2025 Technical Revision to the Marine Survival Forecast of the OCN Coho Work Group Harvest Matrix

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Introduction

Amendment 13 (A13) to the Pacific Fishery Management Council's (PFMC) Pacific Coast Salmon Fishery Management Plan sets Oregon Coastal Natural (OCN) Coho Salmon (*Oncorhynchus kisutch*) allowable exploitation rates using a two-dimensional matrix with observed parental returns and forecasted marine survival as the axes (Table 1). In 2013 a methodology change revising the basis for forecasting marine survival was accepted by the PFMC (Suring and Lewis 2013).

The revision replaced the prior method, which was an index calculated as the number of Oregon Production Index (OPI) hatchery Coho Salmon jacks returning in the prior year divided by the number of OPI hatchery Coho Salmon smolts released in that same brood year. The current marine survival axis is the forecasted OCN smolt-to-adult return rate, described as a marine survival index (MSI). The OCN MSI is calculated annually by using observed OCN smolt-to-adult return rates averaged across six life cycle monitoring (LCM) sites distributed across the Oregon Coast Coho ESU. ODFW staff created a predictive model fit to the OCN MSI using selected oceanographic indicators, jack observations on ODFW spawning ground surveys, and the jack/smolt ratio at the Mill Cr (Yaquina) LCM site as the predictor variables. ODFW created this model using an ensemble of generalized additive models (GAM). In the current PFMC process the model ensemble is refit each year with the addition of the latest set of predictors and OCN MSI data (Suring and Lewis 2013).

ODFW LCM sites are funded in part by Oregon state general funds. In 2017, statewide general fund budget reductions resulted in the closure of the LCM site on the North Fork Nehalem River. A revision to calculate the MSI using the five remaining sites was accepted in 2017 (Suring 2017). In 2025, rising costs in conjunction with ODFW license fees having remained constant resulted in a net budget reduction and monitoring was eliminated at the West Fork Smith and Winchester Creek LCM sites. Beginning with the 2026 forecast we will not be able to refit the models annually using the method adopted in 2017.

We evaluated four alternative approaches to adjust to this change:

- Continue refitting the forecast GAMs annually, calculating the MSI using a multivariate state-space model to interpolate missing LCM sites from remaining sites and previous data;
- Continue refitting the forecast GAMs annually, calculating the MSI using the three remaining sites;
- Discontinue the process of refitting the forecast GAMs annually and use the most recent model (2025) to forecast OCN marine survival into the future;
- Revert to the OPI hatchery jack/smolt indicator used prior to 2013.

Table 1. Amendment 13 fishery impact rate matrix for OCN Coho Salmon.

Parent Spawner Status[1]	**Marine Survival Index** *(Wild adult Coho Salmon survival as predicted by the two-variable GAM ensemble forecast)*			
	Extremely Low *<2%*	**Low** *2%-4.5%*	**Medium** *>4.5%-8%*	**High** *>8%*
High Parent Spawners > 75% of full seeding	**E** ≤ 8%	**J** ≤ 15%	**O** ≤ 30%	**T** ≤ 45%
Medium Parent Spawners > 50% & ≤ 75% of full seeding	**D** ≤ 8%	**I** ≤ 15%	**N** ≤ 20%	**S** ≤ 38%
Low Parent Spawners > 19% & ≤ 50% of full seeding	**C** ≤ 8%	**H** ≤ 15%	**M** ≤ 15%	**R** ≤ 25%
Very Low Parent Spawners > 4 fish per mile & ≤ 19% of full seeding	**B** ≤ 8%	**G** ≤ 11%	**L** ≤ 11%	**Q** ≤ 11%
Critical Parent Spawners ≤ 4 fish per mile	**A** 0 – 8%	**F** 0 – 8%	**K** 0 – 8%	**P** 0 – 8%

Sub-aggregate and Basin Specific Spawner Criteria Data

Sub-aggregate	Miles of Available Spawning Habitat	100% of Full Seeding	"Critical"		Very Low, Low, Medium & High		
			4 Fish per Mile	12% of Full Seeding	19% of Full Seeding	50% of Full Seeding	75% of Full Seeding
Northern	899	21,700	3,596	NA	4,123	10,850	16,275
North-Central	1,163	55,000	4,652	NA	10,450	27,500	41,250
South-Central	1,685	50,000	6,740	NA	9,500	25,000	37,500
Coastwide Total	*3,747*	*126,700*	*14,988*		*24,073*	*63,350*	*95,025*

[1] Parental spawner abundance status for the OCN aggregate assumes the status of the weakest sub-aggregate.

