SOUTHERN RESIDENT KILLER WHALE WORKGROUP REPORT 3: FORECASTING BIAS ASSESSMENT[1]

At the September 2020 Pacific Fishery Management Council (Council) meeting, the Southern Resident Killer Whale (SRKW) Workgroup (Workgroup) provided a draft range of alternatives and recommendations for Council consideration. The Council directed the Workgroup to provide additional information at the November 2020 Council meeting. The following report details the Workgroup's updated consideration and recommendations of using a forecasting bias if the Council selects a threshold (Options 3.1.2.a through 3.1.2d in the draft range of alternatives) as part of the preferred alternative.

Concise Technical Summary:

1.) The Workgroup produced two analyses to assess potential bias in pre versus post-season estimates of Chinook salmon abundance.
2.) Analysis 1 and 2 produced similar results. Neither analysis used the ideal metric (North of Falcon ocean abundance), but they represent the best information available for the Workgroup/Council to make a decision on.
3.) Arithmetic mean values of the ratio of postseason:preseason abundance were slightly greater than 1.0 (1.08 and 1.05). Median values were slightly less than 1.0 (0.95 and 0.93). More weight should be given to median values, due to the skewed nature of the distributions of annual ratios.
4.) Sample sizes were small, and this limited the power of any statistical analysis. Examination of post:pre ratios in the data set for NOF-weighted abundance (assuming a lognormal distribution of annual ratios) produced 95% confidence intervals for the median ratio that overlapped 1.0 (range = 0.88 to 1.18).
5.) There was no evidence of improving forecast performance (i.e., post:pre ratios closer to 1.0) over time, either in the analyses performed for recent FRAM outputs or in analysis of longer-term performance metrics reported by the STT.
6.) Acknowledging sample size limitations, there was some evidence of overforecasting at low abundance and underforecasting at high abundance, which is similar to results found for individual stocks in analysis of longer-term data reported by the STT.
7.) If the Council decides that adjustment of the proposed thresholds based on forecast performance is necessary, the Workgroup suggests an adjustment of 1.08 (median pre:post ratio from analysis 2).

[1] **Note:** While creating this write up, Workgroup members identified and corrected an error in the forecast comparison file that caused comparison errors for Spring stocks in the model (summing maturation in time steps 1 and 4). As the lower Columbia Spring Chinook salmon stocks have a particularly important contribution to NOF TS1 abundance, values in this document differ from those presented on 9/29/2020.

Introduction:

All Southern Resident Killer Whale (SRKW)-Chinook salmon abundance relationship assessments performed by the workgroup were conducted using post-season Chinook salmon model runs. Post-season model runs are based on the best available estimates of abundance and catch collected by agency sampling programs after the season has concluded. While this makes post-season data valuable for determining potential relationships between Chinook salmon abundance and SRKW demographics, salmon management instead uses pre-season model runs to set fishing seasons and to plan for compliance with management objectives. These pre-season model runs use projected abundance forecasts and proposed fishery catches to produce modeling estimates for the coming fishing cycle. As fishing seasons are set using pre-season runs but SRKW workgroup analyses were conducted using post-season runs, the workgroup expressed interest in assessing any potential bias in pre-season abundance forecasts relative to post-season estimated returns. Any forecasting bias could affect the success of any of the proposed range of SRKW management alternatives. Consistent underforecasting (pre-season predictions that are lower than post-season return estimates) could lead to adoption of overly conservative management thresholds. Conversely, overforecasting (predictions that are consistently higher than post-season estimates) could result in pre-season management thresholds that do not leave the intended abundance of Chinook salmon available for SRKW.

Analyses Performed:

As management thresholds proposed are based on North of Falcon starting ocean abundance in the wintertime period, it would be ideal to compare pre- and post-season values using this metric. However, these numbers are not easy to obtain for all of the years of potential interest for this analysis. In 2017, the Fishery Regulation Assessment Model (FRAM; used for domestic management of Chinook salmon stocks North of Falcon), updated its base period data from fishing years 1979–1982 to fishing years 2007–2013. In this update, fishery exploitation rates and maturation rates (alongside several other parameters) changed. This resulted in pre-season abundances in years prior to 2017 using a very different measuring stick than current post-season runs, and so a comparison of abundances using different base periods could be inadvisable. While the FRAM base period workgroup has prepared a set of unofficial pre-season runs with the current version of the base period from 2013–2020, a longer time series of pre-season runs with the current base period would be both difficult and time-consuming.

In the absence of direct starting abundance comparisons from pre- and post-season runs, the workgroup chose to 1) compare pre-season terminal run size (TRS) forecasts against post-season TRS on a stock-by-stock basis and 2) compare pre-season TRS forecasts weighted by Shelton stock distributions against post-season TRS also weighted by Shelton stock distributions for the North of Falcon aggregate. Each approach has strengths and weaknesses that are discussed later in this document. The years used in the analysis were 2008 through 2016, which were chosen because prior to 2008, fewer stocks were included in pre-season management models, which would preclude using these stocks in a longer time series analysis. It is also progressively more difficult to extract TRS information for earlier years, as the format of the management model used was considerably different to the current format. For example, in very early years, to access pre-season model files, Lotus software is needed, but it is unavailable to the workgroup's members at the time this document was written.

