Appendix 11O Anderson-Martin Models

Appendix 11O Anderson-Martin Models

11O.1 Introduction

This appendix describes two analytical tools used in the Sites Reservoir Project analysis of potential temperature-related effects on winter-run Chinook salmon egg mortality—the Martin et al. (2017) and Anderson (2018) egg mortality models. These two models were used to assess water temperature–related effects on winter-run Chinook salmon in Chapter 11, *Aquatic Biological Resources*, specifically under Impact FISH-2, Operations and Maintenance Effects on Winter-Run Chinook Salmon.

11O.2 Methods

11O.2.1. Background

The dissolved oxygen content of water passing through gravel substrate of a redd and sustaining winter-run Chinook salmon eggs is positively correlated with temperature. Warm, anoxic conditions result in egg mortality. This analysis attempted to isolate the thermal component of egg mortality from other components such as density-dependent mortality and redd dewatering. Both the Martin et al. (2017) model and the Anderson (2018) model begin by modeling a redd's lifetime by counting the days required to cross a known cumulative degree-days threshold. Further, both models estimate mortality as a linear, increasing function of temperature past a known temperature threshold, but each conceptual model uses a different set of assumptions. The methods were applied to a set of simulated redds under the No Action Alternative (NAA)[1] and each alternative, and the results were summarized on a seasonal level for comparison of egg mortality outcomes between the NAA and each alternative.

11O.2.2. Winter-Run Chinook Salmon Egg Mortality Analysis Based on Martin et al. (2017)

Martin et al. (2017) built an egg mortality model for winter-run Chinook salmon in the Sacramento River and used regression analysis of historical data to determine that 53.6°F was a critical water temperature threshold of mortality for incubating eggs.

Martin et al. (2017) identified a discrepancy between laboratory and field estimates of egg mortality and proposed a mechanism based on differing flow velocities in the laboratory and field environments. They then outlined a model for estimating temperature-dependent egg

[1] The term *NAA*, which is identical to the No Project Alternative, is used throughout Chapter 11, *Aquatic Biological Resources*, and associated aquatic resources appendices in the presentation of modeled results and represents no material difference from the No Project Alternative, as discussed in Chapter 3, *Environmental Analysis*.

mortality in the field and fit its parameters to in situ winter-run Chinook salmon population data collected between 1996 and 2015 (Martin et al. 2017).

11O.2.2.1. Mortality Calculations

The first step in the Martin et al. (2017) model is to estimate a redd's date of emergence. Individual eggs within the redd hatch but stay within the gravel substrate of the redd and become alevins. These alevins later depart the redd in the emergence stage. The redd's estimated date of emergence is intended to represent the point in the average egg's life span where it leaves the gravel substrate of the redd.

The Martin et al. (2017) model estimates the date of emergence using a linear relationship between water temperature (T, in °F) and maturation: Rate of maturation = 0.00058 * T - 0.018 (Zeug et al. 2012). For each simulated redd, the Zeug et al. (2012) equation was applied to daily temperatures starting the day after redd creation until the cumulative sum of daily maturation rates is greater than one. The day on which this occurs is considered the date of emergence for the redd.

Daily survival is then calculated for every day of the redd's lifespan. Below a temperature threshold of 11.9°C, no temperature-dependent mortality is recorded, and the survival is 1. For each degree Celsius above the threshold, 0.024 is subtracted from the daily survival. The product of the natural exponents of daily survivals is the total survival, and one minus survival is the estimated mortality fraction for that simulated redd.

In summary, the Martin et al. (2017) model uses the Zeug et al. (2012) equation to estimate date of emergence, then estimates daily mortality for each day of the redd's lifespan using a linear relationship.

11O.2.2.2. Spatiotemporal Distribution of Simulated Winter-Run Chinook Salmon Eggs

The Martin et al. (2017) model was applied to HEC 5Q Sacramento River temperature results using the same spatiotemporal distribution of redds in each year. The distribution is the averaged location and timing of redds counted in California Department of Fish and Wildlife winter-run Chinook salmon aerial survey data from 2007 to 2014. Simulated redds were created and subjected to mortality calculations. Mortality of all simulated redds was summed, weighted by the spatiotemporal distribution, to estimate the total seasonal mortality.

No assumption was made regarding the total number of redds, as density-dependent mortality is not considered in this calculation; results indicate only the percentage of the total seasonal winter-run Chinook salmon egg population in the upper Sacramento River that is estimated to have succumbed to temperature-dependent mortality. Because a large percentage of modeled redds survived into October and the HEC 5Q simulation ends at September of 2003, temperature-dependent egg mortality was only estimated for the 1922–2002 water years.

Tables 11O-1 and 11O-2 indicate the river miles and dates for which simulated redds were created as well as the proportion of the total winter-run chinook salmon egg population that each location or time represents. The same temporal distribution was assumed for all locations.

Table 11O-1. Spatial Distribution of Simulated Redds Used in the Martin et al. (2017) Model of Winter-Run Chinook Salmon Egg Mortality

River Reach	River Mile	Mean Percentage (2007–2014)
Keswick to A.C.I.D. Dam.	298	46.4%
A.C.I.D. Dam to Highway 44 Bridge	296	46.1%
Highway 44 Br. to Airport Rd. Br.	284	6.7%
Airport Rd. Br. to Balls Ferry Br.	275	0.3%
Balls Ferry Br. to Battle Creek.	271	0.2%
Battle Creek to Jellys Ferry Br.	266	0.2%
Jellys Ferry Br. to Bend Bridge	257	0.1%
Bend Bridge to Red Bluff Diversion Dam[1]	242	0.0%

Source: California Department of Fish and Wildlife unpubl. data

[1] The Red Bluff Diversion Dam, which was decommissioned in 2013, and the Red Bluff Pumping Plant are co-located, and the names may be used interchangeably when referring to geographic locations.

Table 11O-2. Temporal Distribution of Simulated Redds Used in the Martin et al. (2017) Model of Winter-Run Chinook Salmon Egg Mortality

Date (month/day)	Mean Percentage (2007-2014)
5/15	5.4%
6/1	5.9%
6/9	7.8%
6/16	13.3%
6/24	16.0%
7/1	15.9%
7/9	14.2%
7/16	10.4%
7/24	6.7%
8/1	3.1%
8/16	1.4%

Source: California Department of Fish and Wildlife unpubl. data

11O.2.3. Winter-Run Chinook Salmon Egg Mortality Analysis Based on Anderson (2018)

Anderson (2018) developed a model that built on the findings of Martin et al. (2017) but differed in two key assumptions. While Martin et al. (2017) applied mortality to each day of a redd's lifespan from birth past hatching to emergence, Anderson (2018) used a short critical period instead. Using field data from 2002 through 2015, a critical period just before hatching was found to provide the best fit. This analysis used a critical period of 5 days in length, following the implementation of the Anderson (2018) model on the SacPAS website (http://www.cbr.washington.edu/sacramento/fishmodel/).

Instead of using the Zeug et al. (2012) equation to estimate date of emergence, the Anderson (2018) model uses a different equation to estimate date of hatching. Like the Zeug et al. (2012) equation, daily temperatures are correlated to daily maturation and a cumulative sum of daily maturation is calculated until maturation crosses a known threshold. The date on which this occurs is the hatching date and, in this implementation of the Anderson (2018) model, the 5 days before hatching are the days on which mortality is estimated.

The daily equation was calibrated as by Alderdice and Velsen (1978): ln(Daily development rate) = ln(k) + b * (ln(T - c)), where k = 0.08646, b = 1.23473, c = -2.26721, and temperature is measured in °C. The day on which the cumulative sum of daily development rate passes 100 is considered the redd hatching date.

Like the Martin et al. (2017) model, the Anderson (2018) model assumes a linear relationship between mortality and temperature, with zero mortality below a threshold. The threshold was identical to the Martin et al. (2017) model at 11.9°C, while the slope is not 0.024 but 0.5. This is unsurprising; calibration to substantially the same dataset will naturally result in a much higher slope, or a much larger mortality impact per degree Celsius above the threshold, for a model that only applies mortality to 5 days instead of the full lifespan of the redd. The same formula for adding up daily survivals and finding a total mortality estimate were used as for the Martin et al. (2017) model, as described above in Section 11O.2.2.1, *Mortality Calculations*. The same spatiotemporal redd weighting was applied as the Martin et al. (2017) model; see description above in Section 11O.2.2.2, *Spatiotemporal Distribution of Simulated Winter-Run Chinook Salmon Eggs*.