Methods

Data collection at life cycle monitoring sites

Rupp et al. (2012b) and the 2013 Technical Revision to the OCN Coho Work Group Harvest Matrix (Suring and Lewis 2013) provide the source of the indicators and model process used to produce the marine survival forecast. The seven two-variable GAMs are refit annually to the OCN MSI calculated by averaging the marine survival rate from the LCM sites. An LCM site consists of a paired adult and out-migrant trap. Data are collected in the Oregon Coast Coho ESU (Figure 1) from six sites 1998-2016, five sites from 2017-2024, and three sites from 2025. Spawner abundance at LCM sites was either a direct count from traps at complete barriers or estimated by mark-recapture methodology. Fish that entered traps were identified to species and sex and distinguished as wild or hatchery-produced based on presence or absence of an adipose fin clip. Coho salmon < 45 cm fork length were categorized as jacks and scales were taken from fish between 45 and 55 cm fork length for age assignment. Downstream

juvenile salmonid out-migrants were captured with rotary screw traps or motorized incline plane traps. Fish were enumerated by species and age or size class, with Coho Salmon identified as fry (age 0) or smolts (age 1+). Trap capture efficiency was evaluated daily and weekly out-migrant estimates were summed for season totals. Additional details on adult and juvenile estimation methods and site-specific details are found in Suring et al. (2015).

The LCM smolt to adult marine survival rate was derived by dividing the female spawner abundance, adjusted for total fishery impacts, in year *t* by half of the smolt production, assuming a 1:1 smolt sex ratio, in year *t-1*. Spawner abundance was adjusted for total fishery impacts by dividing abundance by one minus the impact rate.

Marine survival index alternatives

The A13 OCN marine survival index from 2013 onward used data from six LCM sites. From 2017 data from five LCM sites were available and from 2025 data from three sites will be available, thus adjustments to current processes will be needed to provide information to support the A13 matrix approach. We evaluated the alternatives: 1) use the current forecast GAM process but fit to the MSI with interpolated values (referred to as the interpolation method), 2) use the current forecast GAM process but fit to the MSI from the three remaining sites (referred to as the reduced method), 3) using the last available MSI estimated from five LCM sites (2024), no longer refitting the GAMs annually (referred to as the fixed model method), or 4) using the pre-2013 method of using OPI hatchery jack/smolt ratios (referred to as OPIH jacks).

Interpolation Method

The interpolation method used the MARSS R package (Holmes et al. 2024) in R (R Core Team 2025). The model was specified with the default model structure for all parameters except for Q. Q specifies the state process error covariance matrix (Homes et al. 2025). With Q at default, diagonal and unequal, the model would not converge for multiple LCM sites. We observed that marine survival was correlated across LCM sites on the Oregon coast (Figure 2). In the model we can specify that marine survival is correlated using Q = “equalvarcov” (Homes et al. 2021).

Reduced Method

The reduced method is a weighted average of the three remaining sites, similar to the 2017 adopted method that used a five site MSI from the 2013 adopted six site MSI. The Mill Cr (Yaquina) site includes a reservoir with rearing conditions conducive to large smolt sizes and marine survival that is higher than other coastal sites (Suring et al. 2015). To reduce bias the Mill Cr (Yaquina) marine survival estimate is weighted to contribute 1/6 of the MSI for both the five site (adopted 2017) and three site (proposed reduced) methods. The remaining sites are equally weighted to provide the remaining 5/6 of the average MSI.