Analysis 1: Compare Terminal Run Sizes Without Shelton Distributions Applied

This data set compared pre- and post-season TRS for all FRAM stocks along the West Coast, excluding Mid Oregon Coast (not available in pre-season runs prior to 2017). Note that unlike the primary abundance analyses of the workgroup, Klamath and Rogue were not included in this analysis because they are not FRAM stocks. Similarly, note that FRAM TRS abundances rather than those resulting from South of Falcon models were used for Central Valley Fall. One stock that may be of particular importance to the NOF area in time step 1 and has been excluded from the analysis is Upriver Columbia Springs as this is not a FRAM stock.

Forecasting bias varied greatly across stocks, with some stocks having considerably higher post-season returns than pre-season forecasts on average (e.g., South Fork Nooksack Springs, Tulalip Fall Fingerlings, and Washington North Coast Falls; Table 1) and some stocks having considerably lower post-season returns than pre-season forecasts on average (e.g., White River Spring Yearlings; Table 1). When aggregating all FRAM stocks on the West Coast, the arithmetic mean and median post-season:pre-season TRS ratios for the time period examined were 1.08 and 0.95, respectively (Table 2).

Analysis 2: Compare Terminal Run Sizes With Shelton Distributions Applied

Terminal run size data used in analysis 2 was the same as used in analysis 1, except that FRAM stocks were combined into Shelton stock aggregates. Each Shelton stock's aggregate TRS was multiplied by the stock's estimated percentage of the stock distribution in the winter (TS1) North of Falcon spatio-temporal region reported in Shelton et al., 2019[2]. The potential advantage to this approach is that stocks that are more likely to contribute to ocean abundances in the winter North of Falcon period are given a greater weight, and it is the modeled NOF winter abundance that is the basis of the threshold abundances proposed for consideration by the SRKW WG. The disadvantage is that several additional assumptions must be made relative to analysis 1 that are discussed later in this document.

Across all Shelton stocks, the mean post-season returns were higher than pre-season forecasts, with the exception of Central Valley Fall (post:pre ratio of 88%; Table 3). The median post-season returns were higher than pre-season forecasts for 7 of 10 stocks, with Upper Columbia, Puget Sound, and Central Valley having post:pre ratios of 84%, 99%, and 94%, respectively (Table 3). However, note that Upper Columbia is generally the largest contributor to aggregate NOF TS1 abundance in this analysis and aggregate NOF TS1 post:pre ratios had an arithmetic mean across years of 1.05 with a median of 0.93 (Table 4).

[2] Shelton, A. O., W. H. Satterthwaite, E. J. Ward, B. E. Feist, and B. Burke. 2019. Using hierarchical models to estimate stock-specific and seasonal variation in ocean distribution, survivorship, and aggregate abundance of fall run Chinook salmon. Canadian Journal of Fisheries and Aquatic Sciences 76:95-108. https://dx.doi.org/10.1139/cjfas-2017-0204

Analysis of Results, Caveats, and Considerations:

Both the arithmetic mean and median post:pre ratio were similar in analysis 1 and 2, with the mean ratio being slightly larger than 1 and the median being slightly lower than 1. Note that the annual post:pre ratios follow skewed distributions with no hard upper bound (Figure 1), whereas ratios lower than zero are impossible. The arithmetic mean can be sensitive to large outliers, whereas the median finds a value for which 50% of observations are above and 50% are below. The arithmetic mean will tend to be larger than the median for skewed distributions with long right-hand tails. Note also that the choice of post:pre or pre:post ratio as the performance metric is somewhat arbitrary, but this choice could be consequential if determining bias on the basis of the arithmetic mean. It is possible for both the post:pre and the pre:post arithmetic mean ratios to be greater than one, which would lead to logically inconsistent conclusions about the direction of bias, whereas the median is robust[3] to the choice of post:pre versus pre:post.

The group examined the distribution of post:pre ratios (Figure 1) and found that the distribution of both analyses had five instances of post:pre ratios less than 1.0 and four instances of post:pre ratios greater than 1.0. Though the true nature of the distribution, and especially its central tendency, is difficult to conclude definitively based on the small number of data points available, post:pre ratios appear clustered under the 1.0 post:pre ratio, with a long skew to greater post:pre ratios.

Some workgroup members expressed concern that it may be inappropriate to use historic estimates of forecast bias as forecasting methodology is constantly changing, with regional biologists striving to improve forecasting accuracy. On the other hand, the STT and SSC recently noted that salmon escapements have been increasingly variable, and thus more difficult to forecast, in the last decade[4]. Estimates of bias developed using dates back to 2008 may not be consistent with current methodology used and may overestimate or underestimate bias. In the time series of data available for analysis 1 and analysis 2, there did not appear to be a trend toward improved forecasting performance (Figure 2). An examination of Chinook forecast performance for individual stocks reported by the STT over a longer time period (back to the mid 1980's for Columbia River and Klamath Chinook stocks, back to the mid 1990's for Puget Sound Chinook salmon stocks) did not reveal any evidence for improving forecast performance over time[5] (Figure 3).

We examined trends in post:pre ratios at varying abundances and noted that many of the lower abundance points in the analysis were below a post:pre ratio of 1.0 (3 of the 4 lowest points; Figure 4) and many of the higher abundance data points were above a post:pre ratio of 1.0 (3 of the 4 highest points; Figure 4). This indicates a potential bias to overforecasting at low returns and underforecasting at high returns, but small sample sizes limit the ability to definitively conclude that this trend is occurring. Although this data set does not meet many of the assumptions for linear regression (postseason estimates are not known without error, residuals are not normally

[3] Though if the sample size is even (not the case here), the median is the midpoint between the two observations closest to the median. In this scenario, the midpoint may not be equal when examining a particular metric and its inverse. This problem is minimized or eliminated with large sample sizes or if a continuous distribution is fit to the data.

