Exhibit DWR-1352

Technical Memorandum

To: California Department of Water Resources (DWR)

From: Marin Greenwood, Ph.D. (Aquatic Ecologist, ICF) and Corey Phillis, Ph.D. (Resource Specialist, Metropolitan Water District of Southern California)

Date: 7/2/2018

Re: Comparison of Predicted Longfin Smelt Fall Midwater Trawl Index for Existing Conditions, No Action Alternative, and California WaterFix CWF H3+ Operational Scenarios Using the Nobriga and Rosenfield (2016) Population Dynamics Model

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Background

This technical memorandum uses the Nobriga and Rosenfield (2016) population dynamics model to compare predicted Longfin Smelt fall midwater trawl indices for California WaterFix (CWF H3+), No Action Alternative (NAA), and Existing Conditions operational scenarios. Note that the main point of comparison for the CWF H3+ scenario is the NAA scenario, as described in DWR's case-in-chief for Part 2 of the State Water Resources Control Board hearing for a change in point of diversion for California WaterFix (e.g., Exhibit DWR-1012, testimony of Marin Greenwood). However, given that the California Department of Fish and Wildlife (DFW) considered a comparison to existing conditions[1] in its findings of fact for issuance of the CWF Incidental Take Permit (ITP; see Exhibit DWR-1095, p.312-313), comparison to an Existing Conditions operational scenario is also provided herein for context.

Reproduction of Nobriga and Rosenfield (2016) Model

We reproduced the methods described in Nobriga and Rosenfield (2016) for calculation of the two-life-stage model that they refer to as '2abc', which includes the embedded hypotheses that understanding the trend in age-0 Longfin Smelt relative abundance requires explicit modeling of spawning and recruit relative abundance; that the production of age-0 fish is density dependent; and that juvenile survival from age 0 to age 2 has changed over time. We chose the 2abc model because visually its median predictions fit the more recent years of empirical data better than the 2ab model (compare Nobriga and Rosenfield 2016 Figures 6A and 6C).

[1] The existing conditions scenario considered in the ITP was the same as the existing conditions scenario included herein.

Model input data used to reproduce the 2abc model were as provided in Table 2 of Nobriga and Rosenfield (2016. The input data are provided in Table A1 of Appendix A. Model 2abc was then reproduced using the R code documented in Script A1 of Appendix A.

Graphical comparison of our reproduction of the Nobriga and Rosenfield (2016) 2abc model (Figure 1a) to the original (Figure 1b) suggests that we were reasonably successful in reproducing the method. Note that Nobriga and Rosenfield's (2016) 95% intervals are wider than ours, possibly the result of a different method of drawing random samples from the data; however, this ultimately does not affect the comparison of scenarios, which is the main purpose of this technical memorandum[2]. Median predictions and the 95% interval[3] are also provided in Table A2 of Appendix A.

[2] The model coefficients and their standard errors that we derived (see Script A1 in Appendix A, subsections describing *Reproduce Survival Model* and *Reproduce Recruits per Spawner Model*) match those derived by Nobriga and Rosenfield (2016: see *Results* section of their paper, p.52).

[3] All references to 95% interval are specifically to the 2.5th and 97.5th percentiles of the simulated predictions.

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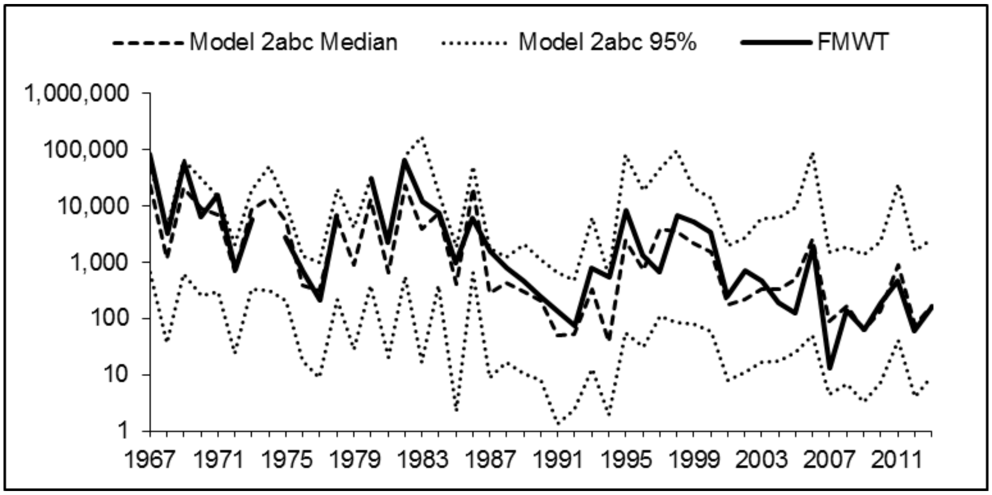
(a) Reproduction