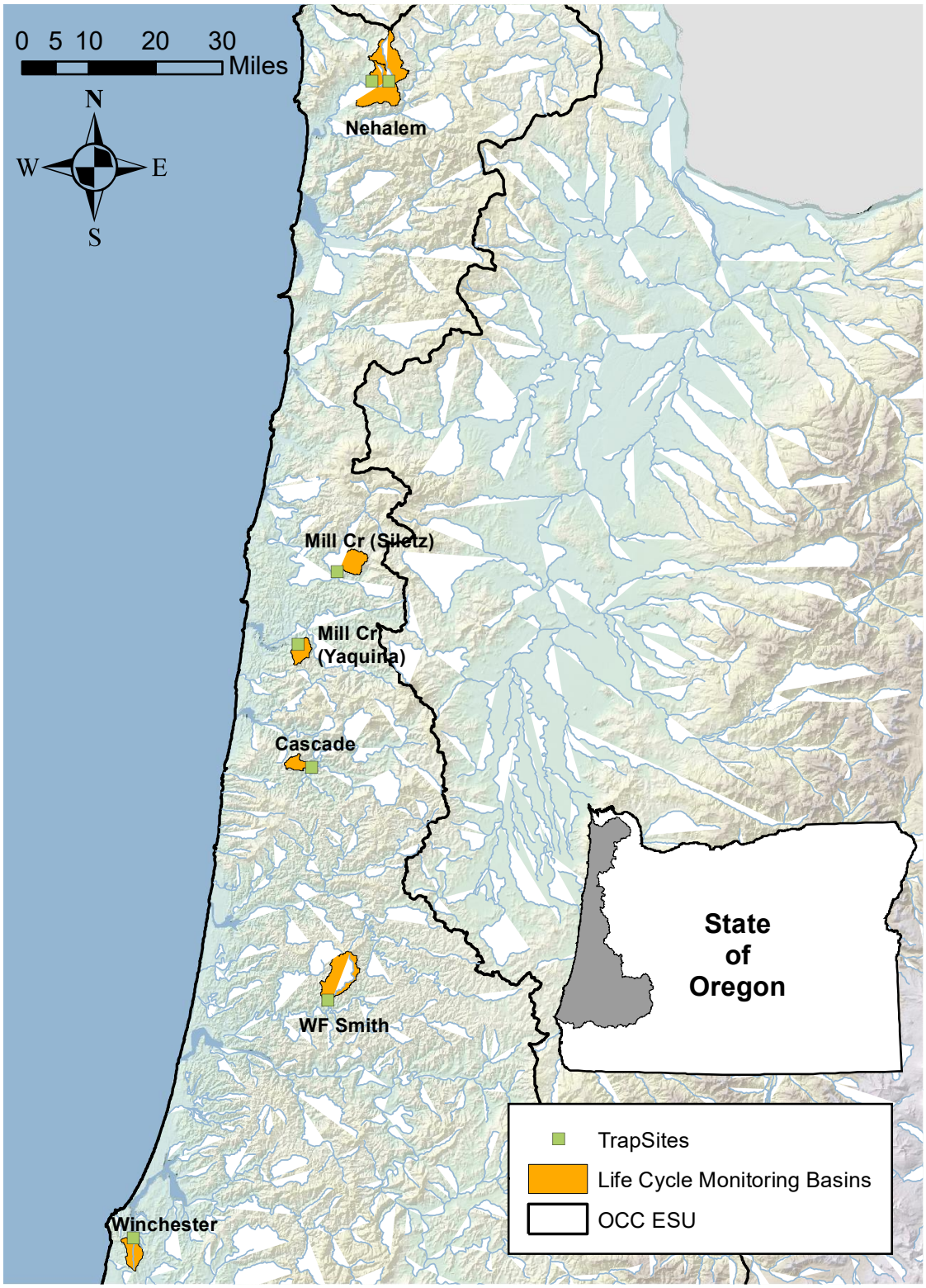

Figure 1. Oregon Department of Fish and Wildlife Life Cycle Monitoring Basins where both Coho Salmon adult returns and juvenile out-migrants are estimated. Monitoring began in 1998, ended at NF Nehalem in 2017, ended at WF Smith and Winchester in 2025, and continues at the three Mid Coast sites.

