



Advisory Announcement
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2021 Prince William Sound and Copper River Salmon Forecast

Forecasts of total run were calculated for Copper River wild Chinook and sockeye salmon, Gulkana Hatchery sockeye salmon, Coghill Lake sockeye salmon, and for wild PWS pink and chum salmon. Prince William Sound Aquaculture Corporation (PWSAC) and Valdez Fisheries Development Association (VFDA) provide additional forecasts for hatchery-specific stocks. In addition to forecasts, a summary of recent 10-year averages (2011–2020) of Commercial Common Property Fishery (CCP) harvest for most wild stocks and Gulkana Hatchery production is included (Table 1). Salmon forecasts are inherently uncertain and are primarily used to gauge the magnitude of expected runs and set early-season harvest management strategy. In 2021, the department will continue to manage PWS Area commercial salmon fisheries inseason based primarily on the strength of salmon abundance indices including sonar counts, weir passage, aerial escapement surveys, and fishery performance data.

2021 Prince William Sound Area Salmon Forecast Summary (thousands of fish)

Area/Production Type	Species	Forecast Type	Forecast Point	Forecast Range	% Above/Below 10-yr Average
Copper River					
<i>Wild Production</i>	Chinook Salmon	Total Run	37	22–53	22.4% Below
<i>Wild Production</i>	Sockeye Salmon	Total Run	1,296	724–1,869	37.4% Below
<i>Gulkana Hatchery Production</i>	Sockeye Salmon	Total Run	51	28–73	81.1% Below
<i>Total Production</i>	Sockeye Salmon	Total Run	1,347	749–1,945	
Coghill Lake					
<i>Wild Production</i>	Sockeye Salmon	Total Run	282	190–375	45.4% Above
Prince William Sound					
<i>Wild Production</i>	Pink Salmon	Total Run	19,187	10,088–28,286	27.5% Above
<i>Wild Production</i>	Chum Salmon	Total Run	508	246–769	4.7% Above

2021 COPPER RIVER CHINOOK SALMON FORECAST SUMMARY

The 2021 Copper River Chinook salmon total run point estimate is **37,000 fish (80% prediction interval: 22,000–53,000 fish)**. The recent 10-year average (2011–2020) Copper River Chinook salmon total run is 48,000 fish. Subtracting the lower bound sustainable escapement goal of 24,000 fish from the total run forecast results in a common property harvest point estimate (all fisheries) of **13,000 fish (range: 0–29,000 fish)**.

FORECAST METHODS

For 2021, 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 2020. Methods and details of this analysis are covered in separate reports (Joy et al. 2020 *in press*, Savereide 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 2021 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 2). The state-space model outperformed the average-based models by having a lower mean absolute percentage error (MAPE), mean squared error (MSE), and mean percentage error (MPE) when compared retrospectively. Total run size 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 22 years (1999–2020) 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 2021.

Savereide, J. W., M. Tyers, and S. J. Fleischman. 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. 18-07, Anchorage

Joy, P., J. W. Savereide, M. Tyers, and S. J. Fleischman. *In press*. Run Reconstruction, Spawner-Recruit Analysis, and Escapement Goal Recommendation for Chinook Salmon in the Copper River. Alaska Department of Fish and Game, Fishery Manuscript Series No. XX-XX, Anchorage.

2021 COPPER RIVER SOCKEYE SALMON FORECAST SUMMARY

The 2021 wild Copper River sockeye salmon total run point estimate is **1,296,000 fish (80% prediction interval: 724,000–1,869,000 fish)**. The recent 10-year average (2011–2020) Copper River wild sockeye salmon total run is 2,070,000 fish. Gulkana Hatchery sockeye salmon total run is predicted to be **51,000 fish (80% prediction interval: 28,000–73,000 fish)** for a total Copper River sockeye salmon run (wild + hatchery production) of **1,347,000 fish (80% prediction interval: 749,000–1,945,000 fish)**. Total Copper River sockeye salmon common property harvest (all fisheries) is predicted to be **844,000 fish (80% prediction interval: 429,000–1,259,000 fish)** with a CCP harvest of **652,000 fish (80% prediction interval: 237,000–1,067,000 fish)**.