(b) Original

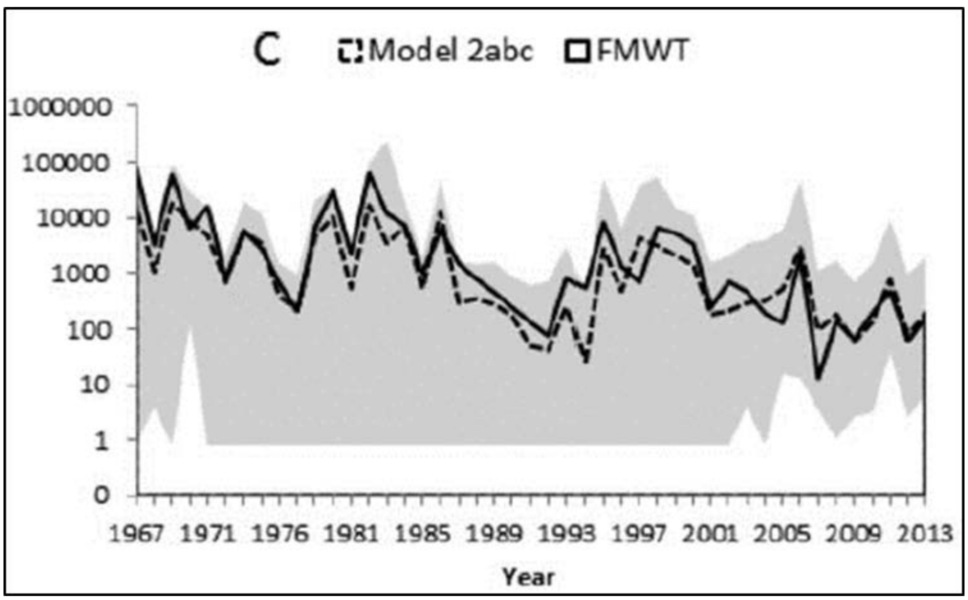


Figure 1. Nobriga and Rosenfield (2016) 2abc Model Predictions Compared to Historical Fall Midwater Trawl Survey Longfin Smelt Abundance Index: (a) Reproduction of the Method as Described in this Technical Memorandum; (b) Original (from Figure 6C of Nobriga and Rosenfield 2016, with grey shading indicating 95% interval).

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Calculation of Delta Outflow Model Inputs for Scenario Comparison

In order to obtain the required first principal component (PC1) model inputs for comparison of the CWF H3+, NAA, and Existing Conditions operational scenarios, it was first necessary to reproduce the principal components analysis (PCA) in order to provide the predictive model for generating PC1 from the CalSim data. Following Nobriga and Rosenfield (2016), we obtained historical daily Delta outflow data from the DAYFLOW database.[4] We averaged the data for December to May by month and year and calculated z-scores (i.e., subtracted the mean and divided by the standard deviation of the monthly values; Table B1 in Appendix B). We then conducted a PCA using the PRINCOMP procedure in SAS 9.4 software (see first portion of Script B1 in Appendix B). The resulting PC1 outputs were very similar to the original values computed by Nobriga and Rosenfield (2016), suggesting that we had successfully reproduced their method (Table B2 in Appendix B).[5] The PCA coefficients were stored for subsequent prediction of PC1 values.

Mean monthly December-May, 1922-2003, CalSim-II Delta outflow data for the Existing, NAA, and CWF H3+ operational scenarios (Table B3 in Appendix B) were standardized to z-scores based on the mean and standard deviation of the historical 1956-2013 data; the z-scores are shown in the second portion of Script B1 in Appendix B. These z-scores were then used to predict PC1 values for each operational scenario in each water year by applying the SCORE procedure in SAS 9.4 software on the stored PCA coefficients from the historical Delta outflow data (see second portion of Script B1 in Appendix B). The resulting PC1 values (Table B4 in Appendix B) were used as the input for the model simulation of the operational scenarios described in the next section.

Model Simulation to Compare Scenarios

Model simulation to compare the Existing, NAA, and CWF H3+ scenarios used the PC1 flow inputs (Table B4 in Appendix B) as previously described. To produce a simulation for the 82-year time series, and consistent with Nobriga and Rosenfield (2016), the model was initiated with 2 years (i.e., water years 1922 and 1923) of fall midwater trawl indices equal to 798, which represents the median observed FMWT index from 1967 to 2013. We used the juvenile survival function representing recent conditions, i.e., the period after the apparent decline in juvenile survival around 1991, as our main focus for interpretation of differences between scenarios. We

[4] https://www.water.ca.gov/Programs/Environmental-Services/Compliance-Monitoring-And-Assessment/Dayflow-Data

[5] The small differences may have arisen because of varying PCA algorithms in different statistical software packages, for example.

also ran simulations with juvenile survival functions representing pre-1991 and changing before and after 1991 to assess the extent to which this affected the results. Following Nobriga and Rosenfield (2016), we conducted 1,000 stochastic simulations in which random draws were made based on the mean and standard error of the model parameters. Consistent with Nobriga and Rosenfield (2016), we examined the variability among the estimates using the 95% intervals, as well as the percentage of simulations predicting quasi-extirpation (i.e., a fall midwater trawl index < 1). To facilitate comparison with other methods employed in California WaterFix effects analyses, we also summarized differences in median predicted fall midwater index averaged by water year type. The R code used for the analyses is shown in Appendix C[6].