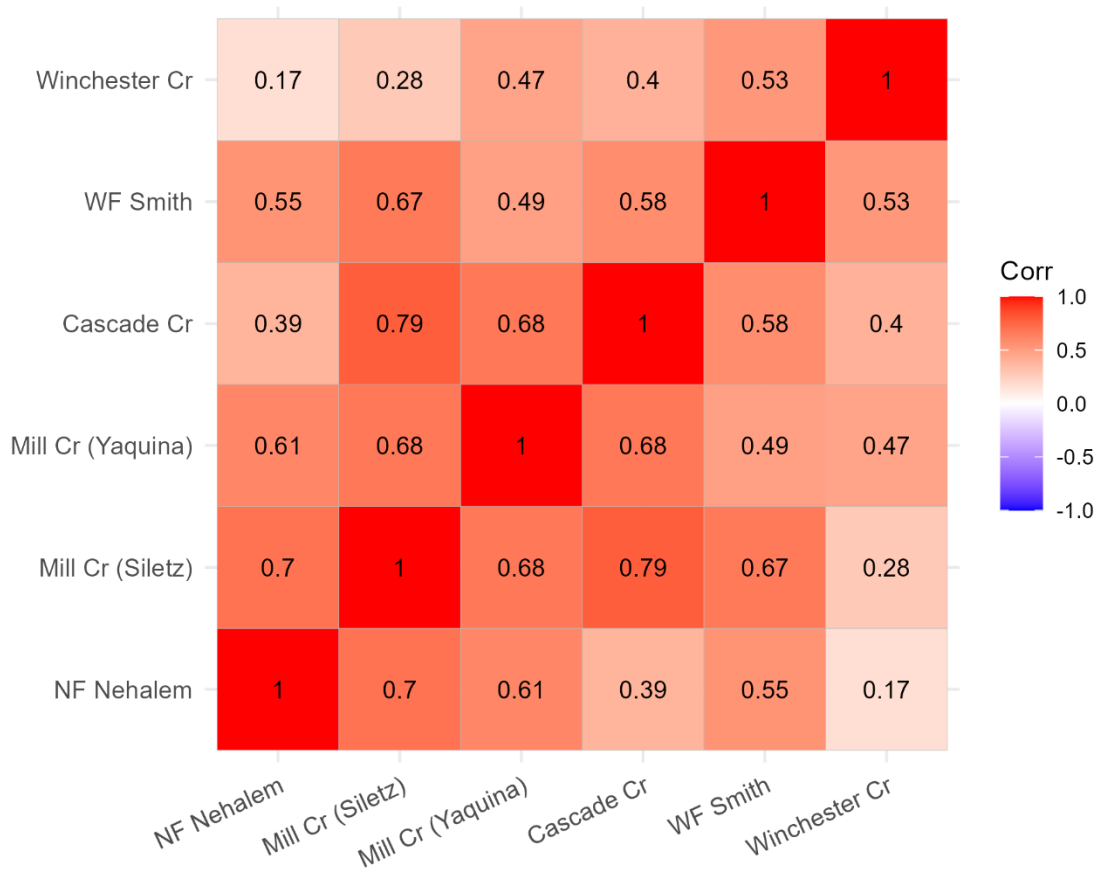

Figure 2. Correlation in marine survival estimates between LCM sites. Sites are ordered from north to south across the bottom. Only the Cascade Cr, Mill Cr (Yaquina), and Mill Cr (Siletz) sites will be operated from 2025 onward.

MSI and forecast alternatives evaluation

We evaluated the interpolation and reduced methods based on how well the alternative MSI calculations compared to the current MSI based on MAE (mean absolute error) and MAPE (mean absolute percent error). We iteratively removed between three and eight years of data at the West Fork Smith and Winchester Creek sites to evaluate how increasing amounts of missing data affected the MSI interpolation and to simulate how the interpolation may perform as we go farther into the future. All four methods were evaluated on how the marine survival forecast model results change with the alternative inputs.

