearling	1995–2019	25	
4	Lk Aberdeen	Coast	Fall	Sub-yearling	1996–2018	11	
5	Naselle	Coast	Fall	Sub-yearling	1995–2018	18	
6	Nemah	Coast	Fall	Sub-yearling	1995–2013	15	
7	Hupp Springs Rearing	Puget Sound	Spring	Mixed	1995–2009	11	
8	Kendall Cr	Puget Sound	Spring	Sub-yearling	1995–2019	19	
9	Marblemount	Puget Sound	Spring	Mixed	1995–2019	25	y
10	Minter Cr	Puget Sound	Spring	Mixed	1999–2019	10	
11	Garrison	Puget Sound	Fall	Mixed	1996–2016	17	
12	George Adams	Puget Sound	Fall	Sub-yearling	1995–2019	25	y
13	Glenwood Springs	Puget Sound	Fall	Mixed	2000–2017	12	
14	Hoodsport	Puget Sound	Fall	Mixed	1996–2019	24	y
15	Issaquah	Puget Sound	Fall	Sub-yearling	1995–2019	25	
16	Minter Cr	Puget Sound	Fall	Mixed	1995–2019	25	
17	Samish	Puget Sound	Fall	Mixed	1995–2019	24	
18	Soos Creek	Puget Sound	Fall	Mixed	1995–2019	25	y
19	Tumwater Falls	Puget Sound	Fall	Mixed	1995–2019	25	
20	Voights Cr	Puget Sound	Fall	Sub-yearling	1995–2019	25	
21	Marblemount	Puget Sound	Summer	Sub-yearling	1995–2019	25	
22	Wallace R	Puget Sound	Summer	Mixed	1995–2019	24	y
23	Carson NFH	Lower Columbia	Spring	Yearling	1995–2019	25	y
24	Cowlitz Salmon	Lower Columbia	Spring	Yearling	1995–2019	24	y
25	Kalama Falls	Lower Columbia	Spring	Yearling	1995–2019	25	y
26	Little White Salmon NFH	Lower Columbia	Spring	Yearling	1995–2019	25	y
27	Speelyai	Lower Columbia	Spring	Mixed	1995–2019	21	
28	Cowlitz Salmon	Lower Columbia	Fall	Sub-yearling	1995–2019	25	y
29	Elochoman	Lower Columbia	Fall	Sub-yearling	1995–2008	14	
30	Fallert Cr	Lower Columbia	Fall	Sub-yearling	1995–2017	12	
31	Kalama Falls	Lower Columbia	Fall	Sub-yearling	1995–2019	25	y
32	Little White Salmon NFH	Lower Columbia	Fall	Sub-yearling	1995–2019	25	y

Number	Hatchery	Region	Run	Release	Years	N	Length
33	North Toutle	Lower Columbia	Fall	Sub-yearling	1995–2019	25	
34	Spring Creek NFH	Lower Columbia	Fall	Sub-yearling	1995–2019	25	y
35	Washougal	Lower Columbia	Fall	Sub-yearling	1995–2019	23	y
36	Eastbank	Upper Columbia	Spring	Mixed	2001–2019	16	
37	Entiat NFH	Upper Columbia	Spring	Yearling	1995–2006	12	
38	Leavenworth NFH	Upper Columbia	Spring	Yearling	1995–2019	25	y
39	Methow	Upper Columbia	Spring	Mixed	1996–2014	14	
40	Winthrop NFH	Upper Columbia	Spring	Yearling	1997–2019	22	y
41	Eastbank	Upper Columbia	Summer	Mixed	1995–2019	25	
42	Entiat NFH	Upper Columbia	Summer	Yearling	2010–2019	10	
43	Wells	Upper Columbia	Summer	Mixed	1996–2017	10	y

Table S2: Summary of the number of females spawned by hatchery. ‘Number’ gives the stock number used in figure 1, ‘Hatchery’ gives the name of the releasing hatchery, ‘Run’ gives the run timing, ‘Min. N’ gives the minimum number of females spawned in a year, ‘Median N’ gives the median number of females spawned across all years, and ‘Max. N’ gives the maximum number of females spawned in a year.

Number	Hatchery	Run	Min. N	Median N	Max. N
1	Solduc	Spring	55	66.0	208
2	Forks Creek	Fall	711	1046.0	2254
3	Humptulips	Fall	41	145.0	217
4	Lk Aberdeen	Fall	15	21.0	99
5	Naselle	Fall	72	644.0	1499
6	Nemah	Fall	230	431.0	1147
7	Hupp Springs Rearing	Spring	107	212.0	723
8	Kendall Cr	Spring	78	286.0	606
9	Marblemount	Spring	120	170.0	463
10	Minter Cr	Spring	72	156.5	262
11	Marblemount	Summer	31	40.0	46
12	Wallace R	Summer	319	823.0	1220
13	Garrison	Fall	18	123.0	603
14	George Adams	Fall	762	1134.0	1922
15	Glenwood Springs	Fall	60	192.5	259
16	Hoodsport	Fall	90	713.0	1994
17	Issaquah	Fall	330	532.0	739
18	Minter Cr	Fall	89	529.0	1588
19	Samish	Fall	939	1608.5	2995
20	Soos Creek	Fall	863	1171.0	2104
21	Tumwater Falls	Fall	787	1281.0	2363
22	Voights Cr	Fall	176	525.0	972
23	Carson NFH	Spring	233	525.0	933
24	Cowlitz Salmon	Spring	358	567.0	943
25	Kalama Falls	Spring	44	148.0	443
26	Little White Salmon NFH	Spring	202	424.0	1087
27	Speelyai	Spring	163	437.0	802
28	Cowlitz Salmon	Fall	376	1148.0	2041
29	Elochoman	Fall	203	474.0	898
30	Fallert Cr	Fall	23	91.0	754
31	Kalama Falls	Fall	749	1117.0	1801
32	Little White Salmon NFH	Fall	646	1350.0	4059
33	North Toutle	Fall	99	382.0	657
34	Spring Creek NFH	Fall	2401	3747.0	6265
35	Washougal	Fall	349	1017.0	2501
36	Eastbank	Spring	43	101.5	241

Number	Hatchery	Run	Min. N	Median N	Max. N
37	Entiat NFH	Spring	58	143.5	281
38	Leavenworth NFH	Spring	212	476.0	572
39	Methow	Spring	69	176.5	337
40	Winthrop NFH	Spring	44	204.0	584
41	Eastbank	Summer	215	382.0	510
42	Entiat NFH	Summer	50	150.0	155
43	Wells	Summer	255	451.5	735

Table S3: Summary of Chinook salmon length data. ‘Number’ gives the stock number used in figure 1, ‘Hatchery’ gives the name of the releasing hatchery, ‘Run’ gives the run timing, ‘N years’ gives the number of years of data, ‘Min. N’ gives the minimum number of body length samples for a year, ‘Median N’ gives the median length samples for a year, and ‘Max. N’ gives the maximum length samples for a year.

