2014 Salmon Methodology Review

Standardized Method to Calculate Chinook Age 2 FRAM Stock Recruit Scalars, Based Upon the Age 3 Forecast

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BACKGROUND

Work on a new Chinook base period and prior of issues with FRAM age composition identified the need for a new way of forecasting the age 2 cohort. FRAM abundance inputs for Chinook at age 2 received extra focus when it was shown that for most sampled Puget Sound marine sport fisheries, FRAM estimated total encountered sublegal sized Chinook deviated significantly from observed total sublegals. The 2013 Methodology Report: 'Correction to FRAM Algorithms for Modeling Size Limit Changes' (Hagen-Breaux et al 2013) addresses only part of the problem.

Age 2 Chinook are the major component of FRAM estimated Sublegal Encounters. Annual forecasts of expected Chinook abundance, by stock, are perhaps the most important component of the pre-season Fishery Regulation Assessment Model (FRAM). Those forecasts are transformed into age specific FRAM 'cohort size', or 'recruit scalars' (ages 2 through 5) as used in the model algorithms, for model input (model input designated as: Age2, Age3, Age4, and Age5). Presently there is very little substance to most Age2 input forecasts. In Chinook FRAM, the Age2 cohort ages up to be the Age3 cohort in the final timestep, magnifying Exploitation Rate (ER) errors due to poor age 2 forecasts.

From California through British Columbia, a variety of forecasting methods are used. An increasing proportion of regional stock forecasts are by age class, but some continue to be in terms of Total Terminal Runsize (TRS) which needs to be portioned into age class prior to model input. Almost all forecasts are based upon data for age 3 through age 6 Chinook, which dominate the terminal (or mature) run reconstruction datasets and coded wire tag (CWT) recovery datasets. Age 2 Chinook contribute very few CWT recoveries and usually are a very small, often ignored, component of TRS. The regionally produced forecasts for many stocks don't include age 2 components; thus the required Age2 model input is creatively generated by staff assigned to pre-season model preparation.

Chinook FRAM is set up with four sequential timesteps (Table 1). For input into the model, the forecast of abundance for the terminal runsizes (mature fish in timestep 3 for summer/fall stocks) need to be expanded to 'ocean abundance' values at the beginning of the first timestep. A standard method is to produce a set of FRAM ocean abundance recruit scalars that, when modeled with a recent "average fishery regime," produce a set of output TRS values matching that year's TRS forecasts. Age 2 Chinook are again not part of this methodology.

So what does the FRAM model use for required Age2 abundance? When required input is missing, the modelers may resort to:

1. Using base period level abundance (FRAM recruit scalar of 1.0).
2. Apply an adjustment (perhaps for mark rate) to recruit scalar of 1.0.
3. Re-use the input recruit scalar from the preceding year.
4. Or apply an adjustment to previous year recruit scalar.

Appendix Table A presents the pre-season Age2 recruit scalarsused for PFMC pre-season modeling for 2004 through 2013. Some Age2 recruit scalars are seen to change year to year, some do not; none are based upon solid survival rate data. If we had a perfect model these Age2 recruit scalars would reflect changing smolt production levels as compared to the Age2 base period levels, with consideration to recent survival patterns. However, given the large uncertainty in estimating survival to age 2, it is more important to have model input Age2 forecasts that are compatible with model algorithms; i.e. Age2 values that are compatible with the exploitation rate denominators and aging in time step 4.

Model fishery-induced mortalities, primarily due to release mortality rates, of Age2 Chinook can be a significant component of ER calculations. Escapement is calculated in timestep 3 after pre-terminal fishery mortality, maturity of remaining cohorts, and terminal fishery mortality upon the mature cohort. At the beginning of timestep 4, all cohorts age. The Age2 Chinook become Age3, and the influence of poor Age2 forecasts amplifies as the higher Adult Equivalence (AEQ) mortality upon Age3 affects exploitation rate calculations. This timestep 4 Age3 fishery mortality may have no relationship to the stocks' escapements, especially so when the Age2 recruit scalar was not provided as part of (or consistent with) the regionally produced annual forecasts. For some stocks the difference in abundance of Age3 in timestep 1 and timestep 4 has surpassed an order of magnitude due only to the Age2 recruit scalar.

For timestep 4 FRAM will recycle the timestep 1 recruit scalars for Age2 fish, while Age3, Age4, and Age5 abundances are from the aging of the younger cohorts. Because of the potential importance of fishery mortalities of Age3 fish in timestep 4 for ER calculations, basing Age2 stock recruit scalars upon a more reliable forecast is desirable. Given that forecasts for age 3 Chinook are more reliable, **the presented method will calculate NewAge2 stock recruit scalars that will "age up" in timestep 4 to produce Age3 abundance that match the original Age3 timestep 1 stock abundances.** These Age2 recruit scalars will be used in timesteps 1 and 4, as FRAM presently does. There will be no change to present methodology to obtain values for Age3 through Age5 recruit scalars. Stock escapement (model output sum of mature fish for ages 3 through 5) values should not change, or change very little.

Table 1. Chinook FRAM timesteps, and which timesteps' fishery related mortality counts toward exploitation rate calculations and which determine escapement.

		Fishing Mortality	
Timestep	Months	Included in ER Calculations?	Affects escapement?
Time 1	Preceding October-April	no	yes
Time 2	May-June (of management year)	yes	yes
Time 3	July-Sept (of management year)	yes	yes
Time 4	Octr-April (of management year)	yes	no

The structure of Chinook FRAM is such that Age2 abundance has almost no effect upon TRS or estimates of spawner escapement. The FRAM model is for a "fishing year", with mature runsize (ages 3 through 5) producing spawner escapement values. When management focus shifted from staying above minimum escapement values to staying below Exploitation Rate (ER) caps, then mortality of Age2 Chinook potentially became a significant factor. Age2 mortality is included in ER calculations but the minimal Age2 escapement is not. Almost all Age2 fishery related mortality is 'release mortality'. All fishery mortality is adjusted by stock specific Adult Equivalence Values (AEQ) that discount mortality of younger fish. In combination this greatly reduces the influence of Age2 mortalities in ER calculations. By FRAM stock:

$$ER = \frac{\sum_{t=2}^{4}(\mathbf{F_{a2}} + F_{a3} + F_{a4} + F_{a5})}{\sum_{t=2}^{4}(\mathbf{F_{a2}} + F_{a3} + F_{a4} + F_{a5}) + \sum_{t=1}^{3}\sum_{a=3}^{5} Esc}$$

Where: a = age

t = timestep

F = fishing related mortality

Esc = escapement

And where: $\sum F_{a3} = \sum(F_{a3,t2} + F_{a3,t3} + \mathbf{F_{a3,t4}})$

There are essentially two types of abundance inputs affecting ER calculations:

1. Values based upon TRS forecasts, and
2. Values based upon questionable Age2 forecasts (yellow highlighted bolded values)

Note that the Age2 forecast determines the abundance of Age3 Chinook in timestep 4, thus , initial Age2 recruit scalars can contribute to a big part of the fishery mortality in the numerator, especially in timestep 4 when they 'age-up' to Age3 (higher AEQ mortality and usually higher BasePeriodExploitationRates, BPER) but do not contribute to the escapement in the denominator. This can be problematic if Age3 timestep 1 and Age3 timestep 4 abundances are largely mismatched.

Basing Age2 abundance upon the Age3 forecast would add consistency to ER calculations.

METHODS

To explore and apply this alternative Age2 forecast method, the final pre-season 2008 and 2012 PFMC Chinook FRAM model runs were used. The purpose was not to re-evaluate the historic set of preseason model runs, but to check if this method was workable under the current base period and for future modeling. In 2008 a new Chinook FRAM calibration was implemented that included adding four new stocks to the base data, and sets (marked and unmarked) of stock Age2 recruit scalars were updated to values that for most stocks remained unchanged for several years (see Appendix Table A). By 2012 many of those Age2 recruit scalars had changed, and the overall fishery structure was more similar to future expectations.

The same versions of FRAM and supporting 'base data' were used for this exercise as were used in each of these two pre-season years. The forward moving calculation (for each stock) to produce Age3 abundance for timestep 4 starts with the Age2 forecast for timestep 1 and proceeds through timestep 3 (the 2 year olds age up to 3's for timestep 4). The FRAM calculations can be represented as:

(1) $$Cohort_{age3,time4} = Cohort_{age2,time1} \prod_{t=1}^{3} [(1-N_t) * (1-F_t) * (1-M_t)]$$

Where:

Cohort = stock cohort abundance (model input)
N = natural mortality rate (Base Period model constants)
F = fishery related mortality rate (resulting from model inputs)
M = maturation rate (Base Period stock constants)
t = timestep

The objective of the NewAge2 abundance is to produce an Age3 timestep 4 abundance equal to the forecasted Age3 timestep 1 value. Initially this was done by back-calculating through equation (1). Substituting the Age3 abundance from timestep 1 into Age3 abundance at timestep 4, and dividing by Age2 natural mortality, fishery mortality, and maturation rates (going backward by timestep) produced the NewAge2 timestep 1 abundance. Then moving forward through equation (1) the NewAge2 abundance produces a timestep 4 abundance of Age3 fish consistent with the pre-season forecast of Age3 fish for timestep 1, and therefore consistent with Age3 escapement in timestep 3.

If all variables, except the initial Age2 and Age3 forecasts, are constants then the process simplifies to:

(2) $$Age3,t1 / Age3,t4 * Age2,t1 = New\ Age2,t1$$

Per equation (1), Age3 abundance in timestep 4 is a function of initial Age2 timestep 1 input. Equation (2) will work with any initial Age2 forecast but may require a couple of FRAM iterations to stabilize.

