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INCORPORATION OF GENETIC STOCK IDENTIFICATION DATA INTO OCEAN FISHERY REAL-TIME FORECASTS OF CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) RUNS

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by

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EXECUTIVE SUMMARY

We incorporated genetic stock identification (GSI) based stock compositions in southeast Alaska (SEAK) troll fishery catch of Chinook salmon into forecasts of terminal returns for Chinook salmon (*Oncorhynchus tshawytscha*) stocks that Pacific Salmon Commission (PSC)'s Chinook Technical Committee (CTC) manages. We compared GSI based forecasts with PSC Chinook model based forecasts. PSC Chinook model data were used for estimation of stock- and age- compositions. Overall PSC Chinook model based forecasts outperformed GSI based forecasts. However, we treat the results with extreme caution because GSI based estimates were from only five years (2004-2008). The 2009 GSI based estimates were not incorporated because age-specific return data by year ended in 2008. Hindcasting forecasts of fish return in a particular year were based on data from 11 years prior to the year. Thus, data prior to 2004 had nothing to do with GSI based estimates; i.e., those data were based on PSC Chinook model data. GSI based forecasts outperformed PSC Chinook model based forecasts in the following 13 Chinook salmon components: during period 1, age 4- and age 5- AKS, age 3-, age 4- and age 5- ORC, age 5- CWF, and age 3- and age 5- RBH+RBT; during period 2, age 5- AKS, age-4 and age 5- URB+SUM, and age 3- and age 5- RBH+RBT. We expect the use of GSI based estimates to improve forecast accuracy and ocean fishery management in the future.

INTRODUCTION

We propose incorporation of stock compositions using genetic data (i.e., genetic stock identification (GSI) stock compositions) into forecasts of terminal returns for Chinook salmon (*Oncorhynchus tshawytscha*) stocks that Pacific Salmon Commission (PSC)'s Chinook Technical Committee (CTC) manages (Table 1). At present, PSC CTC model calculates ocean abundance of fall Chinook salmon stocks, using preseason forecasts of those stock terminal runs as well as other information from coded wire tag (CWT) data (e.g., maturation, and stock- and fishery- specific exploitation rates). Ocean fishery management is based on the estimation of an aggregate abundance (assuming gear selectivity and base period harvest rates), which is scaled to a base period abundance in order to generate an Abundance Index (AI).

CWTs recovered in the ocean (i.e., fish with CWT caught in the ocean) are core data for PSC Chinook model in estimating stock- and age-compositions of Chinook salmon in the ocean. However, PSC Chinook model based estimates of stock compositions of Chinook salmon in the ocean are considered to have considerable uncertainty because some stocks were not tagged or were minimally tagged in the base period (1979-1982) and those estimates do not cover the whole population of Chinook salmon. On the other hand, molecular and population genetics have advanced to estimate stock compositions of fish in the ocean. Indeed Alaska Department of Fish & Game (ADFG) Gene Conservation Lab has been estimating stock compositions of Chinook salmon caught in the ocean during last decade (Templin et al. 2011, Templin et al. 2012a, Templin et al. 2012b, Gilk-Baumer et al. 2013). Although such GSI stock compositions are now available, age compositions cannot be identified by GSI techniques. Estimation of age compositions still need traditional methods such as CWT data or fish scales.

In this report, we make ocean in-season forecasts of stock-specific terminal returns, using genetic data, ocean catch, and fishing efforts. To distinguish traditional preseason forecasts of terminal returns in summer and fall of a year, which are made by February of the year, we use the term, "ocean in-season" forecasts. Data for the ocean in-season forecasts are mainly from ocean fishery catch, and they enable us to make ocean fishery real-time forecasts. These stock-specific forecasts will then be fed back into the PSC Chinook Model to create an updated AI, which can then be used for management. We expect these new methods will improve the status quo methods in estimating ocean abundance and terminal runs, leading to a better harvest management in both ocean and terminal river areas. Objectives of this report are (i) to incorporate GSI stock compositions into ocean fishery real-time forecasts (i.e., ocean in-season forecasts) of terminal returns for stocks that PSC CTC manages, (ii) to provide forecast uncertainty as well as point forecasts, (iii) to evaluate those forecasts based on GSI stock compositions by comparing them with those based on PSC CTC model, which used CWT data.

METHODS

Stocks and data

A subset of the Chinook salmon stocks of PSC CTC's management were analyzed (Table 1). For ocean catch data, and ocean troll fishery effort data, we used southeast Alaska (SEAK) data by period. Chinook salmon of PSC CTC's interest are distributed in the SEAK (Figure 1) during the ocean residence. ADFG Gene Conservation Lab uses the term, "period" for month:

i.e., period 1 = July; period 2 = August. We follow the term in this report. ADFG Gene Conservation Lab estimated stock compositions in the SEAK troll fishery catch, and we applied the GSI stock compositions to the SEAK ocean fishery catch data (Figure 1) to estimate stock-specific ocean catches by period. Such periodic (monthly) data enabled us to update forecasts of stock-specific abundances and terminal returns on a monthly basis, which are useful to a real-time management for ocean fisheries. On the other hand, we used PSC CTC model's estimates of age compositions by stock in the SEAK fishery by year.

On a subset of stocks, we also acquired data on yearly sibling runs by stock and age. The sibling run data were not be available for all stocks whereas the first category data on genetic samples, ocean catches and fishing efforts were available on all stocks in the model.

Based on data on (i) GSI stock compositions in the southeast Alaska troll fishery catch and and (ii) terminal runs, we define nine Chinook salmon groups (Table 1): Alaska Spring (AKS), Oregon Coastal Far North Falls (ORC), Bonneville Tule (CWF), Spring Creek Tule (SPR), aggregated Columbia River Upriver Brights and Upper Columbia River (URB + SUM), Fraser Early (FRE), Fraser Late (FRL), aggregated West Coast Vancouver Island Hatchery and Wild (RBH+RBT), and aggregated Washington Coastal Falls Hatchery and Natural (WCH+WCN). The GSI stock compositions of some stocks were not separated, and thus they were aggregated: e.g., URB+SUM, RBH+RBT, and WCH+WCN (Table 1).

PSC CTC Ocean Model

For stock- and age-compositions of ocean troll fishery catch in the SEAK, we used the PSC Chinook model. These methods are traditional as opposed to GSI based stock compositions, which are new components in this report. The PSC Chinook model and its calculation process for those compositions are well described in Hyun et al. (2012). We don't describe it here to avoid redundancy.

Ocean in-season forecast

The majority of this section is from Hyun et al. (2012). However, we emphasize that in this report, we make ocean in-season forecasts, using ocean data from not only July but also from August. Hyun et al. (2012) did not use August data because mature Columbia River fall Chinook salmon are presumed to leave the SEAK area for their natal river by the end of July.

We developed a simple model in which a fish return is a function of ocean catch and effort using data available on a period basis during the summer commercial fishery in SEAK.

The relationship between fish abundance in the ocean and ocean catch and effort (Gulland 1983) is:

$$O_{s,a,y} = \frac{C_{s,a,y,w}}{q_{a,y}E_{y,w}} = \frac{g_{s,a,y} \cdot C_{y,w}}{q_{a,y}E_{y,w}} \quad (1)$$

where $O_{s,a,y}$ = abundance of stock *s* at age *a* in the ocean during year *y*; $C_{s,a,y,w}$ = cumulative catch of stock *s* at age *a* up to period *w* during year *y*; $q_{a,y}$ = catch-vulnerability coefficient of the fishery in year y that targets fish at age *a*; $E_{y,w}$ = cumulative fishing effort (vessel-days) to period *w* during *y*; $g_{s,a,y}$ = stock *s* and age *a* proportion of catch from the ocean fishery in year *y*;

and $C_{y,w}$ = cumulative catch of all stocks at all ages up to period *w* during year *y*. In eq.1, $O_{s,a,y}$ and $q_{a,y}$ are unknown quantities whereas $g_{s,a,y}$, $C_{y,w}$, $C_{s,a,y,w}$ and $E_{y,w}$ are known. Stock compositions in $g_{s,a,y}$ originated from either GSI method or PSC Chinook model method. Results below show both cases.

On the other hand, a deterministic relationship between fish return size in a year and fish abundance in the ocean in that year is:

$$\begin{aligned} R_{s,a,y} &= O_{s,a,y} \cdot (1 - M_{s,a,y}) \cdot A_{s,a,y} \\ &= O_{s,a,y} \cdot (1 - h \cdot C_{s,a,y,w}) \cdot A_{s,a,y} \end{aligned} \tag{2}$$

where $M_{s,a,y}$ = fishing mortality rate in the ocean; $A_{s,a,y}$ = maturation rate, unknown but assumed to be constant at the same age in year *y*; and h = an unknown positive constant between $M_{s,a,t}$ and $C_{s,a,y}$ (i.e., $M_{s,a,t} = h \cdot C_{s,a,y}$).

Replacing $O_{s,a,t}$ in eq. 2 with that in eq.1, and combining unknown constants ($q_{a,y}$, $A_{s,a,y}$, and h), we have the following equation.

$$R_{s,a,y} = \delta_{s,a,1} \cdot \frac{C_{s,a,y,w}}{E_{y,w}} - \delta_{s,a,2} \cdot \frac{(C_{s,a,y,w}{}^2)}{E_{y,w}} \tag{3}$$

where $\delta_{s,a,1}$ = ($A_{s,a,y} / q_{a,y}$), and $\delta_{s,a,2}$ = ($hA_{s,a,y} / q_{a,y}$). It is important to note that the domains of these parameters are zero or positive (i.e., $\delta_{s,a,1} \geqq 0$ and $\delta_{s,a,2} \geqq 0$), because A, q, and h are all zero or positive. Based on the deterministic model of eq. **Error! Reference source not found.**, its stochastic form is as follows.

$$R_{s,a,y} = \delta_{s,a,w,1} \cdot \frac{C_{s,a,y,w}}{E_{y,w}} + \delta_{s,a,w,2} \cdot \frac{-\left(C_{s,a,y,w}{}^2\right)}{E_{y,w}} + \gamma_{s,a,y,w},\ \gamma_{s,a,y,w} \sim N\left(0, Var(\gamma_{s,a,w})\right) \tag{4}$$

The above equation is a linear regression without intercept term: i.e., '$Y = \delta_1 X_1 + \delta_2 X_2 + error$' form where $X_1 = C / E$, and $X_2 = -C^2 / E$. The response variable *R* in year *y* is related to explanatory variables (C/E, $-C^2 / E$) in the *same* year *y*, because the ocean fishery occurs in the fish return year. $C_{s,a,y,w}$ and $E_{y,w}$ are updated by period *w* within a year, and thus the coefficients in the model of eq. 4 change by period. For this reason, we added subscript *w* to δ_1 and δ_2.

