

Attachment 1

Estimated CVP Operations 90% Exceedance

Storages

Federal End of the Month Storage/Elevation (TAF/Feet)

		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
Trinity		1292	1336	1256	1116	968	813	660	613	578	561	559	588	648
	Elev.	2289	2282	2268	2251	2233	2211	2204	2198	2195	2195	2200	2210	
Whiskeytown		207	238	238	238	238	238	238	206	206	206	206	206	
	Elev.	1209	1209	1209	1209	1209	1209	1199	1199	1199	1199	1199	1199	
Shasta		2392	2343	2174	1923	1566	1303	1230	1191	1209	1280	1408	1615	1943
	Elev.	976	967	953	930	911	905	902	903	909	919	933	954	
Folsom		361	378	417	342	246	246	246	239	234	238	252	275	399
	Elev.	400	406	394	377	377	377	376	375	375	378	383	403	
New Melones		1539	1490	1396	1307	1223	1154	1112	1071	1073	1077	1080	1075	1059
	Elev.	1002	992	981	971	963	957	952	952	953	953	953	950	
San Luis		205	188	153	62	-61	-142	-77	20	66	171	347	362	367
	Elev.	429	412	388	363	342	354	370	389	413	447	444	439	
<b>Total</b>		5973	5634	4988	4180	3613	3409	3339	3365	3533	3853	4122	4621	

State End of the Month Reservoir Storage (TAF)

Oroville		1532	1510	1315	1079	903	807	825	846	886	968	1097	1300
	Elev.	734	732	708	676	649	632	635	639	646	659	679	706
San Luis		583	467	372	325	286	284	283	369	455	594	547	494
<b>Total San Luis (TAF)</b>		885	772	620	434	264	145	206	303	435	627	942	861

Monthly River Releases (TAF/cfs)

Trinity	TAF	36	92	47	28	53	52	23	18	18	18	17	18
	cfs	600	1,498	783	450	857	870	373	300	300	300	300	300
Clear Creek	TAF	12	16	11	9	9	9	12	12	12	12	11	17
	cfs	200	265	190	150	150	150	200	200	200	200	200	275
Sacramento	TAF	357	454	521	615	492	297	281	230	200	200	180	200
	cfs	6000	7379	8750	10000	8000	5000	4570	3873	3250	3250	3250	3250
American	TAF	120	77	137	149	61	49	49	48	49	49	80	49
	cfs	2013	1256	2307	2422	988	821	800	800	800	800	1442	801
Stanislaus	TAF	27	24	9	9	9	9	39	12	12	13	12	18
	cfs	460	384	150	150	150	150	635	200	200	219	214	300
Feather	TAF	57	54	121	161	125	138	59	58	59	59	70	65
	cfs	950	878	2034	2619	2033	2320	960	975	960	960	1261	1057

Trinity Diversions (TAF)

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Carr PP	43	25	99	120	101	100	24	30	21	15	10	7
Spring Crk. PP	15	15	90	110	90	90	45	20	12	10	10	10

Delta Summary (TAF)

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
Tracy	45	76	50	48	60	193	184	93	132	190	49	52	
USBR Banks	0	0	0	0	0	0	0	0	0	0	0	0	
Contra Costa	9.5	9.5	9.5	7.4	8.3	9.5	10.5	12.6	13.8	13.7	10.5	10.5	
<b>Total USBR</b>	54	86	60	55	68	203	195	106	146	204	60	63	
State Export	18	20	15	17	18	31	17	88	88	190	20	67	
<b>Total Export</b>	72	106	75	72	86	234	212	194	234	394	80	130	
COA Balance	56	78	113	184	204	150	126	145	125	125	80	0	
Vernalis	TAF	84	84	40	42	37	43	98	74	75	76	82	104
Vernalis	cfs	1419	1359	671	687	605	722	1595	1242	1225	1244	1475	1699
Old/Middle River Std.													
Old/Middle R. calc.		-884	-1,304	-1,253	-1,187	-1,399	-3,288	-2,521	-2,537	-2,967	-4,962	-1,029	-1,448
Computed DOI		7094	4002	4001	4002	2993	3009	4181	4942	4994	6214	11400	11403
Excess Outflow		0	0	0	0	0	0	0	0	0	1708	0	0
% Export/Inflow		11%	20%	12%	11%	16%	40%	36%	34%	39%	52%	10%	15%
% Export/Inflow std.		35%	35%	35%	65%	65%	65%	65%	65%	65%	65%	45%	35%