However, the annual fishing mortality rates are not constants. To use equations (1) for pre-season planning an average (or expected) set of stock specific fishery mortality rates would be necessary. One source for these rates could be average fishery mortality rates from recent year Chinook Validation Runs, a post-season type of FRAM model run. Another source could be pre-season FRAM mortality from the previous year's planned fisheries.

Chinook FRAM Validation Runs have updated age 3 through age 5 abundances based upon observed Terminal Run Size for those age classes, but continue to use the Age2 recruit scalar from the original pre-season model runs. Applying equation (2) to Chinook FRAM Validation Runs (2003 through 2010 fishing years) produced annual sets of post-season NewAge2 stock abundances. It was seen that there existed a very stable stock specific relationship between the Age3 "forecast" and the NewAge2 "forecast". These constants could be used to calculate NewAge2 stock recruit scalars as:

(3) $$NewAge2Scalars, s, t1 = Age3Scalars, s, t1 * Ks$$

Where:

$$Ks = {}^{Validation\ Run\ NewAge2, s, t1}/_{Validation\ Run\ Age3, s, t1}$$

These calculated stock specific constants ranged from 0.79 to 1.0 (Appendix B). For pre-season application the Age3 recruit scalar at timestep 1 can simply be multiplied by the stock specific constant (k_s) to produce the NewAge2 recruit scalar at timestep 1.

Three variations of calculating a NewAge2 abundance based upon the Age3 abundance have been presented, with the purpose of improving pre-season Age2 abundance model input. For methods (1) and (2), the resulting NewAge2 abundance estimates are divided by Age2 base period abundance to obtain the NewAge2 recruit scalars:

(4) By stock: NewAge2 Recruit Scalars = NewAge2 forecasts/BasePeriod Age2 Abundance

Practical considerations in pre-season application of the three equations.

Equation (1) is applied within a complicated spreadsheet that requires model parameters (by timestep) for age 2 natural mortality rates, and stock specific fishery and maturation rates. The fishery mortality rates are dependent upon annual fishery inputs, either "adopted" from a particular pre-season model run or averaged from recent Validation Runs.

Equation (2) does not require the step by step calculations of equation (1). This condensed method does require a model run, as does equation (1), to obtain values for the variables.

Equation (3) would be the easiest to apply, or directly code into FRAM. A model run with assumed fishery mortality is not needed. The annual Age3 forecast is simply multiplied by stock specific constants (Ks), as derived from NewAge2 Validation Runs. This "short-cut" method of using a constant works because fishery mortality for age 2 Chinook is small and relatively constant from year to year.

The driving variable, in all three equations for the NewAge2 stock abundance estimates, is Age3 at timestep 1. For application of the NewAge2 methodology during pre-season modeling there are two potential sources for the needed Age3 timestep 1 seed abundance. The source of these Age3 abundances could be the annual forecasts. Or the value could be "observed" average Age3 abundance from recent Validation Runs. Neither source is without issue. While the pre-season forecast has inherent forecast error, the Validation Runs lag several years, i.e. for pre-season 2014 planning the most recent Validation year was 2010.

The lack of consistency between Age3 escapement and Age3 fishery mortality in timestep 4 has been identified as a weakness in Chinook FRAM modeling. Using an average Age3 abundance from Validation Runs would address some concerns about Age3 forecast errors, but would introduce error if smolt production and survival has varied since the last set of Validation Runs and the present fishery planning year. Adjustment for hatchery smolt production should be straight forward, but variation in natural production would be difficult to quantify. Differences in annual freshwater and marine survival rates, between the Validation Run years and the present, would need to be addressed.

The age 2 and age 3 cohorts are from different brood years and thus the argument might be made that Age2 abundance should not be expected to be consistent with Age3 input. However, neither should the abundance of the age 2 cohorts invalidate stock specific ER calculations. Possible adjustments for known differences between the Age2 and Age3 brood year smolts (hatchery release levels, marine survival conditions) could be considered on a case by case basis.

RESULTS

The calculated NewAge2 abundances, within the 2008 and 2012 Final PFMC Chinook model runs, increased the overall age 2 population in the model. Some stocks' NewAge2 abundances increased dramatically (greater than 2000% relative increase). A few stocks saw a decrease (as much as 100%). The NewAge2 recruit scalars from 2008 and 2012 FRAM model runs, back-calculated through Equation (1), are presented in Appendix Table A for easy comparison to the original recruit scalars used for those two years. Table 2 presents summary statistics for percent change in Age2 stock abundances, and percent change in total fishery mortality by age, over all stocks. Note that for Age2 cohorts, the percent change in fishery related mortality for each timestep corresponds to the change in Age2 abundance; this is also the case for Age3 fish in timestep 4 (Age2 "aging up").

Graphic representation of the summary statistics for relative percent change in total fishery related mortality of individual stocks, at age and by timestep, is presented in Figures 1 through Figure 4 using box-and-whiskers plots. The box-and-whiskers plots encompass the central quartiles of the data (the central 50% of the data values) in the shaded box with the median value indicated by the heavy black line in the box. The box whiskers include all data values not considered outliers or extreme values. Outliers are marked with open circles and are values between 1.5 and 3 box lengths from the upper or lower edges of the box (Hoaglin et al. 1983). Extreme values are marked by asterisks and are more than three box lengths from the upper or lower edges of the box. Age2 and Age3 outliers, above 500% change in total mortality are not presented in the figures but are summarized in Table 3. The graphic representation of relative change in total fishery mortality for Age3 Chinook also illustrates the "aging-up" process in timestep 4.

Age4 and Age5 cohorts, as well as Age3 in timesteps 1 through 3, showed very little change in fishery mortality resulting from the incorporation of the NewAge2 abundances. However, progressing through the timesteps, an increasing effect is seen in timestep 4 (Figures 2 and 4). This may be attributed to the NewAge2 change in abundance affect upon how fishery quotas were filled. Even though very few age 2 fish are of legal size, there are a lot of them, and the significant increase in overall NewAge2 abundance did increase landed catch for that age class. This would function to allow more of the older fish to survive into the later timesteps and increase their catch, relative to their catch with original Age2 forecasts. Note that more timestep 3 and especially timestep 4 fisheries are modeled with fishery scalars, while earlier timesteps (1 and 2) have relatively more fishery inputs as fishery quota values. However, the scale of relative increase in timestep 4 of Age4 and Age5 mortality, (as high as 10% to 50% for a couple of stocks) is minor compared to the change in Age2 fishery mortality.

Puget Sound Chinook are presently managed with maximum ER caps upon natural stocks, with spawner escapement as another consideration. Re-running the 2008 and 2012 pre-season Chinook model runs with the respective sets of NewAge2 recruit scalars produced different exploitation rates for many stocks, but had little effect on estimates of spawner escapement. For the 2008 model run (Table 4) the effect upon exploitation rates was not as dramatic as seen for the 2012 model run (Table 5).

As an example of NewAge2 recruit scalar affect upon pre-season FRAM outputs we'll look at adjacent Puget Sound fall Chinook stocks, the Unmarked and Marked stocks for Mid Puget Sound Fall Fingerlings (MidPS FF) and for South Puget Sound Fall Fingerling (SPSd FF). These are very large FRAM stocks, and are major contributors to Puget Sound marine sport catch. In both years there is an increase in ER for the component sub-stocks of FRAM's MidPS FF stock, while a sub-stock of FRAM's SPSd FF stock showed a relatively large drop in ER when modeled with NewAge2 recruit scalars. Specifically, total ER for Unmarked Puyallup Falls increased 1.9% in both years while the Unmarked Nisqually Falls showed a decrease of 0.7% and 2.7% for 2008 and 2012 respectively (Table 4 and Table 5). The very low pre-season Age2 recruit scalars for the MidPS FF stocks produced very few Age3 fish for timestep 4 fisheries, while the relatively high pre-season recruit scalars for the Age2 SPSd FF stocks produced an inflated abundance of Age3 in timestep 4. Appendix Table A presents bolded values for the pre-season recruit scalars (2004-2013) used for these stocks, and also shows the NewAge2 recruit scalars calculated for 2008 and 2012. With NewAge2 recruit scalars, the same direction of change in ER values for these stocks would be expected to occur over the last six years of pre-season modeling since neither of these stocks have changed their rather extreme Age2 recruit scalars since 2008.

The population age structures for these stocks, original pre-season compared to NewAge2, is informative. Table 6 presents 2012 age abundance by timestep for the MidPS FF stocks; note the low abundance of Age2 Chinook produced by the original Age2 recruit scalar. The original MidPS FF Age2 (47,249 Marked) is a fraction of its Age3 abundance (307,429 Marked). The original Age2 recruits then 'age up' in timestep 4 to an Age3 abundance (27,696 Marked). The 307,429 value (timestep 1) is based upon a TRS forecast of Age3 fish, while the 27,696 value (timestep 4) is based upon an Age2 recruit scalar unchanged since pre-season 2008. This is an extreme example. The opposite pattern exists for the SPSd FF stocks. Table 7 presents the population age structures for a stock (SPSd FF) that has been modeled with relatively high Age2 recruit scalar. For the Unmarked SPSd FF the original escapement of Age3 fish is from a timestep 3 cohort of 22,677, while the timestep 4 fishery mortality of Age3 fish was calculated from an abundance of 78,901 Age3; producing the inflated original pre-season ER for Nisqually Fall Chinook (Table 5).