A problem occurred where the least squares method applied to the regression model (eq. 4) sometimes led to negative estimates of $\delta_{s,a,w,2}$ when return number (*R*) and ocean catch (*C*) were too small. The parameter $\delta_{s,a,w,2}$ cannot be negative, and when it was estimated to be negative, a likelihood method rather than least squares was used, limiting the parameter domain to the zero or positive space. The resultant likelihood function is as follows:

$$L\left(\delta_{s,a,w,1}, \delta_{s,a,w,2}, Var(\gamma_{s,a,y,w}) \mid R_{s,a,y}\right) = \prod_{k=y-11}^{y-1} N\left(R_{s,a,k} \mid E(R_{s,a,k}), Var(\gamma_{s,a,k,w})\right) \quad (5)$$

where $E(R_{s,a,y}) = \delta_{s,a,w,1} \cdot C_{s,a,y,w} / E_{y,w} + \delta_{s,a,w,2} \cdot [-C_{s,a,y,w}{}^2 / E_{y,w}]$. Data from 11 years are used for hindcasting, so the data range from '$y-11$' to '$y-1$'. Differentiating the above likelihood function with respect to parameters, we estimated the MLEs of these parameters, the standard errors of the MLEs, and the variance-covariance matrix of those estimates. The differentiation was made using ADMB software (Fournier 2011, Fournier et al. 2011). Further, we corrected the MLE of $Var(\gamma_{s,a,w})$, because it is not an unbiased estimator, although MLEs of $\delta_{s,a,w,1}$ and $\delta_{s,a,w,2}$ are unbiased. The unbiased estimator of the error variance, is calculated using the relationship (Neter et al. 1989): the residual mean square = [MLE of $Var(\gamma_{s,a,w})$] $\times n/(n-2)$, where *n* is the number of historical data years and 2 is the number of the coefficients in eq. **Error! Reference source not found.** (i.e., $\delta_{s,a,1}$ and $\delta_{s,a,2}$).

After estimating parameters of eq. 4, we forecast unknown stock and age run (= $\tilde{R}_{s,a,y+1}$) during the ocean fishery season. The mean and variance of the predictive run are estimated as follows:

$$\hat{E}(\tilde{R}_{s,a,y+1}) = \hat{\delta}_{s,a,w,1} \cdot \frac{C_{s,a,y+1,w}}{E_{y+1,w}} + \hat{\delta}_{s,a,w,2} \cdot \frac{-\left(C_{s,a,y+1,w}{}^2\right)}{E_{y+1,w}} \quad (6)$$

$$\widehat{Var}(\tilde{R}_{s,a,y+1}) = \widehat{Var}(\hat{R}_{s,a,y+1}) + \widehat{Var}(\gamma_{s,a,y,w}) \quad (7)$$

where $\widehat{Var}(\hat{R}_{s,a,y+1})$ is the estimate of variance of the mean response and $\widehat{Var}(\gamma_{s,a,y,w})$ is the residual mean square of the regression (eq. 4). The estimation of the variance of the mean response involves the variances and covariances of the parameter estimates: i.e., $\widehat{Var}(\hat{R}_{s,a,y+1})$ = $\mathbf{X}^T \cdot \mathbf{\Sigma(d)} \cdot \mathbf{X}$, where $\mathbf{X}$ is a column matrix that has (0, $C_{s,a,y+1,w}/E_{y+1,w}$, $-C_{s,a,y+1,w}{}^2/E_{y+1,w}$), and $\mathbf{\Sigma(d)}$ is the variance-covariance matrix of $\hat{\delta}_{s,a,w,1}$ and $\hat{\delta}_{s,a,w,2}$. We further could formulate the mean and variance of the sum of age-specific predictive returns.

RESULTS AND DISCUSSION

Stock compositions

Compositions of nine groups in SEAK troll fishery area estimated from GSI data were shown by period 1 (July) and period 2 (August) in 2004-2009 (Figure 2). For comparison, the counterparts estimated by PSC Chinook model in 1979-2008 were also shown in Figure 2. Two major points in Figure 2 were (i) the difference in stock composition estimates between two periods within the GSI method, and (ii) the difference between the GSI and PSC Chinook model methods. The difference between two periods confirms the idea or hypothesis that stock compositions in the SEAK area are not the same even within the same season or year. The difference between the two methods (GSI vs. PSC Chinook model) seems to have been due to a difference in proportion of CWT-stocks or period of CWT application. PSC Chinook model based estimates were based on CWT data, and did not cover the whole population of Chinook

salmon because some stocks were not tagged in the base period, or were minimally tagged (e.g., FRE). Thus for those stocks, we guess GSI based estimates are much better than PSC Chinook model based estimates.

Ocean in-season forecasts

Except for SPR, ocean fishery forecasts of age-specific terminal returns for the other groups were made, using only the ocean catch data. Appendix Tables 1 - 8 show summaries of the forecast performance by group when PSC Chinook model based estimates were used for stock compositions while Appendix Tables 9 -16 display those when GSI based estimates were used. SPR proportion in the SEAK troll fishery catch is almost zero, and thus the SPR catch (in eq. 4) becomes zero. Thus forecasts of SPR returns were not made. Proportions of age 3 CWF and age 5 FRL in the SEAK troll fishery catch were zero, and thus forecasts of those returns were also not made (Figures 3-6).

Overall, PSC Chinook model based forecasts of Chinook salmon returns appeared to outperform GSI based forecasts (Figures 3-6; Appendix Tables 1-16). However, GSI based forecasts outperformed PSC Chinook model based forecasts of the following 13 Chinook salmon components: during period 1, age 4- and age 5- AKS, age 3-, age 4- and age 5- ORC, age 5- CWF, and age 3- and age 5- RBH+RBT; during period 2, age 5- AKS, age-4 and age 5- URB+SUM, and age 3- and age 5- RBH+RBT (Figures 5 and 6). In Figures 5 and 6, the MSEs of forecasts of these components were smaller from GSI based method than those from PSC Chinook model based method.

Conclusions

It is difficult to extract a general conclusion about which method is better, because of different temporal ranges of data between PSC Chinook model and GSI methods (Figure 2). We have only five year data on GSI based stock compositions: 2004-2008. The 2009 data were not incorporated because the age-specific return data by return year end in 2008 (PSC Calibration 2009 was used for this analysis). For ocean fishery forecast of return in a year, data from 11 years prior to the year were used for the hind-casting forecast. For example, for forecast of return in 2004, data from 1993-2003 (11 years prior to 2004) were used. Here, note that data prior 2004 were not from GSI based stock compositions but from the PSC Chinook model based stock compositions. Thus, it is too early to say GSI based stock compositions are not contributive because of the short temporal data. Instead, we note that there may be a good potential from GSI data, as demonstrated for the above 13 components.

It must be recalled that ocean fishery forecasts of Chinook salmon stock returns can be substantially improved by being integrated with preseason forecasts (Hyun et al. 2012). The integrated forecasts of returns were vindicated from our previous report and publication (e.g., Hyun et al. 2012). The current issue lies in a benefit of the new GSI stock compositions, and we did not include the preseason forecasts, because the preseason forecasts would make the same contributions to the integrated forecasts. In other words, only difference in integrated forecasts between the two methods, i.e., GSI and PSC Chinook model methods would have originated from ocean fishery forecasts. That is, if ocean fishery forecasts from GSI based stock compositions are better or worse those from PSC Chinook model based stock compositions, then the resultant integrated forecasts would be better or worse accordingly.

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Table 1. Nine groups based on data about (i) GSI based compositions in the southeast Alaska troll fishery catch and (ii) terminal runs. The GSI based compositions of some stocks are not separated, and thus they are aggregated: e.g., URB+SUM, RBH+RBT, and WCH+WCN.

Abbreviation	Stock name
AKS	Alaska Spring
ORC	Oregon Coastal Far North Falls
CWF	Bonneville Tules
SPR	Spring Creek Tule
URB+SUM	Columbia River Upriver Brights
	Upper Columbia River
FRE	Fraser Early
FRL	Fraser Late
RBH+RBT	West Coast Vancouver Island Hatchery
	West Coast Vancouver Island Wild
WCH+WCN	Washington Coastal Falls Hatchery
	Washington Coastal Natural

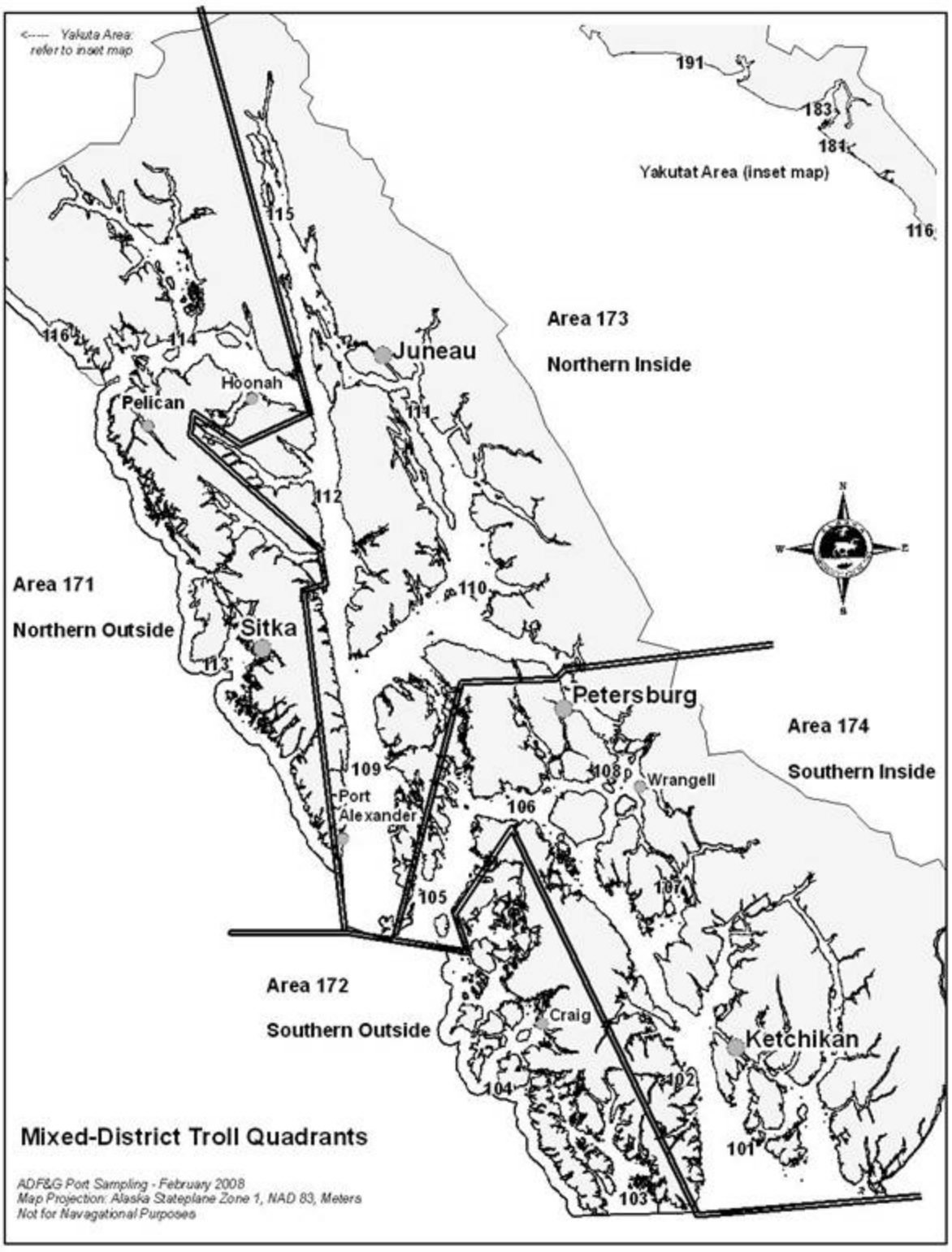

Figure 1. Four quadrants of southeast Alaska troll fishery area (source: Alaska Department of Fish and Game).