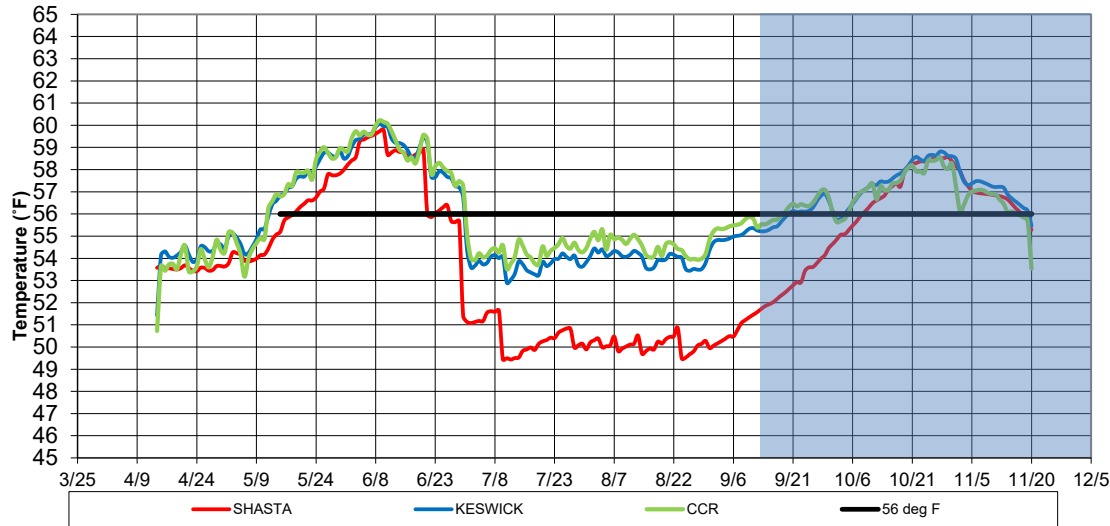
Hydrology

	Trinity	Shasta	Folsom	New Melones
Water Year Inflow (TAF)	347	2,685	1,022	357
Year to Date + Forecasted % of mean	29%	48%	38%	34%

CVP actual operations do not follow any forecasted operation or outlook; actual operations are based on real-time conditions.  
 CVP operational forecasts or outlooks represent general system-wide dynamics and do not necessarily address specific watershed/tributary details.  
 CVP releases or export values represent monthly averages.  
 CVP Operations are updated monthly as new hydrology information is made available December through May.

## Attachment 2 – HEC5Q temperature modelling results for Scenarios 11

**Sacramento River Modeled Temperature  
2021 Apr 90%-Exceedance Water Outlook - L3MTO Meteorology**



	Shasta deg F	Keswick deg F	Clear Creek deg F	Igo deg F	Trinity deg F	Lewiston deg F
Apr	53.6	54.1	53.7	49.6	45.7	48.1
May	55.6	56.7	56.7	50.3	45.9	49.1
Jun	57.8	58.8	58.9	52.6	46.1	49.6
Jul	50.4	53.7	54.3	56.5	46.6	50.3
Aug	50.1	54.0	54.5	58.4	47.4	50.8
Sep	52.1	55.6	56.0	57.5	49.2	50.9
Oct	57.1	57.6	57.3	56.7	50.8	52.6
Nov	55.1	55.3	54.6	53.9	51.7	51.8