[4] https://www.pcouncil.org/documents/2017/03/e2a_sup_ssc_rpt_mar2017bb.pdf/

[5] https://www.pcouncil.org/documents/2020/02/2020-preseason-report-i.pdf/ Tables II-4, II-8, and II-9

distributed) and some points may be statistical "outliers", the relationship between postseason abundance and the post:pre ratio is statistically significant (p=0.04 for raw ratios, p=0.05 for log-transformed ratios). When looking at individual Chinook salmon stocks over the full time period reported by the STT, there similarly appeared to be a tendency toward overforecasting at low abundance (Figure 5).

Under the assumption that many of the errors in forecasting arise from multiplicative processes, one might assume that the postseason:preseason ratios are lognormally distributed, and fit a lognormal distribution to the data via maximum likelihood. Assuming this distributional form holds, the maximum likelihood estimates of the log-scale mean and standard error produce an approximate 95% confidence interval on the median spanning from 0.88 to 1.18.

Statistical considerations aside, it is not clear whether the default assumption should be that forecasts are unbiased, and the presence of bias must be conclusively demonstrated; or if the possibility of bias should be accounted for unless forecasts can be conclusively shown to have bias less than some level of concern.

One advantageous aspect of analysis 2 over analysis 1 is that stocks are weighted based upon their modeled contribution to the North of Falcon abundance. However, there are several additional assumptions that are made when applying Shelton distributions to a TRS. The ocean distribution percentages applied represent theoretical spatial usage during the wintertime period. A majority of the TRS used in the analysis is from fall stocks and is occurring outside of the wintertime period. In actuality, the total TRS is not ideal to use as a metric for assessing ocean abundance, because expansions from TRS to ocean abundance are dependent upon age, maturation rates, fishing rates, and natural mortality. Terminal run sizes are generally weighted highly to age classes 3 and 4, whereas ocean abundances differ in that they are more weighted toward age 3s. A large portion of the younger fish available in the ocean are not a part of the TRS, as they are likely to return in future years. Despite this caveat, there are four years (2013–16) with available pre- and post-season North of Falcon TS1 ocean abundances, and results from these years were similar to those from analysis 2 (Table 5). Additionally, the results from analysis 2 were similar to the results from analysis 1, indicating that there are likely not any major causes for concern in using analysis 2. Nevertheless, use of ocean abundances would be preferable in the future if the question of forecast error was revisited.

The workgroup is considering an adjustment to any derived abundance thresholds of 1.08 (inverse of the median post:pre ratio). Such an adjustment would be applied to any abundance threshold derived using post-season abundance estimates for pre-season management purposes. 1.08 should be considered rather than the 1.19 proposed in the September 2020 SRKW WG report[6], since the previously proposed value was based on incorrect TRS estimates for Spring stocks.

[6] https://www.pcouncil.org/documents/2020/08/h-3-a-srkw-workgroup-report-1-pacific-fishery-management-council-salmon-fishery-management-plan-impacts-to-southern-resident-killer-whales-draft-range-of-alternatives-and-recommendations.pdf/

Considerations:

When considering the above analysis, if the Council selects an abundance threshold for SRKW management purposes, the Council should contemplate the following potential actions:

1. Apply a forecast bias adjustment of 1.08 to any abundance thresholds suggested based on the median pre:post ratio of NOF TS1 weighted TRS estimates from 2008–16.

2. Schedule a periodic review of forecast performance conducted by one or more Council advisory bodies, given that forecasting methodology changes over time and that it may be possible to compare ocean abundances over a larger span of years in the future. This review could be valuable in the context of overall abundance, as per the analysis described in this document for SRKW, but could also be of value for salmon management by examining post:pre differences in individual stocks. Appropriate timing for this review might every two years; occurring after FRAM post-season runs are produced.