Number	Hatchery	Run	Age	N years	Min. N	Median N	Max. N
2	Forks Creek	Fall	4	15	11	56.0	256
2	Forks Creek	Fall	5	14	14	28.0	147
9	Marblemount	Spring	3	19	3	7.0	44
9	Marblemount	Spring	4	23	38	64.0	97
9	Marblemount	Spring	5	22	6	31.5	83
12	Wallace R	Summer	3	13	3	6.0	30
12	Wallace R	Summer	4	15	49	82.0	117
12	Wallace R	Summer	5	15	8	33.0	48
14	George Adams	Fall	3	24	3	36.5	93
14	George Adams	Fall	4	24	13	52.0	92
14	George Adams	Fall	5	18	3	7.5	28
16	Hoodsport	Fall	3	19	4	15.0	42
16	Hoodsport	Fall	4	20	14	27.0	75
16	Hoodsport	Fall	5	11	3	6.0	16
20	Soos Creek	Fall	3	25	7	23.0	72
20	Soos Creek	Fall	4	25	19	57.0	98
20	Soos Creek	Fall	5	23	3	14.0	31
23	Carson NFH	Spring	4	24	78	337.0	1455
23	Carson NFH	Spring	5	24	3	21.0	270
24	Cowlitz Salmon	Spring	4	25	14	48.0	225
24	Cowlitz Salmon	Spring	5	25	6	34.0	230
24	Cowlitz Salmon	Spring	3	12	3	8.0	33
25	Kalama Falls	Spring	4	22	3	20.0	59
25	Kalama Falls	Spring	5	24	6	27.5	58
26	Little White Salmon NFH	Spring	4	25	71	223.0	709
26	Little White Salmon NFH	Spring	5	24	3	25.5	211
28	Cowlitz Salmon	Fall	3	24	4	10.5	37
28	Cowlitz Salmon	Fall	4	25	4	19.0	51
28	Cowlitz Salmon	Fall	5	17	3	6.0	12
31	Kalama Falls	Fall	3	16	3	7.0	45
31	Kalama Falls	Fall	4	25	6	21.0	69
31	Kalama Falls	Fall	5	21	4	8.0	29
32	Little White Salmon NFH	Fall	3	23	3	17.0	67
32	Little White Salmon NFH	Fall	4	25	52	233.0	655
32	Little White Salmon NFH	Fall	5	25	14	130.0	366
34	Spring Creek NFH	Fall	3	25	150	415.0	804

Number	Hatchery	Run	Age	N years	Min. N	Median N	Max. N
34	Spring Creek NFH	Fall	4	25	6	103.0	317
35	Washougal	Fall	3	22	3	11.0	28
35	Washougal	Fall	4	25	7	16.0	41
35	Washougal	Fall	5	15	3	8.0	18
38	Leavenworth NFH	Spring	4	25	75	329.0	1503
38	Leavenworth NFH	Spring	5	25	3	32.0	343
40	Winthrop NFH	Spring	4	24	6	221.5	1113
40	Winthrop NFH	Spring	5	21	3	11.0	171
43	Wells	Summer	4	25	12	42.0	95
43	Wells	Summer	5	25	39	73.0	122
43	Wells	Summer	3	11	3	7.0	20

Supplemental figures

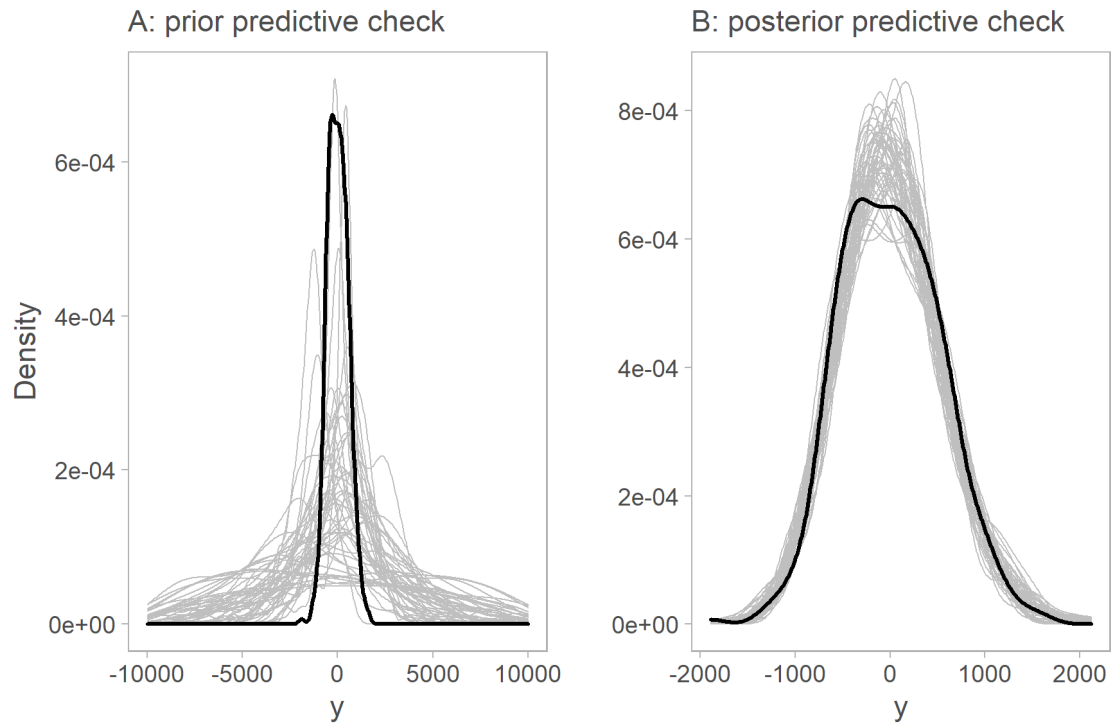


Figure S1: Predictive checks for the fecundity-length regression model. (A) Prior predictive check, black line shows the density of observed fecundity values (mean centered) and the light grey lines show 50 prior model predictions. (B) Posterior predictive check, black line shows the density of observed fecundity values (mean centered) and the light grey lines show 50 posterior model predictions.