Table 8 presents escapements for selected Columbia River Chinook stocks, before and after Age2 recruit scalars adjustments. Escapements should not change much, if any, because Age2 fish are not included in FRAM calculations of "mature terminal runsize". Note that escapement occurs in timestep 3 before the Age2 cohort "ages up". Exploitation rate calculated for Columbia Natural Tule stock uses a brood year approach and thus was not considered sensitive to the Age2 forecasts. The ER value for 2008 did not change but the 2012 ER went up 0.2% (Table 8). We speculate this is because of the overall changes in abundance of all stocks contributing to the major fisheries impacting Columbia River Natural Tule stocks.

Table 2. Summary statistics, over all stocks, of percent change in Age2 abundance and Total Mortality (by age and timestep) with NewAge2 recruit scalars. Ratios are from preseason 2008 and 2012 model runs, calculated as (NewAge2 – preseasonAge2)/preseasonAge2 values.

2008	Age2	Change in Age2 Total Mortality					Change in Age3 Total Mortality				
	Abundance	1	2	3	4	Total	1	2	3	4	Total
Average:	132.3%	**119.9%**	**134.8%**	**133.0%**	**122.3%**	137.7%	1.8%	0.2%	-0.3%	**141.3%**	-2.8%
Minimum:	-96.7%	-96.5%	-96.6%	-96.5%	-96.4%	-96.5%	0.0%	-0.1%	-4.4%	-96.6%	-83.7%
Maximum:	2993.5%	3194.0%	2993.4%	2986.6%	3225.2%	3061.3%	8.1%	4.2%	2.4%	3004.3%	23.6%
St Dev:	505.5%	535.1%	508.7%	507.7%	541.9%	520.6%	2.0%	0.8%	0.9%	519.1%	14.8%
# of Stocks:	64	56	64	64	56	64	66	66	66	64	66

2012	Age2	Change in Age2 Total Mortality					Change in Age3 Total Mortality				
	Abundance	1	2	3	4	Total	1	2	3	4	Total
Average:	101.6%	112.0%	101.9%	106.1%	116.4%	106.7%	1.0%	0.0%	0.8%	105.9%	-3.5%
Minimum:	-100.0%	-100.0%	-100.0%	-100.0%	-100.0%	-100.0%	0.0%	-0.9%	0.0%	-100.0%	-100.0%
Maximum:	2186.4%	2325.4%	2185.8%	2253.7%	2411.4%	2288.3%	6.1%	2.3%	3.9%	2215.3%	17.6%
St Dev:	360.8%	392.7%	361.1%	369.0%	403.5%	372.4%	1.2%	0.3%	0.7%	366.0%	19.1%
# of Stocks:	63	56	63	63	56	63	62	62	62	63	64

2008	Age2	Change in Age4 Total Mortality					Change in Age5 Total Mortality				
	Abundance	1	2	3	4	Total	1	2	3	4	Total
Average:	132.3%	0.0%	0.0%	-0.4%	1.8%	0.0%	0.0%	0.0%	-0.1%	2.1%	0.2%
Minimum:	-96.7%	0.0%	-0.1%	-6.6%	-1.0%	-5.1%	0.0%	-0.3%	-5.9%	-21.4%	-4.3%
Maximum:	2993.5%	0.1%	0.0%	0.7%	8.5%	2.2%	0.0%	0.0%	1.9%	48.9%	3.8%
St Dev:	505.5%	0.0%	0.0%	1.2%	2.0%	1.0%	0.0%	0.1%	1.2%	9.8%	1.1%
# of Stocks:	64	66	66	66	66	66	63	67	67	63	67

2012	Age2	Change in Age4 Total Mortality					Change in Age5 Total Mortality				
	Abundance	1	2	3	4	Total	1	2	3	4	Total
Average:	101.6%	0.0%	0.0%	0.6%	1.7%	0.5%	-0.1%	0.0%	0.8%	2.9%	1.0%
Minimum:	-100.0%	-0.4%	-0.4%	0.0%	-1.0%	0.0%	-9.1%	-5.8%	-5.8%	-0.4%	-1.3%
Maximum:	2186.4%	0.3%	0.3%	3.4%	5.0%	2.0%	7.7%	7.7%	8.0%	43.6%	9.1%
St Dev:	360.8%	0.1%	0.1%	0.7%	1.5%	0.5%	1.7%	1.2%	2.2%	7.9%	2.1%
# of Stocks:	63	67	67	67	62	67	63	65	65	65	67

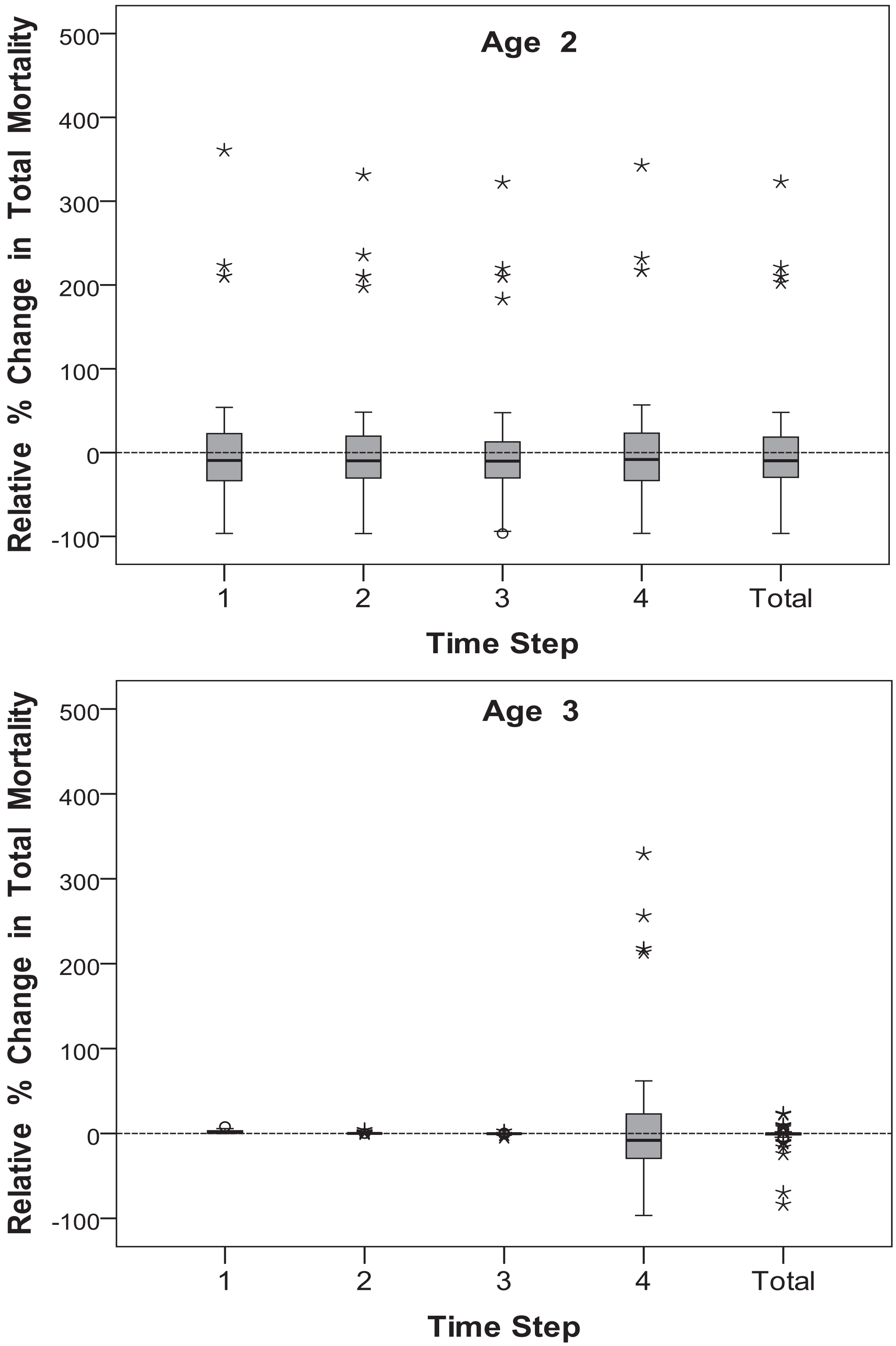

Figure 1. Box-and-whiskers plots of relative change for all stocks in Total Mortality of the Age2 and Age3 cohorts as NewAge2 forecasts were inserted into the 2008 final PFMC Chinook model run. Outliers above 500% removed from plot but are presented in Table 3. See text for quantile and outlier definitions for box-and-whiskers plots.