11O.3 Winter-Run Chinook Temperature-Dependent Egg Mortality Results (Martin and Anderson Models)

The following results of the Martin and Anderson models are included for winter-run Chinook salmon temperature-dependent egg mortality for the following alternatives:

- No Action Alternative 0514212
- Alternative 1A 051722
- Alternative 1B 051722
- Alternative 2 051722
- Alternative 3 051722

Title	Model Parameter	Table Numbers	Figure Numbers
Upper Sacramento Winter-Run Chinook Salmon, Martin Model	NA	11O-3 to 11O-6	11O-1 to 11O-6
Upper Sacramento Winter-Run Chinook Salmon, Anderson Model	NA	11O-3 to 11O-6	11O-7 to 11O-12

Report formats

- Tables comparing NAA with Alternative 1A, Alternative 1B, Alternative 2, and Alternative 3 (exceedance values, long-term average, and average by water year type)
- Exceedance charts including all alternatives

Table 11O-3a. Annual Temperature-Dependent Winter-Run Chinook Salmon Mortalities, No Action Alternative 051422[1]

Statistic	Martin	Anderson
Probability of Exceedance[2]		
10%	15.2%	6.5%
20%	2.5%	2.0%
30%	1.1%	1.0%
40%	0.9%	0.7%
50%	0.8%	0.6%
60%	0.6%	0.5%
70%	0.5%	0.4%
80%	0.5%	0.3%
90%	0.4%	0.3%
Long Term		
Full Simulation Period[2]	4.4%	2.5%
Water Year Types[3,4]		
Wet (32%)	1.3%	0.8%
Above Normal (15%)	0.5%	0.4%
Below Normal (17%)	1.2%	0.9%
Dry (22%)	2.5%	1.5%
Critical (15%)	21.3%	11.9%

[1] All scenarios are simulated at current climate condition and 0 cm sea level rise.
[2] Based on the 82-year simulation period.

[3] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (Water Right Decision 1641 [D-1641] [State Water Resources Control Board 1999]).
[4] These results are displayed with calendar year–year type sorting.

Table 11O-3b. Annual Temperature-Dependent Winter-Run Chinook Salmon Mortalities, Alternative 1A 051722[1]

Statistic	Martin	Anderson
Probability of Exceedance[2]		
10%	13.8%	6.3%
20%	2.3%	2.0%
30%	1.3%	1.0%
40%	0.9%	0.7%
50%	0.8%	0.6%
60%	0.7%	0.5%
70%	0.5%	0.4%
80%	0.5%	0.3%
90%	0.4%	0.3%
Long Term		
Full Simulation Period[2]	4.2%	2.4%
Water Year Types[3,4]		
Wet (32%)	1.3%	0.8%
Above Normal (15%)	0.5%	0.4%
Below Normal (17%)	1.2%	0.9%
Dry (22%)	2.4%	1.5%
Critical (15%)	19.9%	10.6%

[1] All scenarios are simulated at current climate condition and 0 cm sea level rise.
[2] Based on the 82-year simulation period.
[3] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (D-1641 [State Water Resources Control Board 1999]).
[4] These results are displayed with calendar year–year type sorting.

Table 11O-3c. Annual Temperature-Dependent Winter-Run Chinook Salmon Mortalities, Alternative 1A 051722 minus No Action Alternative 051422[1]

Statistic	Martin	Anderson
Probability of Exceedance[2]		
10%	-1.4%	-0.3%
20%	-0.1%	0.0%
30%	0.1%	0.0%
40%	0.0%	0.0%
50%	0.0%	0.0%

Statistic	Martin	Anderson
60%	0.0%	0.0%
70%	0.0%	0.0%
80%	0.0%	0.0%
90%	0.0%	0.0%
Long Term		
Full Simulation Period[2]	0.2%	-0.2%
Water Year Types[3,4]		
Wet (32%)	0.0%	0.0%
Above Normal (15%)	0.0%	0.0%
Below Normal (17%)	0.0%	0.1%
Dry (22%)	-0.1%	0.0%
Critical (15%)	-1.4%	-1.3%

[1] All scenarios are simulated at current climate condition and 0 cm sea level rise.
[2] Based on the 82-year simulation period.
[3] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (D-1641 [State Water Resources Control Board 1999]).
[4] These results are displayed with calendar year–year type sorting.

Table 11O-4a. Annual Temperature-Dependent Winter-Run Chinook Salmon Mortalities, No Action Alternative 051422[1]

Statistic	Martin	Anderson
Probability of Exceedance[2]		
10%	15.2%	6.5%
20%	2.5%	2.0%
30%	1.1%	1.0%
40%	0.9%	0.7%
50%	0.8%	0.6%
60%	0.6%	0.5%
70%	0.5%	0.4%
80%	0.5%	0.3%
90%	0.4%	0.3%
Long Term		
Full Simulation Period[2]	4.4%	2.5%
Water Year Types[3,4]		
Wet (32%)	1.3%	0.8%
Above Normal (15%)	0.5%	0.4%
Below Normal (17%)	1.2%	0.9%
Dry (22%)	2.5%	1.5%

Statistic	Martin	Anderson
Critical (15%)	21.3%	11.9%

[1] Based on the 82-year simulation period.
[2] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (D-1641 [State Water Resources Control Board 1999]).
[3] These results are displayed with calendar year–year type sorting.
[4] All scenarios are simulated at current climate condition and 0 cm sea level rise.

Table 11O-4b. Annual Temperature-Dependent Winter-Run Chinook Salmon Mortalities, Alternative 1B 051722[1]

Statistic	Martin	Anderson
Probability of Exceedance[2]		
10%	11.9%	5.7%
20%	2.2%	2.0%
30%	1.2%	1.0%
40%	0.9%	0.7%
50%	0.8%	0.6%
60%	0.7%	0.5%
70%	0.5%	0.5%
80%	0.5%	0.3%
90%	0.4%	0.3%
Long Term		
Full Simulation Period[2]	4.2%	2.3%
Water Year Types[3,4]		
Wet (32%)	1.3%	0.8%
Above Normal (15%)	0.6%	0.4%
Below Normal (17%)	1.2%	0.9%
Dry (22%)	2.4%	1.5%
Critical (15%)	19.7%	10.0%

[1] Based on the 82-year simulation period.
[2] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (D-1641 [State Water Resources Control Board 1999]).
[3] These results are displayed with calendar year–year type sorting.
[4] All scenarios are simulated at current climate condition and 0 cm sea level rise.

Table 11O-4c. Annual Temperature-Dependent Winter-Run Chinook Salmon Mortalities, Alternative 1B 051722 minus No Action Alternative 051422[1]

Statistic	Martin	Anderson
Probability of Exceedance[2]		
10%	-3.3%	-0.9%
20%	-0.2%	0.1%

Statistic	Martin	Anderson
30%	0.1%	0.1%
40%	0.0%	0.0%
50%	0.0%	0.0%
60%	0.1%	0.0%
70%	0.0%	0.0%
80%	0.0%	0.0%
90%	0.0%	0.0%
Long Term		
Full Simulation Period[2]	-0.3%	-0.3%
Water Year Types[3,4]		
Wet (32%)	0.0%	0.0%
Above Normal (15%)	0.1%	0.1%
Below Normal (17%)	0.0%	0.0%
Dry (22%)	-0.2%	0.0%
Critical (15%)	-1.6%	-1.9%

[1] Based on the 82-year simulation period.
[2] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (D-1641 [State Water Resources Control Board 1999]).
[3] These results are displayed with calendar year–year type sorting.
[4] All scenarios are simulated at current climate condition and 0 cm sea level rise.

Table 11O-5a. Annual Temperature-Dependent Winter-Run Chinook Salmon Mortalities, No Action Alternative 051422[1]

Statistic	Martin	Anderson
Probability of Exceedance[2]		
10%	15.2%	6.5%
20%	2.5%	2.0%
30%	1.1%	1.0%
40%	0.9%	0.7%
50%	0.8%	0.6%
60%	0.6%	0.5%
70%	0.5%	0.4%
80%	0.5%	0.3%
90%	0.4%	0.3%
Long Term		
Full Simulation Period[2]	4.4%	2.5%
Water Year Types[3,4]		
Wet (32%)	1.3%	0.8%

Statistic	Martin	Anderson
Above Normal (15%)	0.5%	0.4%
Below Normal (17%)	1.2%	0.9%
Dry (22%)	2.5%	1.5%
Critical (15%)	21.3%	11.9%

[1] Based on the 82-year simulation period.
[2] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (D-1641 [State Water Resources Control Board 1999]).
[3] These results are displayed with calendar year–year type sorting.
[4] All scenarios are simulated at current climate condition and 0 cm sea level rise.