Run date: 4/29/21 S11

**EOM Sept storage: 1.2 MAF**

Trinity profile date: 4/8/21

Whiskeytown profile date: 4/13/21

Shasta profile date: 4/14/21

Projected Side gates: First Jul 29 Full Aug 25

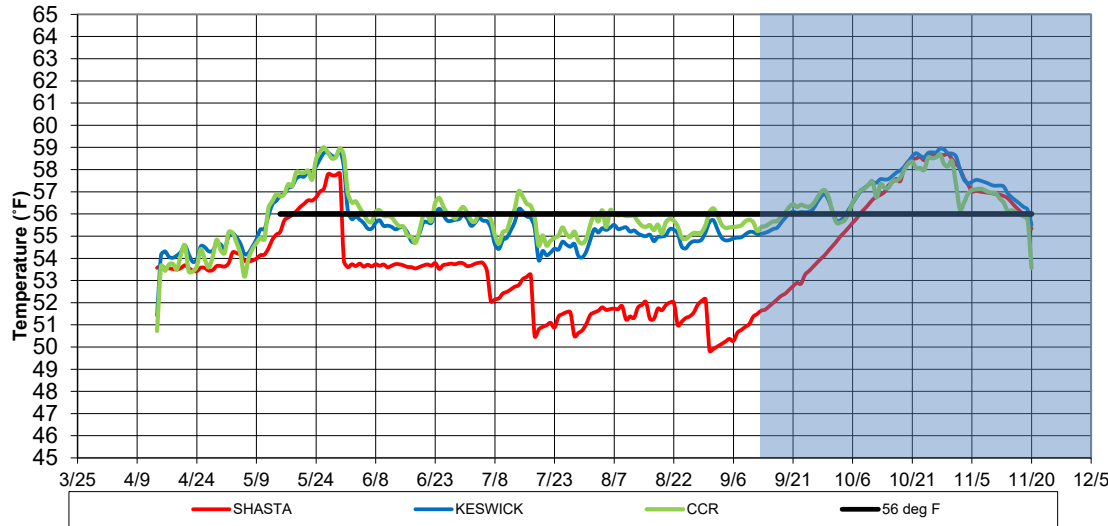
Shaded area denotes period of model limitations - see Fall Temperature Index

**End of September Cold-Water-Pool less than 56 deg F: 170 TAF**

**End of April Cold-Water-Pool less than 52 deg F: 1.4 MAF**

## Attachment 2 – HEC5Q temperature modelling results for Scenarios 12

**Sacramento River Modeled Temperature  
2021 Apr 90%-Exceedance Water Outlook - L3MTO Meteorology**



	Shasta deg F	Keswick deg F	Clear Creek deg F	Igo deg F	Trinity deg F	Lewiston deg F
Apr	53.6	54.1	53.7	49.6	45.7	48.1
May	55.5	56.7	56.7	50.3	45.9	49.1
Jun	53.7	55.6	55.9	52.6	46.1	49.6
Jul	52.1	55.0	55.5	56.5	46.6	50.3
Aug	51.6	55.1	55.6	58.4	47.4	50.8
Sep	52.0	55.6	56.0	57.5	49.2	50.9
Oct	57.2	57.7	57.4	56.7	50.8	52.6
Nov	55.1	55.4	54.7	53.9	51.7	51.8

Run date: 4/29/21 S12

**EOM Sept storage: 1.2 MAF**

Trinity profile date: 4/8/21

Whiskeytown profile date: 4/13/21

Shasta profile date: 4/14/21

Projected Side gates: First Jul 29 Full Sep 1

Shaded area denotes period of model limitations - see Fall Temperature Index

**End of September Cold-Water-Pool less than 56 deg F: 150 TAF**

**End of April Cold-Water-Pool less than 52 deg F: 1.4 MAF**

**Attachment 3: CEQUAL-W2 Temperature Modelling results for Scenarios 11 and 12.**

Watercourse Engineering, Inc.  
 Mike Deas  
 5/3/2021

DRAFT - Preliminary Analyses

Target Tw for S12 and S11 (provided by Reclamation, T. Patton)

**Assumptions**

	S12	S11	
<b>HYDROLOGY</b>			
April 90% forecast inflows	x	x	
April 90% forecast outflows	x	x	
 <b>OPERATIONS</b>			
90% powerbypass through 6/1	x		
Upper River Outlets and Middle Gate blend through 6/21		x	(Blend to 60F max)
 <b>TRANSFERS</b>			
Aug-Oct (0.25-0.25-0.5)	x	x	(Total transfers = 150 TAF)
 <b>TAILBAY TARGET</b>			
S12 schedule	x		
S11 schedule		x	
 <b>METEOROLOGY</b>			
2015 Meteorology	x	x	
 <b>GATE SETTING</b>			
1) 04/21 – 05/15			RRU only (with 300 cfs through the TCDM outlets)
2) 05/15 – 06/01			RRU and TCDM outlets blending to 15.5. C

- 3) 06/01 - 06/30 TCDM-TCDL
- 4) 06/30 – 07/29 TCDL only
- 5) 07/29 – 09/05 TCDL-TCDS (Side gate start 7/29)
- 6) 09/05 – 01/01 TCDS only

## NOTES

Extended blending of Upper River Outlets and Middle Gates produces a unique condition.