Table 1: Stock-specific results from analysis 1

		2008		2009		2010		2011		2012	
Fram Stk Num	**Stk Name**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**
1	NkSm FF	35356	19111	26337	23733	42184	33703	41695	39734	42729	43830
2	NFNK Sp	2056	2947	2356	2475	2991	2856	2010	3029	1805	3185
3	SFNK Sp	809	54	613	62	814	162	734	50	629	85
4	Skag FF	15635	18784	12811	17483	9032	13665	9115	15218	15812	9730
5	SkagFYr	289	7462	140	8323	853	1877	809	1342	522	434
6	SkagSpY	4022	4014	2733	2707	3849	2126	3252	3622	6090	3615
7	Snoh FF	11049	9436	3324	7842	4425	9599	2292	7975	9506	3865
8	SnohFYr	4333	4113	1237	3421	2784	3960	2858	3271	2499	2021
9	Stil FF	1986	803	1341	1596	983	1257	1857	1738	1924	918
10	Tula FF	4099	1613	1983	3394	4446	2977	5567	3176	631	5212
11	MidPSFF	53586	59290	38971	52456	37778	51411	38833	52760	45458	40127
12	UWAc FF	3269	2149	2844	1894	3800	2889	1942	2308	1486	1832
13	SPSd FF	95600	62295	63566	57235	81258	62035	60730	78479	61751	66320
14	SPS Fyr	2599	2253	594	2608	655	2160	714	2127	1087	3796
15	WhiteSp	3631	6571	1603	1781	1582	1851	2967	1829	4385	2676
16	HdCl FF	51196	38750	49898	45233	52282	48011	77491	47319	121644	53559
17	HdCl FY	437	328	640	208	474	503	401	492	250	638
18	SJDF FF	1508	3350	2436	2753	1839	1887	2696	2530	3446	2660
19	OR Tule	18938	27165	11071	27586	19461	15284	24866	34683	29366	43005
20	WA Tule	45213	34292	67185	66465	92291	76088	86027	100089	57166	81829
21	LCRWild	7815	4324	8036	9157	12514	10528	16210	13721	12828	17445
22	BPHTule	97085	95037	56057	64422	158176	173383	83930	125351	67599	70128
23	UpCR Su	55899	70517	54234	86397	72747	115647	80961	92528	58599	94601
24	UpCR Br	309206	254245	296336	402713	446905	428869	426641	536614	406897	497108
25	Cowl Sp	8823	15446	11713	7327	17965	19952	10750	10827	22946	8878
26	Will Sp	34881	34620	41309	45715	126485	64148	89037	105045	73347	84700
27	Snake F	9653	2515	9203	2494	23686	2455	22613	2512	21680	2472
28	OR No F	40592	46165	55901	46120	74383	80522	101298	101570	94263	98667
29	WCVI Tl	107270	76387	98026	67692	106167	77126	166481	91207	84313	64539
30	FrasRLt	150914	133980	115660	107588	366283	153624	253279	303502	90157	115976
31	FrasREr	158617	120554	144666	157413	216159	142929	174500	158410	81781	160093
32	LwGeo S	25890	20998	19291	22292	24380	21385	27359	19059	20246	15622
33	WhtSpYr	346	1276	241	466	90	453	317	629	139	412
34	LColNat	5111	4734	6210	6850	8843	6653	8924	9562	7072	9968
35	CentVal	82884	90535	50837	86138	164305	138612	181395	402298	476946	447735
36	WA NCst	37223	9777	35532	11663	46394	29972	59323	26295	49027	28725
37	Willapa	22659	31394	33538	42954	38835	33318	55631	37036	35231	39459
38	Hoko Rv	483	944	369	1034	903	1800	1524	1431	636	2125

Fram Stk Num	Stk Name	2013 Post	2013 Pre	2014 Post	2014 Pre	2015 Post	2015 Pre	2016 Post	2016 Pre	Arithmetic Mean Percent Diff (Post/Pre)
1	NkSm FF	38801	47352	30389	45332	38875	38899	39014	30712	111%
2	NFNK Sp	2985	2420	3031	2383	2484	2846	3268	3131	93%
3	SFNK Sp	1127	136	864	138	2513	469	600	699	810%
4	Skag FF	13188	13865	12566	17932	15257	12638	18317	15504	94%
5	SkagFYr	847	314	217	955	128	1085	776	964	68%
6	SkagSpY	4660	3921	4003	4329	4049	4722	6001	4557	119%
7	Snoh FF	6494	6277	4481	6994	6101	5390	11840	5001	111%
8	SnohFYr	2210	2956	4535	2878	1420	1549	1946	3364	89%
9	Stil FF	1124	1378	600	1511	815	734	1100	491	131%
10	Tula FF	2218	9527	2022	4043	4527	1109	10450	1251	218%
11	MidPSFF	43608	42647	25293	45324	35441	31469	49959	27940	97%
12	UWAc FF	94	1903		19					86%
13	SPSd FF	71845	64772	25937	56493	29992	40240	60506	25283	115%
14	SPS Fyr	640	2251	563	1602	839	1412	1882	553	77%
15	WhiteSp	6024	2073	1970	2681	2979	1831	6522	3585	141%
16	HdCl FF	85531	78244	30024	95358	41555	66323	80724	50754	123%
17	HdCl FY	606	911	461	1567	246	989	635	1085	93%
18	SJDF FF	4674	3344	4713	6263	4608	5398	3204	3891	94%
19	OR Tule	13389	28115	26341	17999	21368	28772	12237	37870	75%
20	WA Tule	93452	57772	75518	80493	110768	67263	68933	104763	111%
21	LCRWild	29589	15375	26625	34533	34857	20972	13865	25176	119%
22	BPHTule	103071	45997	155636	114015	201240	178755	50070	107542	107%
23	UpCR Su	68042	78598	78821	64748	127450	104374	91381	99962	86%
24	UpCR Br	1160286	585543	888413	1323260	1006256	721454	506574	744899	104%
25	Cowl Sp	14843	9004	15777	11270	47862	16711	41242	33738	153%
26	Will Sp	54619	65987	54402	58472	92012	61159	49228	71188	106%
27	Snake F	61482	2470	47034	2431	53247	2472	26760	2472	1240%
28	OR No F	120451	98059	135864	120308	147710	133603	105494	183475	100%
29	WCVI Tl	197039	37532	124302	225563	232146	128293	182551	231125	175%
30	FrasRLt	221367	90238	190871	146895	171299	74032	119929	54610	161%
31	FrasREr	179031	92325	232647	184758	246398	173761	132900	211639	118%
32	LwGeo S	19396	18824	34750	21406	24120	25048	26919	15710	126%
33	WhtSpYr	133	346	78	297	232	266	79	142	43%
34	LColNat	8486	6996	8255	8136	10554	7700	6521	11111	102%
35	CentVal	617384	458741	308167	328967	166298	336735	149081	156622	88%
36	WA NCst	46304	20755	52886	29046	58613	27918	36178	28607	220%
37	Willapa	38334	32976	42606	31771	50231	36446	26085	35374	108%
38	Hoko Rv	1067	1097	1845	2492	2815	3071	1289	2355	66%

Table 2:

Yearly stock-aggregate post and pre-season terminal run sizes. Post:pre represents the ratio of post-season TRS estimates divided by pre-season estimates.