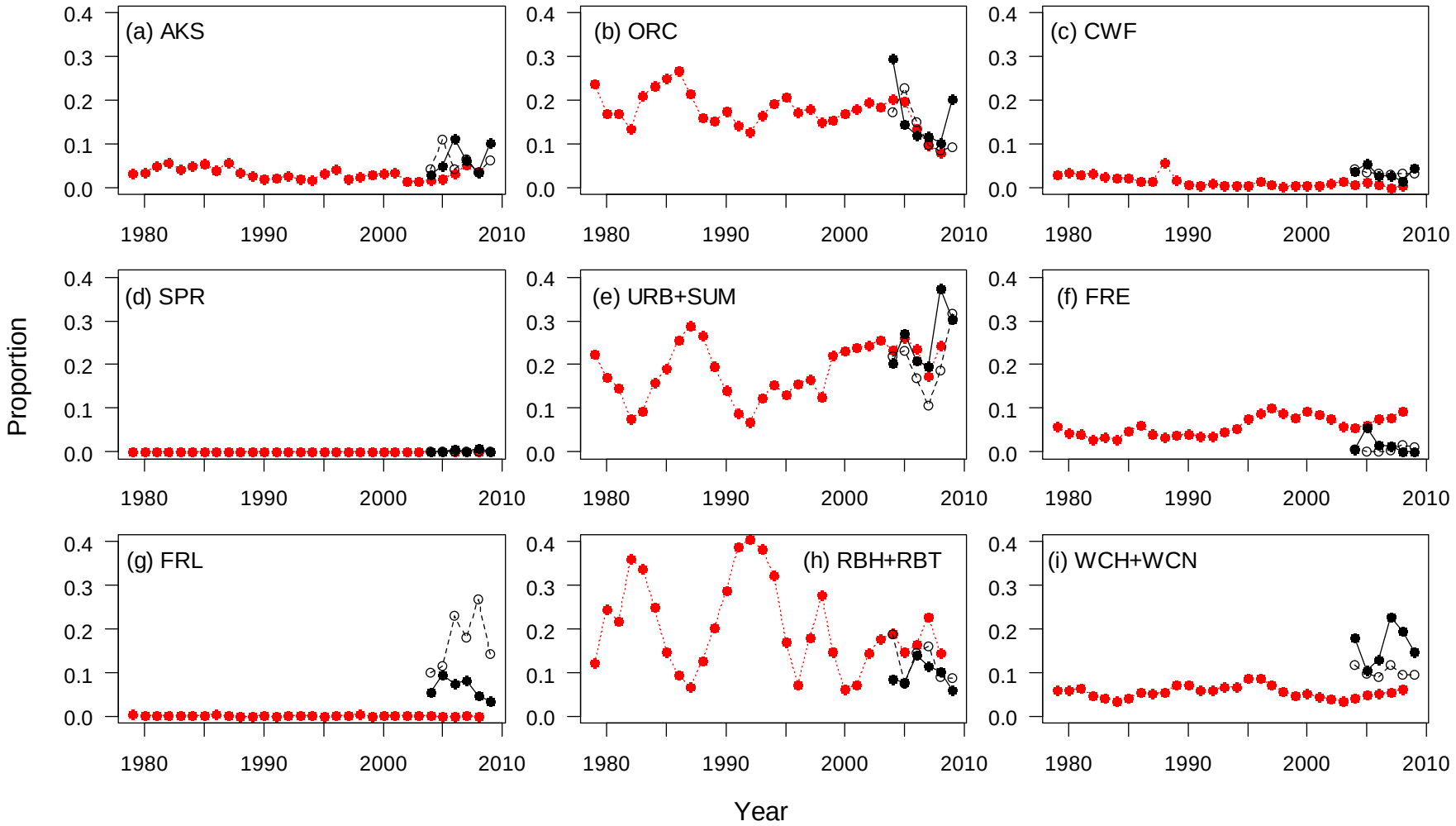

Figure 2. Chinook salmon stock compositions caught in southeast Alaska (SEAK) troll fishery area, which were estimated from genetic stock identification (GSI) data and from PSC Chinook model. Circles from 2004-2009 are stock compositions estimated from GSI data during Period 1 (July), and dots are those during Period 2 (August). Red dots from 1979-2008 are stock compositions estimated from PSC Chinook model.

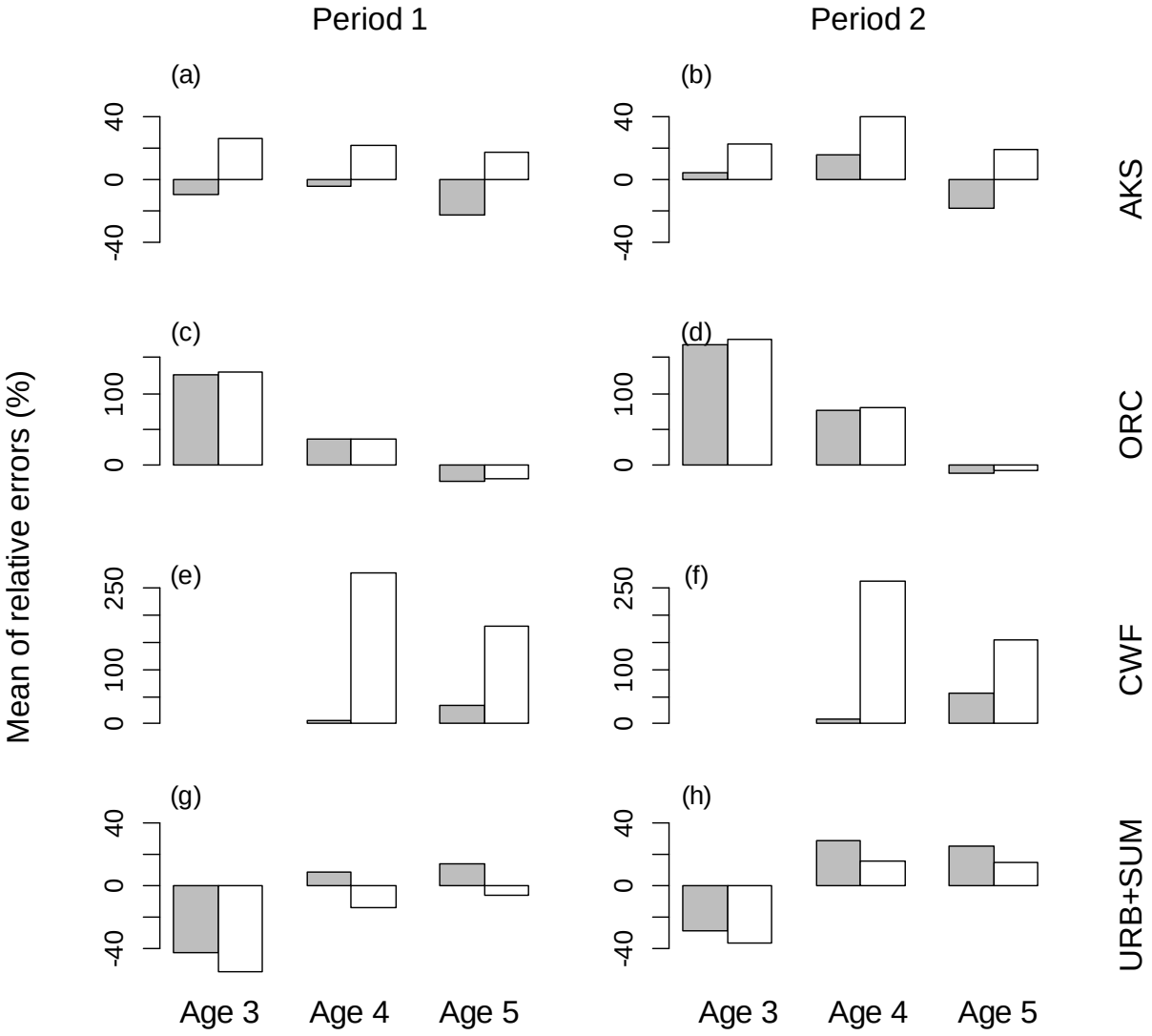

Figure 3. Comparison of PSC Chinook model based (grey bar) and GSI based (white bar) forecasts of AKS, ORC, CWF, and URB+SUM returns in 2004 - 2008 in terms of the mean of relative errors (%) of forecasts. Proportion of age 3 CWF in the SEAK troll fishery catch is zero, and thus forecasts of age 3 CWF returns were not made. See Table 1 for stock abbreviations. Period 1 = July, and Period 2 = August.