These conditions are outside the range of historic operations (i.e., untested).

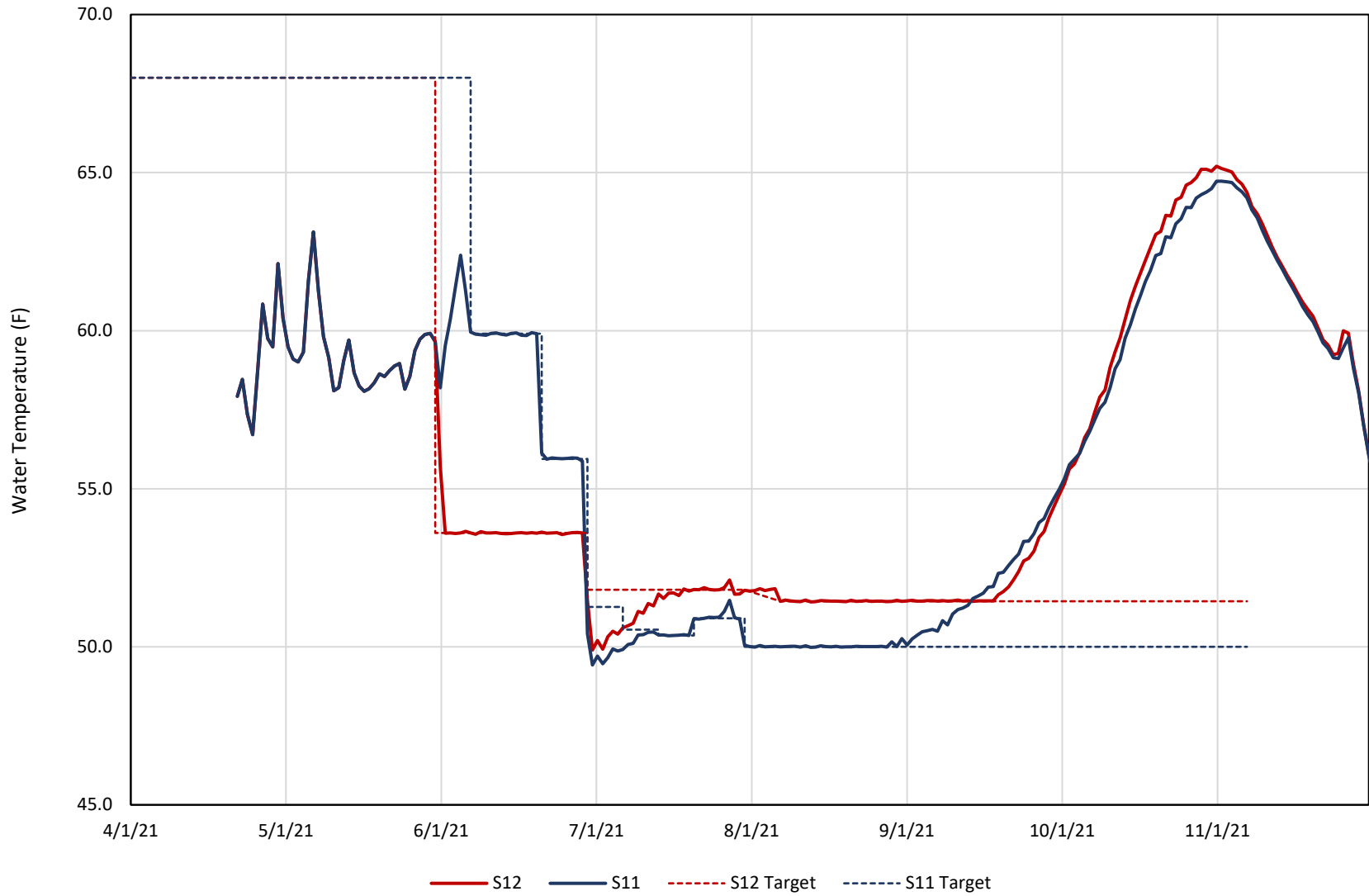
Extended operations on the Middle Gate often result in overprediction of release water temperatures late in the Middle Gate operation period.

