WASHINGTON DEPARTMENT OF FISH AND WILDLIFE AND OREGON DEPARTMENT OF FISH AND WILDLIFE JOINT STATEMENT ON THE 2025 OPI-H FORECAST METHODOLOGY

Background

This statement provides Council with a technical overview of the concerns identified during the annual Oregon Production Index Technical Team (OPITT) meeting on February 5th, 2025, and work done to address these concerns. During this meeting, concerns were raised regarding the 2025 Oregon Production Index Hatchery coho (OPI-H) forecast methodology and results. Since the OPITT forecasting meeting, analysts from Washington Department of Fish and Wildlife (WDFW) and Oregon Department of Fish and Wildlife (ODFW) have investigated the structure and components of the autoregressive integrated moving average (ARIMA) model to better understand these concerns and assess potential modifications to the forecast methodology for improving the forecast performance.

In November 2023, the Council adopted an ARIMA based forecast methodology for predicting OPI-H for use beginning in 2024. The multi-model approach utilizing ARIMA model structures and environmental predictors was shown to have a 41 percent lower mean absolute percent error (MAPE) than the previous OPI-H forecasting approach on average over the prior 15 years. More information on this method can be found in the 2023 November Council meeting under the Methodology Review item D3. During the first year of implementation, the 2024 ARIMA forecast was 54 percent of the postseason estimate (403,100 forecast, 742,300 postseason estimate) with an absolute percent error (APE) of 46 percent. Relative to the forecasts used in the previous 10 years, this represents the 2nd lowest APE. However, during the 2025 OPITT forecast meeting, the following concerns were raised regarding the 2025 OPI-H forecast:

1. The lagged by one-year Pacific Decadal Oscillation (lag1_PDO) variable used in the forecasting model was lower for 2025 than for *all* previous years over which the model was fit and has diverged from a previously correlated relationship with regional sea-surface temperature (SST). Furthermore, the lag1_PDO variable had a positive coefficient in the models, which differs from the hypothesized effect pathway involving regional sea-surface temperature.
2. The forecast predicted a record low ratio of adults returning in 2025 from the previous year's jack return.
3. The OPI-H forecast was a record low ratio of the Oregon Coast Natural coho (OCN) forecast, which is developed using a different methodology.

Since the OPITT forecast meeting, analysts from WDFW and ODFW have investigated these concerns. Our findings and suggested modifications to the forecast methodology to improve forecast performance are presented below.

Concerns

Concern 1: Record low PDO, divergence of PDO from regional SST, and unexpected coefficient values

The average of the Pacific Decadal Oscillation (PDO) in 2024 (lag1_PDO variable for 2025 prediction) was lower than all years used to fit the model (1969–2023). Additionally, in 2023 and 2024, PDO and Ocean Niño Index (ONI) strongly diverged for the first time in the time series (Figure 1). NOAA explains that "while these two basin scale indices are not always in phase, the strong separation of these two indices

is the first occurrence in the past 26 years. Because the PDO is an index of the spatial SST pattern in the north Pacific, the strongly negative PDO values over the past few years likely reflect the increased SST gradient across the north Pacific, from warmer sea surface temperatures in the western Pacific compared to the eastern Pacific. As a result, this basin-scale index no longer reflects regional sea surface temperatures (which have been warmer than average since July) as well as in previous years." (NOAA 2023). Furthermore, NOAA warns that the strong divergence of PDO and ONI "indicates that basin-scale indices such as the PDO should be interpreted cautiously and are best placed into a broader ecological context with the other ocean ecosystem indicators." (NOAA, 2024).