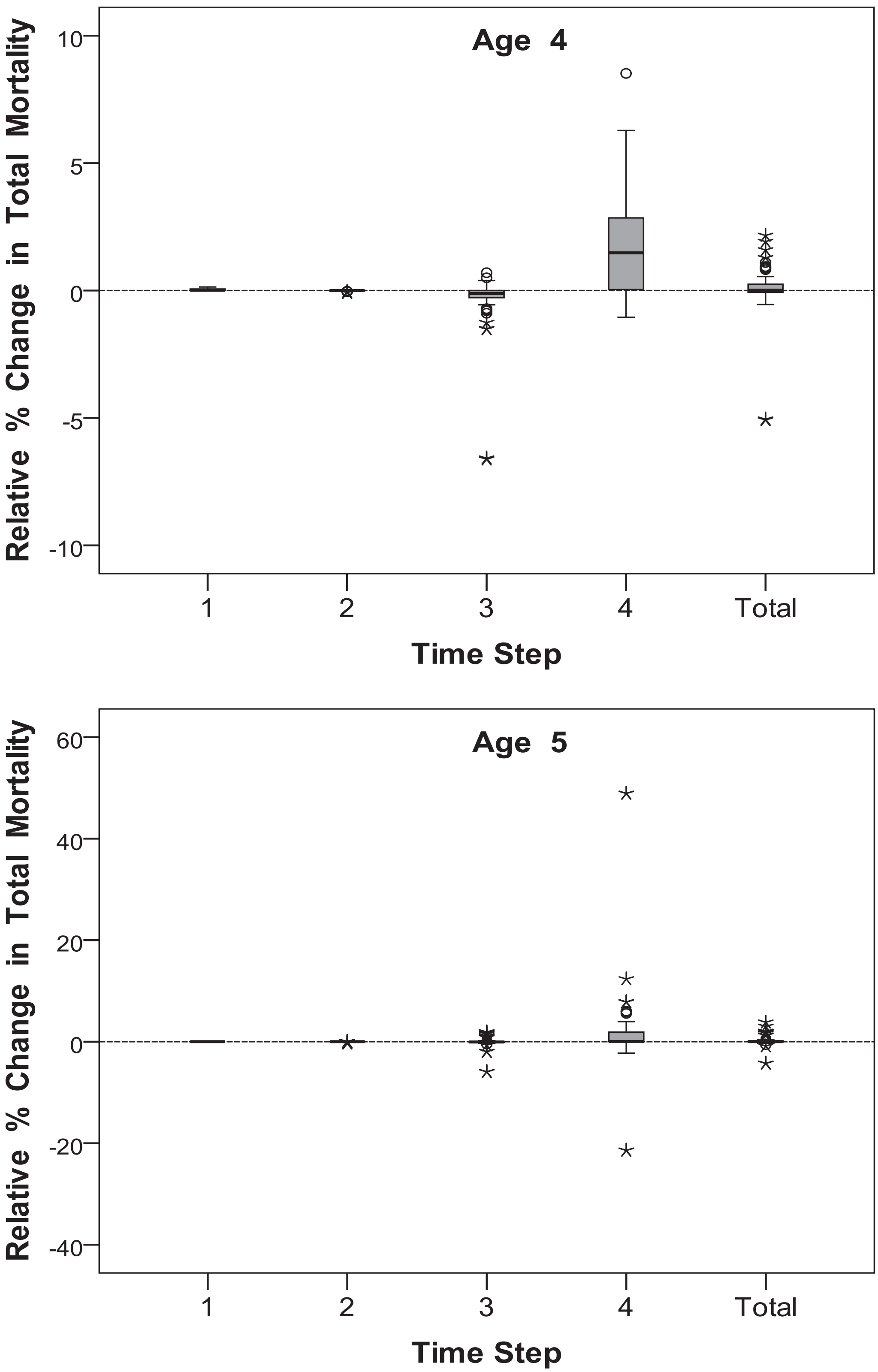

Figure 2. Box-and-whiskers plots of relative change for all stocks in Total Mortality of the Age4 and Age5 cohorts as NewAge2 forecasts were inserted into the 2008 final PFMC Chinook model run. All stocks included in figure.

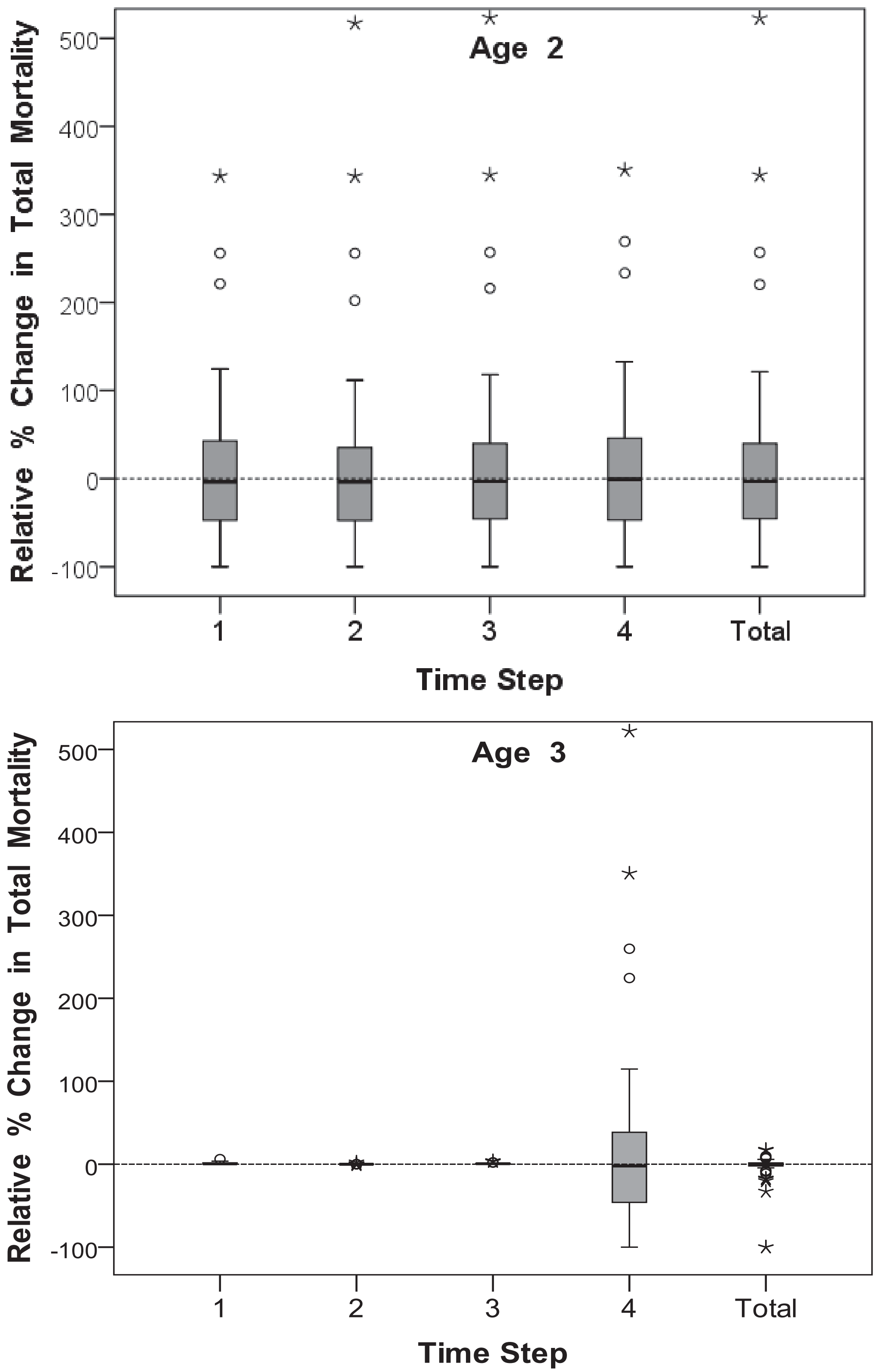

Figure 3. Box-and-whiskers plots of relative change for all stocks in Total Mortality of the Age2 and Age3 cohorts as NewAge2 forecasts were inserted into the 2012 final PFMC Chinook model run. Outliers above 500% removed from plot but are presented in Table 3.