These conditions, coupled with blending to atypical temperatures (e.g., 60F), should be considered when interpreting model results.

In sum, the model is being applied outside the range of historic operations.

Coupled with forecast assumptions, results should be discussed broadly when used in decision-making.

# DRAFT Sacramento River Modeled Temperatures at Shasta Dam with Bypass and Transfers



## Attachment 4

### HEC5Q Temperature and Temperature Dependent Modeling Methods and Assumptions

Spatially-explicit daily average Sacramento River water temperatures forecasts from the HEC-5Q model results are used as inputs to generate temperature-dependent egg mortality estimates. For this period, historical temperatures on the Sacramento River at Shasta Dam, Keswick Dam, above Clear Creek, Balls Ferry, Jelly's Ferry, and Bend Bridge are interpolated to estimate temperatures at river miles where simulated redds were located. Between September 15 and November 29, daily temperatures at the simulated redds' river miles are estimated based on a relationship between cold water pool volume less than 56 degrees F at the end of September in Shasta Lake and water temperatures above Clear Creek derived by Central Valley Operations. Reclamation thinks this relationship is more reliable in that time period than outputs from the HEC-5Q model. The 90% confidence interval value from this analysis was used as a conservative estimate. The average difference between the simulated temperatures above Clear Creek and the simulated temperatures at the redds' river miles during this period are used to adjust above Clear Creek estimated temperatures for each river mile. These temperatures are indicated in the table below.

*Table 3. Forecasted water temperatures in degrees Fahrenheit at Keswick (KWK; RKM 483) and Clear Creek (CCR; RKM 470) after 9/14/2021 for each scenario. These water temperatures were used for TDM modelling, instead of HEC-5Q modelled temperatures for 9/14/2021-11/29/21.*

Scenario	KWK	CCR
11	59.6	60.7
12	59.7	60.8

Temperature-dependent egg mortality estimates are calculated by modeling a redd's lifetime based on the days required to cross a known cumulative degree-day threshold and estimating mortality as an increasing function of temperature past a temperature threshold. Two models were used: 1. Martin et al (2017)<sup>1</sup> for stage independent modeling whereby a single temperature threshold is used from spawning and incubation through emergence; and 2. Anderson et al. (2018)<sup>2</sup> for stage dependent modeling for targeting different temperatures before, during, and after the most sensitive stages during egg incubation. The methods are applied to a set of simulated redds representative of redd construction timing and location from 2012-2020 and the results summarized on a seasonal level for comparison. Further information about the model's assumptions are documented in Table A1 below.

---

<sup>1</sup> Martin B.T. et al. (2017). Phenomenological vs. biophysical models of thermal stress in aquatic eggs. Ecology Letters 10:50-59.

<sup>2</sup> Anderson, J. (2018). Using river temperature to optimize fish incubation metabolism and survival: a case for mechanistic models. ResearchGate Preprint. 10.1101/257154.

Table A1. Water temperature and winter-run Chinook temperature-dependent mortality assumptions.