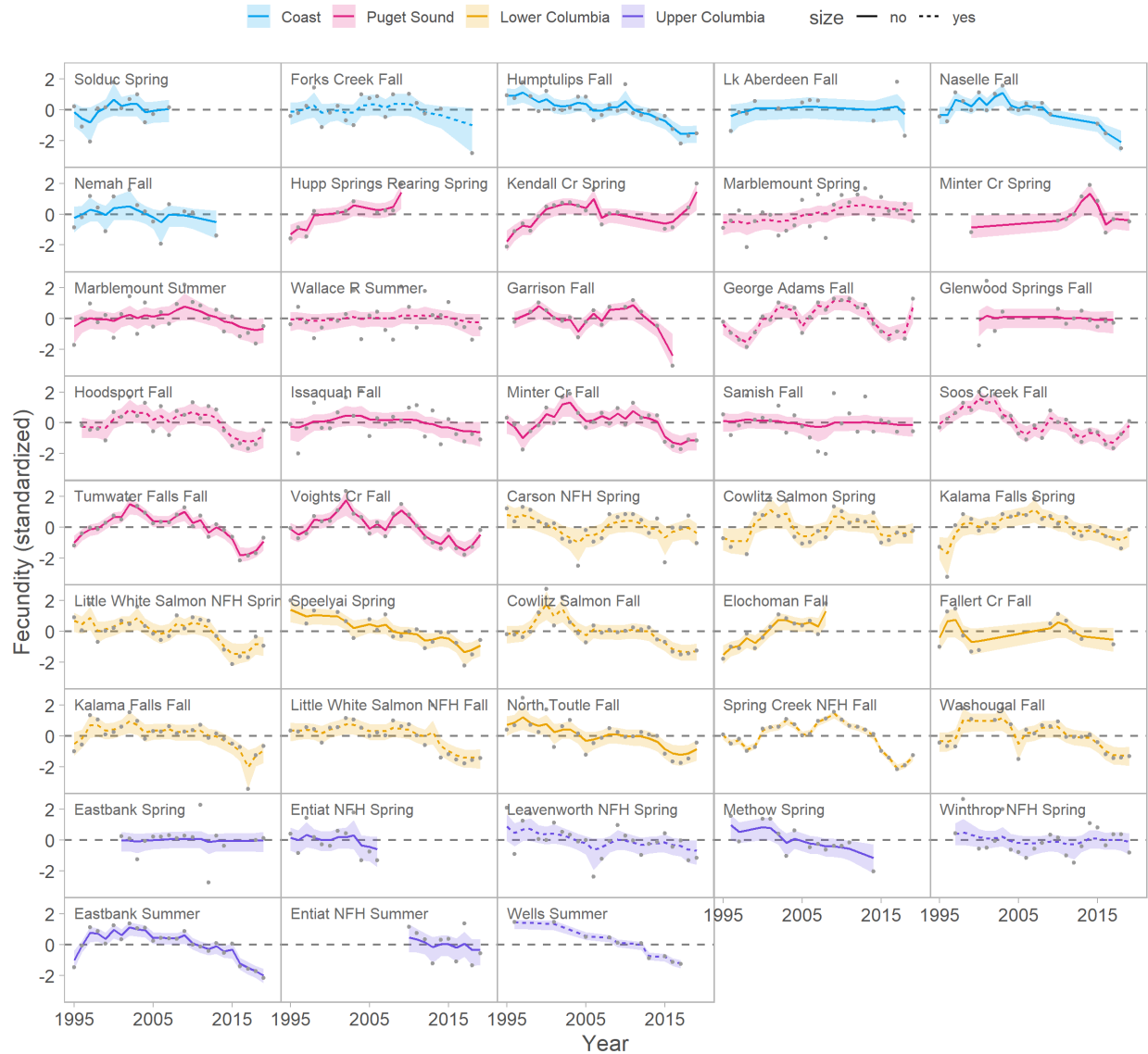


Figure S2: Stock-specific fecundity trends from the univariate state-space random walk models. Shaded regions give the 90% credibility intervals. Light grey dots indicate observed data and dark grey dots indicate data that were missing. Dashed trend lines indicate stocks that had length data available.

