

Appendix 12J

Winter-Run Chinook Salmon Life Cycle Modeling

Line items and numbers identified or noted as “No Action Alternative” represent the “Existing Conditions/No Project/No Action Condition” (described in Chapter 2 Alternatives Analysis). Table numbering may not be consecutive for all appendixes.”

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APPENDIX 12J

Winter-Run Chinook Salmon Life Cycle Modeling

12J.1 Overview

This appendix provides a summary of modeling performed to simulate survival and abundance throughout the life-cycle and all life stages of the winter-run Chinook salmon population. The Interactive Object-oriented Simulation (IOS) winter-run Chinook salmon life-cycle model, developed by Cramer Fish Sciences, was used for the Sacramento River for the Draft Environmental Impact Report/Environmental Impact Statement (DEIR/EIS). A description of the IOS model and the results used in the detailed evaluation of the Sites Reservoir Project (Project) action alternatives (alternatives) are included. Results were used or referenced in Chapter 12 Aquatic Biological Resources. The fisheries impact assessment and methodology is described in Chapter 12 Aquatic Biological Resources and in Appendix 12B Fisheries Impact Assessment Methodology and Appendix 12C Fisheries Impact Summary.

12J.1.1 Introduction

The analytical framework used to evaluate the alternatives is summarized in Chapter 5 Guide to the Resource Analyses and Appendix 6B Water Resources System Modeling. Assumptions used in modeling the alternatives are summarized in Appendix 6A Modeling of Alternatives.

IOS simulates survival and abundance throughout the life-cycle and all life stages of the winter-run Chinook salmon population, from spawning in the upper reaches of the Sacramento River, migrating downriver and through the Sacramento-San Joaquin Delta (Delta) to the Pacific Ocean, and then returning to the upper Sacramento River to spawn again. IOS results include the annual number of returning spawners, and the annual survival rates for the life-stages from egg to fry and smolt rearing, and annual survival rates for passage through the Delta. The report is included as part of this appendix.

IOS uses the daily flow outputs from the Upper Sacramento River Daily Operations Model (USRDOM) and the daily temperature outputs from the Upper Sacramento River Water Quality Model (USRWQM). The USRDOM model is described in Appendix 6C Upper Sacramento River Daily River Flow and Operations Modeling and the USRWQM model is described in Appendix 7E River Temperature Modeling.

12J.2 Results

This section includes the results of the IOS winter-run Chinook salmon life-cycle model for the alternatives evaluated in the DEIR/EIS. The fisheries impact assessment and methodology is described in Chapter 12 Aquatic Biological Resources and in Appendix 12B Fisheries Impact Assessment Methodology and Appendix 12C Fisheries Impact Summary.

12J.2.1 Introduction

IOS annual survival and abundance results for the winter-run Chinook salmon life-cycle are included in this appendix. This document includes summary tables and exceedance plots comparing the results. Summary tables and exceedance probability charts are included for the following parameters for Sacramento River winter-run Chinook salmon:

- Annual Returning Spawners

- Annual Egg to Fry Survival Rates
- Annual Fry to Smolt Rearing Survival Rates
- Annual Overall Delta Survival Rates

Summary tables include long-term average and averages by water year type (SWRCB D-1641 40-30-30 Index). The tables also include the absolute and relative differences between alternatives.

IOS results are not intended to predict specific numbers of Chinook salmon, but rather to indicate a trend in salmon survival and abundance in response to the alternative evaluated. Further guidance on the appropriate use of model results is presented in Appendix 6B Water Resources System Modeling.

12J.2.2 Comparisons

For each parameter, a report is provided for the following comparisons:

- Alternative A compared to No Action Alternative
- Alternative B compared to No Action Alternative
- Alternative C compared to No Action Alternative
- Alternative D compared to No Action Alternative

Appendix 12J
Winter-Run Chinook Salmon Life Cycle Modeling
Results

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Alternative A Compared to No Action Alternative

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**Table AQ-01-3a
Winter-Run Chinook Salmon**

Long-term Average and Average by Water Year Type Annual Survival			
Analysis Period	Annual Survival Rates		
	Egg to Fry	Fry to Smolt	Overall Delta
Long-term			
Full Simulation Period¹			
No Action Alternative	0.79	0.36	0.29
Alternative A	0.81	0.37	0.29
Difference	0.02	0.01	0.00
Water Year Types²			
Wet (32.5%)			
No Action Alternative	0.91	0.36	0.30
Alternative A	0.90	0.37	0.29
Difference	-0.01	0.01	0.00
Above Normal (12.5%)			
No Action Alternative	0.90	0.34	0.30
Alternative A	0.89	0.35	0.29
Difference	-0.01	0.00	0.00
Below Normal (17.5%)			
No Action Alternative	0.86	0.36	0.31
Alternative A	0.89	0.35	0.31
Difference	0.03	0.00	0.00
Dry (22.5%)			
No Action Alternative	0.76	0.38	0.29
Alternative A	0.81	0.37	0.29
Difference	0.05	0.00	0.00
Critical (15%)			
No Action Alternative	0.38	0.32	0.26
Alternative A	0.46	0.38	0.26
Difference	0.08	0.06	-0.01

¹ Based on the 81-year simulation period

² As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 1995). Water years may not correspond to the biological years in IOS.