Table 11O-5b. Annual Temperature-Dependent Winter-Run Chinook Salmon Mortalities, Alternative 2 051722[1]

Statistic	Martin	Anderson
Probability of Exceedance[2]		
10%	12.5%	5.9%
20%	2.3%	2.0%
30%	1.2%	1.0%
40%	0.9%	0.7%
50%	0.8%	0.6%
60%	0.7%	0.5%
70%	0.5%	0.4%
80%	0.5%	0.3%
90%	0.4%	0.3%
Long Term		
Full Simulation Period[2]	4.3%	2.4%
Water Year Types[3,4]		
Wet (32%)	1.3%	0.8%
Above Normal (15%)	0.5%	0.4%
Below Normal (17%)	1.2%	0.9%
Dry (22%)	2.4%	1.5%
Critical (15%)	20.4%	10.7%

[1] Based on the 82-year simulation period.
[2] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (D-1641 [State Water Resources Control Board 1999]).
[3] These results are displayed with calendar year–year type sorting.
[4] All scenarios are simulated at current climate condition and 0 cm sea level rise.

Table 11O-5c. Annual Temperature-Dependent Winter-Run Chinook Salmon Mortalities, Alternative 2 051722 minus No Action Alternative 051422[1]

Statistic	Martin	Anderson
Probability of Exceedance[2]		
10%	-2.7%	-0.7%
20%	-0.1%	0.0%
30%	0.1%	0.0%
40%	0.0%	0.0%
50%	0.0%	0.0%
60%	0.0%	0.0%
70%	0.0%	0.0%
80%	0.0%	0.0%
90%	0.0%	0.0%
Long Term		
Full Simulation Period[2]	-0.1%	-0.2%
Water Year Types[3,4]		
Wet (32%)	0.0%	0.0%
Above Normal (15%)	0.0%	0.0%
Below Normal (17%)	0.1%	0.1%
Dry (22%)	-0.1%	0.0%
Critical (15%)	-0.8%	-1.2%

[1] Based on the 82-year simulation period.
[2] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (D-1641 [State Water Resources Control Board 1999]).
[3] These results are displayed with calendar year–year type sorting.
[4] All scenarios are simulated at current climate condition and 0 cm sea level rise.

Table 11O-6a. Annual Temperature-Dependent Winter-Run Chinook Salmon Mortalities, No Action Alternative 051422[1]

Statistic	Martin	Anderson
Probability of Exceedance[2]		
10%	15.2%	6.5%
20%	2.5%	2.0%
30%	1.1%	1.0%
40%	0.9%	0.7%
50%	0.8%	0.6%
60%	0.6%	0.5%
70%	0.5%	0.4%

Statistic	Martin	Anderson
80%	0.5%	0.3%
90%	0.4%	0.3%
Long Term		
Full Simulation Period[2]	4.4%	2.5%
Water Year Types[3,4]		
Wet (32%)	1.3%	0.8%
Above Normal (15%)	0.5%	0.4%
Below Normal (17%)	1.2%	0.9%
Dry (22%)	2.5%	1.5%
Critical (15%)	21.3%	11.9%

[1] Based on the 82-year simulation period.
[2] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (D-1641 [State Water Resources Control Board 1999]).
[3] These results are displayed with calendar year–year type sorting.
[4] All scenarios are simulated at current climate condition and 0 cm sea level rise.

Table 11O-6b. Annual Temperature-Dependent Winter-Run Chinook Salmon Mortalities, Alternative 3 051722[1]

Statistic	Martin	Anderson
Probability of Exceedance[2]		
10%	10.5%	5.1%
20%	2.5%	2.0%
30%	1.3%	1.0%
40%	1.0%	0.8%
50%	0.8%	0.7%
60%	0.7%	0.6%
70%	0.6%	0.5%
80%	0.5%	0.4%
90%	0.4%	0.3%
Long Term		
Full Simulation Period[2]	4.0%	2.1%
Water Year Types[3,4]		
Wet (32%)	1.3%	0.8%
Above Normal (15%)	0.7%	0.6%
Below Normal (17%)	1.3%	1.0%
Dry (22%)	2.3%	1.4%
Critical (15%)	18.3%	8.9%

[1] Based on the 82-year simulation period.

[2] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (D-1641 [State Water Resources Control Board 1999]).
[3] These results are displayed with calendar year–year type sorting.
[4] All scenarios are simulated at current climate condition and 0 cm sea level rise.

Table 11O-6c. Annual Temperature-Dependent Winter-Run Chinook Salmon Mortalities, Alternative 3 051722 minus No Action Alternative 051422[1]

Statistic	Martin	Anderson
Probability of Exceedance[2]		
10%	-4.7%	-1.4%
20%	0.1%	0.1%
30%	0.1%	0.0%
40%	0.0%	0.1%
50%	0.1%	0.1%
60%	0.1%	0.0%
70%	0.1%	0.1%
80%	0.0%	0.1%
90%	0.0%	0.0%
Long Term		
Full Simulation Period[2]	-0.5%	-0.4%
Water Year Types[3,4]		
Wet (32%)	0.0%	0.0%
Above Normal (15%)	0.2%	0.3%
Below Normal (17%)	0.1%	0.1%
Dry (22%)	-0.2%	-0.1%
Critical (15%)	-3.0%	-3.0%

[1] Based on the 82-year simulation period.
[2] As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (D-1641 [State Water Resources Control Board 1999]).
[3] These results are displayed with calendar year–year type sorting.
[4] All scenarios are simulated at current climate condition and 0 cm sea level rise.

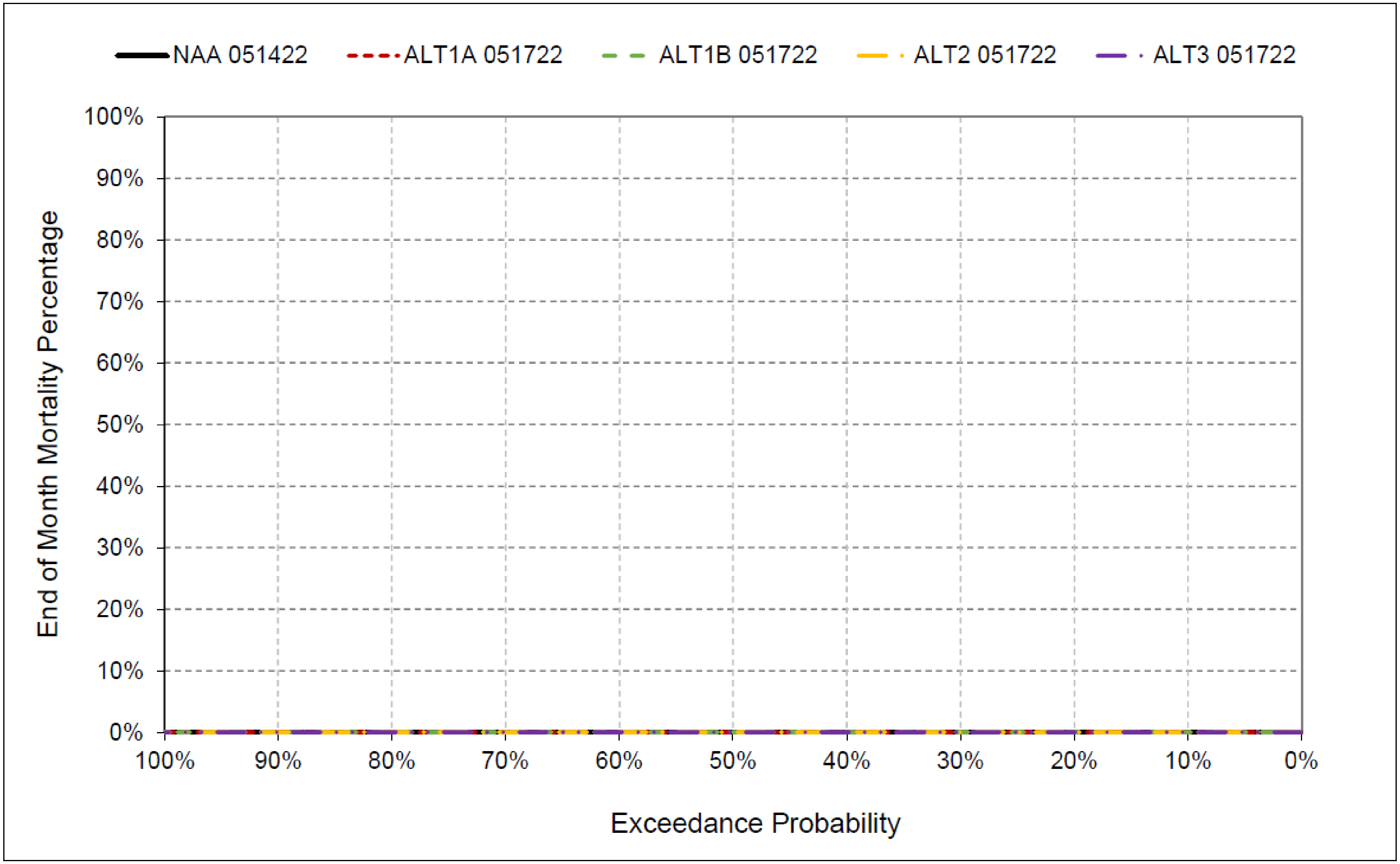

Figure 11O-1. Exceedance of Temperature-Based Egg Mortality for Winter-Run Chinook Salmon (Anderson Model), May