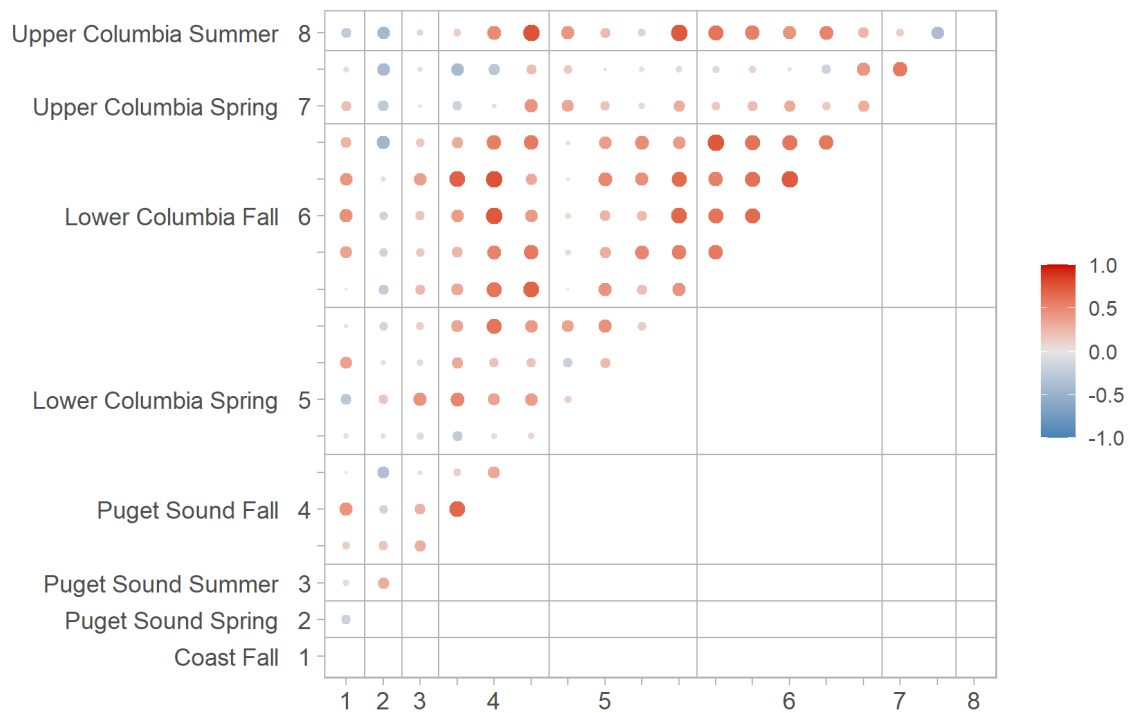


Figure S3: Pairwise correlations of fecundity time series for the 18 stocks that had length and age data. Positive correlations are shown in red and negative correlations in blue. Area of each bubble is proportional to the magnitude of the pairwise correlation between two stocks. Correlations were computed using the raw fecundity data.

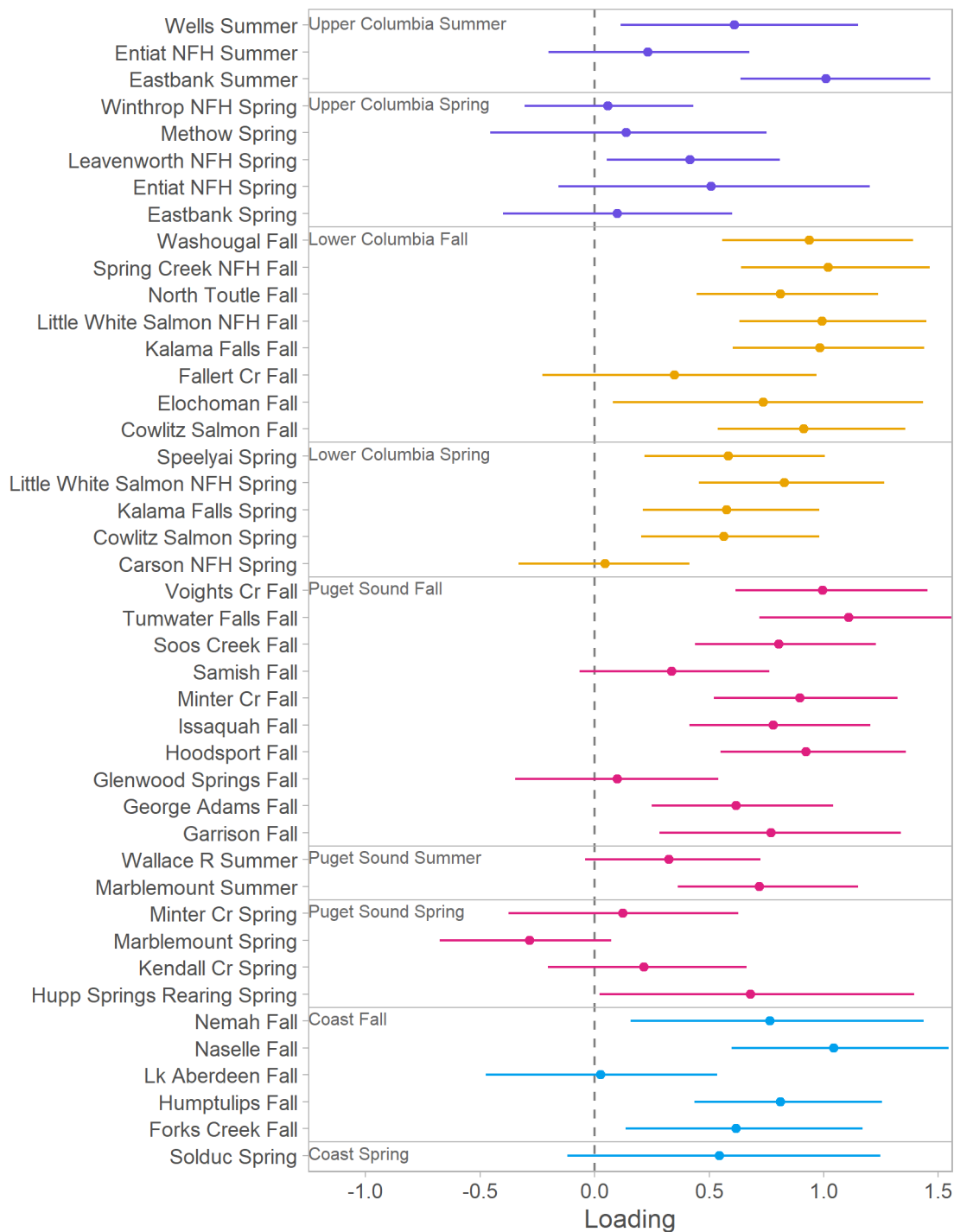


Figure S4: Median stock-specific loadings (dots) from single-trend fecundity DFA model with 90% credibility intervals (horizontal segments).