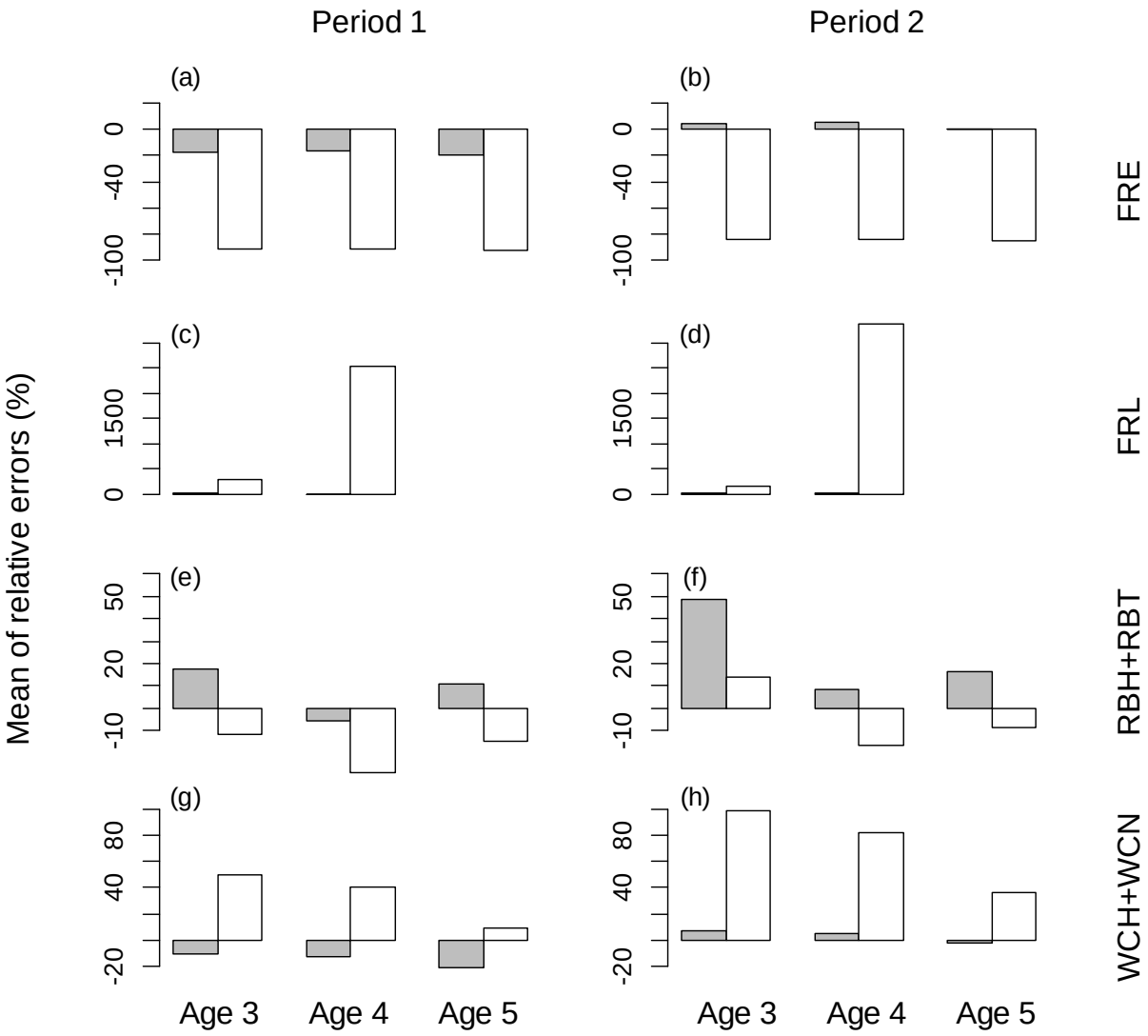

Figure 4. Comparison of PSC Chinook model based (grey bar) and GSI based (white bar) forecasts of FRE, FRL, RBH+RBT, and WCH+WCN returns in 2004 - 2008 in terms of the mean of relative errors (%) of forecasts. Proportion of age 5 FRL in the SEAK troll fishery catch is zero, and thus forecasts of age 5 FRL returns were not made. See Table 1 for stock abbreviations. Period 1 = July, and Period 2 = August.

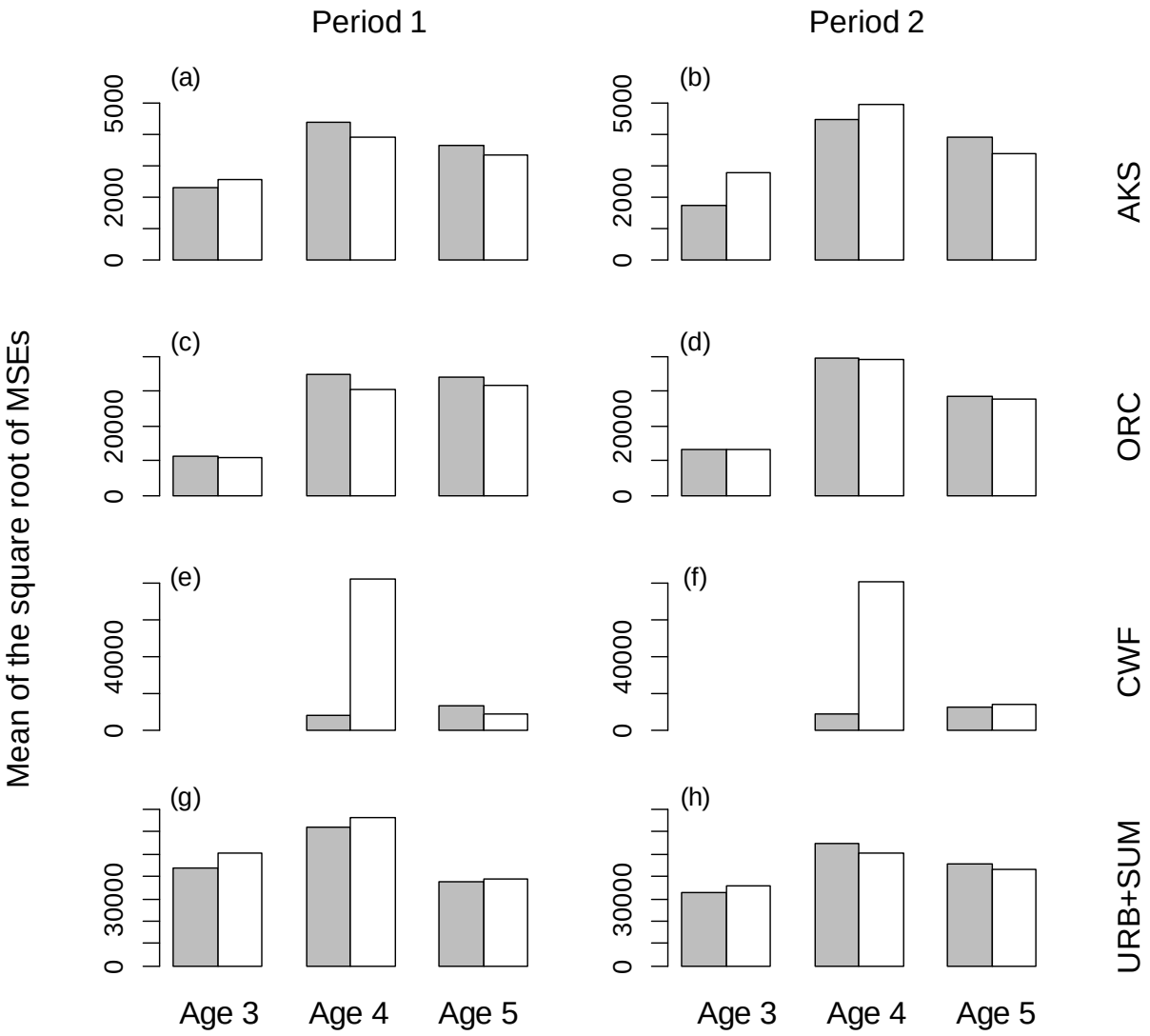

Figure 5. Comparison of PSC Chinook model based (grey bar) and GSI based (white bar) forecasts of AKS, ORC, CWF, and URB+SUM returns in 2004 - 2008 in terms of in the mean of $\sqrt{MSE}$ of forecasts. Proportion of age 3 CWF in the SEAK troll fishery catch is zero, and thus forecasts of age 3 CWF returns were not made. See Table 1 for stock abbreviations. Period 1 = July, and Period 2 = August.

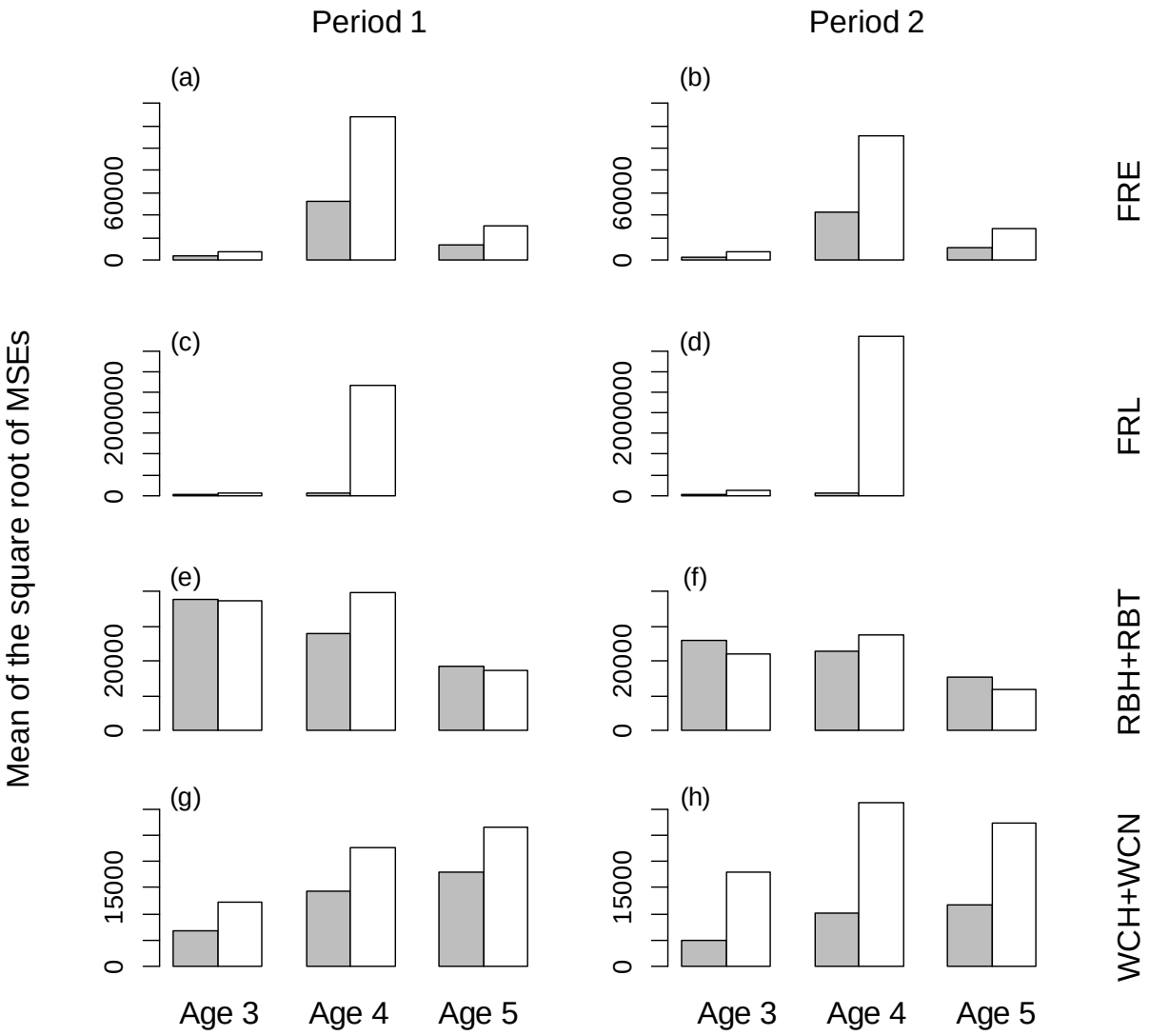

Figure 6. Comparison of PSC Chinook model based (grey bar) and GSI based (white bar) forecasts of FRE, FRL, RBH+RBT, and WCH+WCN returns in 2004 - 2008 in terms of in the mean of $\sqrt{MSE}$ of forecasts. Proportion of age 5 FRL in the SEAK troll fishery catch is zero, and thus forecasts of age 5 FRL returns were not made. See Table 1 for stock abbreviations. Period 1 = July, and Period 2 = August.

