Winter- and Spring-run Chinook Analyses

Marin Greenwood and Rick Wilder
ICF

WR & SR Chinook Analyses

Overview of *4.3 Take of Sacramento River Winter-run Chinook Salmon* and *4.4 Take of Central Valley Spring-run Chinook Salmon*

- Construction Effects
- Maintenance Effects
- Operations Effects
- Mitigation Measure Effects
- Monitoring Effects
- Take Analysis
- Analysis of Potential for Jeopardy

WR & SR Chinook Analyses

4.3.4 Effects Of Water Facility Operations

- *4.3.4.1.2.1.2.1 Entrainment*
  - Phase 1 recommendation: "That time series plots…omit the solid lines depicting the point predictions from the fish response model…"

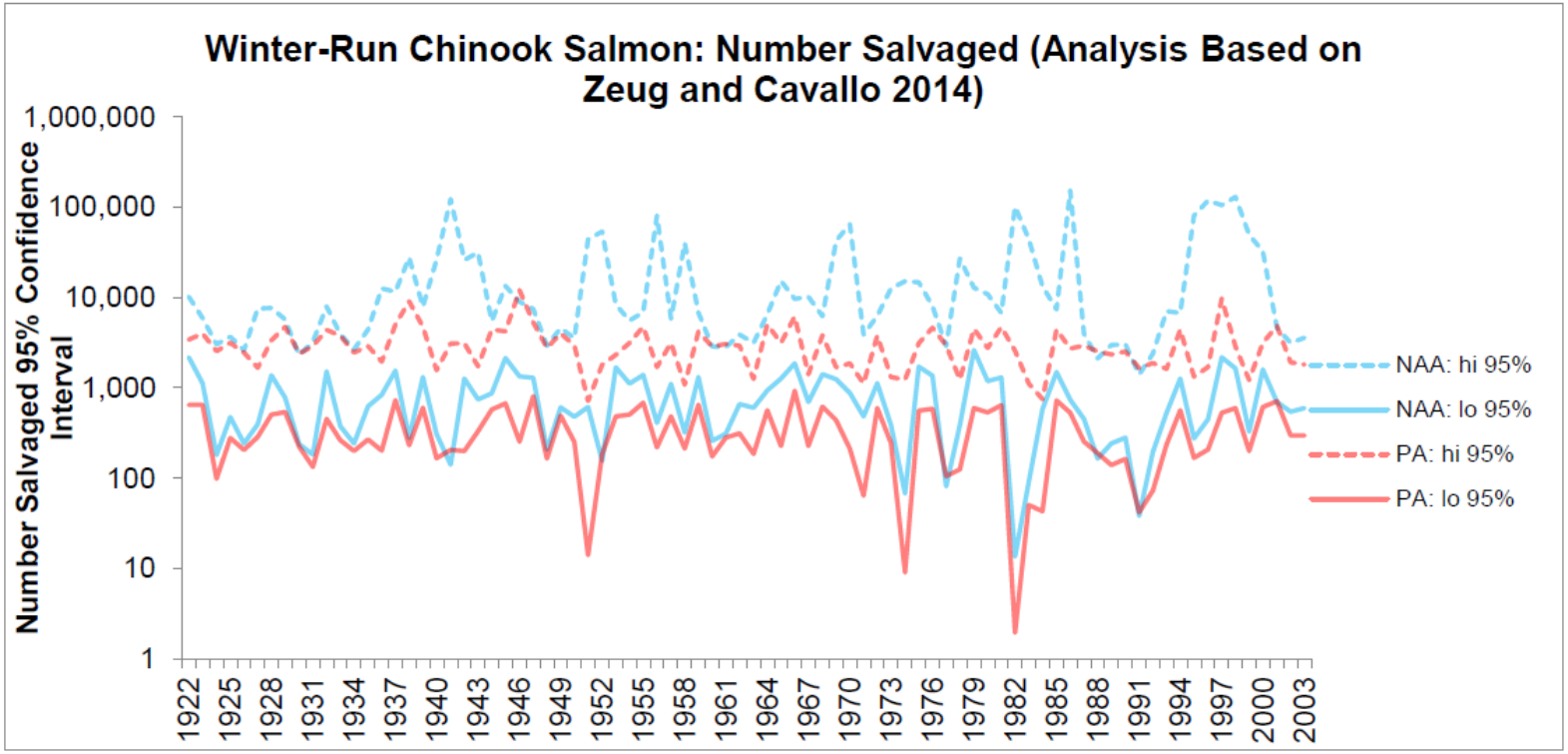


Figure 4.3-3. 95% Confidence Intervals of Annual Number of Winter-Run Chinook Salmon Salvaged (From 1,000,000 Released), from the Analysis Based on Zeug and Cavallo (2014).

WR & SR Chinook Analyses

4.3.4 Effects Of Water Facility Operations

- *4.3.4.1.2.1.4 Delta Cross Channel*
  - Added consideration of DCC gate opening duration in November
  - Potential greater frequency of multi-day openings under PP, possibly attracting then delaying
  - Further study needed: use of alternative pathways, duration of holding below closed gates

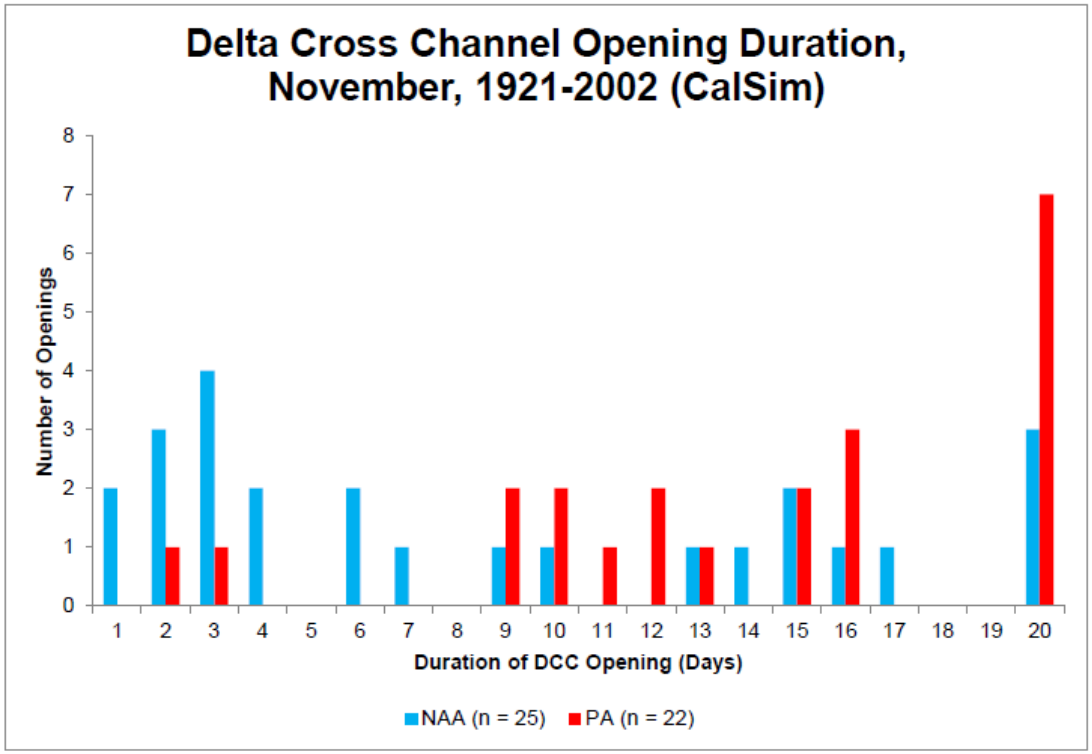


Figure 4.3-8. Duration of Delta Cross Channel Openings that Began in November, from CalSim Modeling of 1921-2002