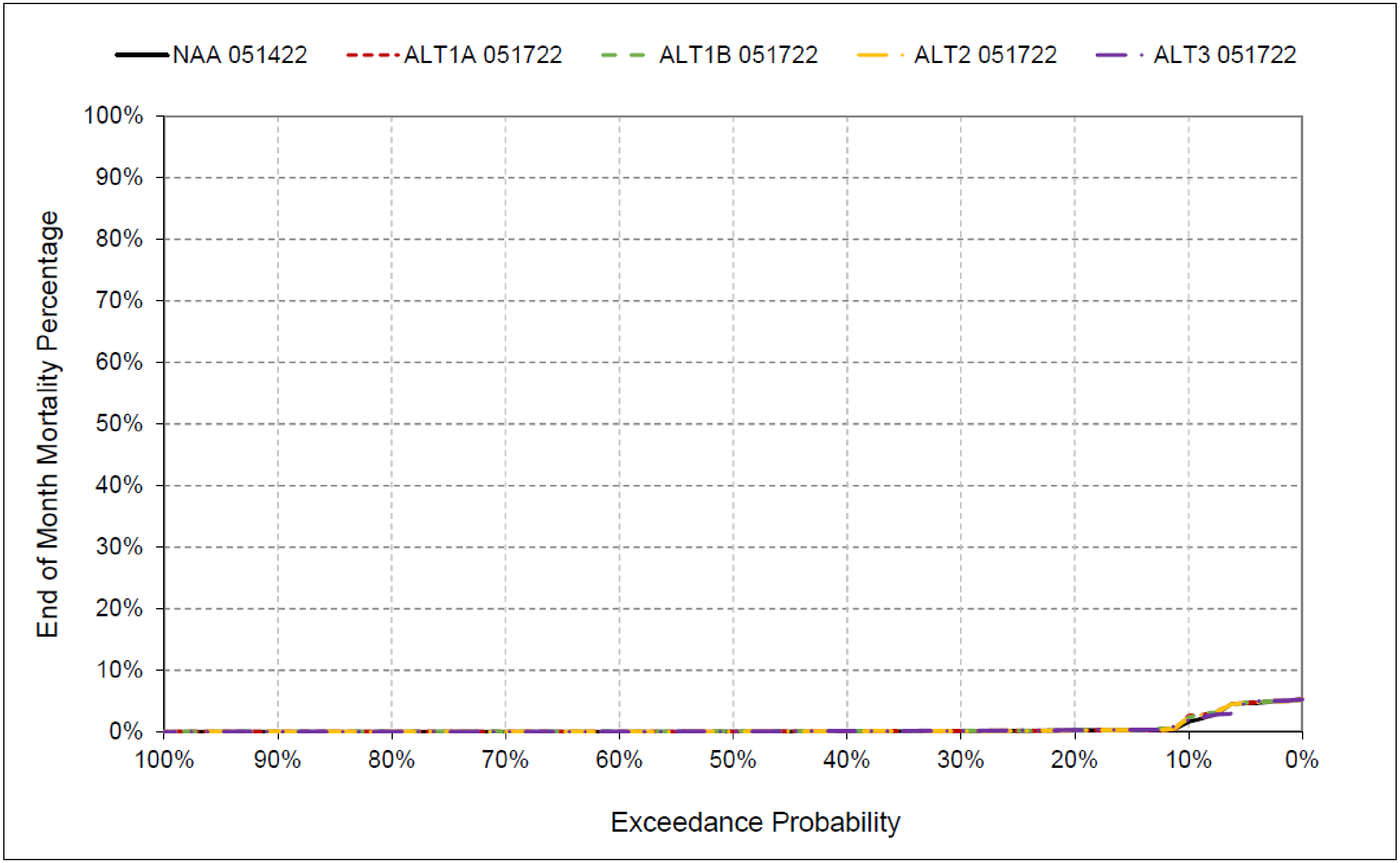

Figure 11O-2. Exceedance of Temperature-Based Egg Mortality for Winter-Run Chinook Salmon (Anderson Model), June

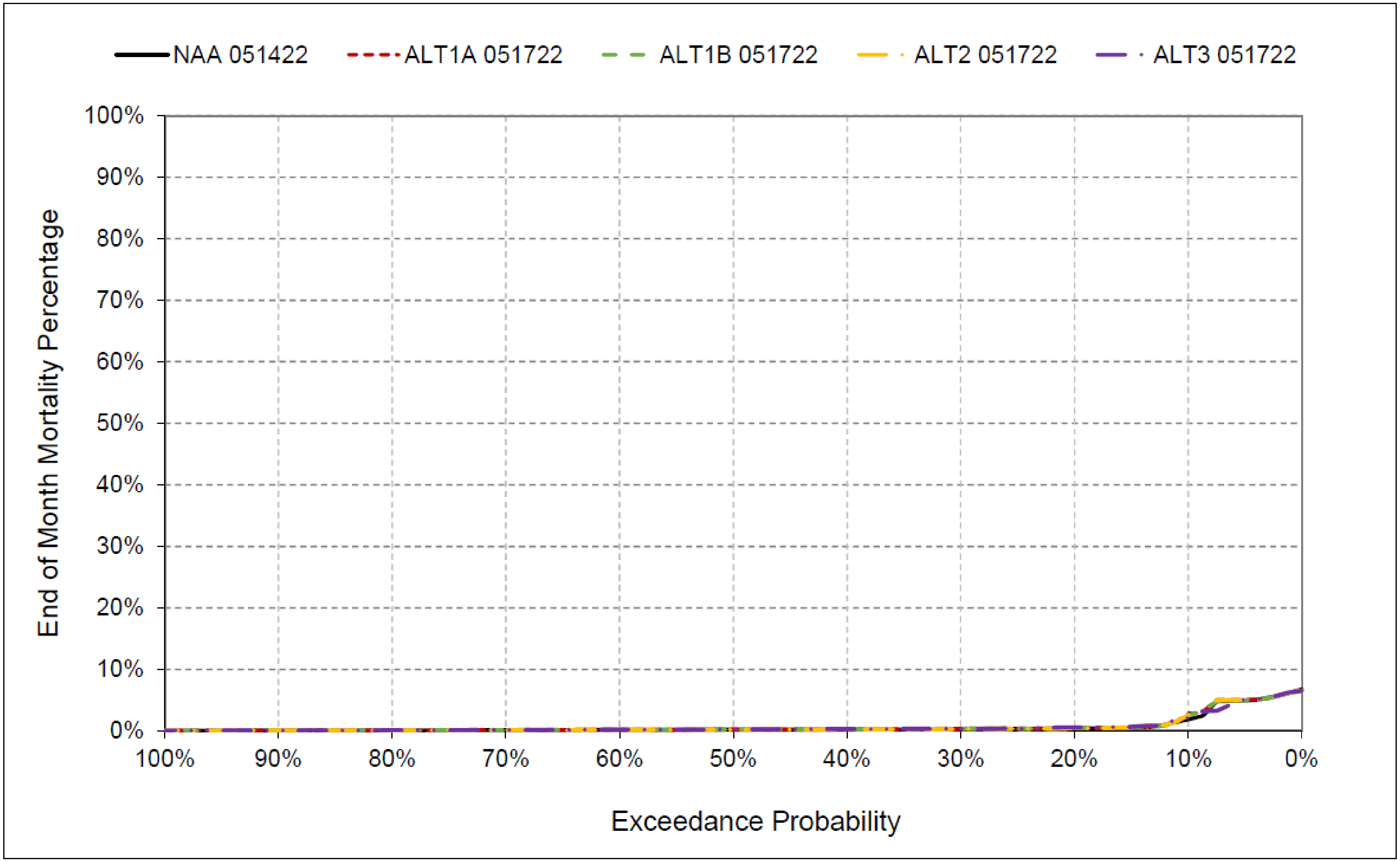

Figure 11O-3. Exceedance of Temperature-Based Egg Mortality for Winter-Run Chinook Salmon (Anderson Model), July