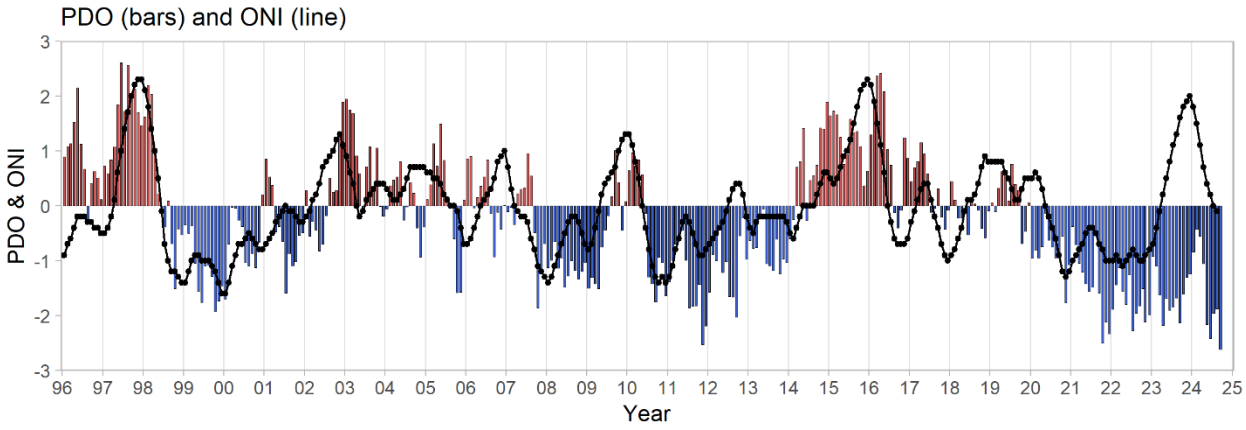

Figure 1. Time series of shifts in sign of the PDO (bars) and the ONI (line) from 1996 to present. Red bars indicate positive (warm) years; blue bars negative (cool) years.

Additionally, the lag1_PDO environmental variable was included within all of the ten ARIMA models that had the lowest mean average percent error (MAPE) over the 2010–2024 period, with an average coefficient value across models of 0.16 (sd = 0.1, range = 0.13–0.17; Table 1). In contrast, early work on the PDO and salmon returns in the Pacific Northwest identified a negative correlation (Mantua 1998).

Table 1. Coefficient values, model weights, and 2025 predictions for the 10 ARIMA models that had the lowest 2010–2024 mean absolute prediction error.

Model Wt.	intercept	lag1_log Jack OPI	lag1_NPGO	**lag1_PDO**	WS ST_A	MEI. OND	UWI .JAS	SST. AMJ	PDO. MJJ	UWI. SON	lag1_log_SmAdj	ar1	sar1	ma1	2025 Prediction
0.10	6.56	0.72	0.13	0.16	-0.3	0.04	-0.0							-0.4	318,711
0.10	6.55	0.73	0.14	0.15	-0.3	0.04		0.02						-0.5	318,516
0.10	6.55	0.71	0.13	0.17	-0.3		-0.1							-0.4	311,146
0.10	6.55	0.71	0.13	0.17	-0.3		-0.1		0.00					-0.4	311,535
0.10	6.55	0.71	0.14	0.16	-0.2		-0.1	0.02						-0.4	311,922
0.10	6.55	0.72	0.14	0.16	-0.3			0.02				-0.5	-0.3		304,734
0.10	6.55	0.72	0.13	0.17	-0.3							-0.5	-0.3		303,314
0.10	6.55	0.73	0.14	0.16	-0.3			0.02		0.01		-0.5	-0.3		300,682
0.10	6.55	0.72	0.13	0.13	-0.2			0.01			0.04	-0.5	-0.4		332,815
0.10	6.55	0.73	0.13	0.16	-0.3	0.03						-0.5	-0.3		311,736
															Weighted Ensemble: 312,551

Concern 2: Adult to Jack Return Ratio

In 2024, approximately 50,700 hatchery jacks returned to OPI-area hatcheries and dams. A 2025 adult return of 312,551 as was presented on February 5th would represent an adult:jack ratio of 6.2, the lowest ratio seen in the 40-year time series. Over the last 15 years (2010–2024) the ratio of adult abundance to jacks has averaged 13.6 (sd = 6.3, range = 6.8–25.6, Supplementary Table S.1). Using the average ratio of adult abundance to jack returns has not performed as well as other modeling approaches but provides an independent estimate for comparison with those that rely on indices of ocean conditions.

Concern 3: OCN to OPI Ratio

The other major stock in the OPI area is OCN coho, which has a forecasted abundance of 289,000 for 2025. The 2025 OCN forecast is 92 percent of the OPI-H forecast or 48 percent of the combined forecast total (Supplementary Table S.2). This proportion of OCN to OPI-H abundance has never been seen in the time-series from 1996–2024. In the past 15 years, the average proportion of OCN to OPI-H abundance has been 37 percent (sd = 0.14, range = 22–68).