The interpolated and reduced methods for estimating MSI were used as the response variable in the GAMs to forecast marine survival. This is similar to the current method with the alternative MSIs substituted for the current OCN MSI in the model input dataframe from 2020 to present. The MSI alternatives were evaluated with five years of data from the WF Smith and Winchester Cr LCM sites removed. The fixed method parameterized the GAMs with the MSI and indicator data from 1998-2019. This fixed model was then used to create a forecast with indicator data from 2020-2025. The models were run using the information that would have been available at the time of forecast in that year. The

exception is we used final results for all indicators, such as the spawning ground survey peak jack count/mile, whereas during the normal process only preliminary results would have been available for use for some indicators.

After forecasts were created the Amendment 13 marine survival categories were delineated following the 2013 revision matrix. The OPI-H jack/smolt data is sourced from the PFMC preseason report I (PFMC 2025) and marine survival categories were delineated following the breakpoints in Sharr et al. (2000), consistent with methods prior to the 2013 revision.

The code used to make these calculations is available at https://github.com/ODFW-IFSP/OPITT/tree/main/Marine%20Survival%20Index.

Results

Interpolated and reduced marine survival indexes

MSIs were able to be calculated after removing between three and eight years of data from the WF Smith and Winchester Cr LCM sites using the interpolated or reduced methods. The interpolated method showed better fidelity to the 2017 adopted (five site) method than the reduced method as evaluated with MAE and MAPE (Table 2). The interpolated method had better fit compared to the alternative method even when more years of data were removed (Table 2). However, the difference between methods was reduced as more data were removed. In the dataset with five years removed, which was used for the forecast model comparison, the interpolated MSI was slightly more correlated with the five site MSI (r = 0.89) than the reduced MSI (r = 0.84). The interpolated MSI was in the same marine survival matrix category as the observed five site MSI over the past five years whereas the reduced MSI was in the higher category in 2023 and 2024 (Figure 3).

Table 2. MAE and MAPE values comparing the interpolated (MARSS) and reduced (three site) marine survival index alternatives to the current marine survival index calculation. Fit was evaluated after removing between three and eight years of data from the WF Smith and Winchester Cr LCM sites.

Marine survival index alternative evaluation				
Years Removed	**MAE MARSS**	**MAE Three Sites**	**MAPE MARSS**	**MAPE Three Sites**
3	0.014	0.030	0.288	0.559
4	0.012	0.025	0.213	0.436
5	0.011	0.021	0.180	0.369
6	0.009	0.018	0.145	0.327
7	0.014	0.017	0.225	0.310
8	0.012	0.017	0.206	0.340