WR & SR Chinook Analyses

4.3.4 Effects Of Water Facility Operations

- *4.3.4.1.2.2.1.6 Delta Passage Model*
  - Phase 1 recommendation: "That time series plots…omit the solid lines depicting the point predictions from the fish response model…"

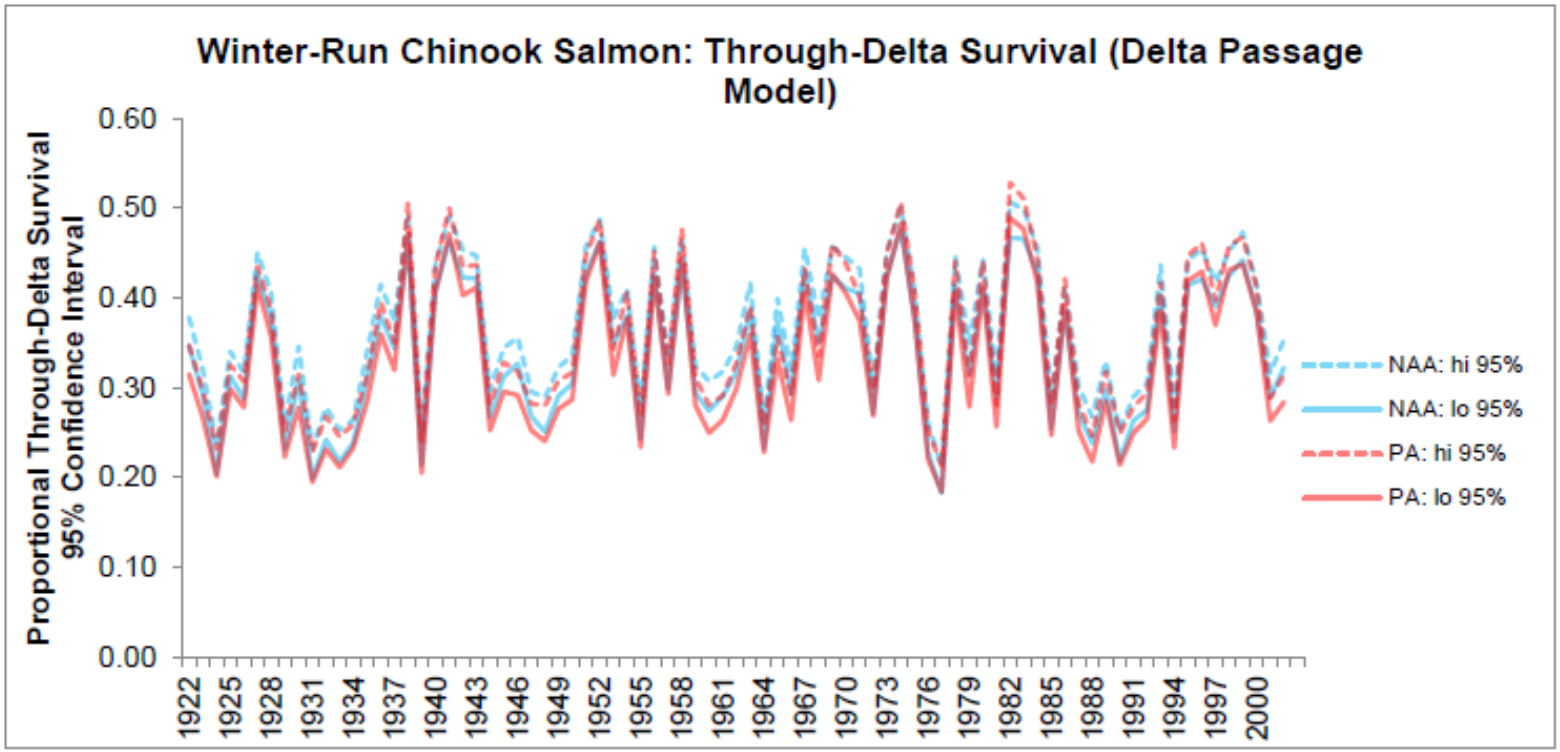


Figure 4.3-11. Time Series of 95% Confidence Interval Annual Juvenile Winter-Run Chinook Salmon Through-Delta Survival Estimated from the Delta Passage Model

WR & SR Chinook Analyses

4.3.4 Effects Of Water Facility Operations

- *4.3.4.1.2.2.1.7 Analysis Based on Perry (2010)*
  - Phase 1 recommendation: "That boxplot and exceedance plot figure legends state that the plots exclude model uncertainty, unless that uncertainty can be incorporated."