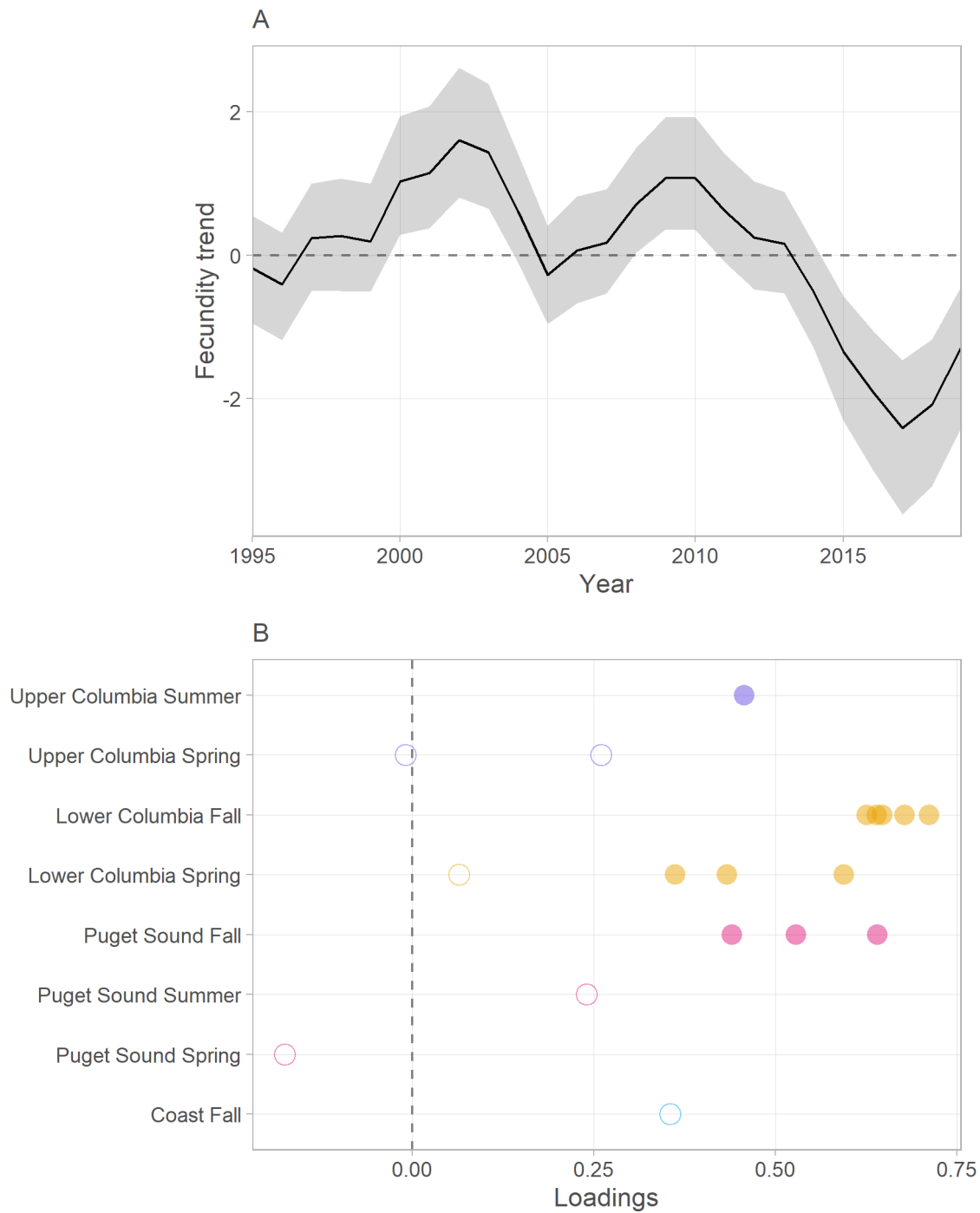


Figure S5: Common fecundity trend and stock-specific loadings from the DFA model that only included the 18 stocks with length and age data. Top panel (A) shows the common fecundity trend across all stocks with 95% credibility interval. Bottom panel (B) shows the median stock-specific loadings on the single trend. Solid dots indicate loadings where the 90% credibility interval excludes zero.

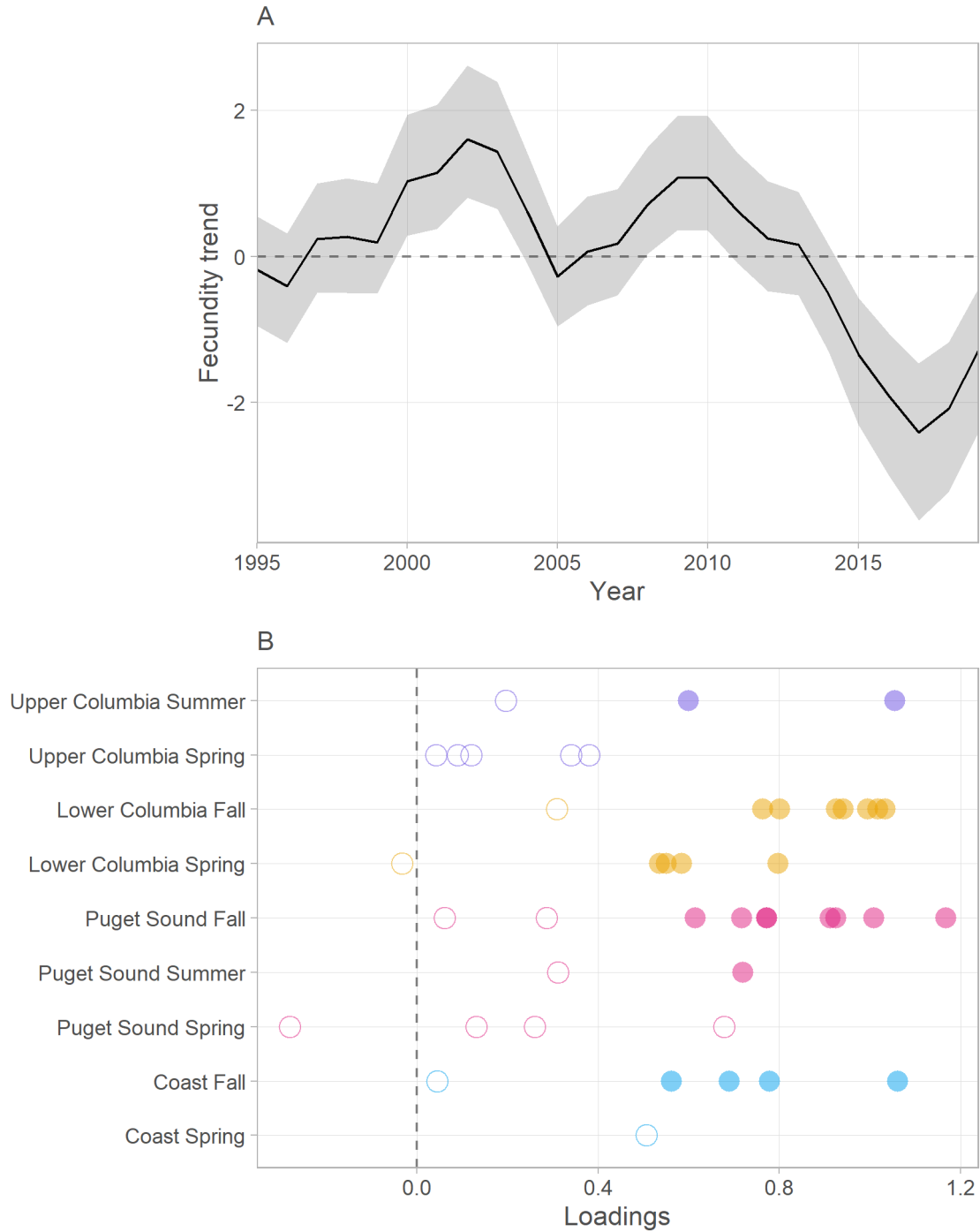


Figure S6: Common fecundity trend and stock-specific loadings from the DFA model fit using a diagonal and unequal variance-covariance matrix. Top panel (A) shows the common fecundity trend across all stocks with 95% credibility interval. Bottom panel (B) shows the median stock-specific loadings on the single trend. Solid dots indicate loadings where the 90% credibility interval excludes zero.