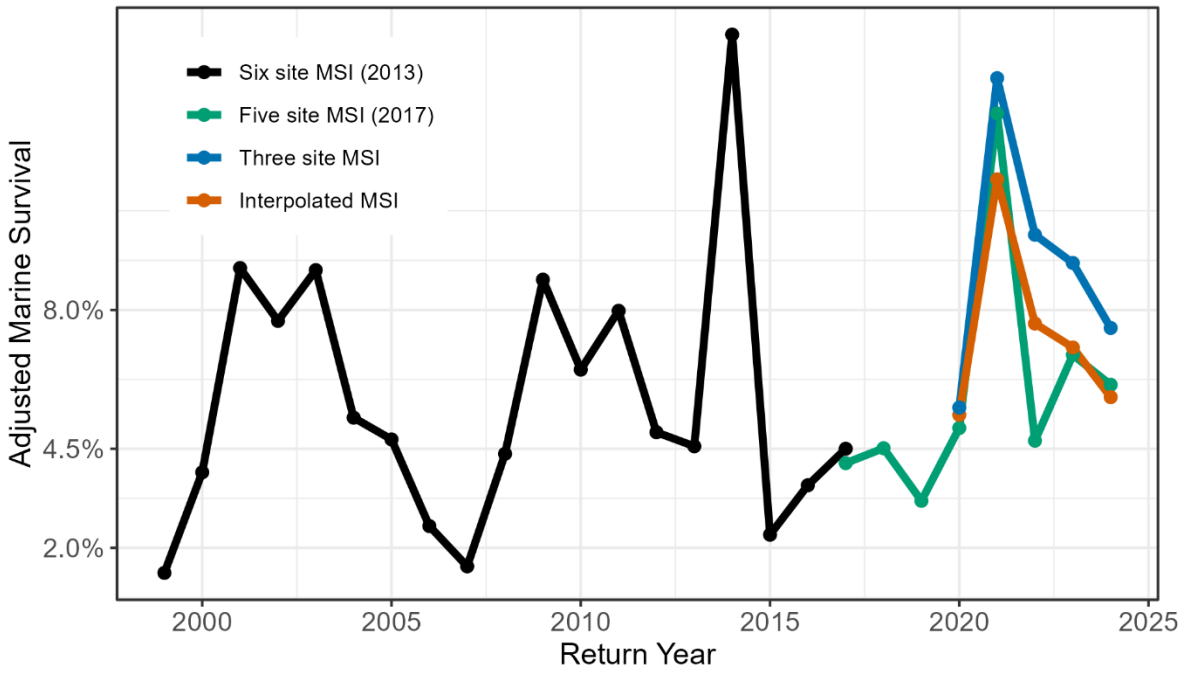

Figure 3. Alternative marine survival index (MSI) estimates using six sites (adopted 2013), five sites (adopted 2017), three sites, and interpolated (MARSS model). The y-axis labels show the matrix category breaks. The interpolated estimate is made with five years of data removed from the two sites discontinued in 2025 to simulate model performance with future missing data.

Forecast comparisons

Marine survival forecasts and matrix categories were generated for five years, 2021-2025, using two MSI alternatives, the fixed model, and the OPIH jack/smolt indicator (Table 3, Figure 4). All forecast alternatives predicted the same marine survival matrix category except the OPIH jack/smolt indicator which was higher in 2021. Of the alternatives the interpolated MSI forecast most closely resembled the adopted forecast and had the lowest MAPE of 0.015. The reduced MAPE was 0.064 and the fixed MAPE was 0.072.

Table 3. Marine survival forecast results from the two-variable GAM ensembles fit to alternative marine survival indexes (MSI). The OPIH jacks/smolt indicator has different category break points. Forecasts that did not match the five site MSI forecast category, the adopted MSI as of the 2025 forecast, are shaded red.

Marine Survival Forecasts					
	Five Site MSI	Interpolated MSI	Three Site MSI	Fixed Model	OPIH Indicator
2021	**Medium** 6.71%	**Medium** 6.7%	**Medium** 6.7%	**Medium** 7.01%	**High** 0.45%
2022	**Medium** 6%	**Medium** 6.02%	**Medium** 5.99%	**Medium** 6.06%	**Medium** 0.31%
2023	**Medium** 6.6%	**Medium** 6.83%	**Medium** 6.95%	**Medium** 6.78%	**Medium** 0.31%
2024	**Medium** 6.68%	**Medium** 6.82%	**Medium** 7.25%	**Medium** 6.86%	**Medium** 0.38%
2025	**Medium** 6.02%	**Medium** 6.09%	**Medium** 7.07%	**Medium** 7.53%	**Medium** 0.25%