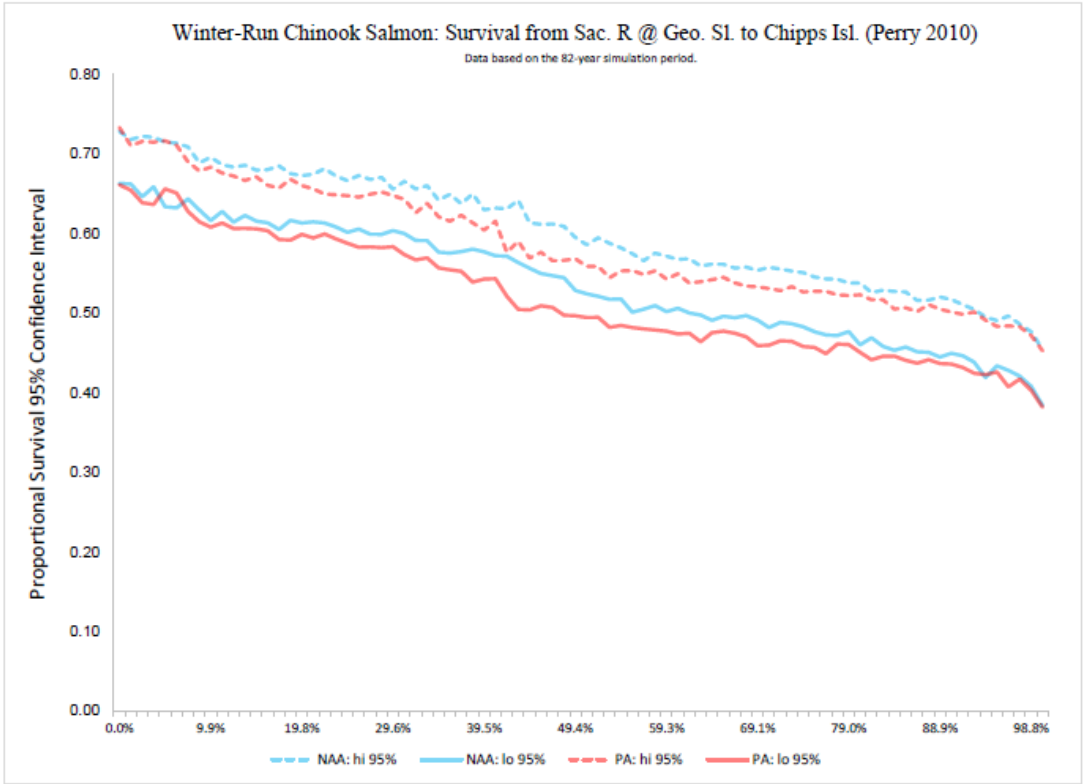


Figure 4.3-14. Exceedance Plot of Juvenile Winter-Run Chinook Salmon Annual Total Survival from the Sacramento River at Georgiana Slough to Chipps Island, Estimated from the Analysis Based on Perry (2010).

WR & SR Chinook Analyses

4.3.4 Effects Of Water Facility Operations

- *4.3.4.1.2.2.1.8 Life Cycle Models (IOS and OBAN)*
  - Phase 1 recommendation: "That boxplot and exceedance plot figure legends state that the plots exclude model uncertainty, unless that uncertainty can be incorporated."

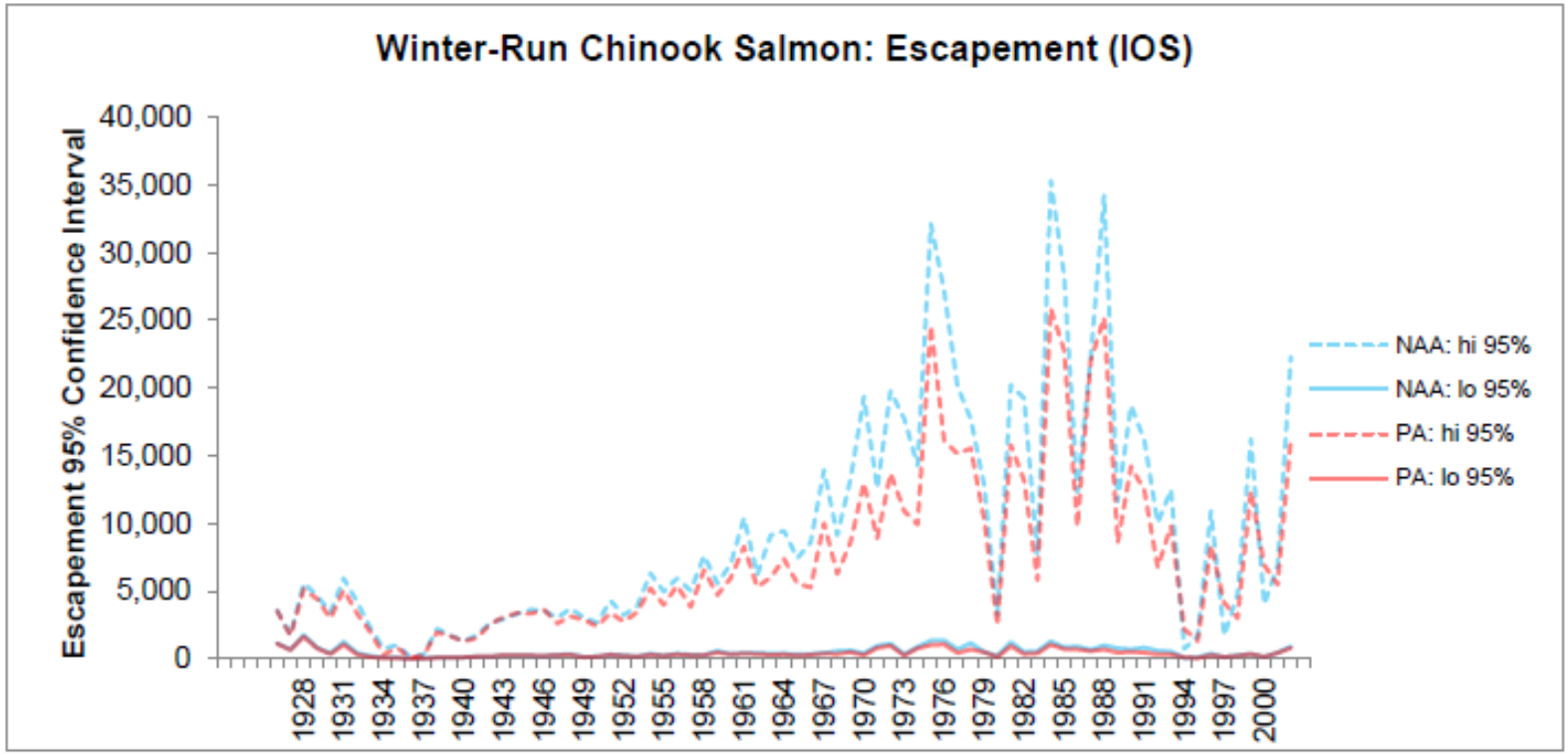


Figure 5.D-151. Time Series of 95% Confidence Interval IOS Annual Winter-Run Chinook Salmon Escapement Estimates.

WR & SR Chinook Analyses

4.4.4 Effects Of Water Facility Operations

- *4.4.4.1.2.2.1.6 Delta Passage Model*
  - Phase 1 recommendation: "That time series plots…omit the solid lines depicting the point predictions from the fish response model…"