Results

There was appreciable variability in the predictions of Longfin Smelt fall midwater trawl index based on the post-1991 ('poor') juvenile survival function, with 95% intervals generally spanning several orders of magnitude (Figures 2 and 3[7]). This high variability was considerably greater than differences between scenarios, which tracked very closely when comparing the CWF H3+ scenario to both the NAA (Figure 2) and Existing (Figure 3). A similar percentage of simulations predicted quasi-extirpation (fall midwater trawl index < 1) by the end of the time series in 2003: 11.7% for CWF H3+, 11.8% for NAA, and 11.6% for Existing (Figure 4). There was little difference (3% or less) in median predicted fall midwater trawl index averaged by water year type between CWF H3+ and NAA, whereas the median indices averaged 8-9% greater in wet and above normal years under CWF H3+ compared to Existing (Table 1). Both NAA and CWF H3+ scenarios had relatively greater median indices than Existing in these wetter years, reflecting in large part greater winter Delta outflow as a result of climate change modeling assumptions (more precipitation occurring as rainfall rather than snow compared to Existing; Table 2).

The analyses conducted with the pre-1991 ('good') and changing pre-/post-1991 ('observed') juvenile survival functions showed similar patterns to those previously described for the post-1991 juvenile survival functions, although the relative differences between scenarios generally were somewhat less (Tables 3 and 4).

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[6] The post-1991, pre-1991, and changing pre-/post-1991 juvenile survival functions are respectively referred to as 'poor', 'good', and 'observed' in the R code.

[7] The data underlying the results plots are provided in Table D1 of Appendix D.

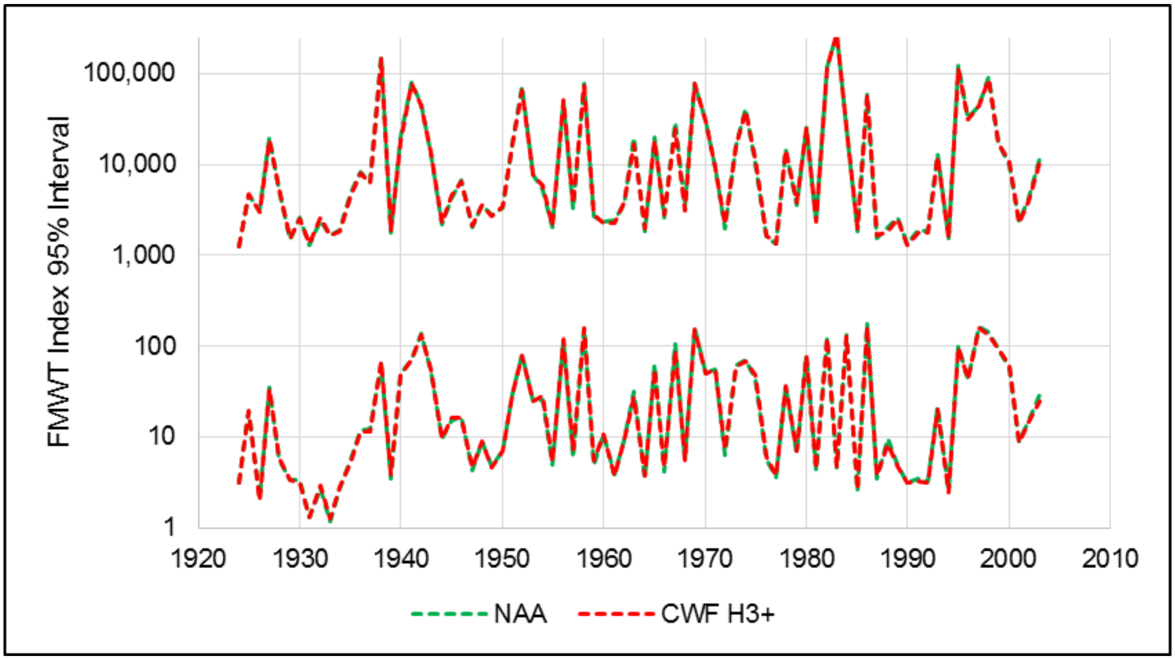

Figure 1. Longfin Smelt Fall Midwater Trawl Index: 95% Interval for California WaterFix H3+ and No Action Alternative Operational Scenarios, Based on Simulation Reproducing Nobriga and Rosenfield (2016) 2abc Model With Post-1991 Juvenile Survival Function Applied to 1922-2003 CalSim-II Model Outputs.