Findings

In response to the concerns raised at the OPITT meeting, WDFW and ODFW staff evaluated modest changes to forecasting OPI-H with consideration to the complexity of the model, the unprecedented shift in PDO/SST correlation, and the time frames/weights the model utilizes to judge relationships to abundance. Three possible alternative approaches were considered: 1) the removal of lag1_PDO as a variable with no other changes to the forecast, 2) truncating the testing-years (shifting from 15 years to a shorter time-series), and 3) applying year-based exponential decaying weights. The results from these approaches suggest that year-based exponential decaying weights provided a substantial reduction in the MAPE compared to the current forecast methodology and address the concerns described above.

The MAPE is used in the current methodology to identify the top 10 individual models and to calculate their weights for averaging during the ensemble process. The forecast presented at the OPITT meeting on February 5th calculated MAPE as the *unweighted* average over 15 years. The alternative implementation calculates MAPE as a *weighted* average where the most recent year has the highest weight, and each preceding year's weight is reduced by 25 percent relative to the following year, through 15 years. This addition may improve the model's ability to assess quick regime changes that may occur with the environmental co-variates.

Staff evaluated performance by developing forecasts for the previous 15 years, as if there was no knowledge of the postseason abundance estimates in those years, and then calculating the average absolute forecast error as a percentage of the abundance in those years. This metric is the 15-year MAPE. The performance of the model is evaluated using the 15-year MAPE which measures how forecasts differ from the actual abundances over a number of years. The alternative implementation of applying exponential-decay rates performed better than the current unweighted implementation in the performance evaluation (33% vs 39% MAPE), which we believe to be due to it better balancing recent and historical performance. We tested this approach across decay rates of 0 percent through 95 percent and found that a decay-rate of 45 percent or less produced a lower MAPE than the current forecast, but a 25 percent decay rate resulted in the lowest MAPE (Figure 2).

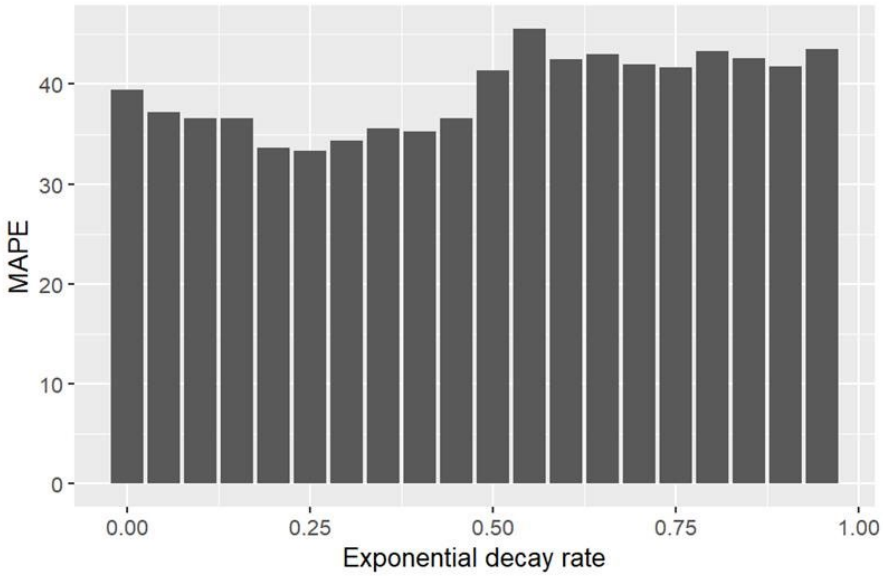

Figure 2. MAPE of the ARIMA model with yearly exponential-decay rates in weighting used to construct ensembles.

This process produces a forecast of 493,640 compared to the current forecast methodology result of 312,551 which uses the unweighted MAPE implementation (Figure 3). Using the exponential decay-weighted MAPE implementation, none of the top-performing models in 2010 to 2024 included the lag1_PDO covariate (Table 2). When compared with the 2024 jack return value, this forecast yields a ratio of 9.7 adults per jack, a much closer value to the 15-year average (13.6 adults per jack). In comparison to the 2025 OCN forecast, this forecast would result in the OCN forecast being 59 percent of the OPI-H forecasted abundance, which is within the observed range and no longer represents a record high proportion (Supplementary Table S.2).