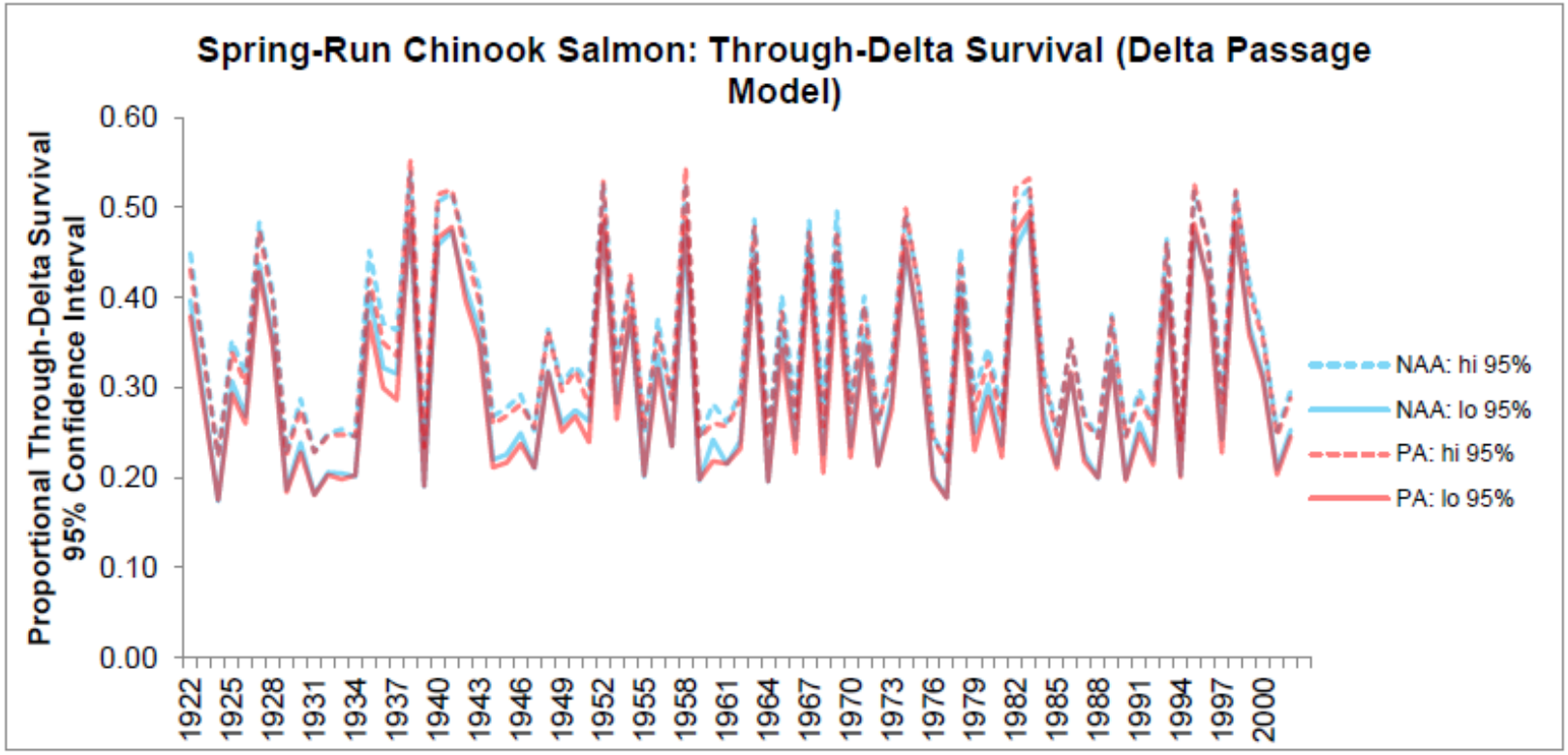


Figure 4.4-6. Time Series of Mean (With 95% Confidence Interval) Annual Juvenile Spring-Run Chinook Salmon Through-Delta Estimated from the Delta Passage Model.

WR & SR Chinook Analyses

4.4.4 Effects Of Water Facility Operations

- *4.4.4.1.2.2.1.7 Analysis Based on Newman (2003)*
  - Phase 1 recommendation: "That boxplot and exceedance plot figure legends state that the plots exclude model uncertainty, unless that uncertainty can be incorporated."

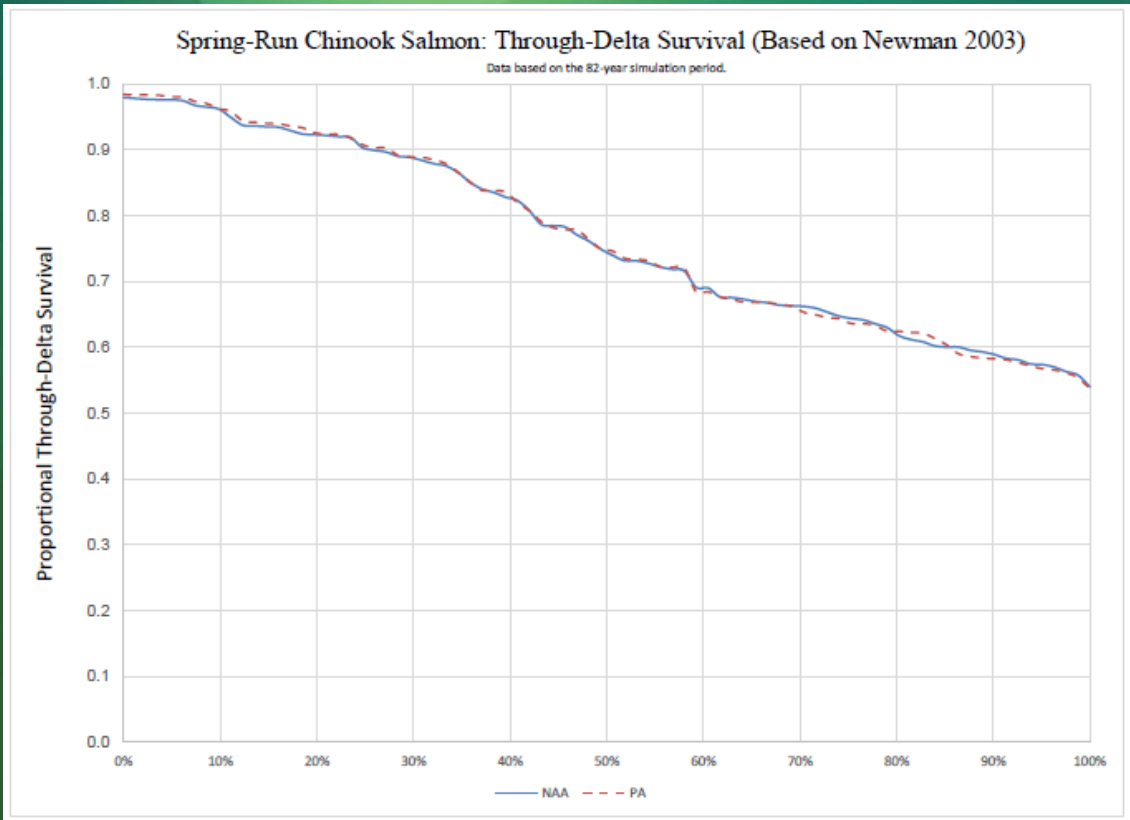
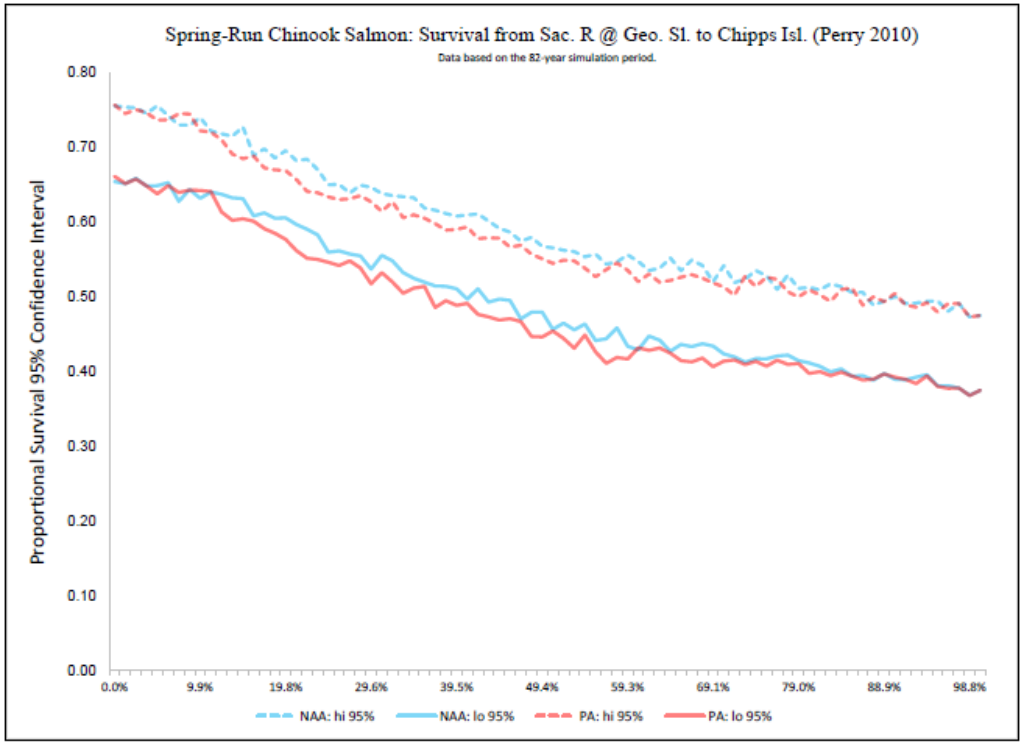