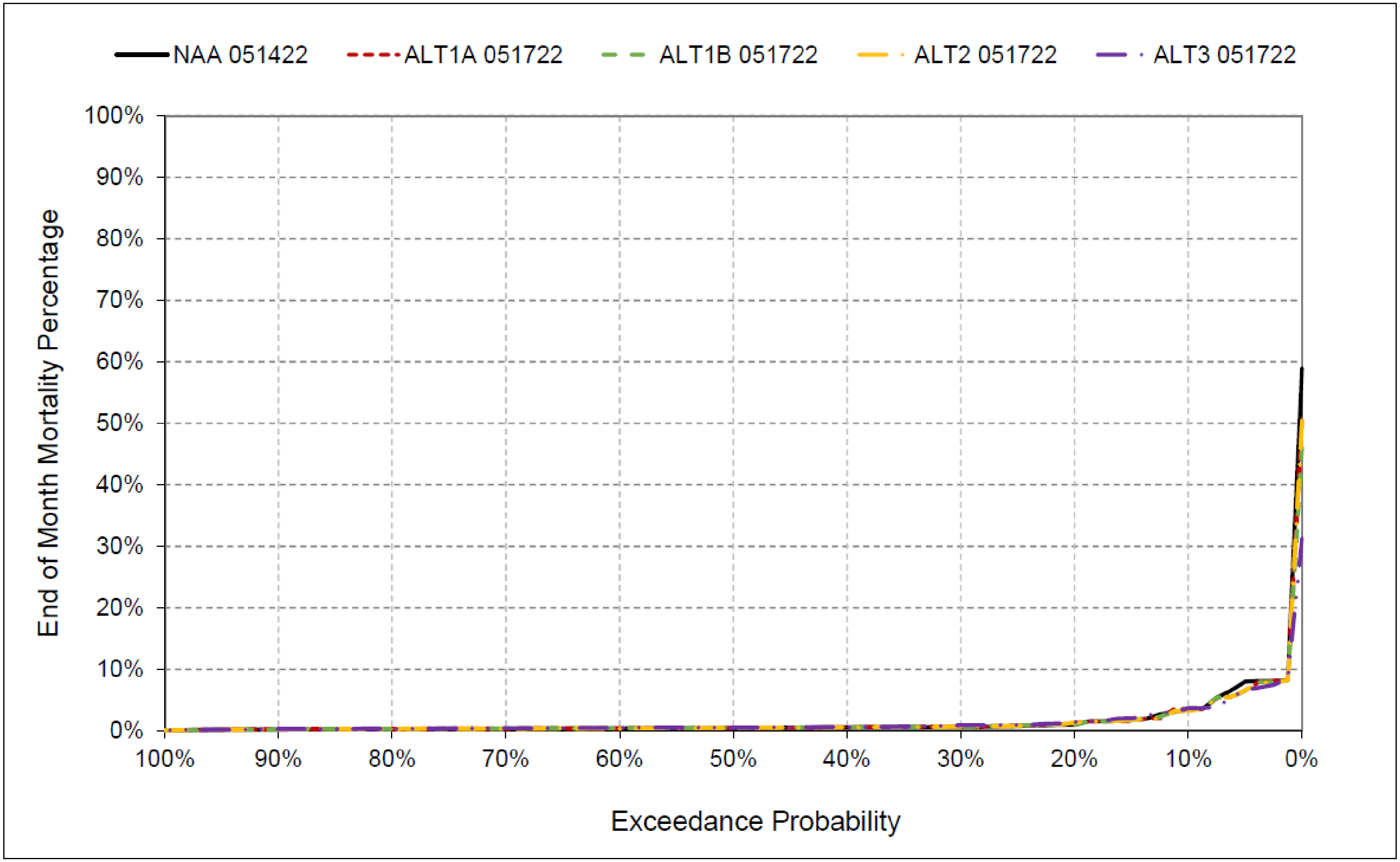

Figure 11O-4. Exceedance of Temperature-Based Egg Mortality for Winter-Run Chinook Salmon (Anderson Model), August

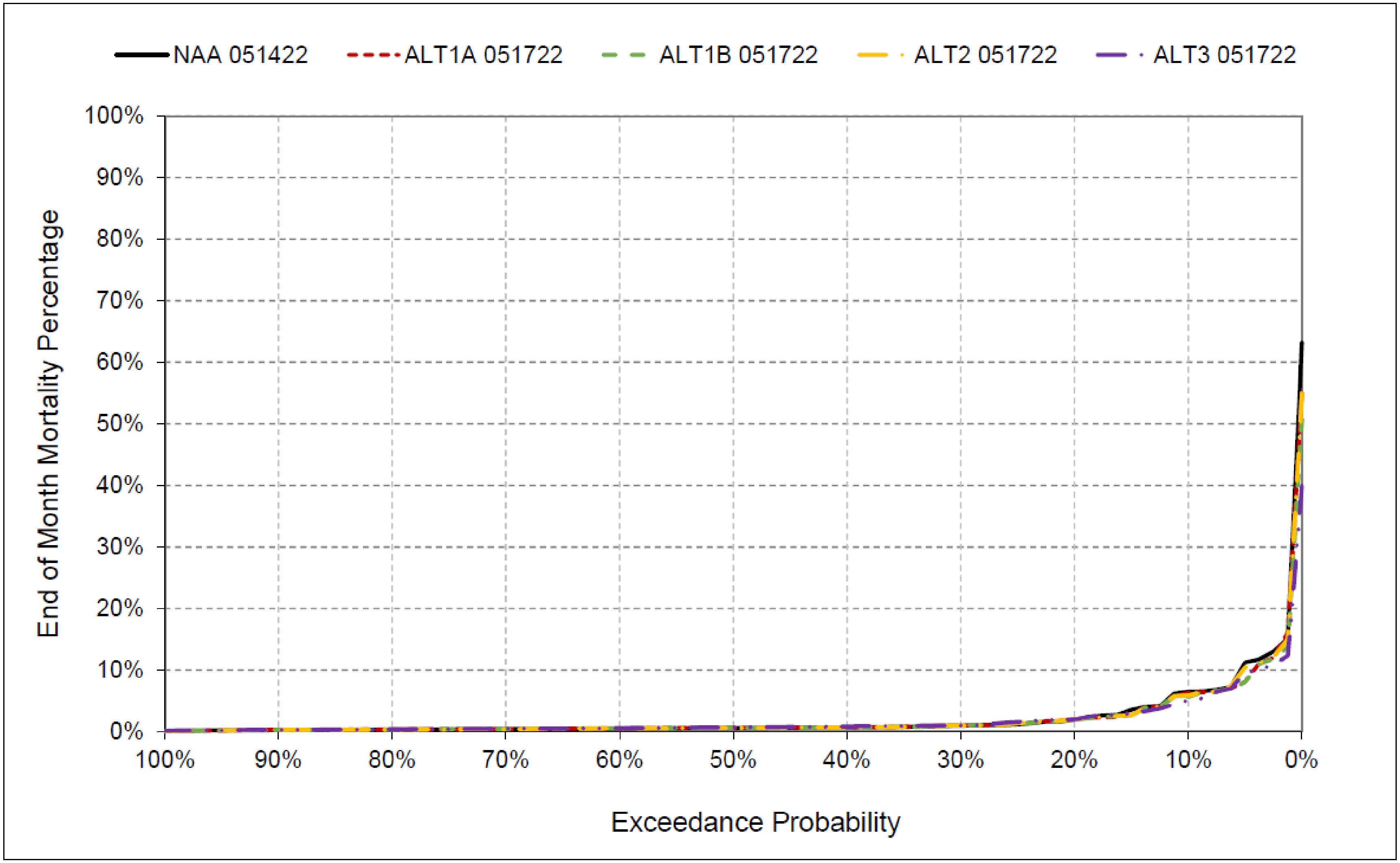

Figure 11O-5. Exceedance of Temperature-Based Egg Mortality for Winter-Run Chinook Salmon (Anderson Model), September