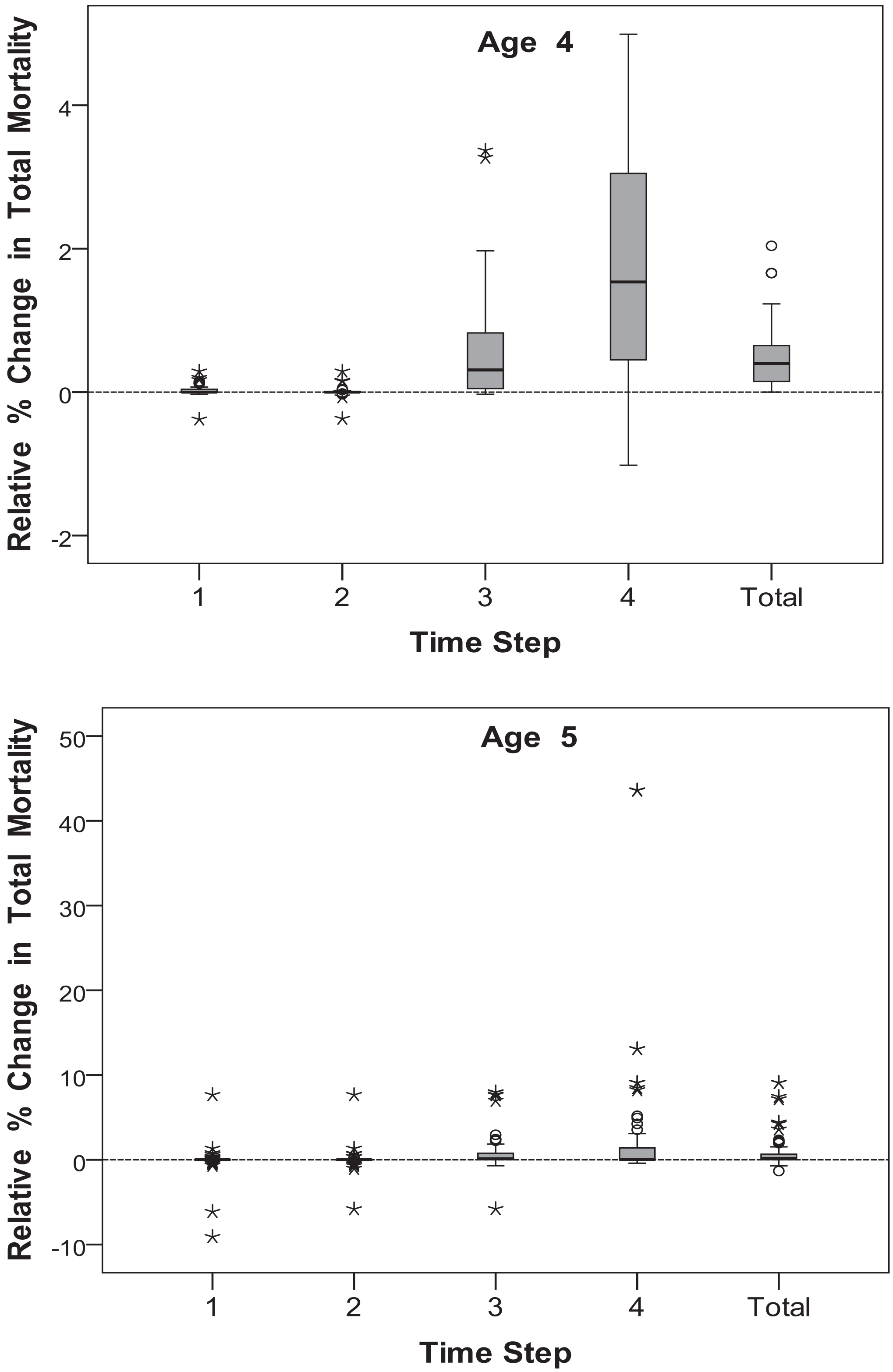

Figure 4. Box-and-whiskers plots of relative change for all stocks in Total Mortality of the Age4 and Age5 cohorts as NewAge2 forecasts were inserted into the 2012 final PFMC Chinook model run. All stocks included in figure.

Table 3. Stocks with greatest change in Age2 abundance for 2008 & 2012, and their recruit scalars for preseason 2004 – 2013.

Year	Stock	Age 2 Recruit Scalars			Range of pre-season Age 2 Recruit Scalars
		Original	Adjusted	Percent Change	
2008	U-Skag FF	0.1001	1.646	1544.36%	Ranged from .1488 to .8749 for 2004-2007, dropped to .1001 in 2008 and remained at that level through pre-season 2010. Value was .2886 for 2011 and 2012, and .0149 for 2013.
	M-Skag FF	0.0031	0.0959	2993.55%	Ranged from .0002 to .0234 for 2004-2007, went to .0031 in 2008 and remained at that level through pre-season 2010. Value was .0110 for 2011 and 2012, and .0003 for 2013.
2008	U-SkagFYr	0.1996	2.9937	1399.85%	Ranged from .0391 to .1989 for 2004-2007, went to .1996 for 2008 and 2010, dropped to .1174 for 2009. No Age 2 recruit scalars for 2011 and 2012, but for 2013 value was .0895.
	M-SkagFYr			no forecast for 2008	
2008	U-SnohFYr	0.0293	0.0961	227.99%	Age 2 recruit scalar ranged from .0185 to .1984 for 2004-2013.
	M-SnohFYr	0.0347	0.3681	960.81%	Age 2 recruit scalar ranged from .0347 to .0837 for 2004-2013.
2008	U-MidPSFF	0.0588	1.0096	1617.01%	Ranged from .2136 to .2927 for 2004-2007, but dropped to .0588 for 2008 through pre-season 2013.
	M-MidPSFF	0.2680	0.7787	190.56%	Ranged from .8742 to 1.085 for 2004-2007, dropped to .2680 in 2008 through pre-season 2013.
2008	U-Will Sp	0.1565	0.4856	210.29%	Was .3683 and .3975 for 2004 and 2005, then was .1565 for following years except 2009 when value was .4470.
	M-Will Sp	1.4093	4.3705	210.12%	3.3149 and 3.5771 for 2004 and 2005, then was 1.4089 for following years except 2009 when value was 1.1158.
2008	U-LwGeo S	0.7764	3.3488	331.32%	1.0885 for 2004 and 2005, then at 1.6723 for 2006 and 2007, 0.7764 for 2008-2010, and .7766 for 2011-2013.
	M-LwGeo S	0.0660	0.0496	-24.85%	Age 2 recruit scalar was .0454 for 2004 and 2005, then was .0697 for 2006 and 2007, then 0.0660 for 2008-2013.
2012	U-Skag FF	0.2886	0.6114	111.85%	Age 2 recruit scalar ranged from .1488 to .8749 for 2004-2007, dropped to .1001 in 2008 and remained at that level through pre-season 2010. Value was .2886 for 2011 and 2012, and .0149 for 2013.
	M-Skag FF	0.0110	0.2515	2186.36%	Age 2 recruit scalar ranged from .0002 to .0234 for 2004-2007, went to .0031 in 2008 and remained at that level through pre-season 2010. Value was .0110 for 2011 and 2012, and .0003 for 2013.
2012	U-Tula FF	0.3503	1.058	202.03%	Highly variable Age 2 recruit scalars ranged from 0.3503 (2012) to 24.1551 (2005).
	M-Tula FF	7.4467	3.9027	-47.59%	Highly variable Age 2 recruit scalars ranged from 0.4524 (2004) to 38.4530 (2006).
2012	U-MidPSFF	0.0588	0.4739	705.95%	Ranged from .2136 to .2927 for 2004-2007, but dropped to .0588 for 2008 through pre-season 2013.
	M-MidPSFF	0.2680	2.9749	1010.04%	Ranged from .8742 to 1.085 for 2004-2007, dropped to .2680 in 2008 through pre-season 2013.
2012	U-SPS Fyr	0.0112	0.0097	-13.39%	Ranged from .0196 to .1842 for 2004-2007, dropped to .0112 in 2008 through pre-season 2013.
	M-SPS Fyr	0.1984	1.2178	513.81%	Ranged from 3.3506 to 4.4900 2004-2007, dropped to .1985 in 2008 through pre-season 2013.
2012	U-WA Tule	0.0485	0.0451	-7.01%	Age 2 recruit scalar ranged from 1.7816 to 2.3268 2004-2007, but dropped to .2441 in 2008 and remained at that level through pre-season 2011. For 2012 and 2013 the value was .0485
	M-WA Tule	0.6305	2.2445	255.99%	Age 2 recruit scalar ranged from .0254 to .0331 2004-2007, but rose to .5695 in 2008 and remained at that level through pre-season 2011. For 2012 and 2013 the value was .6305
2012	U-Will Sp	0.1565	1.6976	984.73%	Was .3683 and .3975 for 2004 and 2005, at .1565 for all following years except 2009 when value was .4470.
	M-Will Sp	1.4089	6.2488	343.52%	Was 3.3149 and 3.5771 for 2004 and 2005, at 1.4089 for following years except 2009 when value was 1.1158.
2012	U-CentVal	2.9956	3.6837	22.97%	Stock added to FRAM in 2008. Ranged from .3060 to .3250 for 2009-2011, 2.6746 to 2.9956 for 2012 and 2013.
	M-CentVal	0.1789	1.7927	902.07%	Stock added to FRAM in 2008. Ranged from .0180 to .0194 for 2009-2011, at .1789 for both 2012 and 2013.

Table 4. Comparison of FRAM estimated pre-season 2008 exploitation rates and natural escapements of selected Puget Sound Chinook stocks (MSF compatible) to FRAM results modeling the NewAge2 recruit scalars.

	Model Prediction			
Stock	Total ER	SUS ER	SUS Preterm . ER	Natural Escapement
Spring/Early:				
Nooksack (n)	24.1%	5.1%	1.7%	375
Skagit (n)	32.3%	19.0%	7.7%	1446
White	15.9%	13.9%	1.6%	5585
Dungeness	37.3%	2.7%	2.5%	1033
Summer/Fall:				
Skagit	47.1%	15.8%	4.0%	20253
Stillaguamish (n)	33.0%	14.8%	13.8%	355
Snohomish (n)	25.4%	12.9%	11.7%	4401
Lake Wa. (Cedar R.) (n)	40.4%	20.0%	7.3%	678
Green	56.0%	35.7%	7.3%	9695
Puyallup	47.0%	26.6%	7.3%	1153
Nisqually	71.5%	53.4%	12.5%	1928
Western Strait-Hoko	19.4%	2.3%	2.3%	925
Elwha	38.6%	2.8%	2.6%	2222
Mid-Hood Canal tribs. (n)	30.4%	8.4%	8.3%	57
Skokomish	58.3%	36.8%	8.3%	1207

FRAM Version: **5.3**
FRAM Description: **2008 preseason Final PFMC**
FRAM Run Number: **2108**

	Model Prediction			
Age2 from Age3 forecasts!				
Stock	Total ER	SUS ER	SUS Preterm . ER	Natural Escapement
Spring/Early:				
Nooksack (n)	23.9%	5.1%	1.7%	375
Skagit (n)	32.0%	18.8%	7.4%	1446
White	15.9%	13.9%	1.6%	5585
Dungeness	37.1%	2.7%	2.5%	1033
Summer/Fall:				
Skagit	49.8%	15.9%	4.7%	20260
Stillaguamish (n)	30.7%	12.6%	11.5%	355
Snohomish (n)	20.1%	7.3%	6.1%	4401
Lake Wa. (Cedar R.) (n)	42.6%	22.3%	9.8%	678
Green	57.8%	37.5%	9.8%	9666
Puyallup	48.9%	28.6%	9.8%	1152
Nisqually	70.8%	52.6%	10.7%	1924
Western Strait-Hoko	18.4%	2.2%	2.2%	926
Elwha	38.4%	2.8%	2.6%	2223
Mid-Hood Canal tribs. (n)	30.8%	8.7%	8.6%	57
Skokomish	58.5%	37.0%	8.6%	1207

FRAM Version: **5.3**
FRAM Description: **2008 preseason with NewAge2**
FRAM Run Number: **NewAge2 from Age3; Chin2108**

Table 5. FRAM estimated pre-season 2012 exploitation rates and natural escapements of selected Puget Sound Chinook stocks (MSF compatible) compared to FRAM results with NewAge2 recruit scalars.