Appendix Table 1. Based on PSC Chinook model, ocean fishery forecasts of age-specific Alaska Spring (AKS) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
3	2004	1	3681	6950	-47.0	635	6726	0	1812622	12501208
3	2005	1	2440	3429	-28.9	0	6177	1	2730000	3708881
3	2006	1	4989	6323	-21.1	977	9001	1	3145309	4925609
3	2007	1	3084	3011	2.4	0	7003	1	3001356	3006704
3	2008	1	4611	3206	43.8	949	8272	1	2619842	4592711
3	2004	2	4840	6950	-30.4	1583	8097	1	2072656	6524514
3	2005	2	3575	3429	4.3	189	6961	1	2240342	2261639
3	2006	2	5880	6323	-7.0	2306	9454	1	2496197	2692331
3	2007	2	3703	3011	23.0	460	6945	1	2054472	2532816
3	2008	2	4190	3206	30.7	1563	6817	1	1348639	2317321
4	2004	1	3802	4901	-22.4	0	10075	1	7688460	8896072
4	2005	1	4790	10125	-52.7	0	11169	1	7952529	36413503
4	2006	1	6650	8286	-19.7	0	14293	1	11415248	14091252
4	2007	1	12751	8638	47.6	4399	21102	1	13630207	30543393
4	2008	1	8234	6532	26.1	574	15895	1	11467579	14365413
4	2004	2	4947	4901	0.9	0	12095	1	9985478	9987586
4	2005	2	7051	10125	-30.4	0	14376	1	10485179	19936798
4	2006	2	7971	8286	-3.8	278	15663	1	11563798	11663306
4	2007	2	15752	8638	82.4	7335	24169	1	13844783	64457247
4	2008	2	8254	6532	26.4	1581	14927	1	8700988	11666042
5	2004	1	2316	5563	-58.4	0	7951	1	6205477	16750059
5	2005	1	1971	2548	-22.6	0	7528	1	6033861	6366782
5	2006	1	2699	6257	-56.9	0	8401	1	6352140	19010170
5	2007	1	1995	3446	-42.1	0	8129	1	7352654	9458755
5	2008	1	6847	4127	65.9	0	13914	1	9759973	17158096
5	2004	2	1492	5563	-73.2	0	7014	1	5957395	22527397
5	2005	2	3229	2548	26.7	0	8530	1	5491429	5955033
5	2006	2	1226	6257	-80.4	0	7465	1	7605905	32918840
5	2007	2	2909	3446	-15.6	0	9208	1	7753406	8042020
5	2008	2	6186	4127	49.9	0	13396	1	10159487	14399389

Appendix Table 2. Based on PSC Chinook model, ocean fishery forecasts of age-specific Oregon Coastal Far North Falls (ORC) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
3	2004	1	20446	10002	104.4	0	45699	1	1.25E+08	2.34E+08
3	2005	1	11571	8426	37.3	0	35673	1	1.14E+08	1.23E+08
3	2006	1	4594.6	3596	27.8	0	28378	1	1.11E+08	1.12E+08
3	2007	1	3785.8	771	391.0	0	24020	1	8.00E+07	8.91E+07
3	2008	1	6088.3	3677	65.6	0	26209	1	7.91E+07	8.49E+07
3	2004	2	26533	10002	165.3	1379.7	51686	1	1.24E+08	3.97E+08
3	2005	2	16488	8426	95.7	0	41755	1	1.25E+08	1.90E+08
3	2006	2	5278.3	3596	46.8	0	30573	1	1.25E+08	1.28E+08
3	2007	2	4469.2	771	479.7	0	27789	1	1.06E+08	1.20E+08
3	2008	2	5437.8	3677	47.9	0	28820	1	1.07E+08	1.10E+08
4	2004	1	88630	39093	126.7	27075	150185	1	7.40E+08	3.19E+09
4	2005	1	44182	53078	-16.8	0	110030	1	8.47E+08	9.26E+08
4	2006	1	34750	44693	-22.2	0	100602	1	8.47E+08	9.46E+08
4	2007	1	12557	9159	37.1	0	77302	1	8.19E+08	8.31E+08
4	2008	1	18756	12420	51.0	0	77385	1	6.72E+08	7.12E+08
4	2004	2	118605	39093	203.4	67959	169252	0	5.01E+08	6.82E+09
4	2005	2	59860	53078	12.8	0	124284	1	8.11E+08	8.57E+08
4	2006	2	43212	44693	-3.3	0	106428	1	7.81E+08	7.83E+08
4	2007	2	18638	9159	103.5	0	80113	1	7.39E+08	8.28E+08
4	2008	2	20530	12420	65.3	0	81097	1	7.17E+08	7.83E+08
5	2004	1	76459	81812	-6.5	16476	136441	1	7.03E+08	7.32E+08
5	2005	1	58004	106178	-45.4	1616.6	114391	1	6.21E+08	2.94E+09
5	2006	1	40519	61902	-34.5	0	104947	1	8.11E+08	1.27E+09
5	2007	1	32535	37082	-12.3	0	93219	1	7.20E+08	7.40E+08
5	2008	1	20010	23518	-14.9	0	79280	1	6.86E+08	6.99E+08
5	2004	2	105043	81812	28.4	54012	156074	1	5.09E+08	1.05E+09
5	2005	2	71256	106178	-32.9	15555	126956	1	6.06E+08	1.83E+09
5	2006	2	45359	61902	-26.7	0	93565	1	4.54E+08	7.28E+08
5	2007	2	37687	37082	1.6	0	83081	1	4.03E+08	4.03E+08
5	2008	2	17467	23518	-25.7	0	61339	1	3.76E+08	4.13E+08

Appendix Table 3. Based on PSC Chinook model, ocean fishery forecasts of age-specific Bonneville Tules (CWF) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
4	2004	1	39329	40433	-2.7	21828	56829	1	5.98E+07	6.11E+07
4	2005	1	41089	38265	7.4	23714	58465	1	5.90E+07	6.70E+07
4	2006	1	25714	28120	-8.6	9251	42177	1	5.30E+07	5.88E+07
4	2007	1	NA	10512	NA	0	16011	NA	5.01E+07	NA
4	2008	1	17526	14025	25.0	0	35127	1	6.05E+07	7.28E+07
4	2004	2	44596	40433	10.3	30575	58617	1	3.84E+07	5.57E+07
4	2005	2	52002	38265	35.9	37467	66537	1	4.13E+07	2.30E+08
4	2006	2	25656	28120	-8.8	10049	41262	1	4.76E+07	5.37E+07
4	2007	2	NA	10512	NA	0	15313	NA	4.58E+07	NA
4	2008	2	13668	14025	-2.5	0	30557	1	5.57E+07	5.59E+07
5	2004	1	1762.4	20973	-91.6	0	89825	1	1.52E+09	1.88E+09
5	2005	1	11514	9715	18.5	1498	21529	1	1.96E+07	2.28E+07
5	2006	1	5212.7	11914	-56.2	0	14462	1	1.67E+07	6.16E+07
5	2007	1	5742.2	3429	67.5	0	15953	1	2.04E+07	2.57E+07
5	2008	1	4165.1	1261	230.3	0	14422	1	2.06E+07	2.90E+07
5	2004	2	2425	20973	-88.4	0	85133	1	1.34E+09	1.68E+09
5	2005	2	14988	9715	54.3	6261	23716	1	1.49E+07	4.27E+07
5	2006	2	6177.4	11914	-48.1	0	15037	1	1.53E+07	4.82E+07
5	2007	2	7393.4	3429	115.6	0	16858	1	1.75E+07	3.32E+07
5	2008	2	4344.1	1261	244.5	0	13946	1	1.80E+07	2.75E+07

Appendix Table 4. Based on PSC Chinook model, ocean fishery forecasts of age-specific Columbia River Upriver Brights and Upper Columbia River (URB+SUM) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
3	2004	1	67160	122058	-45.0	25294	109026	0	3.43E+08	3.36E+09
3	2005	1	30598	71240	-57.0	0	83750	1	5.52E+08	2.2E+09
3	2006	1	26705	52574	-49.2	0	87849	1	7.31E+08	1.4E+09
3	2007	1	22203	36267	-38.8	0	85753	1	7.89E+08	9.87E+08
3	2008	1	102380	131580	-22.2	28485	176276	1	1.07E+09	1.92E+09
3	2004	2	90208	122058	-26.1	41099	139316	1	4.71E+08	1.49E+09
3	2005	2	45985	71240	-35.5	0	92437	1	4.22E+08	1.06E+09
3	2006	2	33045	52574	-37.1	0	82353	1	4.75E+08	8.56E+08
3	2007	2	28911	36267	-20.3	0	80025	1	5.11E+08	5.65E+08
3	2008	2	100010	131580	-24.0	44057	155962	1	6.12E+08	1.61E+09
4	2004	1	141272	111193	27.1	21623	260920	1	2.8E+09	3.7E+09
4	2005	1	141968	188593	-24.7	20631	263306	1	2.88E+09	5.05E+09
4	2006	1	97367	118100	-17.6	0	220348	1	2.96E+09	3.39E+09
4	2007	1	75106	69210	8.5	0	198069	1	2.95E+09	2.99E+09
4	2008	1	110854	71963	54.0	0	233826	1	2.96E+09	4.47E+09
4	2004	2	192415	111193	73.0	116093	268737	0	1.14E+09	7.74E+09
4	2005	2	209872	188593	11.3	111512	308231	1	1.89E+09	2.34E+09
4	2006	2	112212	118100	-5.0	18929	205494	1	1.7E+09	1.74E+09
4	2007	2	88839	69210	28.4	0	181234	1	1.67E+09	2.05E+09
4	2008	2	98825	71963	37.3	5990	191660	1	1.68E+09	2.41E+09
5	2004	1	209813	194999	7.6	111040	308586	1	1.91E+09	2.13E+09
5	2005	1	84745	78566	7.9	8361	161128	1	1.14E+09	1.18E+09
5	2006	1	138927	137912	0.7	59430	218424	1	1.23E+09	1.24E+09
5	2007	1	43000	45787	-6.1	0	111826	1	9.26E+08	9.33E+08
5	2008	1	78444	48838	60.6	9856	147032	1	9.19E+08	1.8E+09
5	2004	2	260895	194999	33.8	167914	353876	1	1.69E+09	6.03E+09
5	2005	2	111118	78566	41.4	40337	181900	1	9.79E+08	2.04E+09
5	2006	2	132158	137912	-4.2	54834	209482	1	1.17E+09	1.2E+09
5	2007	2	49729	45787	8.6	0	119685	1	9.56E+08	9.72E+08
5	2008	2	72297	48838	48.0	1844	142751	1	9.7E+08	1.52E+09