<b>Parameter</b>	<b>Scenarios 11 and 12 Run Date 04/29/21</b>	<b>Scenarios 11 and 12 Run Date 04/29/21</b>
Meteorology source	Forecasted Meteorology 50% L3MTO	Forecasted Meteorology 50% L3MTO
Operations Forecast	April forecast (based on April 1 90% hydrology)	April forecast (based on April 1 90% hydrology)
Time period	HEC5Q forecast: 4/14/21-11/29/21 TDM Input: 1/1/2021-11/29/2021	HEC5Q forecast: 4/14/21-11/29/21 TDM Input: 1/1/2021-11/29/2021
Reservoir Model used	HEC-5Q	HEC-5Q
River Model used	HEC-5Q until 9/14 then historic relationship to end of September storage below 56 degrees F	HEC-5Q until 9/14 then historic relationship to end of September storage below 56 degrees F
Shasta Profile date	4/14/21	4/14/21
TCD Gate operations	HEC-5Q	HEC-5Q
Sacramento water temperatures used	HEC-5Q output at locations specified by SacPAS. These are the same locations where SacPAS simulates redds. Actual KWK and CCR water temperatures for 1/1/2021-4/28/21	HEC-5Q output at locations specified by SacPAS. These are the same locations where SacPAS simulates redds. Actual KWK and CCR water temperatures for 1/1/2021-4/28/21
Biological Model used	SacPAS Fish model	SacPAS Fish model
Temperature Mortality Model	Stage-independent mortality using the following temperature user input files: <ul style="list-style-type: none"> <li>• 11 adj with 2014.csv</li> <li>• 12 adj with 2014.csv</li> </ul>	Stage-dependent mortality using the following temperature user input files: <ul style="list-style-type: none"> <li>• 11 adj with 2014.csv</li> <li>• 12 adj with 2014.csv</li> </ul>
Egg emergence timing model	Linear. 958 ATUs (degrees C), as indicated for Zeug et al. on SacPAS under Egg to emergence timing model.	487 (degree C days)
TDM redd time distribution	Observed 2012-2020	Observed 2012-2020
TDM redd space distribution	Observed 2012-2020	Observed 2012-2020
TDM Tcrit (50th percentile)	12.04 degrees C	12.14 degrees C
TDM bT (50th percentile)	0.026°C-1d-1	1.17°C-1d-1
Critical Days	All	3



Summary Document for Shasta/Keswick Operational Scenarios  
 Prepared by the Southwest Fisheries Science Center on May 3<sup>rd</sup>, 2021

Below are results for two USBR scenario ran May 3<sup>rd</sup> 2021. The scenario has hydrology (Input 90% exceedance) and air temperature (50% exceedance of L3MTO) as inputs. Inputs from the scenario are used to generate daily average Sacramento River water temperatures using the RAFT model and associated temperature-dependent egg mortality and survival estimates using the NMFS stage-independent temperature mortality model (Martin et al. 2017) for the 2021 temperature management season.

Further details of modeling methods are at: <https://oceanview.pfeg.noaa.gov/CVTEMP/>

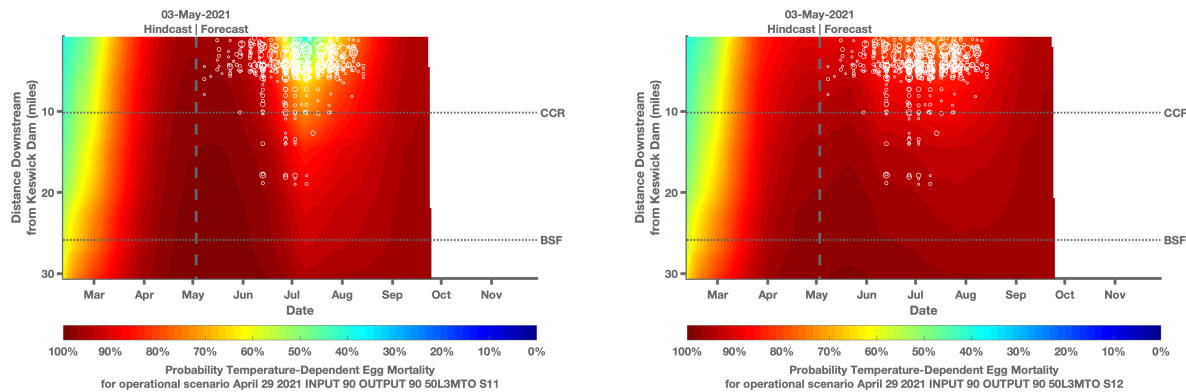


Figure1: Estimated temperature-dependent egg survival produced by the NMFS stage-independent temperature mortality model under the two May 3<sup>rd</sup> 2021 scenarios. 2012-2019 redd distributions are used for all plots.

Table 1: Estimated temperature-dependent egg mortality under different scenarios assuming a 2012-2019 spatial and temporal redd distribution using output from the RAFT water temperature model.

Scenario	RIVER MODEL	Mean (%)	Median (%)
APR_29_2021_INPUT_90_OUTPUT_90_50L3MTO S11	RAFT	70	71
APR_29_2021_INPUT_90_OUTPUT_90_50L3MTO S12	RAFT	76	82