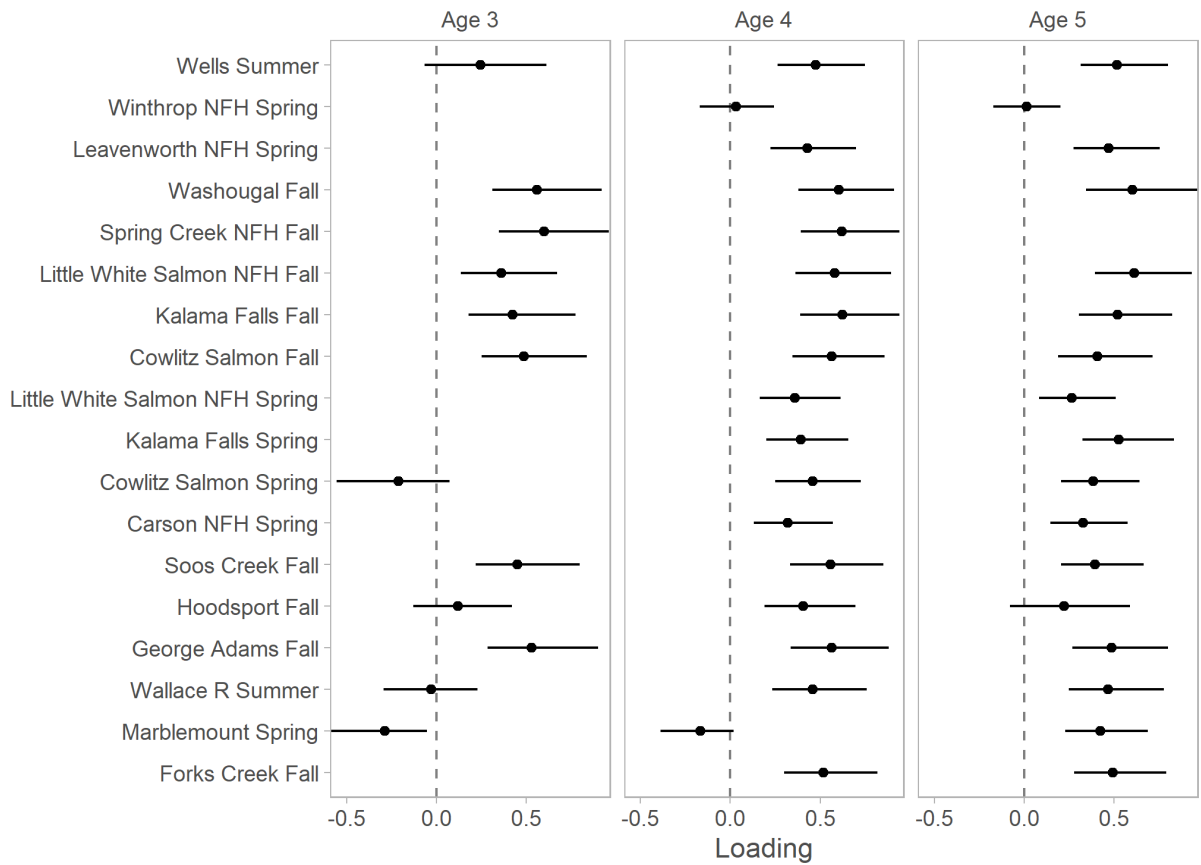


Figure S7: Median stock-specific loadings (dots) from single-trend length-at-age DFA models with 90% credibility intervals (horizontal segments).