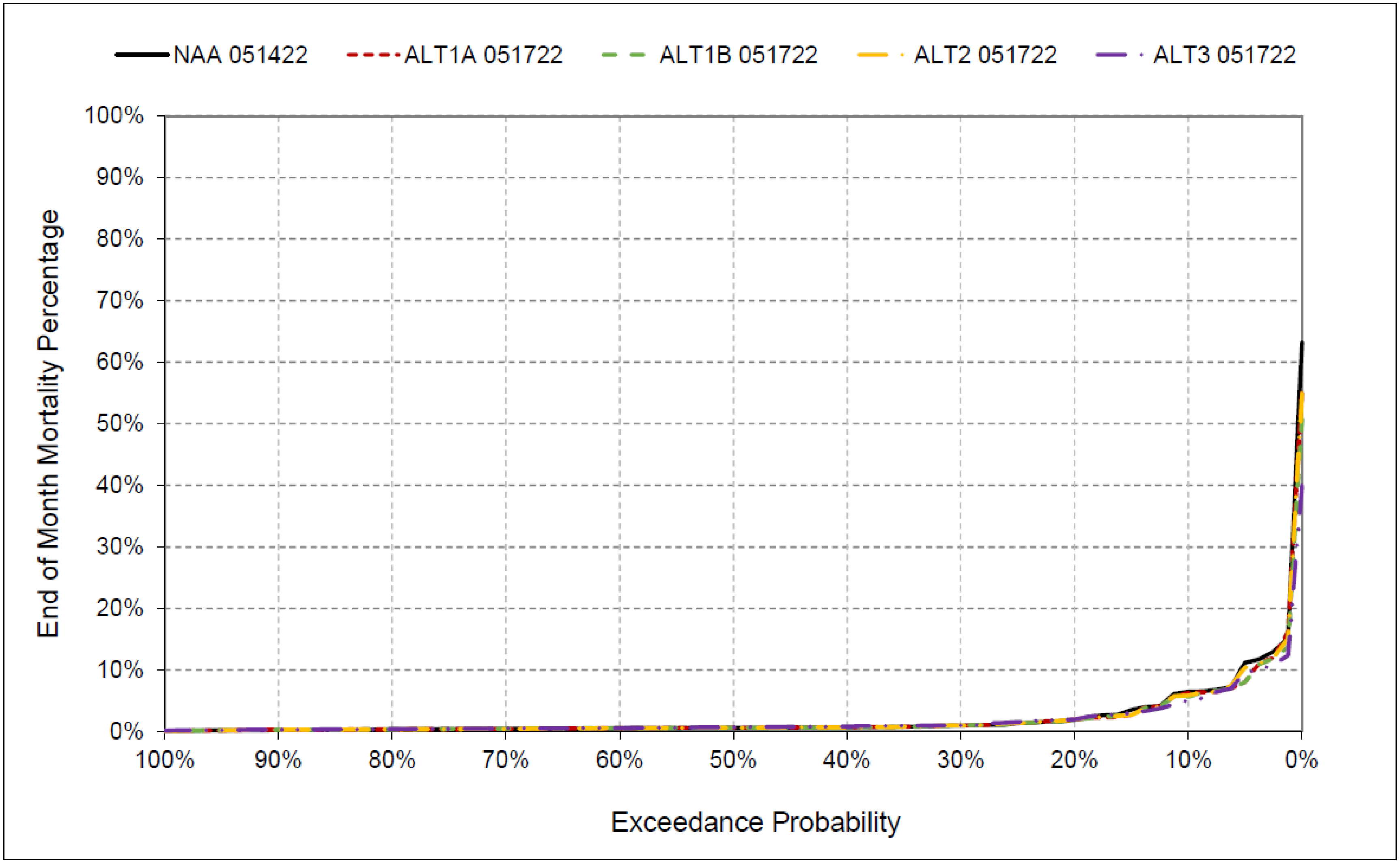

Figure 11O-6. Exceedance of Temperature-Based Egg Mortality for Winter-Run Chinook Salmon (Anderson Model), October

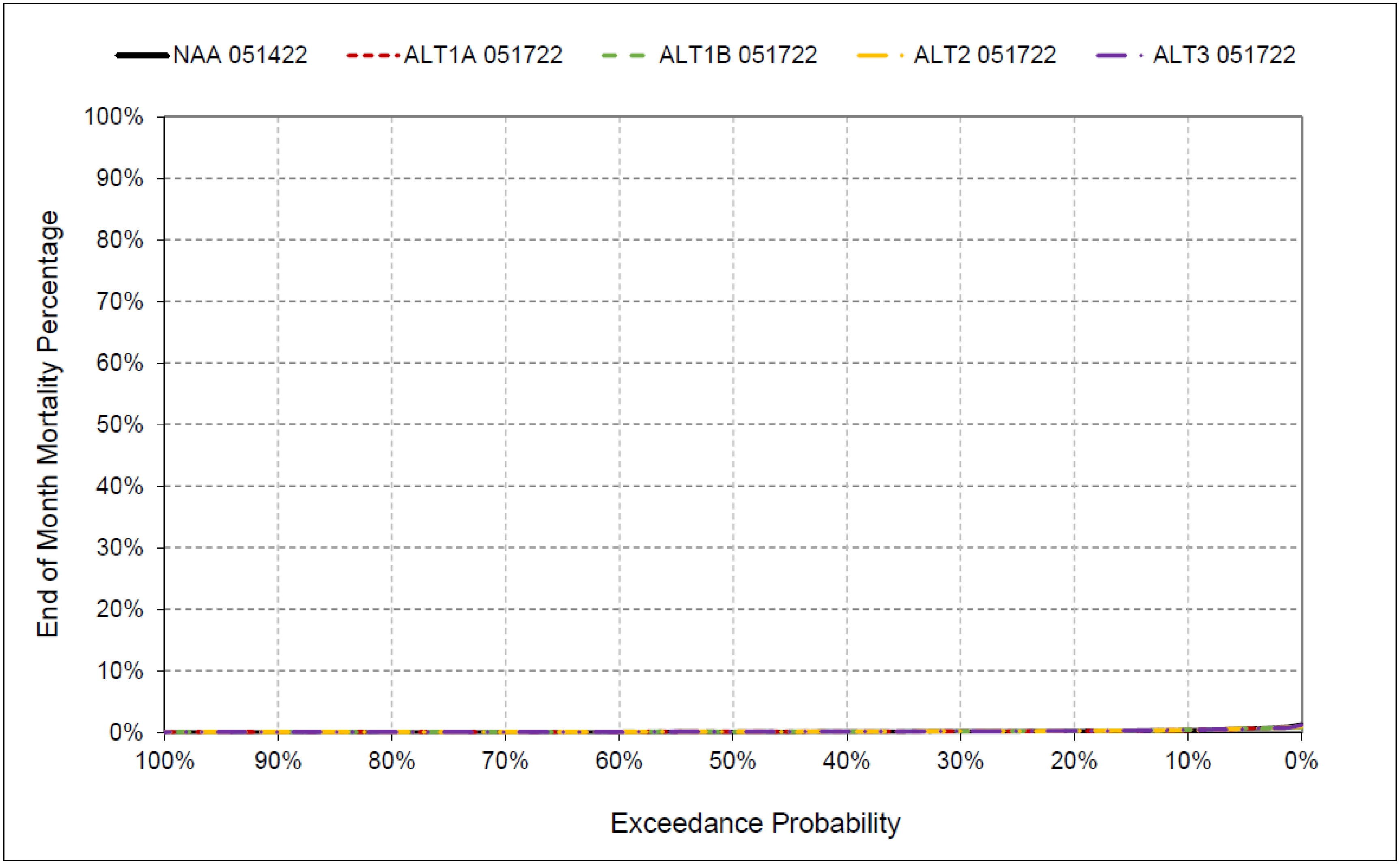

Figure 11O-7. Exceedance of Temperature-Based Egg Mortality for Winter-Run Chinook Salmon (Martin Model), May

