



**Advisory Announcement**  
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**2023 Prince William Sound and Copper River Salmon Forecast**

Forecasts of total run were calculated for Copper River Chinook salmon, Copper River wild sockeye salmon, Gulkana Hatchery sockeye salmon, Coghill Lake sockeye salmon, and for wild Prince William Sound (PWS) pink and chum salmon. Prince William Sound Aquaculture Corporation (PWSAC) and Valdez Fisheries Development Association (VFDA) provide additional forecasts for hatchery-specific stocks. Salmon forecasts are inherently uncertain and are primarily used to gauge the general magnitude of expected runs and set early-season harvest management strategy. In 2023, the department will continue to manage PWS and Copper River area commercial salmon fisheries in season based primarily on the strength of salmon abundance indices including sonar counts, weir passage, aerial escapement surveys, and fishery performance data.

**Table 1. Categorical ranges of total run.**

Category	Percentile
Poor	Less than 20 <sup>th</sup>
Weak	20 <sup>th</sup> to 40 <sup>th</sup>
Average	40 <sup>th</sup> to 60 <sup>th</sup>
Strong	60 <sup>th</sup> to 80 <sup>th</sup>
Excellent	Greater than 80 <sup>th</sup>

**Table 2. 2023 Prince William Sound Area salmon run forecast summary (thousands of fish) and percentile category.**

Area/Run Type	Species	Forecast Point	Forecast Range	% Above/Below 10-yr Average	Total Run 10-yr Average	Category
Copper River						
<i>Wild</i>	Chinook salmon	53	38–74	15% Above	46	Average
<i>Wild</i>	Sockeye salmon	1,646	1,017–2,275	9% Below	1,806	Average
<i>Gulkana Hatchery</i>	Sockeye salmon	49	30–68	68% Below	155	Weak
<i>Total Run</i>	Sockeye salmon	1,695	1,047–2,343	14% Below	1,961	Average
Coghill Lake						
<i>Wild</i>	Sockeye salmon	453	357–549	165% Above	171	Excellent
Prince William Sound						
<i>Wild</i>	Pink salmon	20,230	10,420–30,040	26% Above	16,100	Strong
<i>Wild</i>	Chum salmon	389	154-625	17% Below	470	Weak

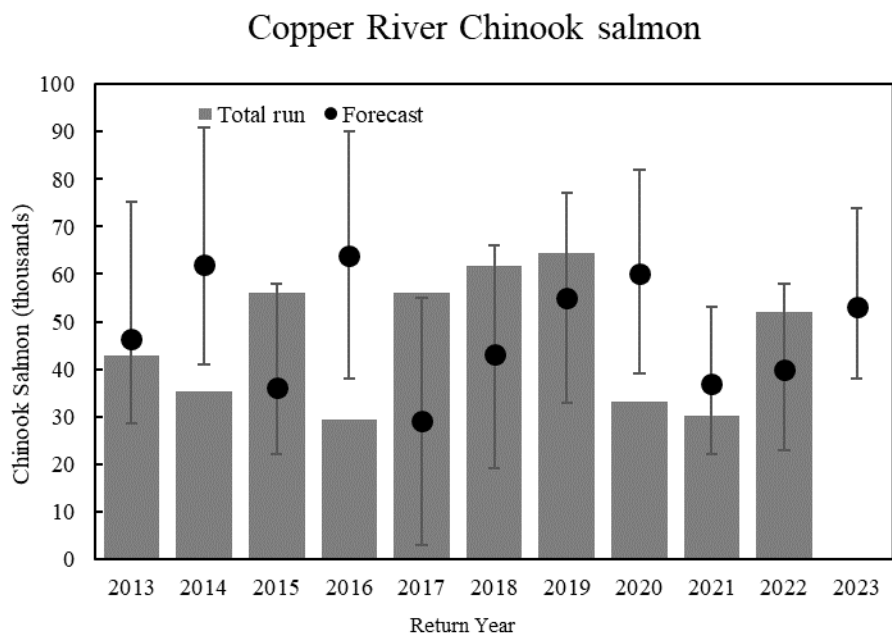
## 2023 COPPER RIVER CHINOOK SALMON FORECAST SUMMARY

The 2023 Copper River Chinook salmon total run forecast point estimate is **53,000 fish (80% prediction interval: 38,000–74,000 fish)**. This is 15% above the recent 10-year average (2013–2022) total run of 46,000 fish. The sustainable escapement goal for Copper River Chinook salmon is 21,000 to 31,000 fish. The categorical ranges of Chinook salmon total run strength were formulated from the 20th, 40th, 60th, and 80th percentiles of historical total runs over the recent 10 years (2013–2022; Table 1).