	Model Prediction pre-season Chin1512				Model Prediction Age2 from Age3 Chin1512			
					NewAge2 forecasts			
Stock	Total ER	SUS ER	SUS Preterm. ER	Natural Escapement	Total ER	SUS ER	SUS Preterm. ER	Natural Escapement
Spring/Early:								
Nooksack (n)	35.1%	7.0%	3.0%	309	35.4%	7.2%	3.2%	309
				236				236
				73				73
Skagit (n)	33.1%	18.8%	8.3%	942	33.7%	19.4%	8.9%	938
				468				467
				276				275
				197				197
White	19.2%	18.2%	3.6%	2141	20.2%	19.1%	4.7%	2,141
Dungeness	63.9%	3.4%	3.3%	656	64.6%	4.3%	4.2%	656
Summer/Fall:								
Skagit	40.4%	14.3%	4.9%	8,398	42.9%	14.8%	5.8%	8,390
				5,796				5,790
				288				287
				1,168				1,167
Stillaguamish (n)	23.4%	13.5%	8.2%	338	24.5%	14.7%	9.4%	337
				296				295
				43				43
Snohomish (n)	16.4%	9.1%	7.5%	2,301	15.6%	8.3%	6.6%	2,300
				1,453				1,452
				848				848
Lake Wa. (Cedar R.)	34.1%	17.8%	9.6%	994	36.5%	20.2%	12.2%	993
Green	31.0%	14.6%	9.6%	1,911	33.4%	17.1%	12.2%	1,910
Puyallup	**48.5%**	32.2%	9.6%	2,206	**50.4%**	34.1%	12.2%	2,202
Nisqually	**55.3%**	41.2%	20.7%	1,072	**52.6%**	38.3%	16.6%	1,069
Western Strait-Hoko	21.6%	2.8%	2.8%	2,118	21.5%	2.8%	2.8%	2,117
Elwha	63.2%	3.4%	3.3%	1,887	63.9%	4.2%	4.1%	1,886
Mid-Hood Canal tribs. (n)	25.9%	12.2%	12.0%	196	26.4%	12.7%	12.5%	196
Skokomish	47.9%	34.3%	12.6%	1,889	48.4%	34.8%	13.1%	1,885

FRAM Version:	**2.09**	**FRAM Version:**	**2.11**
FRAM Description:	**2012 preseason Final PFMC**	**FRAM Description:**	**2012 preseason with NewAge2**
FRAM Run Number:	**1512**	**FRAM Run Number:**	**NewAge2 from Age3; Chin1512**

Table 6. Original pre-season 2012 population age structure, for the Unmarked and Marked **Mid Puget Sound Fall Fingerling stocks**, compared to population age structure with NewAge2 abundances.

		2012 **original** abundance at start of Timestep					2012 **NewAge2** abundance at start of Timestep			
Stock	Age	T1	T2	T3	T4		T1	T2	T3	T4
U-MidPSFF	2	**10,366**	7,654	7,021	**10,366**		**83,549**	61,676	56,581	**83,549**
U-MidPSFF	3	**48,968**	39,358	36,755	**6,077**		**48,968**	39,353	36,751	**48,954**
U-MidPSFF	4	12,941	11,094	10,227	29,200		12,941	11,094	10,227	29,185
U-MidPSFF	5	1,232	1,082	985	2,058		1,232	1,082	985	2,058
M-MidPSFF	2	**47,249**	34,884	32,003	**47,249**		**524,476**	387,171	355,186	**524,476**
M-MidPSFF	3	**307,429**	246,289	229,737	**27,696**		**307,429**	246,257	229,707	**307,304**
M-MidPSFF	4	29,118	24,704	22,762	180,445		29,118	24,703	22,762	180,332
M-MidPSFF	5	777	679	618	4,369		777	678	617	4,365

Table 7. Original pre-season 2012 population age structure, for the Unmarked and Marked **South Puget Sound Fall Fingerling stocks**, compared to population age structure with NewAge2 abundances.

		2012 **original** abundance at start of Timestep					2012 **NewAge2** abundance at start of Timestep			
Stock	Age	T1	T2	T3	T4		T1	T2	T3	T4
U-SPSd FF	2	**133,927**	98,908	90,702	**133,927**		**51,078**	37,715	34,585	**51,078**
U-SPSd FF	3	**30,092**	24,145	22,677	**78,901**		**30,092**	24,141	22,673	**30,074**
U-SPSd FF	4	8,139	6,908	6,385	17,572		8,139	6,908	6,385	17,561
U-SPSd FF	5	292	269	259	2,615		292	269	259	2,614
M-SPSd FF	2	**1,575,763**	1,163,741	1,067,181	**1,575,763**		**703,625**	519,533	47,6424	**703,625**
M-SPSd FF	3	**414,536**	331,211	310,779	**928,342**		**414,536**	331,151	310,723	**414,285**
M-SPSd FF	4	84,368	71,036	65,657	236,122		84,368	71,035	65,656	235,958
M-SPSd FF	5	633	582	560	25,623		633	582	560	25,601

Table 8. FRAM estimated pre-season 2008 and pre-season 2012 ocean escapements, and brood year ER, of selected Columbia River Chinook stocks (MSF compatible) compared to results with NewAge2 recruit scalars.

Table 5 PFMC Preseason Report for 2008		
	Adult Ocean Escapement or Other Crit.	
	Chin2108	Chin2108 with NewAge2
Col Upriver Brt	175.9	175.9
Mid-Col Brt	45.2	45.2
Col Lower Hatch	60.4	60.4
Col Nat Tule Brood Year ER	35.9%	35.9%
Col LRW	3.8	3.8
Spring Creek	86.2	86.2

Table 5 PFMC Preseason Report for 2012		
	Adult Ocean Escapement or Other Crit.	
	Chin1512	Chin1512 with NewAge2
Col Upriver Brt	353.0	353.0
Mid-Col Brt	90.7	90.7
Col Lower Hatch	128.4	128.1
Col Nat Tule Brood Year ER	**40.9%**	**41.1%**
Col LRW	16.2	16.2
Spring Creek	60.0	59.9

DISCUSSION

When the initial structure of Chinook FRAM was conceived there was more of a focus on stock escapement (age 3 through 5). The present management focus has shifted to ER caps. The importance of accurate Age2 forecasts appears to have been lost during this transition. Age2 abundance is an important component of total fishery mortality.

The lack of data for age 2 survival rates (limited terminal return information, almost no CWT fishery recoveries), and subsequent poor quality of input Age2 Chinook forecasts has long been known, but ignored. The work toward an updated Chinook Base Period and the recent work to better model sublegal encounters motivated this effort to address the Age2 forecast dilemma. Although it was surprising to see how stagnant the modeled Age2 annual forecasts had become (Appendix Table A), choosing an alternative is difficult when the provided regionally produced forecasts are only for "total runsize" of combined ages 3 through 5, or at best by Age3, Age4, and Age5, with no Age2 forecast. What has not been investigated before is the potential effect of Age2 forecasts on stock specific exploitation rates.

Initially it was expected that the NewAge2 forecasts would raise the ER for some stocks and drop it for others. Since Age2 calculated fishery mortality is significantly reduced by the AEQ factor the changes to ER were not expected to be great (AEQ mortality is used for ER calculations). This was generally the case for 2008 (**Table 4**), while for 2012 (**Table 5**) all but three Puget Sound stocks showed an increase in ER. A couple of stocks had an absolute ER increase in the neighborhood of 2%; one stock saw a drop of nearly 3%. When we struggle during pre-season negotiations to stay below an ESA driven ER cap, often trying to find tenths of a percent reduction, changes of a full percent or more could be disruptive to the present annual fishery structure.

However, the results from re-running 2008 and 2012 with NewAge2 recruit scalars should not be taken as absolute. This present exercise took a narrow focus and only changed the one parameter of Age2 recruit scalars in these two pre-season model runs. With every pre-season there are potentially changes, with usually subtle effects, in the FRAM application and many input parameters. Some changes, or corrected "model glitches" aren't so subtle. An example is the natural mortality rates used in the 2008 Outfile, or the base period calibration result that is input into FRAM (Table 9). After the 2008 pre-season, it was discovered that the Outfiles used up to that year were created with the wrong natural mortality rates for timestep 4. The 2008 model run with NewAge2 recruits would have produced a different result with the corrected Outfile, but wouldn't have been directly comparable to the pre-season 2008 product.

Several types of annual input parameters are calculated/calibrated using the post-season Validation Runs. Validation Runs, a type of post-season FRAM run, incorporate observed fishery catch and observed Terminal Run Size of stocks' Age3, 4, and 5 year old fish to back-calculate their initial recruit scalars. But this isn't the case for the Age2 recruit scalar. Validation Runs have reused the annual pre-season Age2 recruit scalars. If realistic Age2 abundances are provided for Validation Runs then we can expect changes to parameters such as input 'fishery scalars' for Puget Sound marine sport retention and non-retention fisheries. The fishery scalar reflects an average effort that should produce a model estimated landed catch consistent with observed landed catch. Since, over all FRAM stocks, the NewAge2 recruits increase overall Chinook abundance then reduced 'fishery scalars' would be needed to keep model estimated landed catch consistent with observed levels. This applies particularly for timestep 4 fisheries when NewAge2 "age-up". In general, this should somewhat reduce ERs produced in the NewAge2 versions of pre-season 2008 and 2012 model runs. The largest affect of using NewAge2 recruit methodology may be in the re-distribution of fishery impacts among FRAM stocks contributing to timestep 4 fisheries.