Figure 4.4-8. Exceedance Plot of Spring-Run Chinook Salmon Annual Through-Delta Survival Estimated from the Analysis Based on Newman (2003).

WR & SR Chinook Analyses

4.4.4 Effects Of Water Facility Operations

- *4.4.4.1.2.2.1.8 Analysis Based on Perry (2010)*
  - Phase 1 recommendation: "That boxplot and exceedance plot figure legends state that the plots exclude model uncertainty, unless that uncertainty can be incorporated."



Note: Data are sorted by mean estimate, with only 95% confidence intervals shown.

Figure 4.4-11. Exceedance Plot of Juvenile Spring-Run Chinook Salmon Annual Total Survival from the Sacramento River at Georgiana Slough to Chipps Island, Estimated from the Analysis Based on Perry (2010).

WR & SR Chinook Analyses

4.4.4 Effects Of Water Facility Operations

- *4.4.4.1.2.2.1.9 SalSim Through-Delta Survival Function*
  - Main quantitative analysis specifically related to SR Chinook salmon from San Joaquin basin (added to final BA)

$$\text{Base survival probability} = \min(\exp(a_0 + a_1 \times Q + a_2 \times \text{stripers} + a_3 \times T + a_4 \times \text{releaseCode}), 0.99)$$

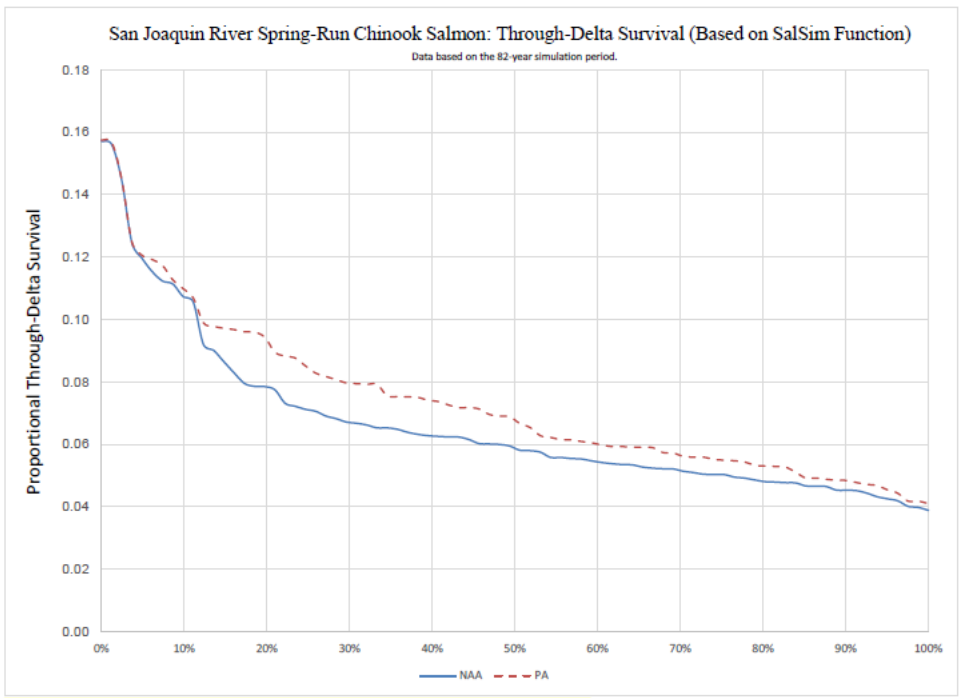
Table 5.E-18. SalSim Through-Delta Survival Variables, Coefficients, and Input Data Used for the Analysis of Effects on EFH.

Parameter	Variable	Description	Coefficient Value	Input data	Notes
a_0	N/A	constant	3.493422	N/A	
a_1	Q	Mean daily flow at the Stockton Deepwater Ship Channel on day of entry to Delta (cfs)	0.1296343	DSM2-HYDRO: RSAN058	Divided by 1,000
a_2	stripers	Abundance of striped bass in the Delta	-0.0297244	File stripers.csv in SalSim documentation appendices (www.salsim.com)	Divided by 1,000,000. Used mean of 2000-2009 (1,316,315) for all years (both scenarios).
a_3	T	Mean of 7-day maximum water temperature at Mossdale on day of entry into Delta (°F)		DSM2-QUAL: Daily mean water temperature data from RSAN087 (Mossdale)	Divided by 10. Daily mean from DSM2-QUAL was converted into daily maximum based on a regression of CDEC data from Mossdale (April 1-June 29, 2002-2015: daily max. = 1.0343×daily mean – 0.9287; $r^2 = 0.9903$; n = 1,208)
a_4	releaseCode	Release location of fish in the Delta (always = 1 for SalSim, i.e., Mossdale)	-0.38105	N/A	

WR & SR Chinook Analyses

4.4.4 Effects Of Water Facility Operations

- *4.4.4.1.2.2.1.9 SalSim Through-Delta Survival Function*
  - Phase 1 recommendation: "That boxplot and exceedance plot figure legends state that the plots exclude model uncertainty, unless that uncertainty can be incorporated."



Note: Plot only includes annual mean responses and does not consider model uncertainty.

Figure 5.4-25. Exceedance Plot of San Joaquin River Spring-Run Chinook Salmon Smolt Annual Through-Delta Survival Estimated from the Juvenile Delta Module Survival Function of SalSim.

Chinook Salmon Take Analysis – Upstream Effects

- Section 4.3, Take of Sacramento River Winter-run Chinook Salmon
  - Section 4.3.4.2, Upstream Hydrologic Changes
- Section 4.4, Take of Central Valley Spring-run Chinook Salmon
  - Section 4.4.4.2, Upstream Hydrologic Changes

Upstream Hydrologic Changes

- Rivers:
  - Sacramento River only
  - Other rivers screened out due to minimal effects of PP (Feather River, Clear Creek) or no covered fish present (e.g., American River, Stanislaus River, Trinity River)

Upstream Hydrologic Changes

- Analysis based on modeling *without* longfin smelt spring Delta outflow requirement
- Requirement achieved by export cuts only
- Differences in reservoir storage are negligible (Appx 4.D)

Table 4.D-1. Water-year-type Mean of Shasta Reservoir Storage (Thousand Acre-Feet), May and September, from the 1922–2003 CalSim-II Simulation.