Year	**Post**	**Pre**	**Post:Pre**
2008	1,510,963	1,318,227	1.15
2009	1,328,841	1,497,692	0.89
2010	2,269,001	1,835,681	1.24
2011	2,127,030	2,439,367	0.87
2012	2,011,892	2,127,989	0.95
2013	3,334,440	2,031,040	1.64
2014	2,652,505	3,102,665	0.85
2015	2,997,307	2,365,909	1.27
2016	1,944,062	2,337,145	0.83
Arth. Mean	2,241,782	2,117,302	1.08
Median	2,127,030	2,127,989	0.95

Table 3: Shelton stock aggregate pre-season forecast and post-season TRS multiplied by North of Falcon timestep 1 distributions. Mean represents the arithmetic mean

	2008		2009		2010		2011		2012	
Shelton Stk	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**
CENTV	9560	10443	5864	9936	18952	15988	20923	46403	55014	51644
LCOL	71016	67505	60576	71146	118774	114962	89689	115560	70963	90675
LCOLSPR	21852	25033	26511	26521	72225	42050	49893	57936	48147	46789
NOR	4254	4838	5858	4833	7795	8438	10616	10644	9878	10340
PUSO	99513	81569	73015	81050	86171	84064	87878	91901	109397	83827
PUSOSPR	1630	2229	1132	1124	1399	1117	1392	1374	1957	1496
SGEO	59990	49279	50010	51383	108531	56864	81402	86022	34372	52169
UCOL	113594	99202	109052	149012	164694	165795	160716	191464	147670	180105
WAC	3765	2589	4343	3434	5359	3979	7228	3982	5298	4287
WCVI	836	596	764	528	828	601	1298	711	657	503

	2013		2014		2015		2016		Mean %	Median %
Shelton Stk	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	(Post/Pre)	(Post/Pre)
CENTV	71212	52914	35546	37945	19182	38841	17196	18066	88%	94%
LCOL	101118	62899	119217	104050	154453	123738	61827	116806	100%	103%
LCOLSPR	34731	37495	35089	34871	69937	38935	45235	52463	112%	100%
NOR	12623	10276	14238	12608	15480	14001	11055	19228	100%	100%
PUSO	96515	97891	50794	102107	64575	74365	99590	59811	105%	99%
PUSOSPR	2239	1334	1492	1474	1839	1520	2471	1817	117%	121%
SGEO	75081	36018	81962	63145	79019	48798	50033	50429	130%	122%
UCOL	390960	202059	307439	421462	359783	251070	189360	256839	104%	84%
WAC	5322	3378	6004	3824	6844	4047	3915	4023	144%	145%
WCVI	1536	293	969	1759	1810	1000	1423	1802	175%	140%

Table 4: Yearly aggregated post and pre-season terminal run sizes distributed into North of Falcon time step 1 according to Shelton et al., 2018. Post:pre represents the ratio of post-season estimates divided by pre-season estimates.

Year	**Post**	**Pre**	**Post:Pre**
2008	386011	343283	1.12
2009	337126	398966	0.84
2010	584727	493858	1.18
2011	511036	605998	0.84
2012	483353	521835	0.93
2013	791337	504558	1.57
2014	652750	783245	0.83
2015	772920	596316	1.30
2016	482105	581283	0.83
Arth. Mean	555707	536594	1.05
Median	511036	521835	0.93

Table 5: 2013 through 2016 pre-season and post-season North of Falcon (TS1) ocean abundances versus results from analysis 2.

	TRS split into NOF TS1			NOF TS 1 Starting Abundance		
year	Post	Pre	Comparison	Post	Pre	Comparison
2013	791337	504558	1.57	2440331	1724767	1.41
2014	652750	783245	0.83	1976380	2295716	0.86
2015	772920	596316	1.30	2292946	1874742	1.22
2016	482105	581283	0.83	1438662	1809464	0.8