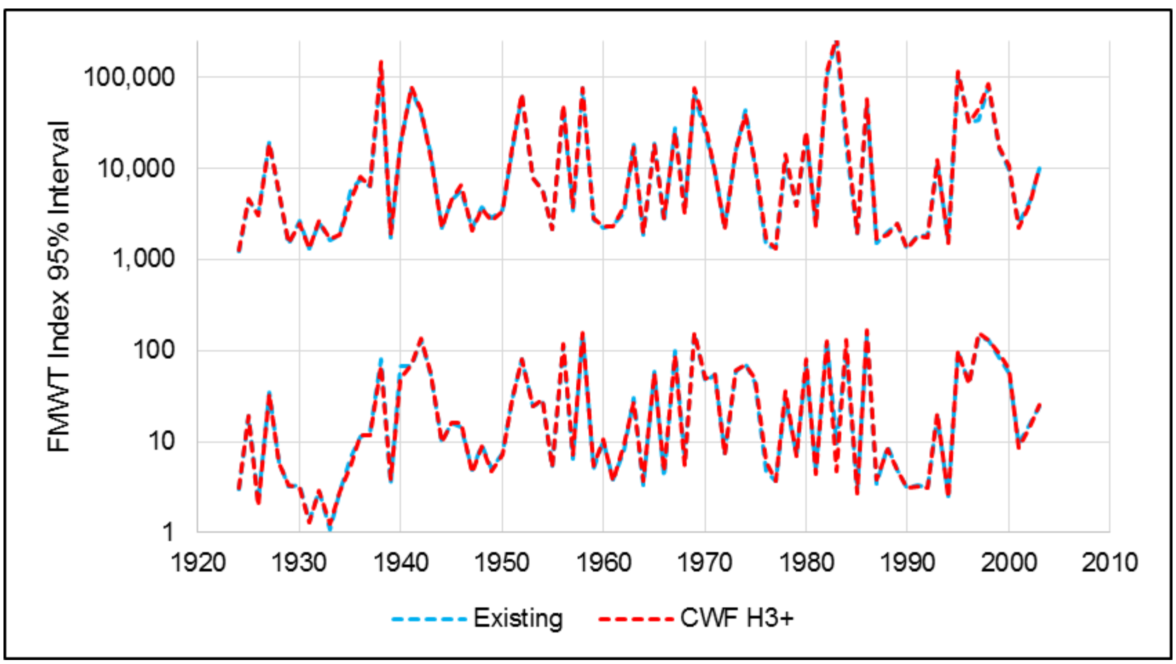

Figure 2. Longfin Smelt Fall Midwater Trawl Index: 95% Interval for California WaterFix H3+ and Existing Conditions Operational Scenarios, Based on Simulation Reproducing Nobriga and Rosenfield (2016) 2abc Model With Post-1991 Juvenile Survival Function Applied to 1922-2003 CalSim-II Model Outputs.