Month	WYT	NAA	PP	PP_{LFS}	PP vs. NAA[1]	PP_{LFS} vs. NAA[1]	PP_{LFS} vs. PP[1]
May	W	4,460	4,461	4,461	1 (0%)	1 (0%)	0 (0%)
	AN	4,427	4,422	4,420	-5 (0%)	-7 (0%)	-2 (0%)
	BN	3,959	3,989	3,998	30 (1%)	39 (1%)	9 (0%)
	D	3,667	3,713	3,722	46 (1%)	55 (2%)	9 (0%)
	C	2,065	2,113	2,118	48 (2%)	52 (3%)	4 (0%)
Sep	W	2,985	2,974	2,980	-11 (0%)	-5 (0%)	6 (0%)
	AN	2,835	2,873	2,871	38 (1%)	36 (1%)	-3 (0%)
	BN	2,615	2,690	2,695	75 (3%)	80 (3%)	5 (0%)
	D	2,459	2,473	2,472	14 (1%)	13 (1%)	0 (0%)
	C	914	977	972	63 (7%)	58 (6%)	-5 (0%)

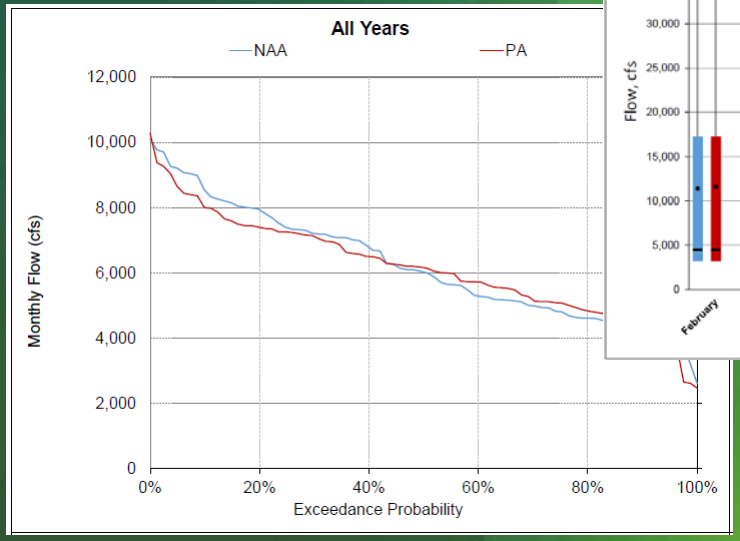
Notes:
[1]Negative values indicate lower values under the first-named scenario in the comparison.
Green shading indicates differences that are > +5% from the perspective of the first-named scenario.

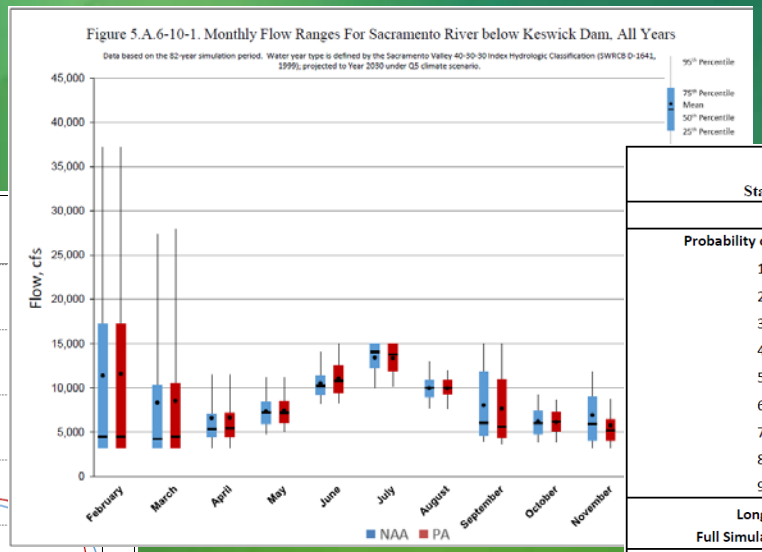
Upstream Hydrologic Changes

- All potential upstream impacts evaluated are related to potential changes in reservoir operations
  - Flow
    - Evaluated the 5 components of flow: timing, frequency, magnitude, duration, and rate of change
  - Water temperature
    - Relative frequency and magnitude of exceedance above thresholds
    - Models predicting mortality based on thresholds

Upstream Hydrologic Changes: Flow

- Default method: compare flows between No Action Alternative (NAA) and Proposed Action (PA)
  - Exceedance plots, box and whisker plots, and mean monthly differences between NAA and PA (BA Appx. 5.A)
  - Key assumption – more flow is better for fish



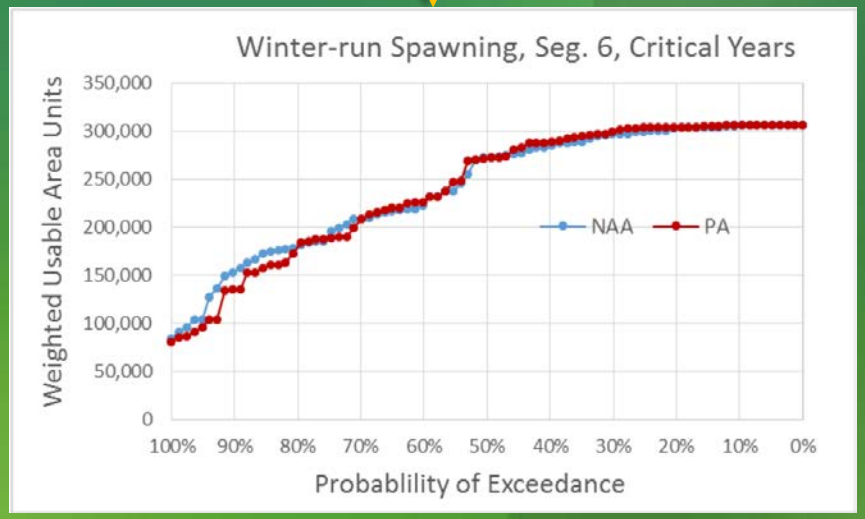


Statistic	October			
	NAA	PA	Diff.	Perc. Diff.
Probability of Exceedance[a]				
10%	8,525	8,003	-522	-6%
20%	7,926	7,397	-529	-7%
30%	7,209	7,118	-91	-1%
40%	6,781	6,500	-281	-4%
50%	6,020	6,157	137	2%
60%	5,290	5,717	427	8%
70%	4,985	5,176	191	4%
80%	4,607	4,831	224	5%
90%	4,032	4,344	312	8%
Long Term Full Simulation Period[b]	6,206	6,142	-64	-1%
Water Year Types[c]				
Wet (32%)	7,607	6,795	-812	-11%
Above Normal (16%)	6,794	6,862	68	1%
Below Normal (13%)	5,547	6,475	929	17%
Dry (24%)	5,399	5,772	374	7%
Critical (15%)	4,482	4,259	-223	-5%