### FORECAST METHODS

For 2023, the Copper River Chinook salmon state-space model was chosen as the forecast method. This model simultaneously reconstructs runs and fits a spawner-recruit model to estimate total return, escapement, and recruitment of Copper River Chinook salmon from 1999 to 2022. Methods and details of this analysis are covered in separate reports (Joy et al. 2021, Saveriede et al. 2018). The model uses harvest, age composition, and direct measures of inriver run abundance to estimate parameters that describe the spawner-recruit relationship for this stock. Uncertainty from the run reconstruction is passed through to the spawner-recruit analysis and all relevant data are considered and weighted by their precision. The model accommodates missing data, measurement error in the data, and changes in age at maturity.

Several forecast methods were examined for the 2023 Copper River Chinook salmon total run forecast including exponential smoothing, 2-, 3-, and 5-year running averages of total run, and projections from the Copper River Chinook salmon state-space model. The state-space model performed similarly when compared retrospectively to the simple average-based methods historically used to forecast this stock, while using more biological information to predict future runs (Table 3). The state-space model outperformed the average-based models by having a lower mean absolute percentage error (MAPE) and mean percentage error (MPE) when compared retrospectively. Total run size in prior years was calculated as the sum of commercial and subsistence harvests of Chinook salmon below Miles Lake, and the mark-recapture point estimate of Chinook salmon inriver abundance. There are currently 24 years (1999–2022) of inriver abundance estimates available for this analysis. The 80% prediction intervals were calculated from the posterior distributions of the model parameters, including the predicted run-size for 2023.



**Figure 1. Total run of Copper River Chinook salmon compared to preseason total run forecasts, 2013–2022, and the 2023 forecast. Error bars represent 80% prediction intervals of forecasts.**

recommendation for Chinook salmon in the Copper River. Alaska Department of Fish and Game, Fishery Manuscript No. 18-07, Anchorage.

Joy, P., J. W. Savereide, M. Tyers, and S. J. Fleischman. 2021. Run reconstruction, spawner–recruit analysis, and escapement goal recommendation for Chinook salmon in the Copper River. Alaska Department of Fish and Game, Fishery Manuscript No. 21-01, Anchorage.

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## 2023 COPPER RIVER SOCKEYE SALMON FORECAST SUMMARY

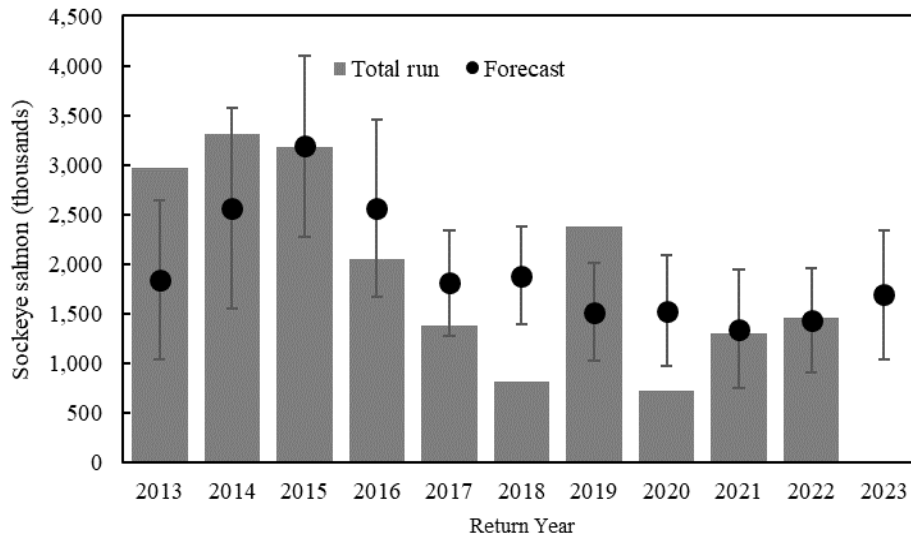
The 2023 wild Copper River sockeye salmon total run forecast point estimate is **1,646,000 fish (80% prediction interval: 1,017,000–2,275,000 fish)**. Gulkana Hatchery sockeye salmon total run is predicted to be **49,000 fish (80% prediction interval: 30,000–68,000 fish)**, for a total Copper River sockeye salmon run (wild + hatchery production) of **1,695,000 fish (80% prediction interval: 1,047,000–2,343,000 fish)**. This is 14% below the recent 10-year average (2013–2022) total run of 1,956,000 fish. Total Copper River sockeye salmon harvest estimate (all fisheries) is predicted to be **1,193,000 fish (80% prediction interval: 826,000–1,560,000 fish)** with a commercial harvest of **987,000 fish (80% prediction interval: 620,000–1,354,000 fish)**. The categorical ranges of sockeye salmon total run strength were formulated from the 20<sup>th</sup>, 40<sup>th</sup>, 60<sup>th</sup>, and 80<sup>th</sup> percentiles of historical total runs over the recent 10 years (2013–2022; Table 1).