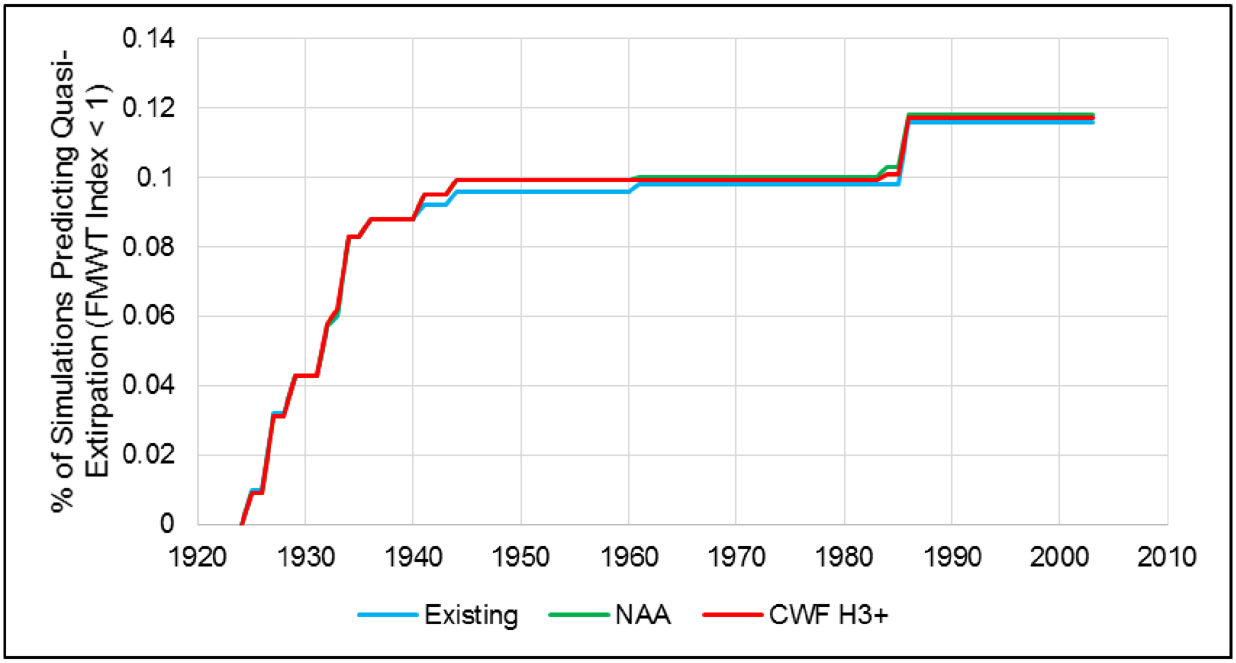

Figure 3. Probability of Quasi-Extirpation (Longfin Smelt Fall Midwater Trawl Index < 1) for California WaterFix H3+, No Action Alternative, and Existing Conditions Operational Scenarios, Based on Simulation Reproducing Nobriga and Rosenfield (2016) 2abc Model With Post-1991 Juvenile Survival Function Applied to 1922-2003 CalSim-II Model Outputs.

Table 1. Longfin Smelt Fall Midwater Trawl Index: Water Year Type Mean of Median Index Predicted for California WaterFix H3+, No Action Alternative, and Existing Conditions Operational Scenarios, Based on Simulation Reproducing Nobriga and Rosenfield (2016) 2abc Model With Post-1991 Juvenile Survival Function Applied to 1922-2003 CalSim-II Model Outputs.

Water Year Type	Existing	NAA	CWF H3+	CWF H3+ vs. Existing	CWF H3+ vs. NAA
Wet	1,832	2,038	1,974	141 (8%)	-64 (-3%)
Above Normal	1,786	1,960	1,939	153 (9%)	-21 (-1%)
Below Normal	829	843	840	11 (1%)	-3 (0%)
Dry	466	473	458	-8 (-2%)	-15 (-3%)
Critical	187	188	184	-4 (-2%)	-5 (-3%)
All years	1,116	1,213	1,184	68 (6%)	-29 (-2%)

Table 2. Water Year Type Mean Delta Outflow (December-May, cubic feet per second) for California WaterFix H3+, No Action Alternative, and Existing Conditions Operational Scenarios, from 1922-2003 CalSim-II Model Outputs.

Water Year Type	Month	Existing	NAA	CWF H3+	CWF H3+ vs. Existing	CWF H3+ vs. NAA
Wet	Dec	42,094	47,330	46,115	4,021 (10%)	-1,215 (-3%)
	Jan	82,882	89,628	88,018	5,136 (6%)	-1,610 (-2%)
	Feb	94,036	103,678	104,173	10,137 (11%)	495 (0%)
	Mar	77,085	81,135	81,730	4,645 (6%)	595 (1%)
	Apr	53,059	53,832	51,845	-1,214 (-2%)	-1,986 (-4%)
	May	40,846	38,859	37,782	-3,064 (-8%)	-1,076 (-3%)
Above Normal	Dec	22,055	24,431	23,628	1,572 (7%)	-803 (-3%)
	Jan	48,020	49,569	47,434	-586 (-1%)	-2,135 (-4%)
	Feb	63,635	67,691	66,029	2,393 (4%)	-1,663 (-2%)
	Mar	49,054	52,341	55,118	6,064 (12%)	2,778 (5%)
	Apr	32,345	31,059	30,833	-1,512 (-5%)	-226 (-1%)
	May	20,639	19,514	19,711	-928 (-4%)	197 (1%)
Below Normal	Dec	9,231	9,036	8,931	-299 (-3%)	-104 (-1%)
	Jan	17,665	17,453	19,806	2,141 (12%)	2,353 (13%)
	Feb	34,627	36,493	35,056	429 (1%)	-1,437 (-4%)
	Mar	18,181	17,686	19,118	937 (5%)	1,432 (8%)
	Apr	16,653	16,328	16,414	-239 (-1%)	86 (1%)
	May	13,405	12,778	12,988	-417 (-3%)	210 (2%)
Dry	Dec	7,516	7,576	7,611	95 (1%)	34 (0%)
	Jan	15,680	15,887	16,363	683 (4%)	476 (3%)
	Feb	25,490	25,882	24,242	-1,248 (-5%)	-1,640 (-6%)
	Mar	22,273	22,432	22,335	62 (0%)	-97 (0%)
	Apr	17,530	16,398	16,275	-1,255 (-7%)	-124 (-1%)
	May	11,379	11,078	11,397	18 (0%)	319 (3%)
Critical	Dec	6,451	6,949	7,150	698 (11%)	201 (3%)
	Jan	12,400	11,434	10,996	-1,405 (-11%)	-438 (-4%)
	Feb	14,767	15,540	14,510	-258 (-2%)	-1,031 (-7%)
	Mar	11,766	11,995	12,160	395 (3%)	165 (1%)
	Apr	9,277	9,190	9,217	-60 (-1%)	27 (0%)
	May	6,793	6,671	6,711	-82 (-1%)	40 (1%)

Table 3. Longfin Smelt Fall Midwater Trawl Index: Water Year Type Mean of Median Index Predicted for California WaterFix H3+, No Action Alternative, and Existing Conditions Operational Scenarios, Based on Simulation Reproducing Nobriga and Rosenfield (2016) 2abc Model With Pre-1991 Juvenile Survival Function Applied to 1922-2003 CalSim-II Model Outputs.