**Table AQ-01-3b
Winter-Run Chinook Salmon**

Long-term Average and Average by Water Year Type Annual Returning Spawners	
Analysis Period	Number of Female Spawners
Long-term	
Full Simulation Period¹	
No Action Alternative	15,636
Alternative A	16,906
Difference	1,270
Percent Difference ³	8
Water Year Types²	
Wet (32.5%)	
No Action Alternative	18,717
Alternative A	20,579
Difference	1,862
Percent Difference	10
Above Normal (12.5%)	
No Action Alternative	13,331
Alternative A	15,097
Difference	1,766
Percent Difference	13
Below Normal (17.5%)	
No Action Alternative	14,002
Alternative A	13,979
Difference	-23
Percent Difference	0
Dry (22.5%)	
No Action Alternative	15,604
Alternative A	16,598
Difference	994
Percent Difference	6
Critical (15%)	
No Action Alternative	13,030
Alternative A	14,487
Difference	1,458
Percent Difference	11
1 Based on the 81-year simulation period	
2 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 1995). Water years may not correspond to the biological years in IOS.	
3 Relative difference of the Annual average	

Alternative B Compared to No Action Alternative

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**Table AQ-01-5a
Winter-Run Chinook Salmon**

Long-term Average and Average by Water Year Type Annual Survival			
Analysis Period	Annual Survival Rates		
	Egg to Fry	Fry to Smolt	Overall Delta
Long-term			
Full Simulation Period¹			
No Action Alternative	0.79	0.36	0.29
Alternative B	0.82	0.36	0.29
Difference	0.03	0.01	0.00
Water Year Types²			
Wet (32.5%)			
No Action Alternative	0.91	0.36	0.30
Alternative B	0.90	0.37	0.29
Difference	-0.01	0.01	0.00
Above Normal (12.5%)			
No Action Alternative	0.90	0.34	0.30
Alternative B	0.89	0.34	0.29
Difference	-0.01	0.00	-0.01
Below Normal (17.5%)			
No Action Alternative	0.86	0.36	0.31
Alternative B	0.88	0.35	0.30
Difference	0.02	0.00	0.00
Dry (22.5%)			
No Action Alternative	0.76	0.38	0.29
Alternative B	0.81	0.37	0.28
Difference	0.05	0.00	0.00
Critical (15%)			
No Action Alternative	0.38	0.32	0.26
Alternative B	0.50	0.36	0.26
Difference	0.12	0.04	-0.01

¹ Based on the 81-year simulation period

² As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 1995). Water years may not correspond to the biological years in IOS.

**Table AQ-01-5b
Winter-Run Chinook Salmon**

Long-term Average and Average by Water Year Type Annual Returning Spawners	
Analysis Period	Number of Female Spawners
Long-term	
Full Simulation Period¹	
No Action Alternative	15,636
Alternative B	16,941
Difference	1,305
Percent Difference ³	8
Water Year Types²	
Wet (32.5%)	
No Action Alternative	18,717
Alternative B	20,644
Difference	1,927
Percent Difference	10
Above Normal (12.5%)	
No Action Alternative	13,331
Alternative B	15,413
Difference	2,082
Percent Difference	16
Below Normal (17.5%)	
No Action Alternative	14,002
Alternative B	14,232
Difference	230
Percent Difference	2
Dry (22.5%)	
No Action Alternative	15,604
Alternative B	16,501
Difference	896
Percent Difference	6
Critical (15%)	
No Action Alternative	13,030
Alternative B	14,139
Difference	1,109
Percent Difference	9
1 Based on the 81-year simulation period	
2 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 1995). Water years may not correspond to the biological years in IOS.	
3 Relative difference of the Annual average	

Alternative C Compared to No Action Alternative

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**Table AQ-01-7a
Winter-Run Chinook Salmon**