The calculations of, and/or acceptance of, several stocks' ER caps are based upon FRAM Validation Run results. Validation Runs should be reproduced with realistic Age2 abundances.

The need to use realistic Age2 forecasts is a given, so the issue at hand is when to implement either the presented NewAge2 forecast methodology or alternative realistic methods. Some potential options:

1. Full implementation of a NewAge2 forecast methodology for pre-season 2015.
   a. Option 1: Direct calculation from annual Age3 forecasts.
      i. Model with average, or anticipated fishery mortality rates.
      ii. Apply average NewAge2/Age3 ratio from Validation Runs.
   b. Option 2: Calculation from average Age3 abundances from recent Validation Runs.
      i. Apply average NewAge2/Age3 ratio from Validation Runs.
      ii. Option to simply average NewAge2 abundances from same Validation Runs.

2. Implement a NewAge2 forecast methodology as part of the Chinook Base Period update, with potential corresponding adjustments to ESA stock ER caps, perhaps by 2016 pre-season.

3. Consult with regional biologists regarding limitations of current Age2 forecasts and discuss options for development of Age2 forecasts for preseason 2015.

Table 9. Time period and age-specific rates used by FRAM to simulate Chinook natural mortality

Chinook FRAM Natural Mortality Rates, by age and timestep:

Age	Timestep 1 Oct. to April	Timestep 2 May to June	Timestep 3 July to Sept.	**2008 Outfile** Timestep 4 Oct. to April	**2012 Outfile** Timestep 4 Oct. to April
2	0.2577	0.0816	0.1199	0.1878	0.2577
3	0.1878	0.0577	0.0853	0.1221	0.1878
4	0.1221	0.0365	0.0543	0.0596	0.1221
5	0.0596	0.0174	0.026	0.0596	0.0596

Supplementary Reference

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Appendix Table A. Age2 pre-season recruit scalars for Chinook FRAM stocks, 2004-2013, and recalculated NewAge2 scalars for 2008 and 2012.

StockName	Pre-season Age2 Recruit Scale Factors (2004 through 2013):										New Age2 from Age3	
	Chin1604	Chin2705	Chin3006	Chin3007	**Chin2108**	Chin2309	Chin1010	Chin1811	**Chin1512**	Chin1213	**Chin2108**	**Chin1512**
U-NkSm FF	0.0955	0.0277	0.0261	0.0261	0.0260	0.0260	0.0260	0.0421	0.0421	0.0421	0.0354	0.0394
M-NkSm FF	0.5858	0.3527	0.3039	0.3039	0.3025	0.3025	0.3025	0.7589	0.7589	0.7589	0.2516	0.7232
U-NFNK Sp	1.4734	1.5632	2.1621	1.3230	3.4646	3.4646	3.5330	2.7510	2.7510	0.3986	1.9597	3.8861
M-NFNK Sp	0.5266	0.4368	3.4182	2.0900	5.4732	5.4732	5.6968	6.4250	6.4250	1.0533	6.0060	8.6634
U-SFNK Sp	2.0000	2.0000	5.5803	3.4940	0.1397	0.1397	0.2757	0.2268	0.2268	0.1134	0.1257	0.0174
M-SFNK Sp												
U-Skag FF	0.6479	0.3917	0.8749	0.1488	0.1001	0.0938	0.1001	0.2886	0.2886	0.0149	1.6460	0.6114
M-Skag FF	0.0179	0.0129	0.0234	0.0002	0.0031	0.0030	0.0031	0.0110	0.0110	0.0003	0.0959	0.2515
U-SkagFYr	0.0785	0.0391	0.0929	0.1989	0.1996	0.1174	0.1996			0.0895	2.9937	
M-SkagFYr												
U-SkagSpY	2.1049	1.8550	1.6927	1.8606	1.6838	0.8460	0.8000	0.8001	0.8001	2.4051	1.0416	0.9571
M-SkagSpY	3.4599	1.6712	1.4137	3.1224	2.2491	2.2456	6.6700	10.2810	10.2810	3.5189	2.1238	2.4213
U-Snoh FF	1.1701	1.5732	1.2471	1.0967	1.7176	0.3749	0.7612	0.3794	0.1332	0.0492	0.0986	0.0735
M-Snoh FF	0.3650	0.8131	0.9496	0.6580	1.0262	0.1597	0.1964	0.0978	0.1264	0.1264	0.0338	0.1712
U-SnohFYr	0.1184	0.0903	0.0433	0.0399	0.0293	0.0532	0.1111	0.0687	0.0185		0.0961	0.0102
M-SnohFYr	0.0837	0.0580	0.0375	0.0377	0.0347	0.0831	0.0819	0.0506	0.0741	0.0741	0.3681	0.0747
U-Stil FF	1.8700	1.8235	1.6380	2.5140	1.2792	0.6803	0.5729	0.1718	0.3334	0.2811	0.8362	0.4077
M-Stil FF	0.1321	0.4830	0.5453	0.5594	1.1344	0.3886	0.0731	0.3670	0.8803	1.9448	0.5146	0.4120
U-Tula FF	3.0887	24.1551	16.8750	6.3756	6.7360	2.2918	0.9042	0.6018	0.3503	0.4312	1.1538	1.0580
M-Tula FF	0.4521	2.6244	38.4530	13.0623	24.0240	5.2121	1.8562	2.1398	7.4467	9.5998	2.3645	3.9027
U-MidPSFF	**0.2136**	**0.2145**	**0.2927**	**0.2560**	**0.0588**	**0.0588**	**0.0588**	**0.0588**	**0.0588**	**0.0588**	**1.0096**	**0.4739**
M-MidPSFF	**0.9027**	**1.0858**	**0.9996**	**0.8742**	**0.2680**	**0.2680**	**0.2680**	**0.2680**	**0.2680**	**0.2680**	**0.7787**	**2.9749**
U-UWAc FF	0.6556		0.0008	0.0008								
M-UWAc FF		0.6341	2.4837	2.4344	1.2879	1.2879	1.2879	1.2869	1.2869	1.2869	1.0656	0.2762
U-SPSd FF		**0.4137**	**0.4013**	**0.4575**	**0.6516**	**0.6516**	**0.6516**	**0.6513**	**0.6513**	**0.6513**	**0.2920**	**0.2484**
M-SPSd FF	**3.4844**	**3.6430**	**4.7382**	**5.4015**	**7.6665**	**7.6665**	**7.6665**	**7.6631**	**7.6631**	**7.6631**	**2.6208**	**3.4218**
U-SPS Fyr	0.1842	0.0493	0.0196	0.0223	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0096	0.0097
M-SPS Fyr	3.3506	3.8380	3.9386	4.4900	0.1985	0.1985	0.1985	0.1984	0.1984	0.1984	0.1700	1.2178
U-WhiteSp	15.2435	21.1897	21.1890	21.1890	14.2047	14.2047	14.2047	14.2040	14.2040	14.2040	12.5540	26.3841
M-WhiteSp												
U-HdCl FF	6.4769	6.0283	2.5444	3.8100	1.5058	1.5058	1.5058	0.6890	0.6890	0.5387	1.7813	0.7521
M-HdCl FF	0.3566	0.3339	2.5361	3.8000	2.6081	2.6081	2.6081	9.1590	9.1590	15.2650	3.3694	7.1247
U-HdCl FY	1.8433	2.0137										
M-HdCl FY			2.0000	2.0000	1.6479	1.6479	1.6479	4.4690	4.4690	4.4690	1.2457	5.8899
U-SJDF FF	1.7888	1.9014	2.2414	2.2414	3.9976	3.9976	3.9976	3.9994	3.9994	3.9994	3.1900	7.0841
M-SJDF FF	0.2351	0.2196	0.1709	0.1709								
U-OR Tule	0.8057	0.3130	0.1835	0.1743	0.4530	0.4530	0.4530	0.4507	0.1940	0.1940	0.1837	0.1632