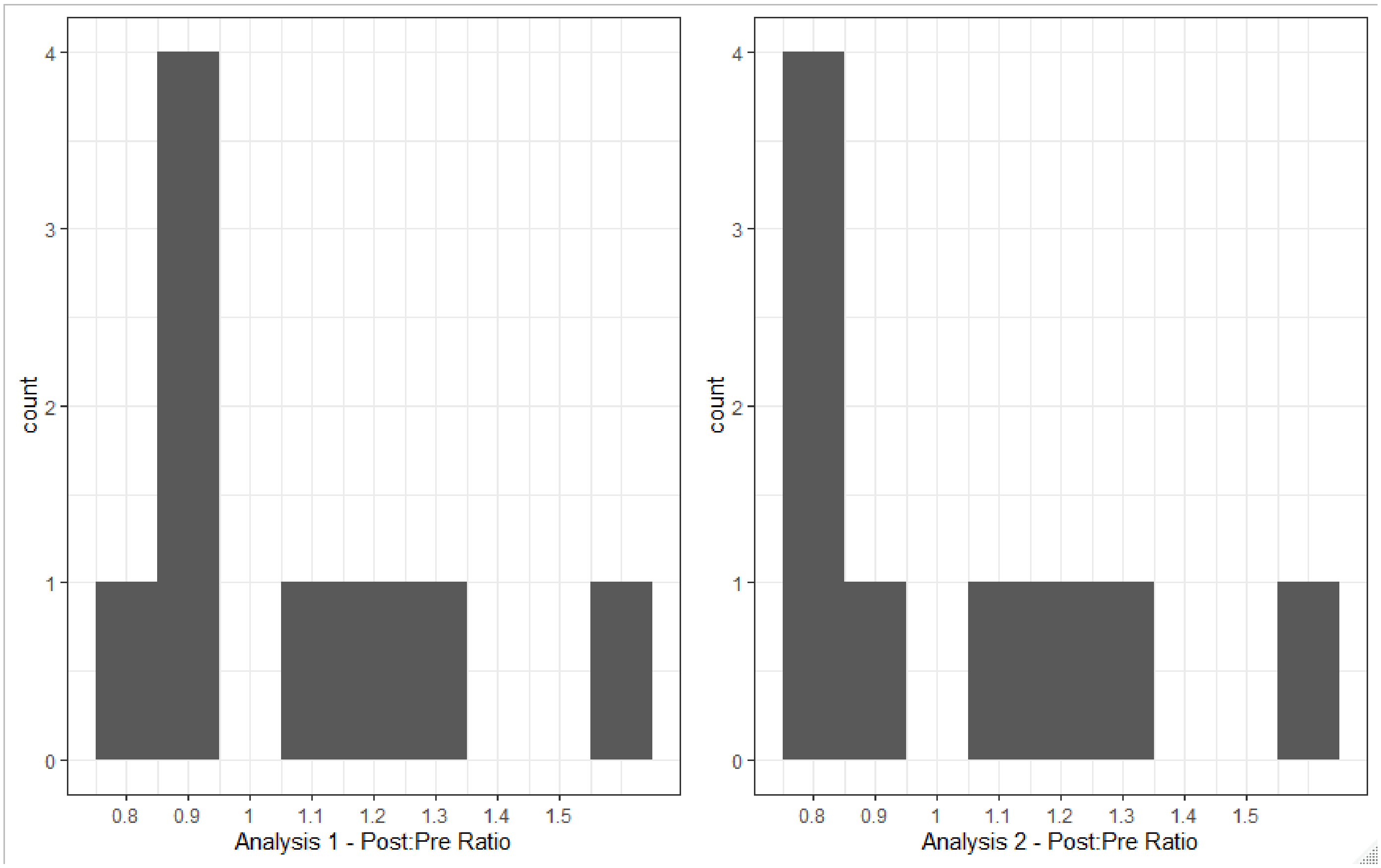

Figure 1: Post:Pre ratio distributions from analysis 1 and analysis 2.