Spawning, Egg Incubation, Alevins – Flow

- Availability of suitable spawning habitat (e.g., Section 4.3.4.2.1.2.1.2)
  - Weighted usable area (WUA) curves from USFWS
  - CALSIM data applied to WUA curves

CALSIM output



Spawning, Egg Incubation, Alevins – Flow

- Redd scour (e.g., Section 4.3.4.2.1.2.1.3)
  - Used CALSIM output to estimate exceedance of 40,000 cfs, the flow needed to mobilize sediments that could scour or entomb redds

Spawning, Egg Incubation, Alevins – Flow

- Redd dewatering risk (e.g., Section 4.3.4.2.1.2.1.4)
  - Followed individual “egg cohorts” for each month of the spawning period for 3 months
  - Based on redd dewatering data from USFWS
  - Compared percent of redds dewatered between NAA and PP

All Life Stages – Water Temperature

- Threshold Analysis (e.g., Section 5.4.2.1.3.1.1.2)
  - Used daily HEC-5Q model outputs
  - Used water temperature thresholds proposed by NMFS and agreed to by all agencies (BA Table 5.D-49)
  - Compared frequency and magnitude of exceedance between NAA and PP

Species	Life Stage	Period	Location	Threshold (°F 7DADM)	Source/Note
Winter-run	Spawning, egg incubation, and alevins	Apr-Oct	Keswick	55.4	USEPA 2003
			Clear Creek	55.4	USEPA 2003
			Balls Ferry	55.4	USEPA 2003
			Bend Bridge	55.4	USEPA 2003
			Red Bluff	55.4	USEPA 2003
	Fry and juvenile rearing and emigration	Jul-Mar	Keswick	61	USEPA 2003; core juvenile rearing
			Clear Creek	61	USEPA 2003; core juvenile rearing
			Balls Ferry	61	USEPA 2003; core juvenile rearing
			Bend Bridge	61	USEPA 2003; core juvenile rearing
			Red Bluff	61	USEPA 2003; core juvenile rearing
			Knights Landing	61	USEPA 2003; non-core juvenile rearing

Eggs – Water Temperature

- Reclamation Egg Mortality Model (BA Attachment 5.D.1; example results: ITP Application Section 4.3.4.2.1.2.1.6)
  - Estimates temperature-related mortality for three life stages (pre-spawned eggs, fertilized eggs, and pre-emergent fry)

Early Life Stages– Flow and Water Temperature

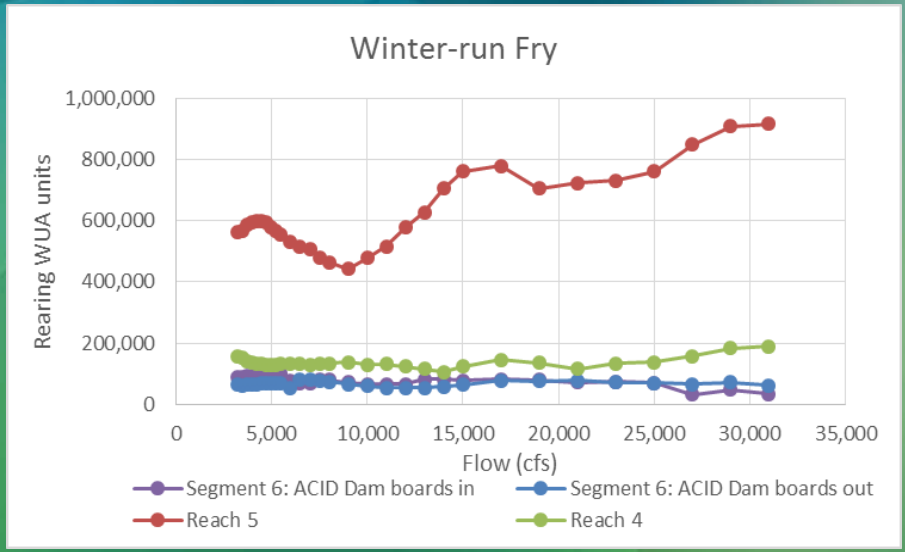
- SALMOD (BA Attachment 5.D.2; example results: ITP Application Section 4.3.4.2.1.6)
  - Estimates flow- and temperature-related mortality of early life stages (through juveniles) based on quantity and quality of habitat
  - Not a true life cycle model (no year-over-year carry-over)

Fry and Juveniles – Flow

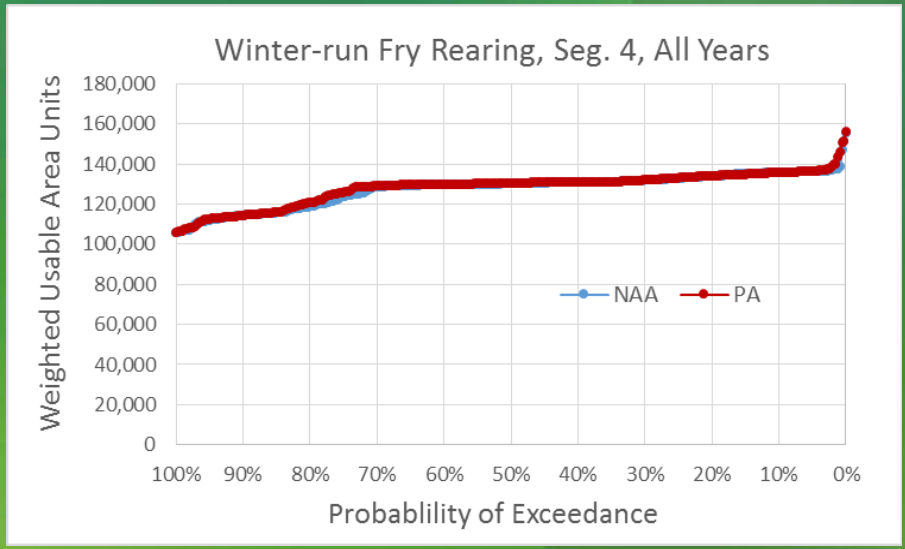
- Juvenile Stranding
  - Occurs with rapid flow changes, but CALSIM uses a monthly time step
  - Therefore, analysis was not possible
  - Instead, provided a description of this data limitations and discussed current ramping restrictions (e.g., Section 4.3.4.2.1.2.2.1)

Fry and Juveniles – Flow

- Juvenile rearing habitat availability (e.g., Section 4.3.4.2.1.2.2.1)
  - Very similar to spawning WUA
  - Based on USFWS curves



CALSIM output



Migration – Flow

- Used default method (more flow is good)
- Additional analysis of very low flows affecting adult passage (physical barriers)