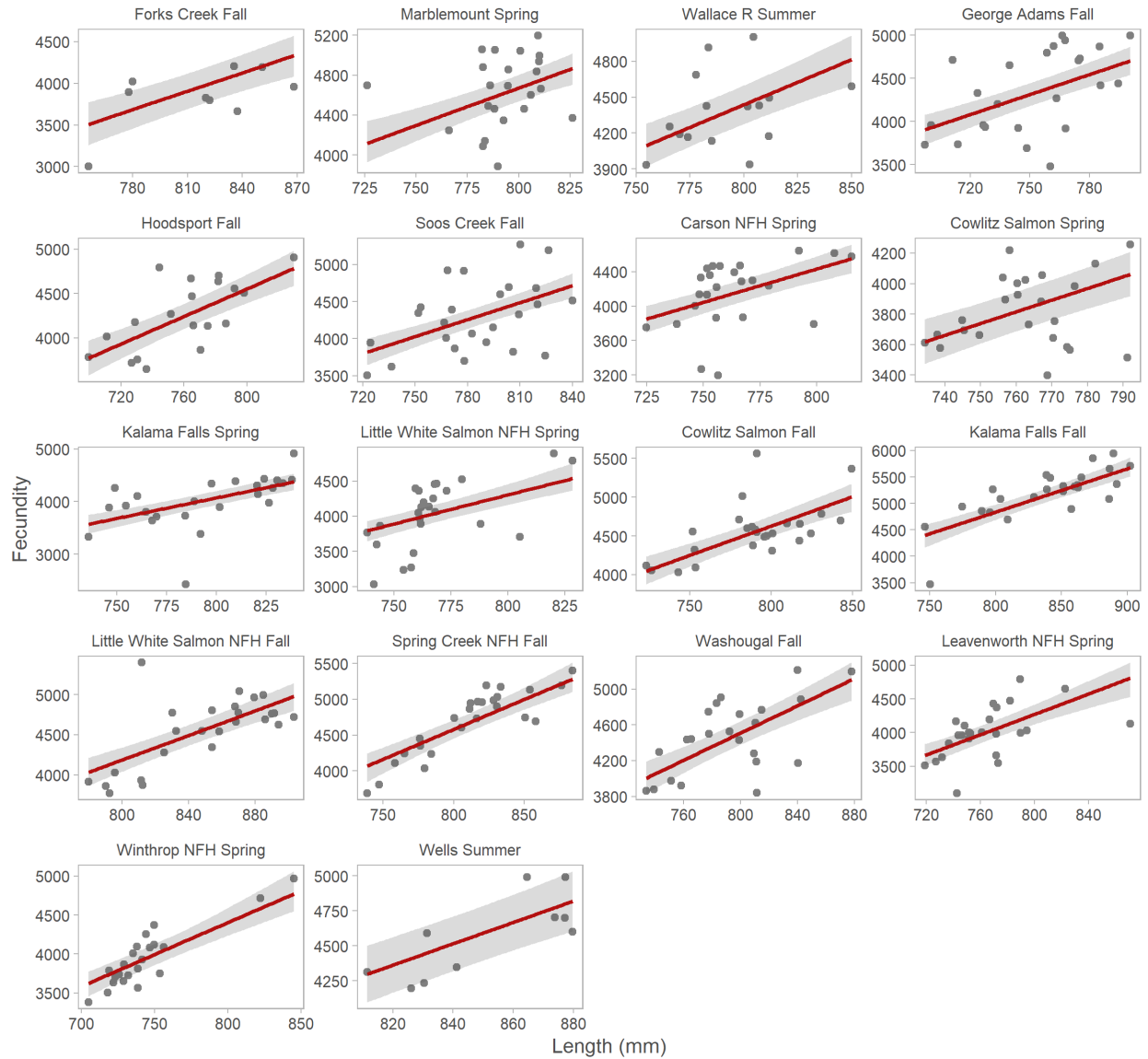


Figure S8: Stock-specific fecundity–length relationships from the hierarchical Bayesian model. Red lines are the stock-specific regression lines, grey bands show the 95% credibility intervals, and grey dots show the observed data (mean stock fecundity for a year and mean stock female body length).

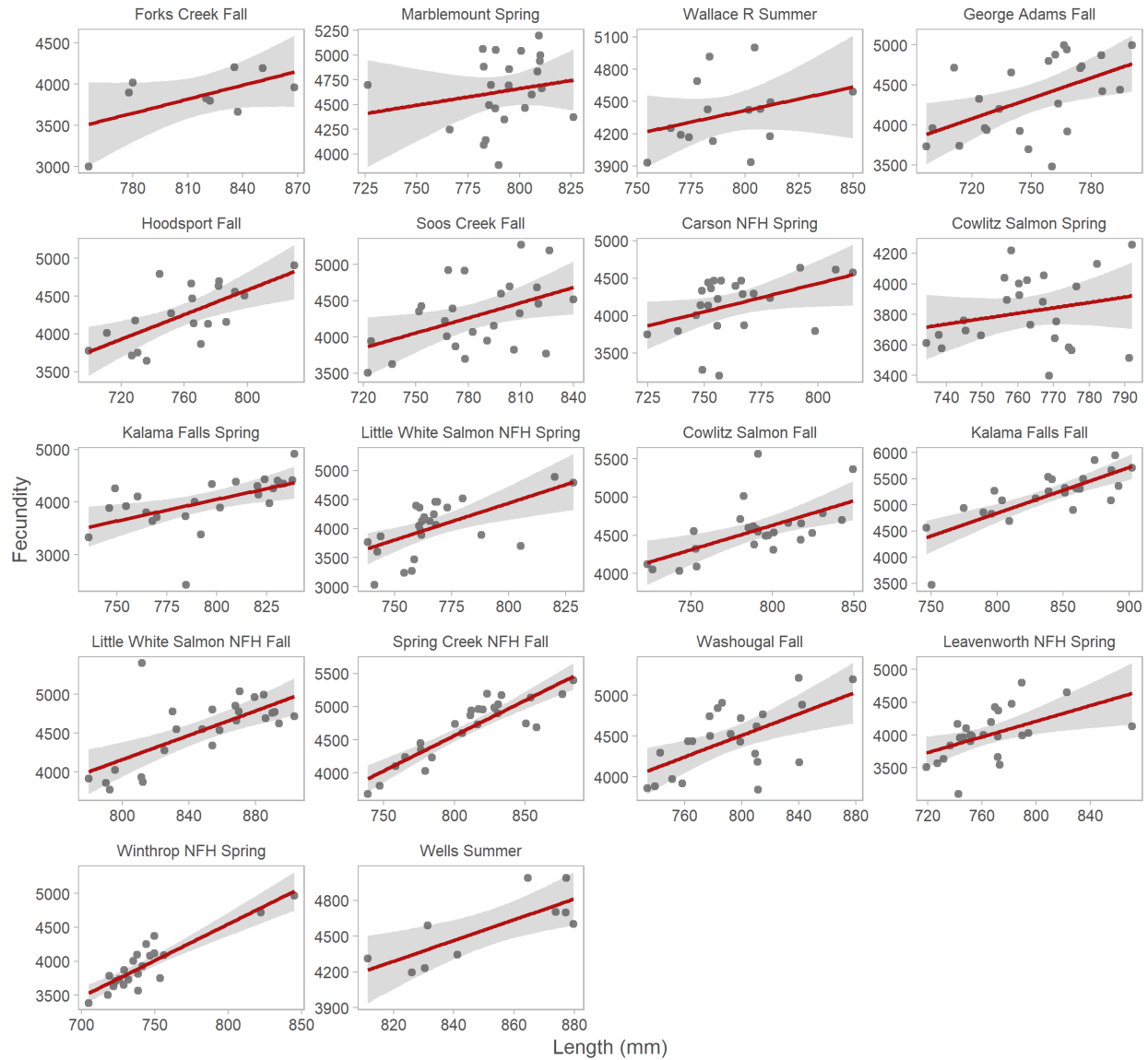


Figure S9: Stock-specific fecundity–length relationships from individual stock models. Red lines are the stock-specific regression lines, grey bands show the 95% credibility intervals, and grey dots show the observed data (mean stock fecundity for a year and mean stock female body length).