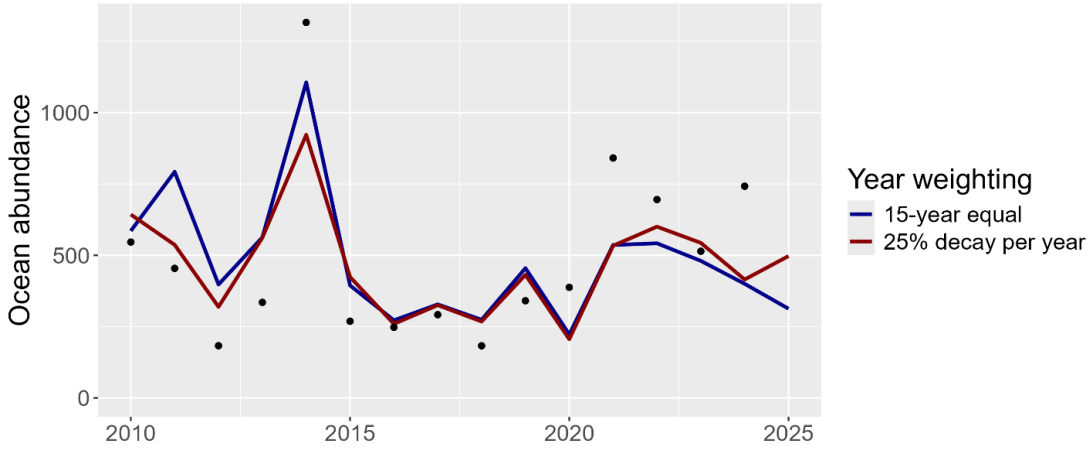

Figure 3. One-year-ahead forecasts (lines) developed with two different implementations of the OPI-H forecast methodology. The blue line represents an implementation where 15 years of performance are weighted equally in model selection and weighting, and the red line represents an approach where more recent years are weighted higher than older years. The black dots represent the observed abundances.

Table 2. Coefficient values, model weights, and 2025 predictions for the 10 ARIMA models that had the lowest 2010–2024 weighted mean absolute prediction error, where the most recent year has the highest weight, and each preceding year's weight is reduced by 25 percent relative to the following year.

Model Wt.	lag1_log_Jack OPI	lag1_NPGO	MEI.OND	UWI.SON	intercept	lag1_log_SmAdj	WSST_AMJ	SST.AMJ	SSH.AMJ	PDO.MJJ	ar1	sar1	sar2	ma1	sma1	sma2	2025 Prediction
0.12	0.62	0.1	0											-0.81			529,919
0.12	0.66	0.1	0	0.06							-0.31			-0.69			504,177
0.12	0.66	0.1		0.06							-0.31			-0.69			504,121
0.1	0.72	0.14	0.1		6.56	0.09	-0.22	0.05						-0.42			479,409
0.11	0.71	0.04	0.02				-0.18		-0.04		-0.53			-0.7	-0.26	0.48	505,246
0.1	0.66	0.08									-0.3			-0.68			527,215
0.09	0.66	0.11		0.07					-0.01	0.03	-0.85	-0.65	-0.33				425,248
0.09	0.64	0.07	-0.03						-0.02	0	-0.83	-0.64	-0.34				500,567
0.08	0.59	0.08							-0.06					-0.8			592,043
0.08	0.78	0.17	0.13		6.56		-0.23	0.07		0.09				-0.5			364,365
																	Weighted Ensemble: 493,640

We conclude that the 2025 forecast presented at the OPITT meeting on February 5th is likely to be lower than the actual 2025 returns possibly due by the historically low 2024 PDO values and the diverging relationship between PDO and regional STT, although this will not be known until February of 2026. The analysis conducted by WDFW and ODFW staff on multiple alternative methods to forecasting OPI-H showed that adjusting the implementation of the current methodology by applying exponential-decay weighting of 25 percent may reduce the likelihood of events, such as the instance described above, and performs better than the current method in a retrospective analysis.