Life Cycle Models

- IOS and OBAN (BA Appendix 5.D, Section 5.D.3; ITP application Section 4.3.4.2.1.6)
  - Both evaluate flow and water temperature effects for winter-run Chinook salmon in the Sacramento River
  - Both indicate that there would be minimal effects upstream, with escapement differences between scenarios caused by differences in Delta survival (neither model captures the effects of real-time operational adjustments or minimization/mitigation measures to limit potential effects)

Summary of Upstream Effects (WR-Section 4.3.4.2.2; SR-Section 4.4.4.2.2)

- Upstream flow and water temperatures under PP largely similar to NAA
- Some reduced flows and elevated water temperatures seen in fall months
- New north Delta intakes provide flexibility to export additional excess run-off in winter and spring months
- This could shift timing of releases because of a reduced need for releasing water in fall months (but carry-over storage and coldwater pool would be higher for the following year)
- CALSIM predicts that this could result in reduced flows and elevated water temperatures in fall months, although this would be managed in real time

Summary of Upstream Effects (WR-Section 4.3.4.2.2; SR-Section 4.4.4.2.2)

- CALSIM is a long-term planning model that uses a pre-defined set of generalized assumptions and cannot account for real-time decision making
- Thus, model outputs do not exactly match what operators would do in real-time
- The PP has the operational flexibility to use real-time management to minimize effects seen in model outputs
- In addition, there is an RPA revision process currently underway to address ongoing temperature issues

WR & SR Chinook Analyses

4.3.7/4.3.8 Analysis of Potential for Jeopardy

- *4.3.8.3/4.4.8.3 Potential to Jeopardize Continued Existence of the Species*
  - Take minimization measures to be applied
    - Cross-references Sections 5.3.3/5.3.4 in Chapter 5
    - Many avoidance and mitigation measures for construction and maintenance
    - Minimization/avoidance through operational criteria (e.g., OMR flow constraints)
    - Importance of preconstruction studies to refine screen design
    - Georgiana Slough nonphysical fish barrier
    - Spring outflow criteria – intended for longfin smelt, potential to affect Chinook salmon (next slides)
  - Loss of habitat fully mitigated
    - Cross-references Sections 5.4.3/5.4.4 in Chapter 5
    - ~155 acres of tidal perennial habitat and 4.3 miles of channel margin habitat to offset construction and operations effects
  - Conclusion: No jeopardy

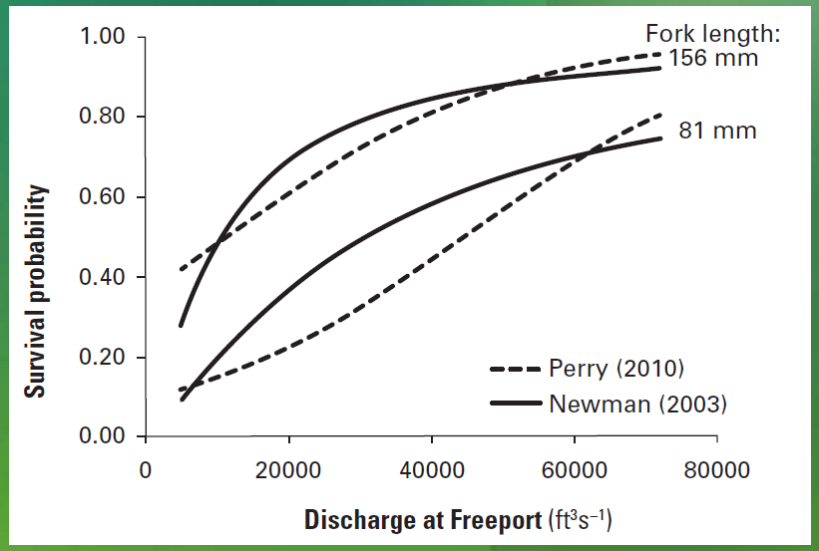
WR & SR Chinook Analyses

4.3.8/4.4.8 Analysis of Potential for Jeopardy

- *4.3.8.3/4.4.8.3 Potential to Jeopardize Continued Existence of the Species*
  - Spring outflow criteria effects: NDD bypass flows

Table 4.D-4. Monthly Water-year-type Mean of Flows Below the North Delta Diversion (Cubic Feet per Second), from the 1922–2003 CalSim-II Simulation.

Month	WYT	NAA	PP	PP_{LFS}	PP vs. NAA[1]	PP_{LFS} vs. NAA[1]	PP_{LFS} vs. PP
Jan	W	49,341	42,889	42,969	-6,452 (-13%)	-6,372 (-13%)	80 (0%)
	AN	38,565	33,003	33,002	-5,563 (-14%)	-5,563 (-14%)	0 (0%)
	BN	18,314	16,395	16,452	-1,920 (-10%)	-1,862 (-10%)	58 (0%)
	D	17,243	15,577	15,584	-1,665 (-10%)	-1,659 (-10%)	7 (0%)
	C	14,090	13,300	13,307	-789 (-6%)	-783 (-6%)	6 (0%)
Feb	W	56,615	48,770	48,684	-7,844 (-14%)	-7,931 (-14%)	-86 (0%)
	AN	46,659	39,972	40,068	-6,687 (-14%)	-6,591 (-14%)	96 (0%)
	BN	30,326	26,251	26,279	-4,075 (-13%)	-4,047 (-13%)	28 (0%)
	D	23,436	20,073	20,108	-3,362 (-14%)	-3,327 (-14%)	35 (0%)
	C	16,010	14,171	14,182	-1,839 (-11%)	-1,828 (-11%)	11 (0%)
Mar	W	47,988	40,145	40,361	-7,844 (-16%)	-7,627 (-16%)	217 (1%)
	AN	40,801	34,100	35,447	-6,700 (-16%)	-5,354 (-13%)	1,347 (4%)
	BN	18,542	15,051	16,060	-3,492 (-19%)	-2,482 (-13%)	1,010 (7%)
	D	21,284	17,259	17,923	-4,025 (-19%)	-3,360 (-16%)	664 (4%)
	C	12,529	11,683	11,636	-846 (-7%)	-894 (-7%)	-47 (0%)
Apr	W	34,998	32,406	30,778	-2,592 (-7%)	-4,220 (-12%)	-1,628 (-5%)
	AN	24,080	22,944	22,401	-1,136 (-5%)	-1,679 (-7%)	-542 (-2%)
	BN	14,076	13,607	13,730	-469 (-3%)	-346 (-2%)	123 (1%)
	D	14,895	14,348	14,207	-547 (-4%)	-688 (-5%)	-141 (-1%)
	C	10,290	10,144	10,166	-147 (-1%)	-124 (-1%)	22 (0%)
May	W	29,839	26,747	26,011	-3,092 (-10%)	-3,828 (-13%)	-736 (-3%)
	AN	16,711	15,444	15,496	-1,266 (-8%)	-1,215 (-7%)	52 (0%)
	BN	12,460	12,027	11,943	-433 (-3%)	-517 (-4%)	-85 (-1%)
	D	11,633	11,382	11,304	-251 (-2%)	-329 (-3%)	-77 (-1%)
	C	8,214	8,031	8,030	-184 (-2%)	-184 (-2%)	0 (0%)



Perry et al. (2016: Figure 6)