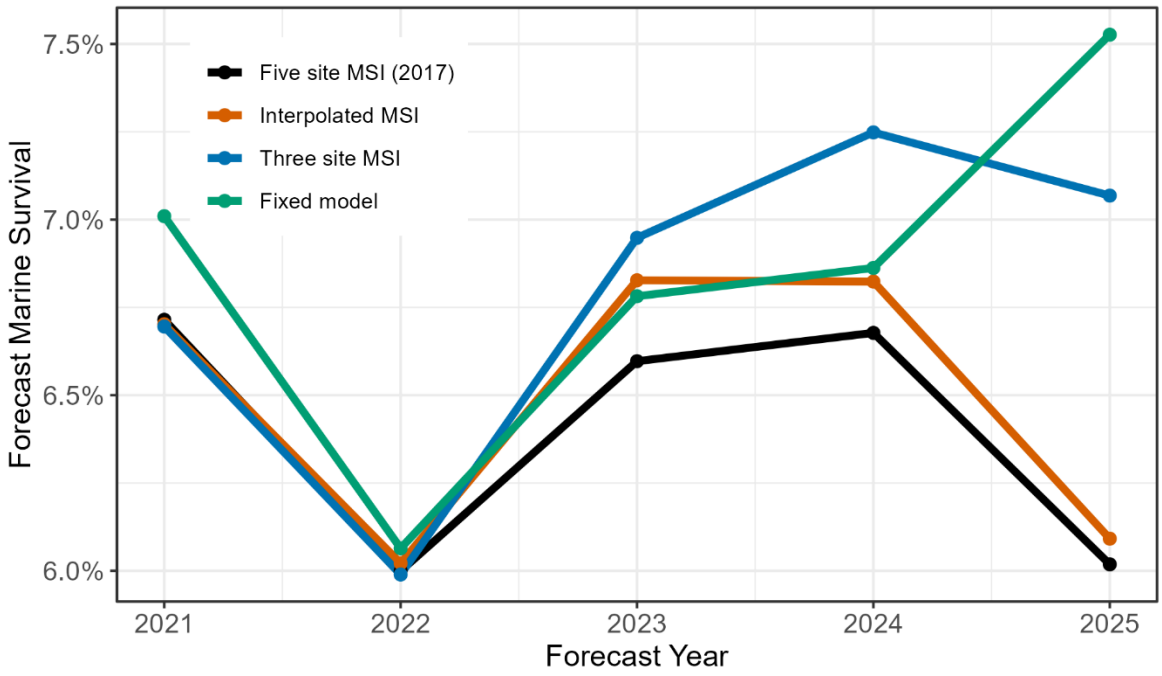

Figure 4. Marine survival forecast results from the two variable GAM ensembles fit to alternative marine survival indexes (MSI). The five site MSI has been the adopted MSI used for forecasts 2018-2025.

Discussion

The 2013 A13 Revision (Suring and Lewis, 2013) provided forecasts that better matched observed marine survival for naturally produced Coho Salmon on the Oregon coast. The loss of one LCM site in 2017 resulted in small changes to the marine survival forecast (Suring 2017), and a five site MSI adequately represented the ESU marine survival. While marine survival at individual LCM sites are correlated to each other, indicating that large scale or common processes account for most of the variation in survival across the ESU, a reduction to a three site MSI does not fit the observed data as well as using a state-space model to interpolate the data from the missing sites. The other two alternatives, the fixed model and OPIH jacks/smolt, did not fit the adopted 2021-2025 forecasts as well as either the interpolated or reduced alternatives.

The MARSS state-space model draws on 26 years of data across the LCM sites. The interpolated marine survival estimates better represent the observed MSI than using a reduced estimate based on three sites (Table 2). Using a model to estimate marine survival increases complexity but also allows flexibility as funding and monitoring opportunities change. If ODFW or another group are able to operate one of the closed LCM sites the data can be incorporated into the proposed process, substituting observed data for interpolated data at any of the three closed sites. The performance of the state-space model may degrade over time, but we did not observe this when removing up to eight years of observations as it had lower error relative to the reduced alternative (Table 2). The interpolated alternative relies on the assumption that the relationship between the closed and operated LCM sites remains consistent in the future, but this assumption also applies to the reduced alternative.

Conclusion

The A13 process is robust to changes in forecast skill (Rupp et al. 2012a) and all MSI alternatives forecast marine survival in the same category from 2021-2025 as the 2017 adopted MSI (Table 3). Only the OPIH jack/smolt indicator may have changed the fisheries management outcomes based on the A13 matrix. Using a fixed model provides poorer fit and brings increased risks in overlooking changes in the relationships between indicators and marine survival. An interpolated MSI increases process complexity but best represents the observed MSI and maintains flexibility as monitoring opportunities change, and we recommend using this alternative for fishery management beginning in 2026.

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