FORECAST METHODS

The 2021 forecast of wild sockeye salmon to the Copper River is the total of estimates 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. These four age classes were predicted 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 3). Predicted return of age-1.1, and -0.3, sockeye salmon were calculated as the 5-year (2016–2020) mean return of those age classes. The 2021 run to Gulkana Hatchery was estimated as the recent 5-year weighted average fry-to-adult survival estimate (0.50%) from all Gulkana I and Gulkana II hatcheries releases combined (onsite and remote). The run was apportioned to brood year using a maturity schedule of 30% age-4 and 70% age-5.

The total common property (all fisheries) harvest forecast 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 CCP harvest estimate was calculated by subtracting inriver goal categories (5 AAC 24.360(b)) and 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 2021. There are currently 56 years (1965–2020) 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.

2021 COGHILL LAKE SOCKEYE SALMON FORECAST SUMMARY

The 2021 Coghill Lake sockeye salmon total run point estimate is **282,000 fish (80% prediction interval: 190,000–375,000 fish)**. Subtracting the escapement target of 30,000 fish from the total run forecast results in a common property harvest point estimate (all fisheries) of **252,000 fish (range: 160,000–345,000 fish)**. The recent 10-year average (2010–2019) Coghill Lake sockeye salmon total run is 194,000 fish.

FORECAST METHODS

The 2021 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 3). 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 to predict the return of age-1.3 sockeye salmon in 2021 used the return of age-1.2 fish in 2020 as the input parameter. An estimated 69,800 age-1.2 sockeye salmon returned to Coghill Lake in 2020, 42% above the recent 10-year average run of 49,000 age-1.2 fish, resulting in a forecast of 187,000 age-1.3 fish for 2021 (66% of the predicted 2021 total run). An estimated 6,600 age-1.1 sockeye salmon returned to Coghill Lake in 2020, above the recent 10-year average run of 2,500 age-1.1 fish, resulting in a forecast of 84,000 age-1.2 fish for 2021 (30% of the predicted 2021 total run). Predicted returns of age-1.1, -2.2, and -2.3 sockeye salmon were calculated as the 2011–2020 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 2016–2020 forecasts and actual runs as the forecast variance.

2021 PWS ODD-YEAR WILD PINK SALMON FORECAST SUMMARY

The 2021 PWS wild pink salmon total run point estimate is **19,187,000 fish (80% prediction interval: 10,088,000–28,286,000 fish)**. The recent 10 odd-year average (2001–2019) PWS wild pink salmon total run is 15,053,000 fish.

FORECAST METHODS

The 2021 PWS wild pink salmon total run forecast uses the exponential smoothing method. Several models were examined for 2021 including exponential smoothing and 2-, 3-, and 5-year running averages of past odd-year total runs (Table 2). Exponential smoothing and moving average models produced similar forecast results in the 19.2–24.0 million fish range. Exponential smoothing and 2-year running average forecasts had very similar performance and outperformed 3- and 5-year running average models when compared retrospectively. The exponential smoothing forecast was selected for 2021 because it marginally outperformed the 2-year running average forecast by having a slightly lower MPE, MSE, and bias when compared retrospectively. The exponential smoothing technique is similar to a running average except that all observations of odd-year total run since 1981 were used in the forecast estimate. Recent observations of total run were weighted more heavily in the analysis while past total run observations were increasingly down-weighted with time, resulting in older total run observations having less influence on the forecast than more recent observations. 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 (1997–2019), coded wire tag recoveries (1985–1996), or average fry-to-adult survival estimates multiplied by fry production and estimated exploitation rates (1977–1984).

There is considerable uncertainty regarding the spawning success of wild pink salmon returning to PWS in 2019 due to severe drought conditions that persisted through much of pink salmon spawn timing. Pre-spawn mortality, lack of water in spawning streams, and high water temperatures were observed in 2019. This forecast does not integrate environmental indices or other indicators of spawning success and the 2021 prediction takes no account of the anomalous conditions observed during the parent year.