### FORECAST METHODS

The 2023 forecast of wild sockeye salmon to the Copper River is the sum of individual forecasts for six age classes. Linear regression models with log-transformed data were used to predict returns for age-1.2, -1.3, -2.2, and -2.3 sockeye salmon. Forecasts of these four age classes were developed from the relationship between returns of each age class, and returns of the age class one year younger from the same brood year (sibling model, Table 5). The predicted return of age-1.1, and -0.3, sockeye salmon were calculated as the 5-year (2018–2022) mean return of these age classes. The 2023 run to Gulkana Hatchery was estimated as the recent 5-year weighted average fry-to-adult survival estimate (0.33%) from all Gulkana I and Gulkana II hatchery releases combined (onsite and remote). The Gulkana Hatchery run was apportioned to brood year using a maturity schedule of 30% age-4 and 70% age-5.

The total harvest point estimate (all fisheries) was calculated by subtracting the Gulkana Hatchery broodstock, hatchery surplus, and wild stock escapement goal needs (upriver and Copper River Delta) from the total run forecast. The commercial harvest estimate was calculated by subtracting Copper River inriver goal categories (5 AAC 24.360(b)) and the lower bound of the Copper River Delta spawning escapement goal, from the total run forecast. An estimated exploitation rate of 70% was used to project the total harvest of Gulkana Hatchery stocks in 2023. There are currently 58 years (1965–2022) of harvest, escapement, and age composition data available for this analysis. Total run 80% prediction intervals were calculated from the mean squared error of the retrospective forecast predictions.

## Copper River sockeye salmon



**Figure 2. Total run of Copper River sockeye salmon compared to preseason total run forecasts, 2013–2022, and the 2023 forecast. Error bars represent 80% prediction intervals of forecasts.**