Appendix Table 5. Based on PSC Chinook model, ocean fishery forecasts of age-specific Fraser Early (FRE) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
3	2004	1	6581	6683	-1.5	52	13109	1	8.33E+06	8.34E+06
3	2005	1	5725	7947	-28.0	0	12167	1	8.11E+06	1.30E+07
3	2006	1	4846	8190	-40.8	0	11296	1	8.13E+06	1.93E+07
3	2007	1	4158	4776	-13.0	0	10605	1	8.12E+06	8.51E+06
3	2008	1	7842	8099	-3.2	1697	13988	1	7.38E+06	7.45E+06
3	2004	2	9078	6683	35.8	3972	14185	1	5.10E+06	1.08E+07
3	2005	2	8741	7947	10.0	3370	14113	1	5.64E+06	6.27E+06
3	2006	2	5915	8190	-27.8	868	10961	1	4.98E+06	1.02E+07
3	2007	2	5238	4776	9.7	95	10380	1	5.17E+06	5.38E+06
3	2008	2	7497	8098.8	-7.4	2455	12539	1	4.97E+06	5.33E+06
4	2004	1	102502	104618	-2.0	4567	200438	1	1.87E+09	1.88E+09
4	2005	1	72633	101133	-28.2	0	168423	1	1.79E+09	2.61E+09
4	2006	1	95036	162081	-41.4	0	191705	1	1.83E+09	6.32E+09
4	2007	1	72767	82043	-11.3	0	176531	1	2.10E+09	2.19E+09
4	2008	1	112275	112856	-0.5	11134	213415	1	2.00E+09	2.00E+09
4	2004	2	143186	104618	36.9	69449	216923	1	1.06E+09	2.55E+09
4	2005	2	111446	101133	10.2	34416	188475	1	1.16E+09	1.27E+09
4	2006	2	117308	162081	-27.6	43134	191483	1	1.08E+09	3.08E+09
4	2007	2	92063	82043	12.2	13405	170722	1	1.21E+09	1.31E+09
4	2008	2	107334	112856	-4.9	29593	185074	1	1.18E+09	1.21E+09
5	2004	1	27890	29727	-6.2	3311	52469	1	1.18E+08	1.21E+08
5	2005	1	17665	25561	-30.9	0	41431	1	1.10E+08	1.73E+08
5	2006	1	18688	32941	-43.3	0	42670	1	1.12E+08	3.16E+08
5	2007	1	20405	24064	-15.2	0	45709	1	1.25E+08	1.39E+08
5	2008	1	26281	27329	-3.8	1447	51115	1	1.21E+08	1.22E+08
5	2004	2	38785	29727	30.5	19136	58434	1	7.54E+07	1.57E+08
5	2005	2	26599	25561	4.1	6519	46679	1	7.88E+07	7.99E+07
5	2006	2	22722	32941	-31.0	3913	41531	1	6.91E+07	1.74E+08
5	2007	2	25523	24064	6.1	5542	45503	1	7.80E+07	8.01E+07
5	2008	2	24672	27329	-9.7	5190	44153	1	7.42E+07	8.12E+07

Appendix Table 6. Based on PSC Chinook model, ocean fishery forecasts of age-specific Fraser Late (FRL) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
3	2004	1	26640	46439	-42.6	0	75026	1	4.58E+08	8.5E+08
3	2005	1	14089	30483	-53.8	0	63777	1	4.82E+08	7.51E+08
3	2006	1	58824	47869	22.9	4536	113112	1	5.76E+08	6.96E+08
3	2007	1	23780	12816	85.6	0	74783	1	5.08E+08	6.29E+08
3	2008	1	112864	65595	72.1	75309	150420	0	2.76E+08	2.51E+09
3	2004	2	29101	46439	-37.3	0	91282	1	7.56E+08	1.06E+09
3	2005	2	16982	30483	-44.3	0	79323	1	7.59E+08	9.42E+08
3	2006	2	63993	47869	33.7	0	131457	1	8.89E+08	1.15E+09
3	2007	2	25211	12816	96.7	0	89477	1	8.07E+08	9.61E+08
3	2008	2	103839	65595	58.3	63944	143733	1	3.11E+08	1.77E+09
4	2004	1	137182	121218	13.2	33854	240510	1	2.09E+09	2.34E+09
4	2005	1	61724	75442	-18.2	0	161509	1	1.95E+09	2.13E+09
4	2006	1	47274	54791	-13.7	0	147147	1	1.95E+09	2.01E+09
4	2007	1	78475	89378	-12.2	0	179400	1	1.99E+09	2.11E+09
4	2008	1	28669	19090	50.2	0	127305	1	1.9E+09	1.99E+09
4	2004	2	177399	121218	46.3	100874	253924	1	1.14E+09	4.3E+09
4	2005	2	87717	75442	16.3	5903	169531	1	1.31E+09	1.46E+09
4	2006	2	54498	54791	-0.5	0	135969	1	1.3E+09	1.3E+09
4	2007	2	93240	89378	4.3	10747	175734	1	1.33E+09	1.34E+09
4	2008	2	25711	19090	34.7	0	103396	1	1.18E+09	1.22E+09

Appendix Table 7. Based on PSC Chinook model, ocean fishery forecasts of age-specific West Coast Vancouver Island Hatchery and Wild (RBH+RBT) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
3	2004	1	59478	114696	-48.1	2705	116251	1	6.30E+08	3.68E+09
3	2005	1	36404	28781	26.5	0	94302	1	6.55E+08	7.13E+08
3	2006	1	53603	86929	-38.3	0	112799	1	6.85E+08	1.80E+09
3	2007	1	11901	5291	124.9	0	72605	1	7.20E+08	7.64E+08
3	2008	1	57299	46092	24.3	0	124555	1	8.84E+08	1.01E+09
3	2004	2	90548	114696	-21.1	51988	129108	1	2.91E+08	8.74E+08
3	2005	2	56546	28781	96.5	24313	88779	1	2.03E+08	9.74E+08
3	2006	2	63921	86929	-26.5	25920	101922	1	2.82E+08	8.12E+08
3	2007	2	14547	5291	174.9	0	53520	1	2.97E+08	3.82E+08
3	2008	2	55498	46092	20.4	12836	98160	1	3.56E+08	4.44E+08
4	2004	1	76142	82318	-7.5	27880	124404	1	4.55E+08	4.93E+08
4	2005	1	72866	108651	-32.9	24258	121473	1	4.62E+08	1.74E+09
4	2006	1	74008	87336	-15.3	27656	120359	1	4.20E+08	5.97E+08
4	2007	1	120653	100358	20.2	71621	169686	1	4.70E+08	8.82E+08
4	2008	1	25895	24380	6.2	0	74117	1	4.54E+08	4.57E+08
4	2004	2	97533	82318	18.5	61303	133764	1	2.57E+08	4.88E+08
4	2005	2	105759	108651	-2.7	67697	143820	1	2.83E+08	2.91E+08
4	2006	2	83715	87336	-4.1	52998	114432	1	1.84E+08	1.97E+08
4	2007	2	139803	100358	39.3	107447	172160	0	2.05E+08	1.76E+09
4	2008	2	22482	24380	-7.8	0	63689	1	3.32E+08	3.35E+08
5	2004	1	82417	60503	36.2	8493	156341	1	1.07E+09	1.55E+09
5	2005	1	13253	19405	-31.7	0	34749	1	9.03E+07	1.28E+08
5	2006	1	18093	22832	-20.8	0	40445	1	9.76E+07	1.20E+08
5	2007	1	12946	12433	4.1	0	32447	1	7.43E+07	7.46E+07
5	2008	1	47210	28272	67.0	24731	69689	1	9.87E+07	4.57E+08
5	2004	2	45689	60503	-24.5	0	124881	1	1.23E+09	1.44E+09
5	2005	2	21118	19405	8.8	6746	35489	1	4.04E+07	4.33E+07
5	2006	2	22565	22832	-1.2	8154	36975	1	4.06E+07	4.07E+07
5	2007	2	17302	12433	39.2	3078	31525	1	3.95E+07	6.32E+07
5	2008	2	44929	28272	58.9	28679	61179	0	5.16E+07	3.29E+08

Appendix Table 8. Based on PSC Chinook model, ocean fishery forecasts of age-specific Washington Coastal Falls Hatchery and Natural (WCH+WCN) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
3	2004	1	18226	20523	-11.2	2630	33822	1	4.75E+07	5.28E+07
3	2005	1	12162	16411	-25.9	0	26927	1	4.26E+07	6.07E+07
3	2006	1	10673	14352	-25.6	0	25644	1	4.38E+07	5.73E+07
3	2007	1	8397.4	7771.4	8.1	0	21622	1	3.42E+07	3.46E+07
3	2008	1	16106	16179	-0.4	3015	29197	1	3.35E+07	3.35E+07
3	2004	2	24342	20523	18.6	13474	35211	1	2.31E+07	3.77E+07
3	2005	2	17822	16411	8.6	7485	28159	1	2.09E+07	2.29E+07
3	2006	2	12459	14352	-13.2	2506	22412	1	1.94E+07	2.29E+07
3	2007	2	10138	7771.4	30.4	1279	18997	1	1.53E+07	2.09E+07
3	2008	2	14758	16179	-8.8	5860	23657	1	1.55E+07	1.75E+07
4	2004	1	32984	37775	-12.7	1026	64942	1	2.00E+08	2.23E+08
4	2005	1	24188	33156	-27.0	0	54781	1	1.83E+08	2.63E+08
4	2006	1	25657	35040	-26.8	0	56958	1	1.91E+08	2.80E+08
4	2007	1	21151	19690	7.4	0	49337	1	1.55E+08	1.57E+08
4	2008	1	26724	28191	-5.2	905	52542	1	1.30E+08	1.32E+08
4	2004	2	44199	37775	17.0	22456	65943	1	9.24E+07	1.34E+08
4	2005	2	35223	33156	6.2	12677	57768	1	9.93E+07	1.04E+08
4	2006	2	29966	35040	-14.5	9349	50584	1	8.31E+07	1.09E+08
4	2007	2	25630	19690	30.2	7502	43759	1	6.42E+07	9.95E+07
4	2008	2	24802	28191	-12.0	7764	41839	1	5.67E+07	6.82E+07
5	2004	1	29642	38602	-23.2	0	66806	1	2.70E+08	3.50E+08
5	2005	1	23816	37253	-36.1	0	59292	1	2.46E+08	4.26E+08
5	2006	1	26518	41051	-35.4	0	62992	1	2.60E+08	4.71E+08
5	2007	1	20588	22171	-7.1	0	53598	1	2.13E+08	2.15E+08
5	2008	1	29770	31444	-5.3	0	62912	1	2.15E+08	2.17E+08
5	2004	2	41378	38602	7.2	14743	68012	1	1.39E+08	1.46E+08
5	2005	2	35777	37253	-4.0	10455	61098	1	1.25E+08	1.27E+08
5	2006	2	32125	41051	-21.7	8175	56075	1	1.12E+08	1.92E+08
5	2007	2	27050	22171	22.0	5201	48899	1	9.33E+07	1.17E+08
5	2008	2	27319	31444	-13.1	5291	49347	1	9.48E+07	1.12E+08