Water Year Type	Existing	NAA	CWF H3+	CWF H3+ vs. Existing	CWF H3+ vs. NAA
Wet	5,390	5,819	5,714	324 (6%)	-105 (-2%)
Above Normal	6,896	7,252	7,266	370 (5%)	15 (0%)
Below Normal	4,672	4,739	4,683	10 (0%)	-56 (-1%)
Dry	2,625	2,698	2,611	-14 (-1%)	-87 (-3%)
Critical	1,210	1,225	1,196	-14 (-1%)	-29 (-2%)
All years	4,234	4,455	4,391	157 (4%)	-65 (-1%)

Table 4. Longfin Smelt Fall Midwater Trawl Index: Water Year Type Mean of Median Index Predicted for California WaterFix H3+, No Action Alternative, and Existing Conditions Operational Scenarios, Based on Simulation Reproducing Nobriga and Rosenfield (2016) 2abc Model With Juvenile Survival Function Changing in 1991 Applied to 1922-2003 CalSim-II Model Outputs.

Water Year Type	Existing	NAA	CWF H3+	CWF H3+ vs. Existing	CWF H3+ vs. NAA
Wet	4,290	4,628	4,515	225 (5%)	-114 (-2%)
Above Normal	5,616	5,973	6,011	395 (7%)	38 (1%)
Below Normal	4,672	4,739	4,683	10 (0%)	-56 (-1%)
Dry	2,501	2,556	2,484	-16 (-1%)	-71 (-3%)
Critical	597	590	577	-19 (-3%)	-12 (-2%)
All years	3,562	3,747	3,689	127 (4%)	-58 (-2%)

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References

Nobriga, M. L., and J. A. Rosenfield. 2016. Population Dynamics of an Estuarine Forage Fish: Disaggregating Forces Driving Long-Term Decline of Longfin Smelt in California's San Francisco Estuary. Transactions of the American Fisheries Society 145(1):44-58.

Appendix A – Inputs and R Code Used to Reproduce Nobriga and Rosenfield (2016) Model, With Predicted Values

Table A1. Time Series of Inputs Used to Reproduce Nobriga and Rosenfield (2016) 2abc Model.

Water Year	Delta Outflow PC1	Fall Midwater Trawl Index	Bay Study Age-0 Index	Bay Study Age-2 Index
1956	2.77			
1957	-0.627			
1958	3.74			
1959	-1.14			
1960	-1.19			
1961	-1.29			
1962	-0.575			
1963	1.21			
1964	-1.5			
1965	1.3			
1966	-1.02			
1967	1.91	81,737		
1968	-1.12	3,279		
1969	2.68	59,350		
1970	0.928	6,515		
1971	0.152	15,903		
1972	-1.6	760		
1973	0.442	5,896		
1974	1.97			
1975	-0.123	2,819		
1976	-1.93	658		
1977	-2.23	210		
1978	0.722	6,619		
1979	-1.05			
1980	1.08	31,184	159,555	1,339
1981	-1.5	2,202	3,049	383
1982	3.04	62,905	278,517	1,656
1983	5.91	11,864	28,755	1,891

Water Year	Delta Outflow PC1	Fall Midwater Trawl Index	Bay Study Age-0 Index	Bay Study Age-2 Index
1984	0.492	7,408	36,774	4,924
1985	-1.67	992	7,341	1,939
1986	1.71	6,160	18,489	1,384
1987	-1.81	1,520	2,428	1,785
1988	-1.97	791	1,409	3,571
1989	-1.7	456	1,054	941
1990	-2.06	243	713	687
1991	-1.98	134	188	351
1992	-1.88	76	495	152
1993	0.006	798	6,046	11
1994	-1.79	545	1,424[a]	414
1995	3.59	8,205	354,186	252[a]
1996	1.2	1,346	5,856	124[a]
1997	1.6	690	7,638	1,432
1998	3.11	6,654	41,729	605
1999	0.414	5,243	58,510	748
2000	0.036	3,437	14,202	704
2001	-1.61	247	1,460	1,158
2002	-1.35	707	9,652	1,752
2003	-0.468	467	2,119	739
2004	-0.514	191	2,418	686
2005	-0.235	129	4,538	569
2006	3.79	1,949	12,148	188
2007	-1.73	13	2,039	447
2008	-1.67	139	3,681	204
2009	-1.57	65	647	272
2010	-1.17	191	748	197
2011	1.21	477	7,833	305
2012	-1.53	61	1,284	733
2013	-1.38	164	8,495	300

Source: Adapted from Nobriga and Rosenfield (2016, Table 2).