### 2023 COGHILL LAKE SOCKEYE SALMON FORECAST SUMMARY

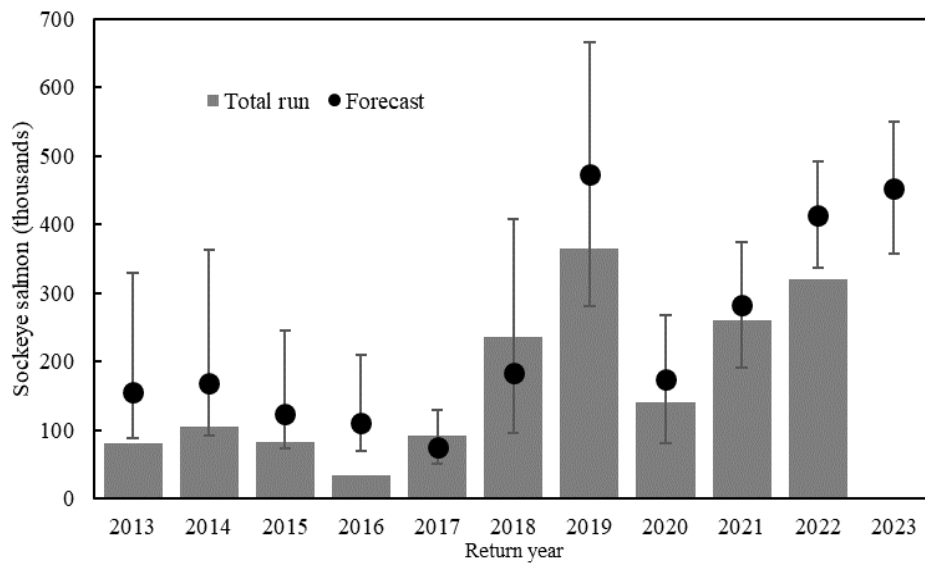
The 2023 Coghill Lake sockeye salmon total run forecast point estimate is **453,000 fish (80% prediction interval: 357,000–549,000 fish)**. This is 165% above the 10-year average (2013–2022) total run of 171,374 fish. Subtracting the escapement target of 30,000 fish from the total run forecast results in a harvest point estimate (all fisheries) of **423,000 fish (range: 327,100–519,000 fish)**. The categorical ranges of sockeye salmon total run strength were formulated from the 20<sup>th</sup>, 40<sup>th</sup>, 60<sup>th</sup>, and 80<sup>th</sup> percentiles of historical total runs over the recent 10 years (2013–2022; Table 1).

### FORECAST METHODS

The 2023 sockeye salmon run forecast to Coghill Lake is the total of estimates for five age classes. Linear regression models with log-transformed data were used to predict returns of age-1.3 and -1.2 sockeye salmon (Table 4). These linear regression models were parameterized using the historical relationship between returns of age-1.3 sockeye salmon and returns of age-1.2 fish one year previous and returns of age-1.2 sockeye salmon and returns of the age-1.1 fish one year previous (sibling models). For example, the model chosen to predict the return of age-1.3 sockeye salmon in 2023 used the return of age-1.2 fish in 2022 as the input parameter. An estimated 244,400 age-1.2 sockeye salmon returned to Coghill Lake in 2022, over four times the recent 10-year average run of 52,400 age-1.2 fish, resulting in a forecast of 429,100 age-1.3 fish for 2023. This 2022 run component (as illustrated in table 5) is the primary driver behind the 2023 forecast being more than double the recent 10-yr total run avg of 171,000 fish. Predicted returns of age-1.1, -2.2, and -2.3 sockeye salmon were calculated as the 2013–2022 mean return of that age class.

Harvest, escapement, and age composition data are available for Coghill Lake sockeye salmon runs since 1962; however, inclusion of escapements prior to the installation of a full weir in 1974 reduce forecast reliability. Therefore, only data collected since 1974 were used. Total run by year was estimated as the total commercial harvest contribution combined with the Coghill River weir escapement count. The 80% prediction intervals for the Coghill Lake sockeye salmon total run were calculated using the squared deviations between the 2018–2022 forecasts and actual runs as the forecast variance.

## Coghill Lake sockeye salmon



**Figure 3. Total run of Coghill Lake sockeye salmon compared to preseason total run forecasts, 2013–2022, and the 2023 forecast. Error bars represent 80% prediction intervals of forecasts.**