2021 PWS WILD CHUM SALMON FORECAST SUMMARY

The 2021 PWS wild chum salmon total run point estimate is **508,000 fish (80% prediction interval: 246,000–769,000 fish)**. The recent 10-year average (2011–2020) PWS wild chum salmon total run is 485,000 fish.

FORECAST METHODS

The 2021 PWS wild chum salmon total run forecast uses the 2-year running average method. Several models were examined for the 2021 PWS wild chum total run forecast including exponential smoothing and 2-, 3-, and 5-year running averages of past total runs (Table 2). For 2021, 2-year running average outperformed the other models by having the lowest MAPE, MPE, MSE, mean absolute squared error (MASE), median symmetrical accuracy and relatively low bias when compared retrospectively. 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 (2004–2020) for each district in PWS.

Table 1.– PWS Area Recent 10-Year (2011–2020) Average CCP Salmon Harvest by Species (thousands of fish)

Area/Production Type	Chinook	Sockeye	Coho	Pink	Chum	Total
Bering River						
<i>Wild Production</i>	0	4	61	0	0	65
Copper River						
<i>Wild Production</i>	13	1,048	218	61 ^b	16	1,347
<i>Hatchery Production</i>	0	182	0	0	0	182
<i>Total Production</i>	13	1,230	218	61 ^b	16	1,529
Prince William Sound						
<i>Wild Production</i>	1	213	N/A ^a	11,946 ^b	282	12,442
Area Totals						
<i>Wild Production</i>	14	1,265	280	11,998	298	13,854

^a Estimates of wild coho salmon harvests in are not available due to limited samples of thermally marked coho otoliths from the commercial harvest

^b Recent 10 odd-year CCP harvest (2001-2019)

Table 2.– 2021 PWS Chinook, Pink, and Chum Salmon Forecast Model Summary

Stock/model	Prediction	MAPE	MPE	Bias
Copper River Chinook				
State-space	37,235	33%	6%	1,073
Exponential	46,582	36%	18%	-4,100
2-year	48,860	35%	14%	-2,673
3-year	53,117	39%	18%	-4,065
5-year	48,963	40%	23%	-6,373
PWS Wild Pink				
Exponential	19,187,448	76%	36%	-226,473
2-year	20,226,381	73%	38%	-458,642
3-year	24,051,436	80%	41%	-1,072,475
5-year	20,529,736	99%	52%	-1,845,178
PWS Wild Chum				
Exponential	334,442	40%	17%	-26,868
2-year	507,501	32%	15%	-24,178
3-year	500,043	34%	16%	-22,859
5-year	519,458	35%	16%	-18,863

Table 3.– 2021 PWS Sockeye Salmon Forecast Model Summary

Stock/Age Class	Brood Year	Model	Prediction	MAPE	P-value	R ²
Copper River Wild Sockeye						
1.2	2017	log 1.2 R/S x BYE	238,054	66%	<.0001	0.139
		log 1.2 x log 1.1	215,741	57%	<.0001	0.301
1.3	2016	1.3 x BYE	1,109,673	51%	<.0001	0.073
		log 1.3R/S x BYE	1,066,972	43%	<.0001	0.326
		log 1.3 x log 1.2	880,191	34%	<.0001	0.391
		log 1.3 x log 0.3	844,228	45%	<.0001	0.057
		1.3 x 1.2	902,387	45%	<.0001	0.411
2.2	2016	log 2.2 x BYE	25,718	69%	<.0001	0.103
		log 2.2 x log 1.2	21,434	64%	<.0001	0.220
2.3	2015	log 2.3 x log 2.2	112,671	64%	<.0001	0.252
		log 2.3 x log 1.3	49,993	69%	<.0001	0.211
Coghill Lake Sockeye						
1.2	2017	log 1.2 R/S x BYE	29,846	170%	<.0001	0.364
		log 1.2 x log 1.1	84,438	125%	<.0001	0.370
1.3	2016	log R/S 1.3 x BYE	26,392	199%	<.0001	0.163
		log 1.3 x log 1.2	186,609	71%	<.0001	0.668

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