Appendix Table 9. Based on GSI method, ocean fishery forecasts of age-specific Alaska Spring (AKS) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
3	2004	1	9556	6950	37.5	5472	13640	1	3.26E+06	1.01E+07
3	2005	1	6506	3429	89.7	0	13804	1	1.04E+07	1.99E+07
3	2006	1	4629	6323	-26.8	1380	7878	1	2.06E+06	4.93E+06
3	2007	1	3075	3011	2.1	0	6406	1	2.17E+06	2.17E+06
3	2008	1	4036	3206	25.9	949	7122	1	1.86E+06	2.55E+06
3	2004	2	11805	6950	69.9	7301	16310	0	3.96E+06	2.75E+07
3	2005	2	4289	3429	25.1	0	12664	1	1.37E+07	1.44E+07
3	2006	2	4876	6323	-22.9	1478	8275	1	2.26E+06	4.35E+06
3	2007	2	3714	3011	23.4	474	6955	1	2.05E+06	2.55E+06
3	2008	2	3700	3206	15.4	1030	6371	1	1.39E+06	1.64E+06
4	2004	1	9875	4901	101.5	3087	16663	1	9.00E+06	3.37E+07
4	2005	1	NA	10125	NA	0	65503	NA	1.52E+09	NA
4	2006	1	6677	8286	-19.4	0	13811	1	9.95E+06	1.25E+07
4	2007	1	8826	8638	2.2	1370	16282	1	1.09E+07	1.09E+07
4	2008	1	6536	6532	0.1	0	13495	1	9.46E+06	9.46E+06
4	2004	2	12067	4901	146.2	4061	20073	1	1.25E+07	6.39E+07
4	2005	2	NA	10125	NA	0	83722	NA	3.00E+09	NA
4	2006	2	9658	8286	16.6	792	18523	1	1.54E+07	1.72E+07
4	2007	2	9550	8638	10.6	718	18382	1	1.52E+07	1.61E+07
4	2008	2	5646	6532	-13.6	0	13678	1	1.26E+07	1.34E+07
5	2004	1	NA	5563	NA	0	13029	NA	2.60E+08	NA
5	2005	1	4213	2548	65.3	0	10778	1	8.42E+06	1.12E+07
5	2006	1	3692	6257	-41.0	0	9687	1	7.02E+06	1.36E+07
5	2007	1	2950	3446	-14.4	0	8853	1	6.81E+06	7.06E+06
5	2008	1	6556	4127	58.9	0	13156	1	8.51E+06	1.44E+07
5	2004	2	NA	5563	NA	0	-2819	NA	4.64E+08	NA
5	2005	2	4513	2548	77.1	0	11162	1	8.64E+06	1.25E+07
5	2006	2	3504	6257	-44.0	0	10150	1	8.63E+06	1.62E+07
5	2007	2	3487	3446	1.2	0	9647	1	7.41E+06	7.42E+06
5	2008	2	5788	4127	40.2	0	12397	1	8.54E+06	1.13E+07

Appendix Table 10. Based on GSI method, ocean fishery forecasts of age-specific Oregon Coastal Far North Falls (ORC) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
3	2004	1	17567	10002	75.6	0	42591	1	1.22E+08	1.80E+08
3	2005	1	13495	8426	60.2	0	37023	1	1.08E+08	1.34E+08
3	2006	1	5198	3596	44.6	0	28510	1	1.06E+08	1.09E+08
3	2007	1	3805	771	393.5	0	23548	1	7.62E+07	8.54E+07
3	2008	1	6433	3677	75.0	0	26078	1	7.54E+07	8.30E+07
3	2004	2	26139	10002	161.3	1026	51251	1	1.23E+08	3.84E+08
3	2005	2	16799	8426	99.4	0	41945	1	1.24E+08	1.94E+08
3	2006	2	5526	3596	53.7	0	30744	1	1.24E+08	1.28E+08
3	2007	2	4608	771	497.7	0	27859	1	1.06E+08	1.20E+08
3	2008	2	6111	3677	66.2	0	29454	1	1.06E+08	1.12E+08
4	2004	1	76146	39093	94.8	15989	136304	1	7.07E+08	2.08E+09
4	2005	1	52851	53078	-0.4	0	114971	1	7.54E+08	7.54E+08
4	2006	1	39822	44693	-10.9	0	100881	1	7.29E+08	7.52E+08
4	2007	1	12491	9159	36.4	0	72453	1	7.03E+08	7.14E+08
4	2008	1	20202	12420	62.7	0	74373	1	5.73E+08	6.34E+08
4	2004	2	116843	39093	198.9	66389	167297	0	4.97E+08	6.54E+09
4	2005	2	60612	53078	14.2	0	125072	1	8.12E+08	8.69E+08
4	2006	2	44386	44693	-0.7	0	107467	1	7.78E+08	7.78E+08
4	2007	2	18845	9159	105.8	0	80247	1	7.37E+08	8.31E+08
4	2008	2	22319	12420	79.7	0	83027	1	7.20E+08	8.18E+08
5	2004	1	65692	81812	-19.7	7411	123973	1	6.64E+08	9.24E+08
5	2005	1	68591	106178	-35.4	9969	127214	1	6.72E+08	2.08E+09
5	2006	1	46329	61902	-25.2	0	108002	1	7.43E+08	9.86E+08
5	2007	1	32934	37082	-11.2	0	89499	1	6.25E+08	6.42E+08
5	2008	1	21286	23518	-9.5	0	76477	1	5.95E+08	6.00E+08
5	2004	2	103484	81812	26.5	52726	154241	1	5.03E+08	9.73E+08
5	2005	2	72647	106178	-31.6	15033	130261	1	6.49E+08	1.77E+09
5	2006	2	47525	61902	-23.2	810	94241	1	4.26E+08	6.33E+08
5	2007	2	38829	37082	4.7	0	83133	1	3.84E+08	3.87E+08
5	2008	2	19596	23518	-16.7	0	62386	1	3.58E+08	3.73E+08

Appendix Table 11. Based on GSI method, ocean fishery forecasts of age-specific Bonneville Tules (CWF) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
4	2004	1	232580	40433	475.2	194373	270786	0	2.85E+08	3.72E+10
4	2005	1	64594	38265	68.8	34860	94328	1	1.73E+08	8.66E+08
4	2006	1	67249	28120	139.1	31536	102961	0	2.49E+08	1.78E+09
4	2007	1	NA	10512	NA	0	38905	NA	2.96E+08	NA
4	2008	1	74840	14025	433.6	21909	127772	0	5.47E+08	4.25E+09
4	2004	2	255877	40433	532.8	223160	288595	0	2.09E+08	4.66E+10
4	2005	2	44298	38265	15.8	22108	66487	1	9.62E+07	1.33E+08
4	2006	2	68212	28120	142.6	46755	89669	0	9.00E+07	1.70E+09
4	2007	2	NA	10512	NA	0	31437	NA	1.93E+08	NA
4	2008	2	65121	14025	364.3	24484	105758	0	3.23E+08	2.93E+09
5	2004	1	NA	20973	NA	0	3281100	NA	2.92E+12	NA
5	2005	1	21895	9715	125.4	4200	39591	1	6.12E+07	2.10E+08
5	2006	1	9967	11914	-16.3	0	22241	1	2.94E+07	3.32E+07
5	2007	1	NA	3429	NA	0	83816	NA	1.06E+11	NA
5	2008	1	6682	1261	429.9	0	18303	1	2.64E+07	5.58E+07
5	2004	2	NA	20973	NA	0	2568899	NA	2.39E+12	NA
5	2005	2	37223	9715	283.1	17299	57146	0	7.76E+07	8.34E+08
5	2006	2	7374	11914	-38.1	0	20003	1	3.12E+07	5.18E+07
5	2007	2	NA	3429	NA	0	299410	NA	1.43E+11	NA
5	2008	2	4041	1261	220.4	0	15746	1	2.68E+07	3.45E+07

Appendix Table 12. Based on GSI method, ocean fishery forecasts of age-specific Columbia River Upriver Brights and Upper Columbia River (URB+SUM) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
3	2004	1	63401	122058	-48.1	22215	104587	0	3.31E+08	3.77E+09
3	2005	1	27486	71240	-61.4	0	82807	1	5.98E+08	2.51E+09
3	2006	1	19757	52574	-62.4	0	83710	1	7.99E+08	1.88E+09
3	2007	1	14364	36267	-60.4	0	82418	1	9.05E+08	1.38E+09
3	2008	1	81382	131580	-38.1	3030	159735	1	1.2E+09	3.72E+09
3	2004	2	84271	122058	-31.0	36305	132237	1	4.5E+08	1.88E+09
3	2005	2	43783	71240	-38.5	0	92162	1	4.57E+08	1.21E+09
3	2006	2	26578	52574	-49.4	0	78086	1	5.18E+08	1.19E+09
3	2007	2	21604	36267	-40.4	0	76344	1	5.86E+08	8.01E+08
3	2008	2	103693	131580	-21.2	42385	165002	1	7.34E+08	1.51E+09
4	2004	1	131353	111193	18.1	12417	250289	1	2.76E+09	3.17E+09
4	2005	1	125682	188593	-33.4	6577	244787	1	2.77E+09	6.73E+09
4	2006	1	70727	118100	-40.1	0	195582	1	3.05E+09	5.29E+09
4	2007	1	47487	69210	-31.4	0	176599	1	3.26E+09	3.73E+09
4	2008	1	86715	71963	20.5	0	216866	1	3.31E+09	3.53E+09
4	2004	2	176346	111193	58.6	100891	251801	1	1.11E+09	5.36E+09
4	2005	2	198093	188593	5.0	107213	288974	1	1.61E+09	1.7E+09
4	2006	2	89181	118100	-24.5	3703	174659	1	1.43E+09	2.26E+09
4	2007	2	65554	69210	-5.3	0	152958	1	1.49E+09	1.51E+09
4	2008	2	104881	71963	45.7	17197	192564	1	1.5E+09	2.59E+09
5	2004	1	195083	194999	0.0	99362	290804	1	1.79E+09	1.79E+09
5	2005	1	77120	78566	-1.8	1637	152603	1	1.11E+09	1.12E+09
5	2006	1	104146	137912	-24.5	28626	179667	1	1.11E+09	2.25E+09
5	2007	1	28951	45787	-36.8	0	101347	1	1.02E+09	1.31E+09
5	2008	1	65291	48838	33.7	0	137839	1	1.03E+09	1.3E+09
5	2004	2	239108	194999	22.6	150275	327941	1	1.54E+09	3.49E+09
5	2005	2	106320	78566	35.3	36735	175905	1	9.46E+08	1.72E+09
5	2006	2	112963	137912	-18.1	40660	185266	1	1.02E+09	1.64E+09
5	2007	2	36913	45787	-19.4	0	106696	1	9.52E+08	1.03E+09
5	2008	2	76557	48838	56.8	5217	147898	1	9.95E+08	1.76E+09