### 2023 PWS ODD-YEAR WILD PINK SALMON FORECAST SUMMARY

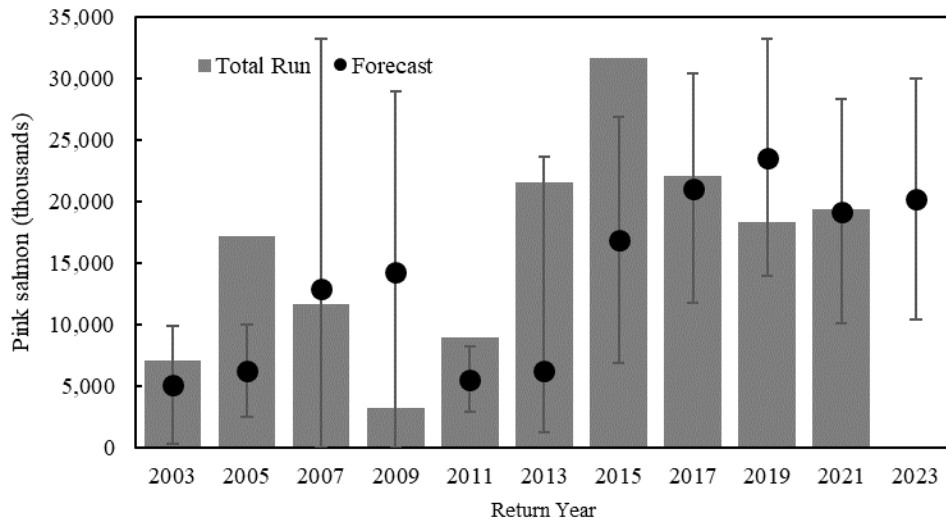
The 2023 PWS wild pink salmon total run forecast point estimate is **20,230,000 fish (80% prediction interval: 10,420,000–30,040,000 fish)**. This is 26% above the recent 10 odd-year average (2001–2021) PWS wild pink salmon total run of 16,100,000 fish. Subtracting the mid-point of the odd-year sustainable escapement goal, 1,838,000, from the total run forecast results in a harvest point estimate of **18,392,000 fish (range: 8,582,000 to 28,202,000)**.

### FORECAST METHODS

Several models were examined for the 2023 PWS wild pink salmon total run forecast including exponential smoothing and 2-, 3-, and 5-year running averages of past even-year total runs. The 2-year running average forecast was selected for 2023 because it outperformed other forecast models by having the lowest mean absolute percent error (MAPE) and median symmetrical accuracy (Table 3). The 80% prediction intervals were calculated from the mean squared error of the retrospective forecast predictions.

Total wild run of pink salmon by year was estimated as the total wild (non-hatchery) contribution to commercial harvests combined with stream escapement indices. The stream escapement index is calculated as the area under the curve of weekly aerial escapement surveys adjusted for estimates of stream life. Hatchery and wild stock contributions were determined from thermal marked otolith recoveries (1997–2022), coded wire tag recoveries (1985–1996), or average fry-to-adult survival estimates multiplied by fry release numbers and estimated exploitation rates (1977–1984).

## Prince William Sound pink salmon



**Figure 4. Total run of Prince William Sound wild pink salmon compared to preseason total run forecasts, 2013–2022, and the 2023 forecast. Error bars represent 80% prediction intervals of forecasts.**

### 2023 PWS WILD CHUM SALMON FORECAST SUMMARY

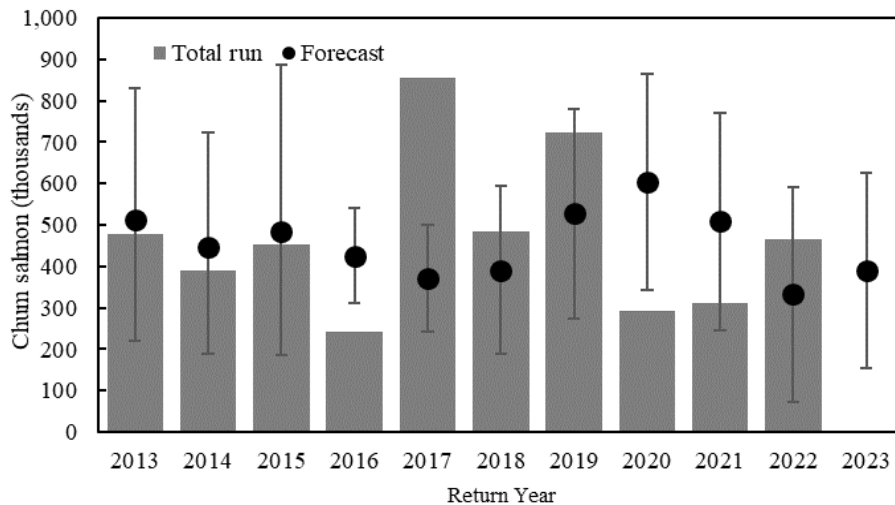
The 2023 PWS wild chum salmon total run forecast point estimate is **389,000 fish (80% prediction interval: 154,000–625,000 fish)**. This is 17% below the recent 10-year average (2013–2022) PWS wild chum salmon total run of 470,000 fish. Subtracting the 10-year average escapement, 169,000, from the total run forecast results in a harvest point estimate of **220,000 fish (range: 0 to 405,000 fish)**. The categorical ranges of chum salmon total run strength were formulated from the 20<sup>th</sup>, 40<sup>th</sup>, 60<sup>th</sup>, and 80<sup>th</sup> percentiles over the recent 10 years (2013–2022; Table 1).