[a]Bay Study Midwater Trawl data were not collected in this year; see Nobriga and Rosenfield (2016) for estimation method.

Script A1. R Code Used to Reproduce Nobriga and Rosenfield (2016) Model

Load data

```
# Load packages ------------------------------------------------------------


if (!require("pacman"))
    install.packages("pacman")

## Loading required package: pacman

library(pacman)
# p_load checks if package is installed, installs if necessary, then loads

p_load(tidyverse, arm)

datNR <- read.csv(
    'data/nobriga-rosenfield-2016-data.csv',
    na.strings = '',
    header = TRUE
)

# Add the lagged data and step decline indicator
datNR$lag2BayAge0 <- lag(datNR$BayAge0, n = 2)

# Step decline in survival begins in 1987, shows up in 1989 Age 2
datNR$Step1989 <- ifelse(datNR$WaterYear < 1987, 0, 1)
# Step shows up in 1991 Age 2
datNR$Step1991 <- ifelse(datNR$WaterYear < 1991, 0, 1)


# Build Models -------------------------------------------------------------
#  models use flow data from N&R, not CalSim

# naming model parameters for clarity and conciseness

# alpha
#  RPS in model 1abc; Age0 per Age 0
a1 <- log(datNR$BayAge0 / datNR$lag2BayAge0)
#  RPS in models 2; Age0 per Age2
a2 <- log(datNR$BayAge0 / datNR$BayAge2)

# S; survival from Bay Age 0 to Bay Age 2. Only in model 2
S02 <- (datNR$BayAge2 / datNR$lag2BayAge0)

#  outflow
#  Using PC1 reported in N&R
```

```
pc1 <- datNR$DeltaOutflowPC1
pc1.sqrd <- (datNR$DeltaOutflowPC1) ^ 2


# step decline year
step89 <- datNR$Step1989
step91 <- datNR$Step1991

# birth year FMWT
byFMWT <- (lag(datNR$FMWT, n = 2))
```

Reproduce Survival Model

```
# Survival -------------------------------------------------------------

#  Model2abc: Survival
##  as modeled in N&R
surv.NR <- glm(log(S02) ~ log(byFMWT) + step91,
               family = gaussian(link = 'identity'))

# confirm coefficients are same as reported in N&R 2016
display(surv.NR)

## glm(formula = log(S02) ~ log(byFMWT) + step91, family = gaussian(link = "i
dentity"))
##             coef.est coef.se
## (Intercept)  3.19     1.03
## log(byFMWT) -0.63     0.11
## step91      -1.68     0.47
## ---
##   n = 32, k = 3
##   residual deviance = 28.0, null deviance = 57.9 (difference = 29.8)
##   overdispersion parameter = 1.0
##   residual sd is sqrt(overdispersion) = 0.98
```

Reproduce Recruits per Spawner Model

```
# Recruitment ----------------------------------------------------------

# Model2abc: Recruitment
rps.NR <- lm(a2 ~ pc1.sqrd + pc1)

# confirm coefficients are same as reported in N&R 2016
display(rps.NR)

## lm(formula = a2 ~ pc1.sqrd + pc1)
##             coef.est coef.se
## (Intercept)  2.94     0.30
## pc1.sqrd    -0.15     0.05
## pc1          0.95     0.15
```

```
## ---
## n = 34, k = 3
## residual sd = 1.29, R-Squared = 0.58
```

Table A2. Predicted Median and 95% Interval of Fall Midwater Trawl Index from Reproduction of Nobriga and Rosenfield (2016) 2abc Model.

Water Year	Observed	Median Prediction	Lower 95% Prediction	Upper 95% Prediction
1958		18,959	565	221,408
1959		1,208	81	4,596
1960		853	0	3,202
1961		901	34	3,148
1962		1,849	47	7,716
1963		9,928	281	38,116
1964		758	25	2,501
1965		11,652	406	32,585
1966		1,197	39	4,771
1967	81,737	22,883	647	53,450
1968	3,279	1,182	37	3,887
1969	59,350	21,385	638	66,698
1970	6,515	8,867	250	30,066
1971	15,903	6,978	293	14,836
1972	760	675	25	2,034
1973	5,896	8,685	328	18,882
1974		13,666	324	50,130
1975	2,819	5,254	209	11,311
1976	658	384	17	1,322
1977	210	322	9	987
1978	6,619	5,972	216	19,404
1979		898	28	4,213
1980	31,184	12,896	381	29,639
1981	2,202	647	20	2,495
1982	62,905	23,290	552	79,192
1983	11,864	3,896	17	170,339
1984	7,408	7,263	381	18,107
1985	992	408	2	1,886
1986	6,160	20,869	650	50,126
1987	1,520	288	9	1,743
1988	791	426	17	1,262