Appendix Table 13. Based on GSI method, ocean fishery forecasts of age-specific Fraser Early (FRE) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
3	2004	1	710	6683	-89.4	0	7054	1	7.86E+06	4.35E+07
3	2005	1	NA	7947	NA	0	7749	NA	1.17E+07	NA
3	2006	1	63	8190	-99.2	0	9746	1	1.83E+07	8.44E+07
3	2007	1	206	4776	-95.7	0	11384	1	2.44E+07	4.53E+07
3	2008	1	1352	8099	-83.3	0	12751	1	2.54E+07	7.09E+07
3	2004	2	980	6683	-85.3	0	5833	0	4.60E+06	3.71E+07
3	2005	2	2636	7947	-66.8	0	9231	1	8.50E+06	3.67E+07
3	2006	2	579	8190	-92.9	0	8089	0	1.10E+07	6.89E+07
3	2007	2	443	4776	-90.7	0	9848	1	1.73E+07	3.61E+07
3	2008	2	1103	8099	-86.4	0	11084	1	1.95E+07	6.84E+07
4	2004	1	11063	104618	-89.4	0	105719	1	1.75E+09	1.05E+10
4	2005	1	NA	101133	NA	0	117681	NA	2.71E+09	NA
4	2006	1	1240	162081	-99.2	0	139661	0	3.74E+09	2.96E+10
4	2007	1	3551	82043	-95.7	0	185210	1	6.45E+09	1.26E+10
4	2008	1	19091	112856	-83.1	0	207105	1	6.91E+09	1.57E+10
4	2004	2	15455	104618	-85.2	0	84836	0	9.41E+08	8.89E+09
4	2005	2	34226	101133	-66.2	0	132163	1	1.87E+09	6.35E+09
4	2006	2	11441	162081	-92.9	0	118983	0	2.26E+09	2.50E+10
4	2007	2	7897	82043	-90.4	0	163885	1	4.75E+09	1.03E+10
4	2008	2	16330	112856	-85.5	0	182739	1	5.41E+09	1.47E+10
5	2004	1	3010	29727	-89.9	0	26463	0	1.07E+08	8.21E+08
5	2005	1	NA	25561	NA	0	30805	NA	1.85E+08	NA
5	2006	1	242	32941	-99.3	0	36203	1	2.53E+08	1.32E+09
5	2007	1	1000	24064	-95.8	0	35117	1	2.27E+08	7.59E+08
5	2008	1	4491	27329	-83.6	0	39414	1	2.38E+08	7.60E+08
5	2004	2	4186	29727	-85.9	0	22282	0	6.40E+07	7.16E+08
5	2005	2	8155	25561	-68.1	0	35113	1	1.42E+08	4.45E+08
5	2006	2	2253	32941	-93.2	0	31422	0	1.66E+08	1.11E+09
5	2007	2	2220	24064	-90.8	0	39356	1	2.70E+08	7.47E+08
5	2008	2	3862	27329	-85.9	0	44725	1	3.26E+08	8.77E+08

Appendix Table 14. Based on GSI method, ocean fishery forecasts of age-specific Fraser Late (FRL) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
3	2004	1	NA	46439	NA	0	NA	NA	2.54E+13	NA
3	2005	1	64314	30483	111.0	0	145401	1	1.28E+09	2.43E+09
3	2006	1	NA	47869	NA	0	NA	NA	5.87E+14	NA
3	2007	1	72876	12816	468.6	0	244270	1	5.74E+09	9.35E+09
3	2008	1	NA	65595	NA	0	NA	NA	NA	NA
3	2004	2	NA	46439	NA	0	NA	NA	NA	NA
3	2005	2	NA	30483	NA	0	NA	NA	NA	NA
3	2006	2	NA	47869	NA	0	NA	NA	NA	NA
3	2007	2	62045	12816	384.1	0	229007	1	5.45E+09	7.87E+09
3	2008	2	42098	65595	-35.8	0	358732	1	1.96E+10	2.01E+10
4	2004	1	9568078	121218	7793.3	7457129	11679027	0	8.71E+11	9.01E+13
4	2005	1	722030	75442	857.1	520743	923317	0	7.92E+09	4.26E+11
4	2006	1	NA	54791	NA	0	NA	NA	NA	NA
4	2007	1	46907	89378	-47.5	0	383867	1	2.22E+10	2.40E+10
4	2008	1	303418	19090	1489.4	0	958109	1	8.38E+10	1.65E+11
4	2004	2	11255605	121218	9185.4	9504777	13006433	0	5.99E+11	1.25E+14
4	2005	2	NA	75442	NA	0	NA	NA	NA	NA
4	2006	2	NA	54791	NA	0	NA	NA	NA	NA
4	2007	2	62978	89378	-29.5	0	398791	1	2.20E+10	2.27E+10
4	2008	2	204390	19090	970.7	0	727337	1	5.34E+10	8.78E+10

Appendix Table 15. Based on GSI method, ocean fishery forecasts of age-specific West Coast Vancouver Island Hatchery and Wild (RBH+RBT) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
3	2004	1	59347	114696	-48.3	2568	116126	1	6.30E+08	3.69E+09
3	2005	1	21562	28781	-25.1	0	78247	1	6.28E+08	6.80E+08
3	2006	1	51827	86929	-40.4	0	111164	1	6.88E+08	1.92E+09
3	2007	1	8946	5291	69.1	0	70017	1	7.29E+08	7.42E+08
3	2008	1	39943	46092	-13.3	0	104280	1	8.09E+08	8.47E+08
3	2004	2	85656	114696	-25.3	47163	124149	1	2.90E+08	1.13E+09
3	2005	2	34756	28781	20.8	1296	68217	1	2.19E+08	2.54E+08
3	2006	2	64188	86929	-26.2	29566	98810	1	2.34E+08	7.51E+08
3	2007	2	10965	5291	107.2	0	46655	1	2.49E+08	2.81E+08
3	2008	2	43609	46092	-5.4	8141	79077	1	2.46E+08	2.52E+08
4	2004	1	75426	82318	-8.4	27184	123668	1	4.55E+08	5.02E+08
4	2005	1	37023	108651	-65.9	0	84790	0	4.46E+08	5.58E+09
4	2006	1	65321	87336	-25.2	0	131495	1	8.56E+08	1.34E+09
4	2007	1	85913	100358	-14.4	16939	154886	1	9.30E+08	1.14E+09
4	2008	1	17037	24380	-30.1	0	84514	1	8.90E+08	9.44E+08
4	2004	2	85502	82318	3.9	49560	121444	1	2.52E+08	2.63E+08
4	2005	2	55174	108651	-49.2	20436	89912	0	2.36E+08	3.10E+09
4	2006	2	78620	87336	-10.0	30702	126537	1	4.49E+08	5.25E+08
4	2007	2	100590	100358	0.2	52977	148202	1	4.43E+08	4.43E+08
4	2008	2	17486	24380	-28.3	0	62961	1	4.04E+08	4.52E+08
5	2004	1	81653	60503	35.0	9457	153849	1	1.02E+09	1.47E+09
5	2005	1	6921	19405	-64.3	0	28146	1	8.80E+07	2.44E+08
5	2006	1	16030	22832	-29.8	0	39802	1	1.10E+08	1.57E+08
5	2007	1	9420	12433	-24.2	0	30812	1	8.94E+07	9.85E+07
5	2008	1	31271	28272	10.6	7893	54649	1	1.07E+08	1.16E+08
5	2004	2	51928	60503	-14.2	0	107544	1	6.04E+08	6.78E+08
5	2005	2	11717	19405	-39.6	0	25809	1	3.88E+07	9.79E+07
5	2006	2	20586	22832	-9.8	5043	36129	1	4.72E+07	5.23E+07
5	2007	2	12627	12433	1.6	0	27931	1	4.58E+07	4.58E+07
5	2008	2	33442	28272	18.3	16924	49960	1	5.33E+07	8.00E+07

Appendix Table 16. Based on GSI method, ocean fishery forecasts of age-specific Washington Coastal Falls Hatchery and Natural (WCH+WCN) returns. Period 1 = July, and Period 2 = August.

Age	Year	Period	Forecast	Actual run	Error (%)	Low	Up	Cover	Var(forecast)	MSE
3	2004	1	50725	20523	147.2	30454	70996	0	8.03E+07	9.92E+08
3	2005	1	16841	16411	2.6	502	33180	1	5.22E+07	5.24E+07
3	2006	1	15220	14352	6.0	0	31299	1	5.05E+07	5.13E+07
3	2007	1	12821	7771	65.0	0	25919	1	3.35E+07	5.90E+07
3	2008	1	20640	16179	27.6	6780	34499	1	3.75E+07	5.74E+07
3	2004	2	75269	20523	266.8	58585	91954	0	5.44E+07	3.05E+09
3	2005	2	22951	16411	39.9	11176	34727	1	2.71E+07	6.99E+07
3	2006	2	18698	14352	30.3	6456	30941	1	2.93E+07	4.82E+07
3	2007	2	16784	7771	116.0	5632	27936	1	2.43E+07	1.06E+08
3	2008	2	22761	16179	40.7	9063	36459	1	3.67E+07	8.00E+07
4	2004	1	91796	37775	143.0	51257	132336	0	3.21E+08	3.24E+09
4	2005	1	32426	33156	-2.2	0	65459	1	2.13E+08	2.14E+08
4	2006	1	34004	35040	-3.0	1312	66696	1	2.09E+08	2.10E+08
4	2007	1	27514	19690	39.7	321	54706	1	1.44E+08	2.06E+08
4	2008	1	35385	28191	25.5	12130	58640	1	1.06E+08	1.57E+08
4	2004	2	136631	37775	261.7	102642	170619	0	2.26E+08	1.00E+10
4	2005	2	42551	33156	28.3	20379	64724	1	9.61E+07	1.84E+08
4	2006	2	38006	35040	8.5	15641	60372	1	9.77E+07	1.07E+08
4	2007	2	32823	19690	66.7	13191	52455	1	7.53E+07	2.48E+08
4	2008	2	41626	28191	47.7	20851	62402	1	8.43E+07	2.65E+08
5	2004	1	45535	38602	18.0	0	207926	1	5.15E+09	5.20E+09
5	2005	1	32596	37253	-12.5	0	68536	1	2.52E+08	2.74E+08
5	2006	1	35597	41051	-13.3	716	70478	1	2.38E+08	2.68E+08
5	2007	1	28192	22171	27.2	0	57333	1	1.66E+08	2.02E+08
5	2008	1	38908	31444	23.7	12828	64989	1	1.33E+08	1.89E+08
5	2004	2	67471	38602	74.8	0	235712	1	5.53E+09	6.36E+09
5	2005	2	42134	37253	13.1	16031	68238	1	1.33E+08	1.57E+08
5	2006	2	38419	41051	-6.4	13620	63217	1	1.20E+08	1.27E+08
5	2007	2	33091	22171	49.3	11245	54937	1	9.33E+07	2.13E+08
5	2008	2	47493	31444	51.0	24128	70857	1	1.07E+08	3.64E+08