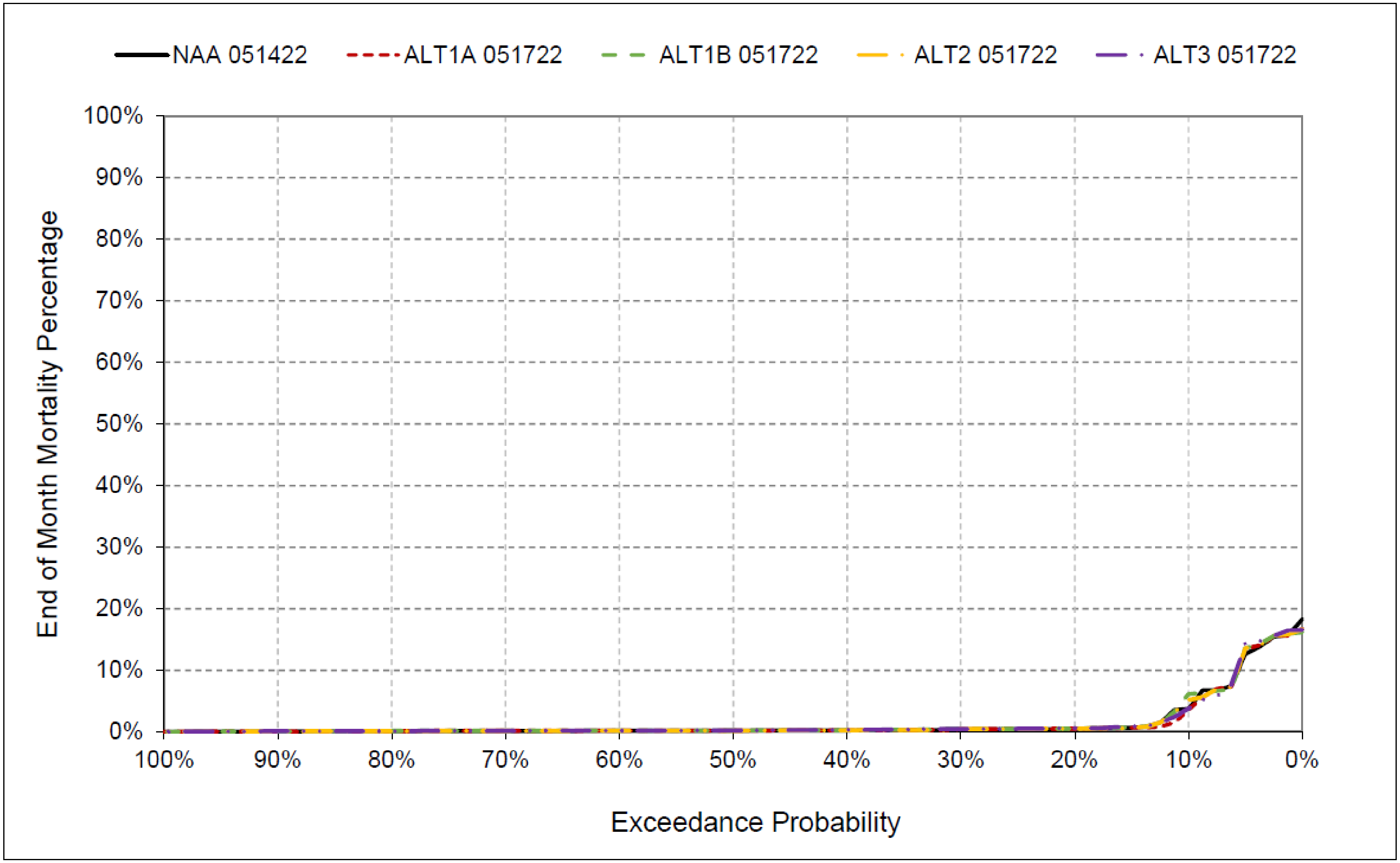

Figure 11O-8. Exceedance of Temperature-Based Egg Mortality for Winter-Run Chinook Salmon (Martin Model), June

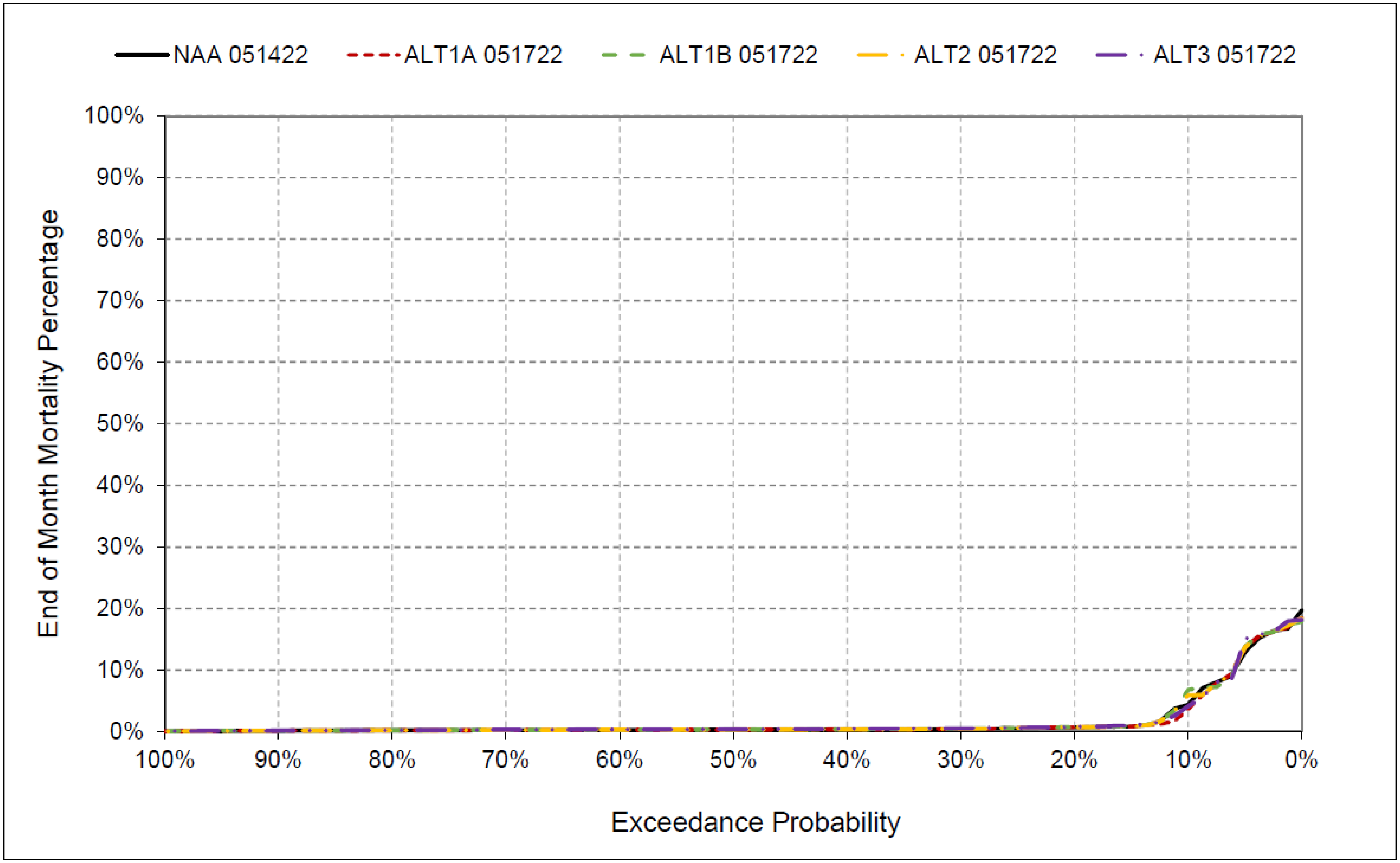

Figure 11O-9. Exceedance of Temperature-Based Egg Mortality for Winter-Run Chinook Salmon (Martin Model), July

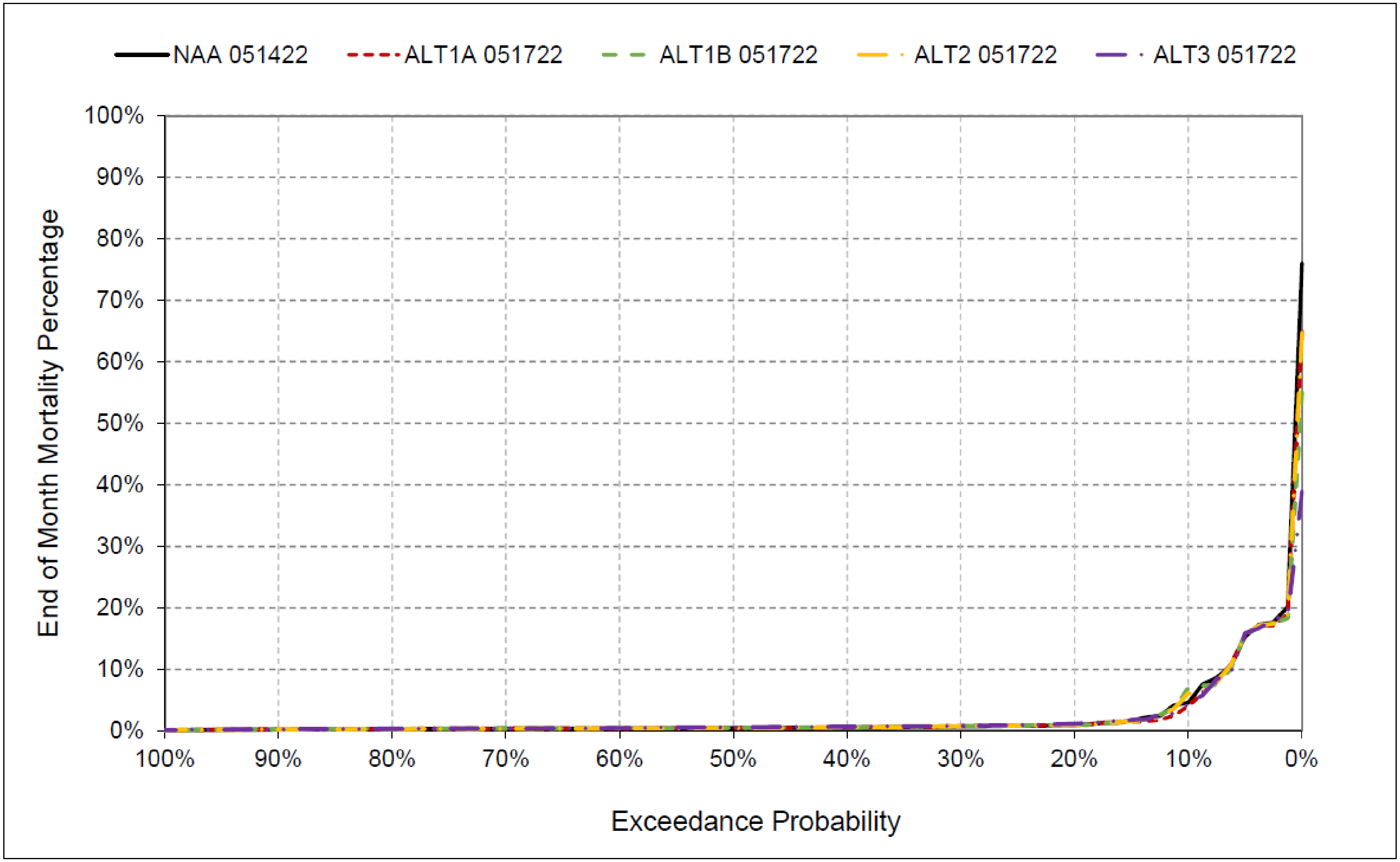

Figure 11O-10. Exceedance of Temperature-Based Egg Mortality for Winter-Run Chinook Salmon (Martin Model), August