Long-term Average and Average by Water Year Type Annual Survival			
Analysis Period	Annual Survival Rates		
	Egg to Fry	Fry to Smolt	Overall Delta
Long-term			
Full Simulation Period¹			
No Action Alternative	0.79	0.36	0.29
Alternative C	0.82	0.36	0.29
Difference	0.03	0.01	0.00
Water Year Types²			
Wet (32.5%)			
No Action Alternative	0.91	0.36	0.30
Alternative C	0.90	0.37	0.29
Difference	-0.01	0.01	0.00
Above Normal (12.5%)			
No Action Alternative	0.90	0.34	0.30
Alternative C	0.89	0.34	0.29
Difference	-0.01	0.00	-0.01
Below Normal (17.5%)			
No Action Alternative	0.86	0.36	0.31
Alternative C	0.88	0.35	0.30
Difference	0.02	0.00	0.00
Dry (22.5%)			
No Action Alternative	0.76	0.38	0.29
Alternative C	0.81	0.37	0.28
Difference	0.05	0.00	0.00
Critical (15%)			
No Action Alternative	0.38	0.32	0.26
Alternative C	0.50	0.36	0.26
Difference	0.12	0.04	-0.01

¹ Based on the 81-year simulation period

² As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 1995). Water years may not correspond to the biological years in IOS.

**Table AQ-01-7b
Winter-Run Chinook Salmon**

Long-term Average and Average by Water Year Type Annual Returning Spawners	
Analysis Period	Number of Female Spawners
Long-term	
Full Simulation Period¹	
No Action Alternative	15,636
Alternative C	16,941
Difference	1,305
Percent Difference ³	8
Water Year Types²	
Wet (32.5%)	
No Action Alternative	18,717
Alternative C	20,644
Difference	1,927
Percent Difference	10
Above Normal (12.5%)	
No Action Alternative	13,331
Alternative C	15,413
Difference	2,082
Percent Difference	16
Below Normal (17.5%)	
No Action Alternative	14,002
Alternative C	14,232
Difference	230
Percent Difference	2
Dry (22.5%)	
No Action Alternative	15,604
Alternative C	16,501
Difference	896
Percent Difference	6
Critical (15%)	
No Action Alternative	13,030
Alternative C	14,139
Difference	1,109
Percent Difference	9
1 Based on the 81-year simulation period	
2 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 1995). Water years may not correspond to the biological years in IOS.	
3 Relative difference of the Annual average	

Alternative D Compared to No Action Alternative

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**Table AQ-01-9a
Winter-Run Chinook Salmon**

Long-term Average and Average by Water Year Type Annual Survival			
Analysis Period	Annual Survival Rates		
	Egg to Fry	Fry to Smolt	Overall Delta
Long-term			
Full Simulation Period¹			
No Action Alternative	0.79	0.36	0.29
Alternative D	0.82	0.37	0.29
Difference	0.03	0.01	0.00
Water Year Types²			
Wet (32.5%)			
No Action Alternative	0.91	0.36	0.30
Alternative D	0.90	0.37	0.29
Difference	-0.01	0.01	0.00
Above Normal (12.5%)			
No Action Alternative	0.90	0.34	0.30
Alternative D	0.90	0.35	0.29
Difference	-0.01	0.00	-0.01
Below Normal (17.5%)			
No Action Alternative	0.86	0.36	0.31
Alternative D	0.88	0.35	0.30
Difference	0.02	-0.01	0.00
Dry (22.5%)			
No Action Alternative	0.76	0.38	0.29
Alternative D	0.81	0.38	0.28
Difference	0.05	0.00	0.00
Critical (15%)			
No Action Alternative	0.38	0.32	0.26
Alternative D	0.50	0.39	0.26
Difference	0.13	0.07	-0.01
1 Based on the 81-year simulation period			
2 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 1995). Water years may not correspond to the biological years in IOS.			

**Table AQ-01-9b
Winter-Run Chinook Salmon**

Long-term Average and Average by Water Year Type Annual Returning Spawners	
Analysis Period	Number of Female Spawners
Long-term	
Full Simulation Period¹	
No Action Alternative	15,636
Alternative D	17,393
Difference	1,757
Percent Difference ³	11
Water Year Types²	
Wet (32.5%)	
No Action Alternative	18,717
Alternative D	21,253
Difference	2,536
Percent Difference	14
Above Normal (12.5%)	
No Action Alternative	13,331
Alternative D	16,097
Difference	2,767
Percent Difference	21
Below Normal (17.5%)	
No Action Alternative	14,002
Alternative D	14,647
Difference	644
Percent Difference	5
Dry (22.5%)	
No Action Alternative	15,604
Alternative D	16,733
Difference	1,129
Percent Difference	7
Critical (15%)	
No Action Alternative	13,030
Alternative D	14,413
Difference	1,383
Percent Difference	11
1 Based on the 81-year simulation period	
2 As defined by the Sacramento Valley 40-30-30 Index Water Year Hydrologic Classification (SWRCB 1995). Water years may not correspond to the biological years in IOS.	
3 Relative difference of the Annual average	