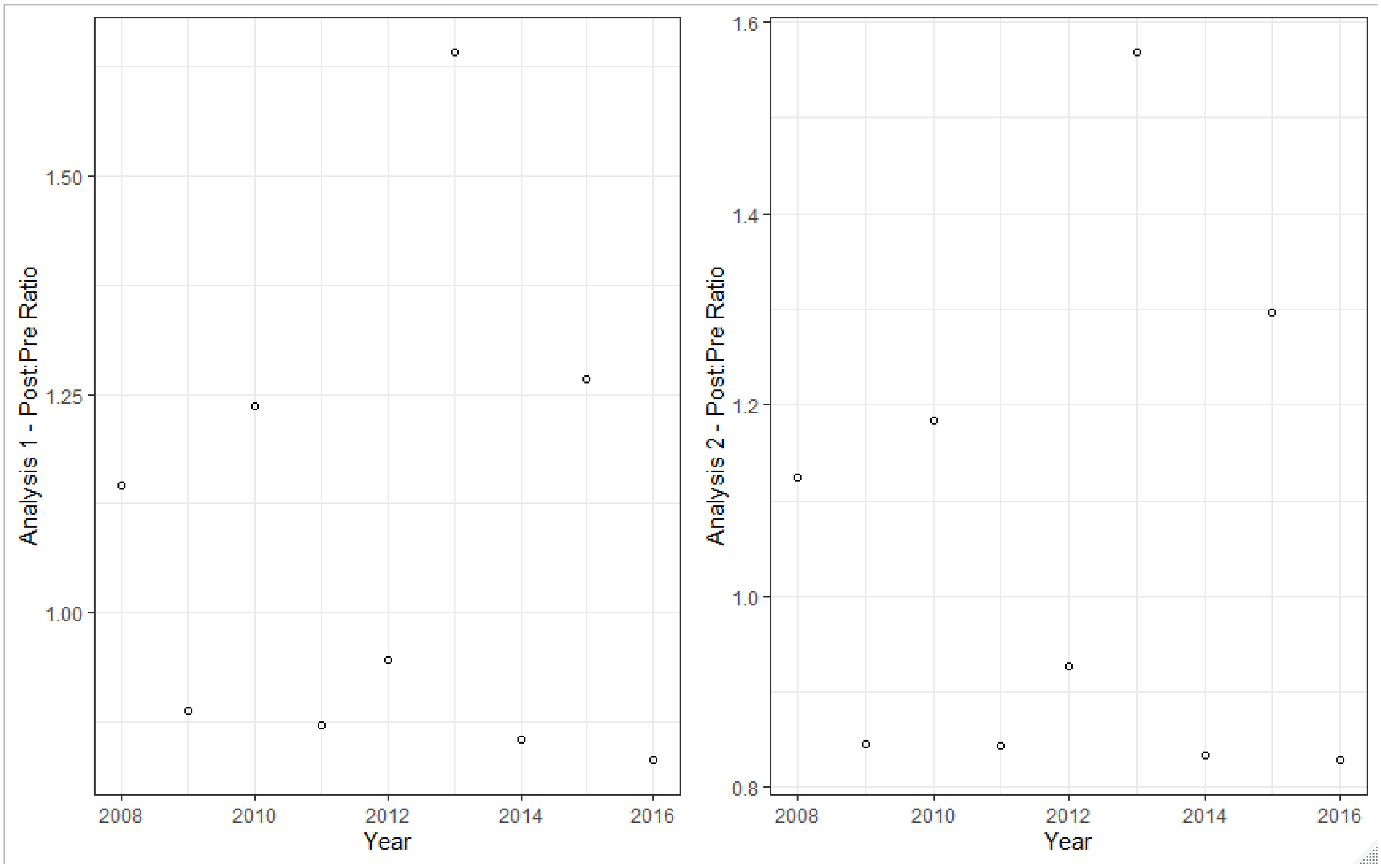

Figure 2: Post:pre ratios over the time series available for both analysis 1 and 2.

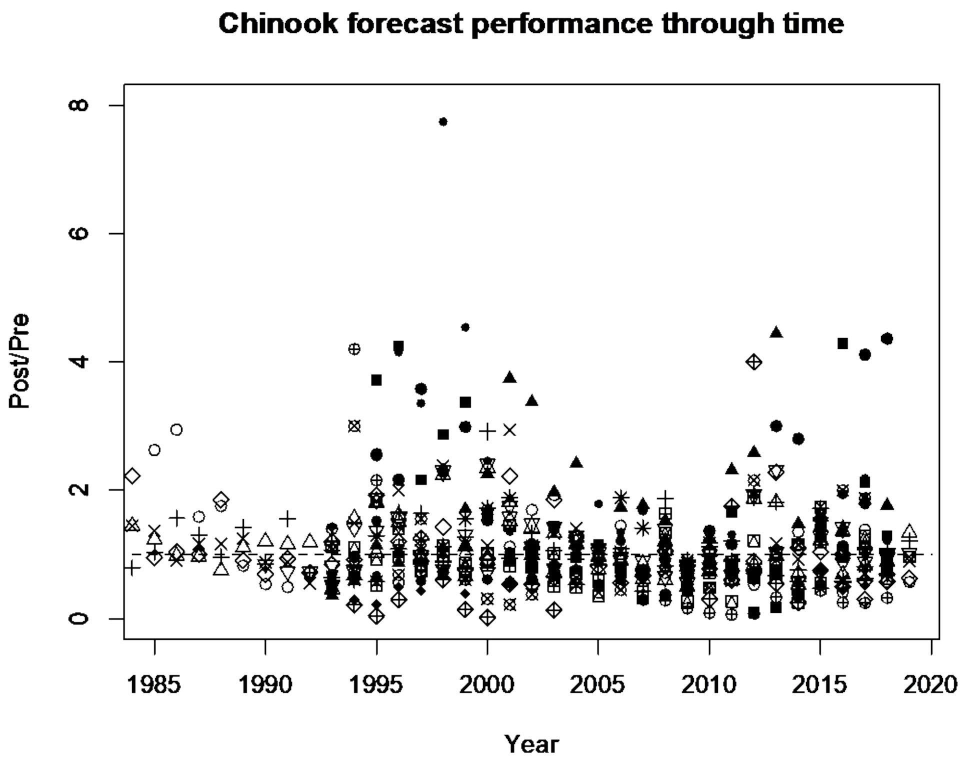

Figure 3: Post:pre ratios over time for individual Chinook stocks whose forecast performance is reported by the Salmon Technical Team in Preseason Report 1 (Tables II-4 [total adults], II-8 [March forecasts], and II-9). Different symbols denote individual Chinook salmon stocks. Years for which either the preseason or postseason abundance was reported as 0 are excluded. The dashed horizontal line at a ratio of 1.0 indicates forecasting without error.