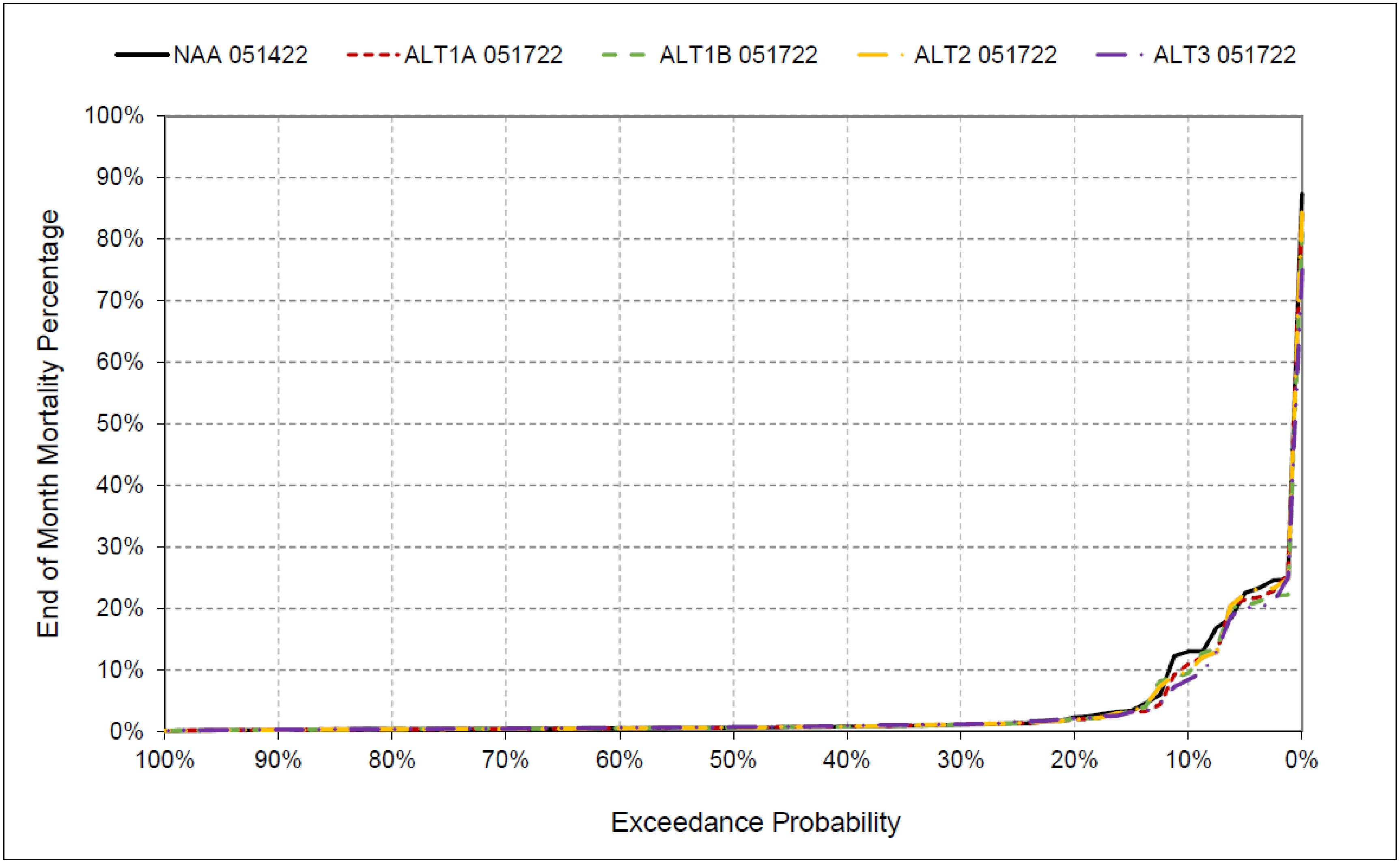

Figure 11O-11. Exceedance of Temperature-Based Egg Mortality for Winter-Run Chinook Salmon (Martin Model), September

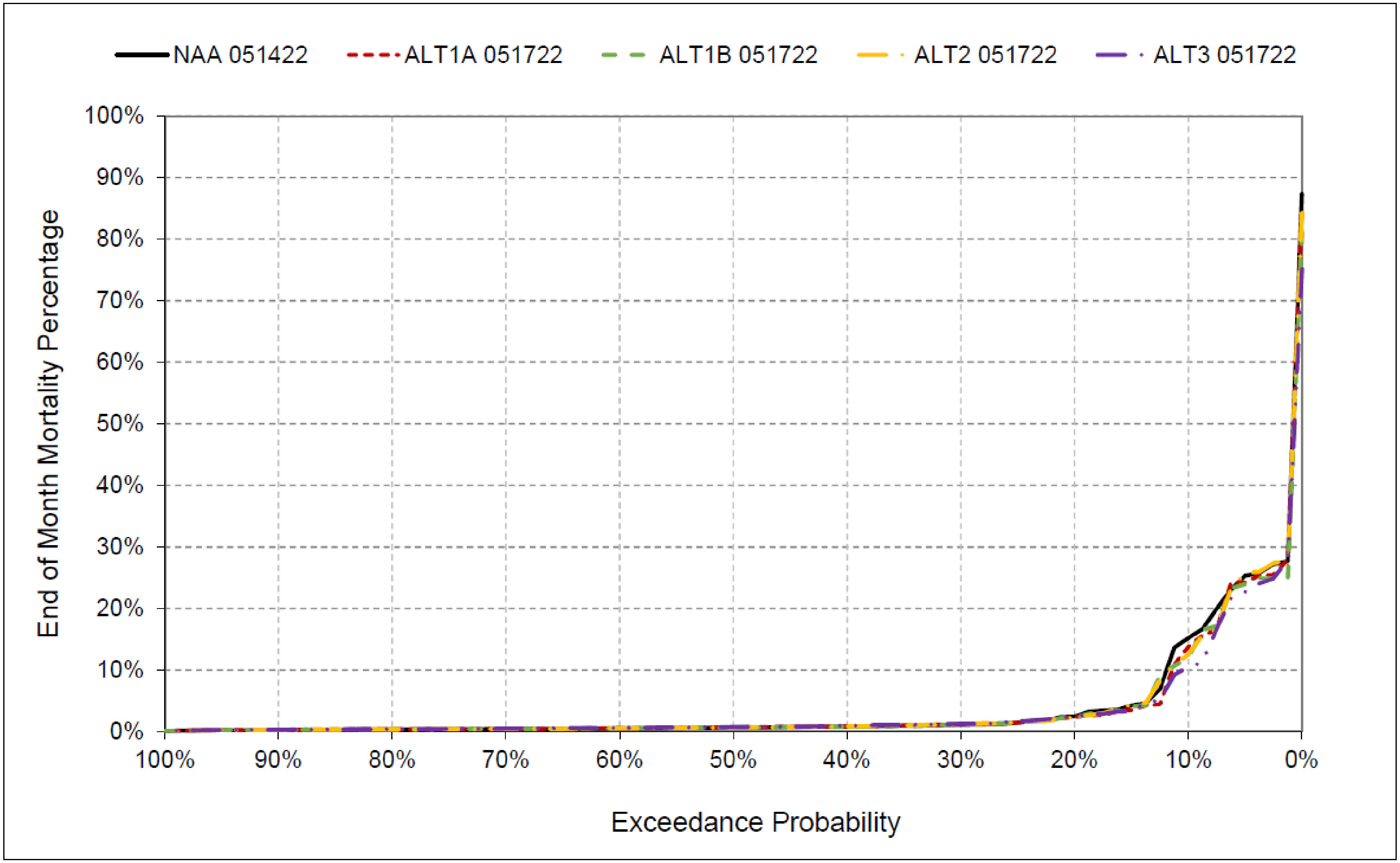

Figure 11O-12. Exceedance of Temperature-Based Egg Mortality for Winter-Run Chinook Salmon (Martin Model), October

11O.4 References

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