### FORECAST METHODS

The 2023 PWS wild chum salmon total run forecast uses the 2-year running average method. Several models were examined for the 2023 PWS wild chum total run forecast including exponential smoothing and 2-, 3-, and 5-year running averages of past total runs (Table 3). For 2023, 2-year running average outperformed the other models by having the lowest MAPE, mean absolute squared error (MASE) and median symmetrical accuracy. The 80% prediction intervals were calculated from the mean squared error of the retrospective forecast predictions.

Total wild run of chum salmon by year was estimated as the total wild (non-hatchery) contribution to commercial harvests combined with the stream escapement index. The stream escapement index is calculated as the area under the curve of weekly aerial escapement surveys adjusted for estimates of stream life. Hatchery and wild stock contributions were estimated using pre-hatchery average natural runs (1998–2003) or thermally marked otolith estimates (2004–2022) for each district in PWS.

## Prince William Sound chum salmon



**Figure 5.** Total run of Prince William Sound wild chum salmon compared to preseason total run forecasts, 2013–2022, and the 2023 forecast. Error bars represent 80% prediction intervals of forecasts.

**Table 3.** 2023 Copper River Chinook salmon forecast model performance summary. Model selected as the run forecast (lowest MAPE) is shaded.

Stock/model	Prediction Point Estimate	80% Prediction Interval	MAPE
State-space	53,006	38,113-73,749	31%
Exponential	45,002	29,717-60,287	36%
2-year	40,997	19,120-62,873	38%
3-year	38,354	16,112-60,596	40%
5-year	48,146	27,912-68,380	33%

**Table 4.** 2023 Prince William Sound wild pink and chum salmon forecast model performance summary. Models selected as the run forecast (lowest MAPE) are shaded.

Run	Prediction	MAPE	
PWS wild pink	Exponential	19,350,000	75%
	2-year	20,230,000	72%
	3-year	19,940,000	78%
	5-year	22,610,000	97%
	PWS wild chum	Exponential	450,724
2-year		389,105	30%
3-year		356,897	32%
5-year		455,668	35%

**Table 5. 2023 Prince William Sound wild sockeye salmon forecast model summary. Models selected for inclusion in the run forecast (lowest MAPE) are shaded.**

Stock/Age Class	Brood Year	Model	Prediction	MAPE
Copper River wild sockeye				
0.3		5-year mean	54,256	
1.1		5-year mean	1,181	
1.2	2019	log 1.2 R/S x BYE	257,301	65%
		log 1.2 x log 1.1	232,376	56%
1.3	2018	1.3 x BYE	1,098,793	50%
		log 1.3R/S x BYE	1,057,191	42%
		log 1.3 x log 1.2	1,189,823	33%
		log 1.3 x log 0.3	995,870	44%
		1.3 x 1.2	1,247,384	47%
2.2	2018	log 2.2 x BYE	26,012	68%
		log 2.2 x log 1.2	30,327	64%
2.3	2017	log 2.3 x log 2.2	138,137	62%
		log 2.3 x log 1.3	90,452	70%
Total			1,646,100	
Coghill Lake sockeye				
1.1		10-year mean	5,686	
1.2	2019	log 1.2 R/S x BYE	29,170	180%
		log 1.2 x log 1.1	3,743	121%
1.3	2018	log R/S 1.3 x BYE	103,059	194%
		log 1.3 x log 1.2	429,149	76%
2.2	2018	10-year mean	8,267	
2.3	2017	10-year mean	6,235	
Total			453,079	

Note: R/S = Return per spawner; BYE = Brood year escapement