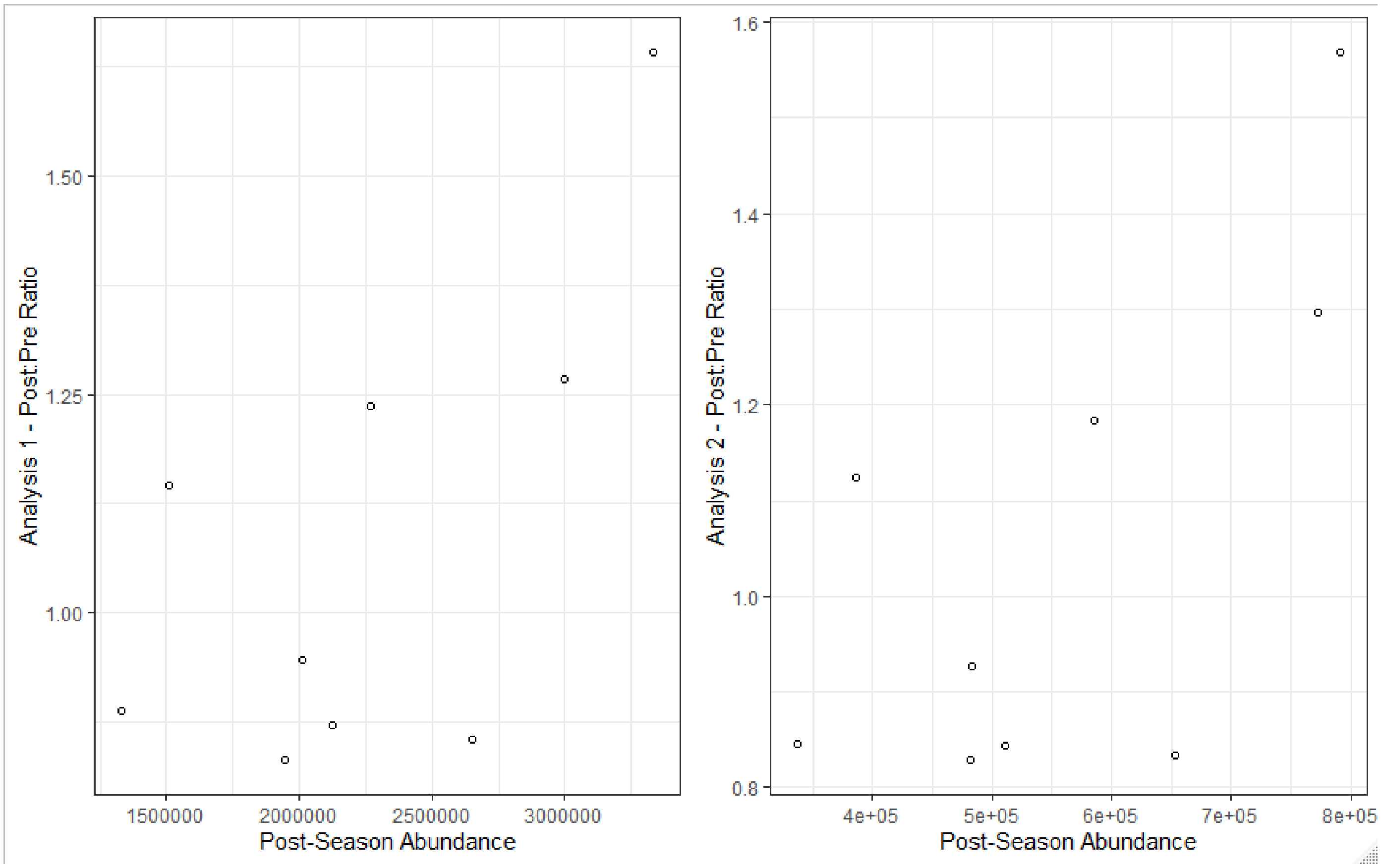

Figure 4: Post:pre ratios over the range of abundances available for analysis 1 and analysis 2.

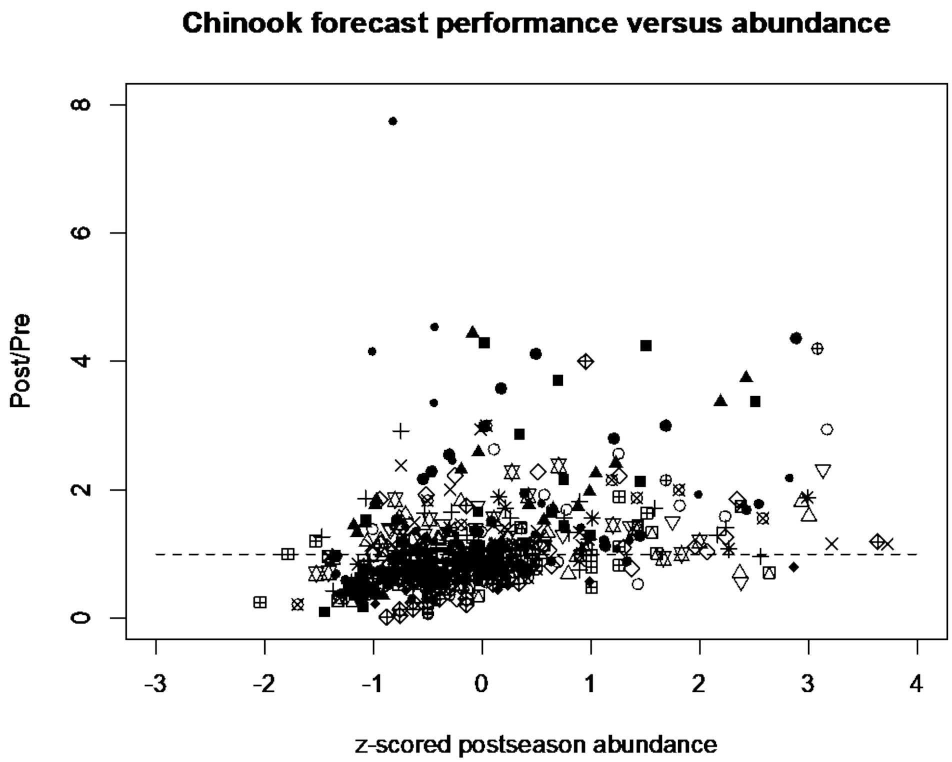

Figure 5: Post:pre ratios for individual Chinook salmon stocks whose forecast performance is reported by the Salmon Technical Team, compared to each stocks' relative abundance. For each stock, annual abundances are converted to a z-score, such that an abundance score of 0 denotes the stock's mean abundance and each unit above or below the mean indicates one standard deviation. Different symbols denote individual Chinook salmon stocks. Years for which either the preseason or postseason abundance was reported as 0 are excluded. The dashed horizontal line at a ratio of 1.0 indicates forecasting without error.

PFMC
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