Joint-State Request

After evaluating concerns raised with the 2025 forecast methodology as well as the performance of various hypothesized forecast methodology improvements, WDFW and ODFW consider the 25 percent

exponential-decay-weighting a sound improvement to the forecast performance. WDFW and ODFW recommend that the Council consider adopting the 2025 OPI-H forecast using a 25 percent exponential decay rate, as well as further investigation of modification to the OPI-H methodology for the 2025 Methodology Review cycle.

Cited

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Supplementary tables and figures

Table S.1. OPI-H jack returns to OPI-areas (year t-1, x1000), OPI-H adult postseason abundance estimates (year t, x1000), and adult per jack metric from 1986 to 2025.

Year (t)	Jack Return (t-1)	Postseason Adult Abundance (t)	Adult per Jack
1986	77.5	2412.0	31.1
1987	32.9	779.4	23.7
1988	85.2	1467.8	17.2
1989	60.8	1922.0	31.6
1990	46.6	713.6	15.3
1991	68.6	1816.5	26.5
1992	25.6	512.6	20.0
1993	27.1	223.3	8.2
1994	5.2	214.1	41.2
1995	11.8	139.4	11.8
1996	17.4	176.5	10.1
1997	20.4	195.6	9.6
1998	9.7	228.3	23.5
1999	29.5	372.5	12.6
2000	34.8	673.1	19.3
2001	87.4	1478.7	16.9
2002	25.2	689.5	27.4
2003	49.9	1009.9	20.2
2004	35.4	693.6	19.6
2005	25.0	454.2	18.2
2006	25.9	524.3	20.2
2007	36.3	545.3	15.0
2008	16.0	571.3	35.7
2009	60.4	1051.0	17.4
2010	25.1	546.5	21.8
2011	23.3	454.2	19.5
2012	17.9	183.1	10.2
2013	26.3	335.1	12.7
2014	51.4	1316.5	25.6
2015	39.6	268.9	6.8
2016	19.7	247.7	12.6
2017	22.9	291.8	12.7
2018	19.2	182.8	9.5
2019	47.4	340.7	7.2
2020	15.2	387.7	25.5
2021	92.3	841.3	9.1
2022	63.7	695.6	10.9
2023	52.7	514.2	9.8
2024	75.0	742.3	9.9
2025*	50.7	312.6	6.2

* 2025 Adult abundance value is a preseason forecast.

Table S.2. OCN and OPI-H postseason abundance estimates (x1000) and proportional statistics of stock abundances.

Year	OCN Postseason Abundance Estimate	OPI-H Postseason Abundance Estimate	OCN per OPI-H	OCN Proportion to Total
1996	86.1	176.5	0.5	0.3
1997	27.8	195.6	0.1	0.1
1998	29.2	228.3	0.1	0.1
1999	51.9	372.5	0.1	0.1
2000	69.0	673.1	0.1	0.1
2001	163.2	1478.7	0.1	0.1
2002	304.5	689.5	0.4	0.3
2003	278.8	1009.9	0.3	0.2
2004	197.0	693.6	0.3	0.2
2005	150.1	454.2	0.3	0.2
2006	116.4	524.3	0.2	0.2
2007	60.0	545.3	0.1	0.1
2008	170.9	571.3	0.3	0.2
2009	257.0	1051.0	0.2	0.2
2010	266.8	546.5	0.5	0.3
2011	311.6	454.2	0.7	0.4
2012	123.8	183.1	0.7	0.4
2013	128.4	335.1	0.4	0.3
2014	403.3	1316.5	0.3	0.2
2015	70.4	268.9	0.3	0.2
2016	83.2	247.7	0.3	0.3
2017	65.6	291.8	0.2	0.2
2018	80.9	182.8	0.4	0.3
2019	107.3	340.7	0.3	0.2
2020	109.3	387.7	0.3	0.2
2021	273.3	841.3	0.3	0.2
2022	200.2	695.6	0.3	0.2
2023	185.7	514.2	0.4	0.3
2024	200.4	742.3	0.3	0.2
2025*	289.0	312.6	0.9	0.5
* 2025 OCN and OPI-H abundance values are a preseason forecast.				