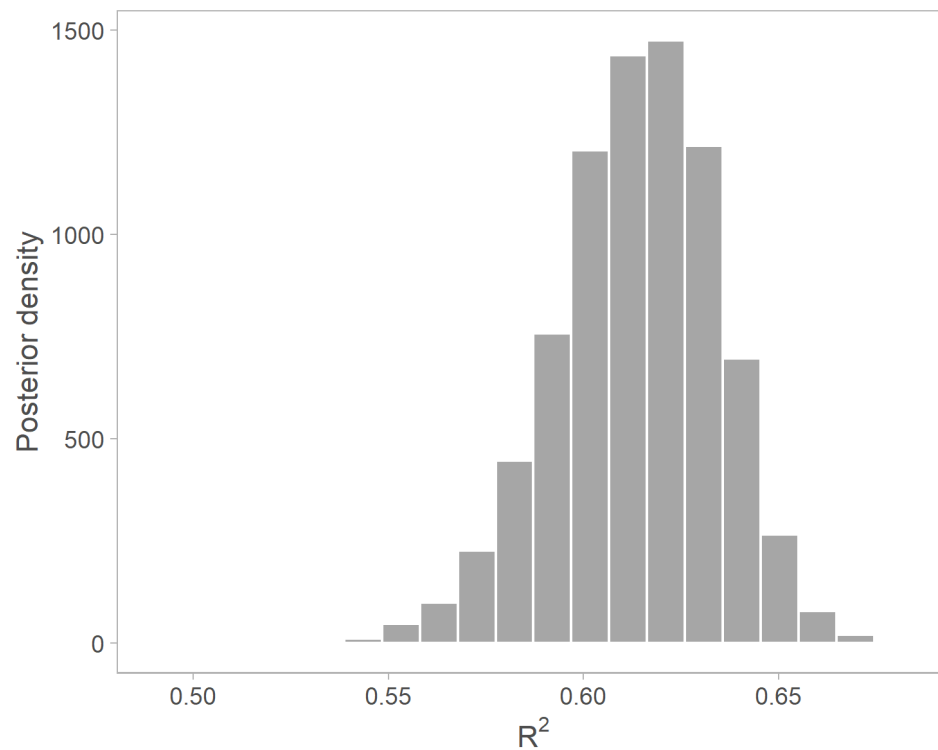


Figure S10: Posterior distribution of R^2 values for the hierarchical fecundity-length model.

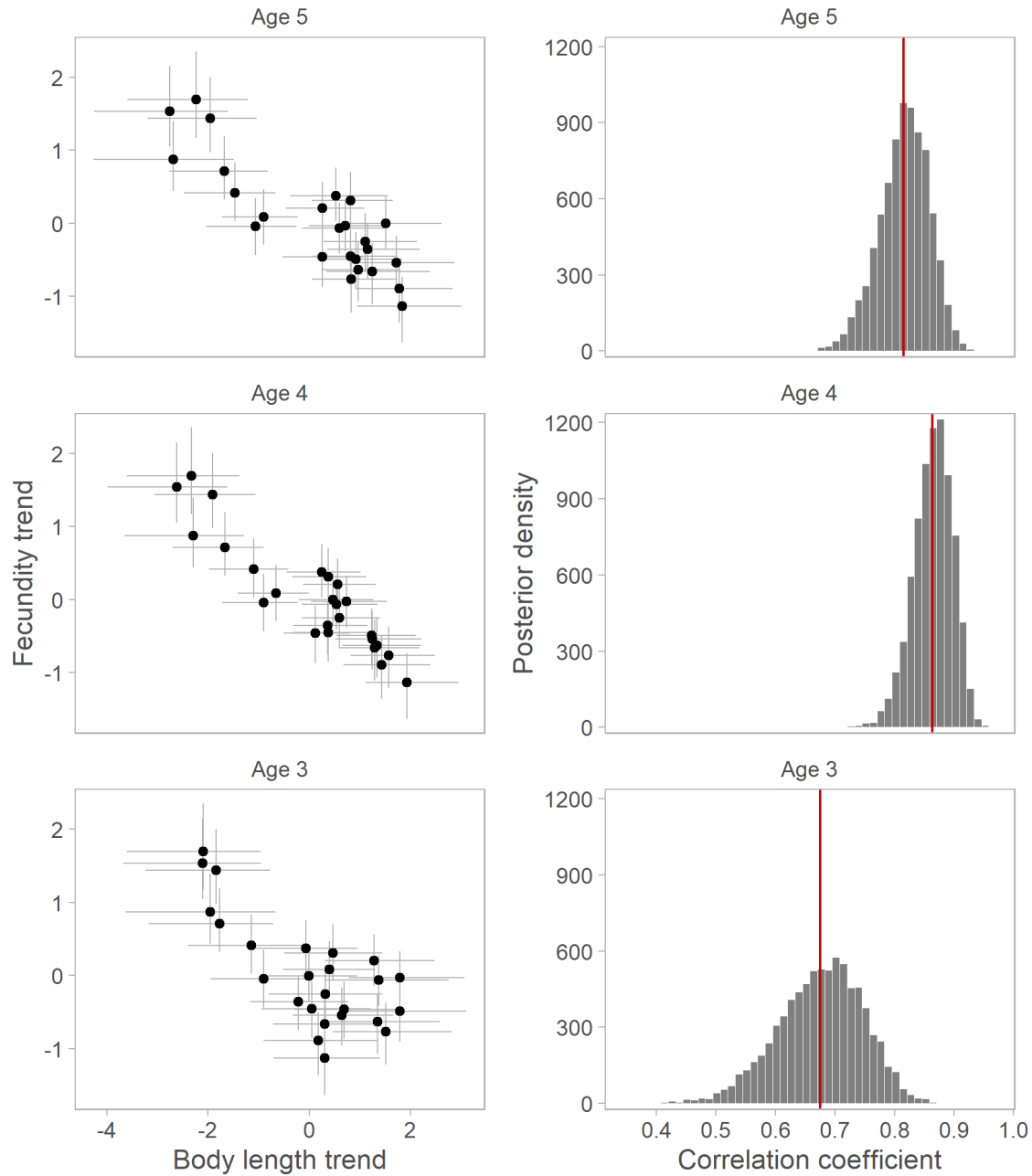


Figure S11: Correlations between common fecundity and length-at-age trends. Left column shows the annual values of the common fecundity trend plotted against the common length-at-age trend values. Grey segments give the 95% credibility intervals in each dimension. Right column shows the distribution of correlation coefficients generated from correlating each MCMC simulation of the common trends for fecundity and length-at-age. Red vertical line shows the mean correlation for each age.