StockName	Pre-season Age2 Recruit Scale Factors (2004 through 2013):										New Age2 from Age3	
	Chin1604	Chin2705	Chin3006	Chin3007	**Chin2108**	Chin2309	Chin1010	Chin1811	**Chin1512**	Chin1213	**Chin2108**	**Chin1512**
M-OR Tule	0.0114	0.0045	0.0026	0.0025	1.0670	1.0670	1.0670	1.0616	1.4550	1.4550	0.4288	0.8320
U-WA Tule	1.7816	2.3268	1.9039	1.8087	0.2441	0.2441	0.2441	0.2430	0.0485	0.0485	0.1012	0.0451
M-WA Tule	0.0254	0.0331	0.0271	0.0257	0.5695	0.5695	0.5695	0.5670	0.6305	0.6305	0.2361	2.2445
U-LCRWild	2.3620	1.9802	1.6926	1.6926	0.3362	0.3362	0.3362	0.3359	0.8250	0.8250	0.3990	0.9032
M-LCRWild	0.0311	0.0260	0.0222	0.0222	0.0083	0.0083	0.0083	0.0083			0.0123	
U-BPHTule	2.4238	1.9903	1.0386	1.0386	0.0503	0.1559	0.0503	0.0500	0.1200	0.1200	0.0684	0.0750
M-BPHTule	0.0296	0.0243	0.0127	0.0127	0.9553	0.8497	0.9553	0.9488	1.2000	1.2000	0.0120	0.8084
U-UpCR Su	7.1304	7.0677	7.8053	7.8053	3.8993	3.8993	3.8993	2.4542	2.4500		0.2310	
M-UpCR Su	1.2583	1.2478	1.3774	1.3774	0.7825	0.7825	0.7825	0.4925	0.4900		4.8400	
U-UpCR Br	8.6140	9.9402	7.9583	7.9583	4.8870	4.8870	4.8870	4.8887	6.2500	6.2500	0.9700	7.3104
M-UpCR Br	0.2600	0.3000	0.2402	0.2402	0.5430	0.5430	0.5430	0.5432	2.3200	2.3200	0.4841	2.7897
U-Cowl Sp												
M-Cowl Sp												
U-Will Sp	0.3683	0.3975	0.1565	0.1565	0.1565	0.4470	0.1565	0.1565	0.1565		0.4876	1.6976
M-Will Sp	3.3149	3.5771	1.4089	1.4089	1.4093	1.1158	1.4093	1.4089	1.4089		4.3889	6.2488
U-Snake F	0.7400	0.7382	0.7400	0.7400	0.7074	0.7074	0.7074	0.8700	0.8700	0.8700	0.6286	0.8394
M-Snake F	1.2600	1.2569	1.2600	1.2600	1.2046	1.2046	1.2046	1.1300	1.1300	1.1300	1.0707	1.0906
U-OR No F	1.9988	1.9988	1.9982	1.9982	0.7917	0.7917	0.7917	0.7918	0.7918	0.7918	0.7542	1.0457
M-OR No F												
U-WCVI Tl	1.2482	1.0617	2.9884	2.9884	0.3532	0.3532	0.3532	0.3532	0.3532	0.3532	0.3255	0.0618
M-WCVI Tl	0.0254	0.0254	0.0608	0.0608	0.0071	0.0071	0.0071	0.0071	0.0071	0.0071	0.0064	0.0013
U-FrasRLt	0.5102	0.8810	1.2068	1.2068	3.3900	3.3900	3.3900	3.3899	3.3899	3.3899	2.9662	1.3683
M-FrasRLt	0.0105	0.0187	0.0249	0.0249	0.0720	0.0720	0.0720	0.0720	0.0720	0.0720	0.0630	0.0608
U-FrasREr	5.3955	5.3955	4.0981	4.0981	3.2900	3.2900	3.2900	3.2903	3.2903	3.2903	3.0094	3.2574
M-FrasREr	0.1101	0.1101	0.0836	0.0836	0.0671	0.0671	0.0671	0.0671	0.0671	0.0671	0.0614	0.0663
U-LwGeo S	1.0885	1.0885	1.6723	1.6723	0.7764	0.7764	0.7764	0.7766	0.7766	0.7766	0.5835	0.4035
M-LwGeo S	0.0454	0.0454	0.0697	0.0697	0.0660	0.0660	0.0660	0.0660	0.0660	0.0660	0.0496	0.0345
U-WhtSpYr	3.5393	3.5393	4.0243	4.0243	8.5992	8.5992	8.5992	8.5865	8.5865	8.5865	7.5051	3.4586
M-WhtSpYr												
U-LColNat					0.7140	0.7140	0.7140	0.7113	2.0000	2.0000	0.5117	2.6912
M-LColNat												
U-CentVal					0.3250	0.3060	0.3250	2.6746	2.9956	2.9956	0.2985	3.6837
M-CentVal					0.0194	0.0180	0.0194	0.1597	0.1789	0.1789	0.0178	1.7927
U-WA NCst					0.2610	0.2610	0.2610	0.2610	0.1957	0.1957	0.2362	0.3959
M-WA NCst									0.0653	0.0653		0.1306
U-Willapa					3.4900	3.4900	3.4900	3.4902	0.7366	0.7366	3.1451	0.4875
M-Willapa					0.1930	0.1930	0.1930	0.1930	2.9466	2.9466	0.1739	1.5388
U-Hoko Rv					1.8272	1.8272	1.8272	3.1741	0.8119	6.0384	0.2591	0.4261
M-Hoko Rv					2.6294	2.6294	2.6294	4.6373	0.8192	3.4548	0.3577	0.4907

Appendix Table B. Summary statistics for FRAM stock specific initial Timestep 1 abundance ratios of NewAge2/Age3, as produced from Chinook FRAM Validation Runs (2003-2010)

	Stock specific 2:3 ratios from 2003-2010 Validation Runs.				
StockName	**Mean**	**Median**	**Min**	**Max**	**SD**
U-NkSm FF	0.96	0.96	0.96	0.97	0.00
M-NkSm FF	0.96	0.96	0.96	0.97	0.00
U-NFNK Sp	0.98	0.98	0.98	0.98	0.00
M-NFNK Sp	0.98	0.98	0.98	0.98	0.00
U-SFNK Sp	0.98	0.98	0.98	0.98	0.00
M-SFNK Sp					
U-Skag FF	0.93	0.92	0.92	0.97	0.02
M-Skag FF	0.93	0.92	0.92	0.97	0.02
U-SkagFYr	0.96	0.96	0.96	0.97	0.00
U-SkagSpY	0.98	0.98	0.98	0.98	0.00
M-SkagSpY	0.98	0.98	0.98	0.98	0.00
U-Snoh FF	0.93	0.93	0.93	0.95	0.01
M-Snoh FF	0.93	0.93	0.93	0.95	0.01
U-SnohFYr	0.95	0.95	0.95	0.95	0.00
M-SnohFYr	0.95	0.95	0.95	0.95	0.00
U-Stil FF	0.93	0.93	0.93	0.95	0.01
M-Stil FF	0.93	0.93	0.93	0.94	0.00
U-Tula FF	0.97	0.97	0.97	0.98	0.00
M-Tula FF	0.97	0.97	0.97	0.97	0.00
U-MidPSFF	0.95	0.95	0.95	0.96	0.00
M-MidPSFF	0.95	0.95	0.95	0.96	0.00
U-UWAc FF					
M-UWAc FF	0.88	0.87	0.86	0.89	0.01
U-SPSd FF	0.96	0.96	0.95	0.96	0.00
M-SPSd FF	0.96	0.96	0.95	0.96	0.00
U-SPS Fyr	0.92	0.92	0.92	0.93	0.00
M-SPS Fyr	0.92	0.92	0.92	0.93	0.00
U-WhiteSp	0.96	0.95	0.95	0.96	0.00
U-HdCl FF	0.94	0.94	0.93	0.94	0.00
M-HdCl FF	0.94	0.94	0.93	0.95	0.00
U-HdCl FY	0.95	0.95	0.95	0.96	0.00
M-HdCl FY	0.95	0.95	0.95	0.96	0.00
U-SJDF FF	0.96	0.96	0.95	0.97	0.00
M-SJDF FF	0.96	0.96	0.95	0.97	0.00
U-OR Tule	0.94	0.94	0.94	0.95	0.00
M-OR Tule	0.94	0.94	0.94	0.95	0.01
U-WA Tule	0.97	0.97	0.96	1.00	0.01
M-WA Tule	0.97	0.97	0.96	0.99	0.01
U-LCRWild	0.98	0.98	0.98	0.99	0.00
M-LCRWild	0.98	0.98	0.98	0.99	0.00
U-BPHTule	0.92	0.92	0.92	0.95	0.01
M-BPHTule	0.93	0.92	0.92	0.95	0.01
U-UpCR Su	0.98	0.98	0.97	0.99	0.01
M-UpCR Su	0.98	0.98	0.97	0.99	0.01

Stock specific 2:3 ratios from 2003-2010 Validation Runs.

StockName	Mean	Median	Min	Max	SD
U-UpCR Br	0.97	0.97	0.96	0.97	0.00
M-UpCR Br	0.97	0.97	0.96	0.98	0.00
U-Cowl Sp					
M-Cowl Sp					
U-Will Sp	0.99	0.98	0.98	0.99	0.00
M-Will Sp	0.99	0.98	0.98	0.99	0.00
U-Snake F	0.97	0.97	0.96	0.98	0.01
M-Snake F	0.97	0.96	0.96	0.98	0.01
U-OR No F	0.98	0.98	0.97	0.99	0.01
M-OR No F	0.98	0.98	0.96	1.00	0.01
U-WCVI Tl	0.98	0.98	0.97	0.98	0.00
M-WCVI Tl	0.98	0.98	0.97	1.00	0.01
U-FrasRLt	0.95	0.94	0.94	0.95	0.00
M-FrasRLt	0.95	0.94	0.94	0.95	0.00
U-FrasREr	0.99	0.99	0.98	0.99	0.00
M-FrasREr	0.99	0.99	0.98	0.99	0.00
U-LwGeo S	**0.81**	0.81	0.80	0.83	0.01
M-LwGeo S	**0.81**	0.81	0.79	0.83	0.01
U-WhtSpYr	0.97	0.97	0.97	0.98	0.00
M-WhtSpYr					
U-LColNat	0.96	0.96	0.95	0.96	0.01
U-CentVal	0.97	0.96	0.94	1.00	0.02
M-CentVal	0.97	0.96	0.94	1.00	0.02
U-WA NCst	0.98	0.98	0.98	0.98	0.00
M-WA NCst	0.98	0.98	0.98	0.99	0.00
U-Willapa	0.98	0.98	0.97	0.99	0.00
M-Willapa	0.98	0.98	0.97	0.99	0.00
U-Hoko Rv	0.98	0.98	0.98	0.98	0.00
M-Hoko Rv	0.98	0.98	0.98	0.98	0.00

Mean	0.96
Median	0.97
Min	0.81
Max	0.99
Count	68