Water Year	Observed	Median Prediction	Lower 95% Prediction	Upper 95% Prediction
1989	456	305	11	2,092
1990	243	212	8	1,139
1991	134	50	1	664
1992	76	54	2	485
1993	798	325	13	6,411
1994	545	40	2	575
1995	8,205	2,453	55	81,517
1996	1,346	726	32	18,351
1997	690	3,936	108	45,841
1998	6,654	3,489	86	95,838
1999	5,243	2,148	80	20,564
2000	3,437	1,483	59	13,809
2001	247	175	8	2,003
2002	707	220	11	2,688
2003	467	329	17	5,958
2004	191	339	17	6,115
2005	129	494	26	9,501
2006	1,949	2,540	51	89,424
2007	13	89	4	1,484
2008	139	167	7	1,826
2009	65	62	3	1,400
2010	191	136	7	2,331
2011	477	881	41	24,388
2012	61	76	4	1,637
2013	164	172	9	2,546

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Appendix B – Delta Outflow Model Input for Scenario Comparison: DAYFLOW Historical Delta Outflow Data, SAS Code, and Calculated Principal Components

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Table B1. DAYFLOW Historical Delta Outflow Data: December-January Monthly Mean (Cubic Meters Per Second) and Standardized z-Scores Based on Mean and Standard Deviation, Water Years 1956-2013.

Water Year	Mean Delta Outflow (m^3s^{-1})						z-Scores					
	December	January	February	March	April	May	December	January	February	March	April	May
1956	3540	5332	2779	1799	1139	1690	2.896	2.498	0.728	0.223	0.072	1.319
1957	394	445	693	1802	580	927	-0.520	-0.648	-0.663	0.225	-0.413	0.254
1958	760	1260	5217	3160	4355	2233	-0.123	-0.124	2.353	1.189	2.863	2.078
1959	409	931	1663	783	330	207	-0.504	-0.335	-0.016	-0.498	-0.631	-0.752
1960	196	403	1396	942	478	351	-0.735	-0.675	-0.194	-0.385	-0.502	-0.550
1961	541	441	1189	805	379	243	-0.361	-0.651	-0.332	-0.482	-0.587	-0.701
1962	457	315	2117	1345	775	515	-0.452	-0.732	0.287	-0.099	-0.244	-0.322
1963	991	595	2922	826	2910	1504	0.129	-0.552	0.823	-0.467	1.609	1.060
1964	646	849	592	370	260	277	-0.246	-0.388	-0.730	-0.791	-0.691	-0.654
1965	3071	3840	1593	789	1612	917	2.387	1.537	-0.063	-0.494	0.482	0.240
1966	853	1231	1032	689	536	278	-0.021	-0.142	-0.437	-0.565	-0.451	-0.652
1967	1712	1770	2383	1595	2200	2111	0.911	0.205	0.464	0.078	0.993	1.907
1968	580	687	1474	1142	281	191	-0.318	-0.493	-0.142	-0.243	-0.673	-0.774
1969	727	3487	4504	2648	1964	1828	-0.158	1.310	1.878	0.826	0.788	1.513
1970	1308	5469	3152	1585	312	305	0.472	2.586	0.977	0.072	-0.646	-0.615
1971	2417	1818	968	908	1047	748	1.677	0.235	-0.479	-0.409	-0.008	0.004
1972	679	604	622	513	214	146	-0.211	-0.546	-0.710	-0.689	-0.731	-0.837
1973	768	2879	2893	2178	628	331	-0.114	0.919	0.804	0.492	-0.371	-0.578
1974	2164	3928	1676	2197	3102	723	1.401	1.594	-0.008	0.506	1.776	-0.030
1975	793	495	1623	1893	977	815	-0.086	-0.616	-0.043	0.290	-0.068	0.098
1976	565	264	212	221	247	111	-0.334	-0.765	-0.984	-0.897	-0.702	-0.885
1977	119	124	138	85	84	111	-0.818	-0.855	-1.033	-0.993	-0.843	-0.886
1978	243	1873	1590	2424	1732	1154	-0.684	0.271	-0.065	0.667	0.587	0.571
1979	249	864	1312	1078	410	380	-0.678	-0.378	-0.250	-0.288	-0.561	-0.509
1980	539	3348	3445	2808	811	589	-0.363	1.220	1.172	0.939	-0.213	-0.218

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Water Year	Mean Delta Outflow (m^3s^{-1})						z-Scores					
	December	January	February	March	April	May	December	January	February	March	April	May
1981	354	519	600	750	330	259	-0.564	-0.601	-0.725	-0.521	-0.630	-0.679
1982	2443	2766	2621	2268	4026	1636	1.705	0.846	0.622	0.556	2.578	1.244
1983	2518	2542	4977	7550	3344	2794	1.786	0.701	2.193	4.305	1.986	2.861
1984	4377	2857	1176	989	414	314	3.805	0.905	-0.341	-0.352	-0.557	-0.602
1985	880	428	441	295	194	206	0.007	-0.659	-0.831	-0.844	-0.748	-0.752
1986	267	431	5817	4798	1318	448	-0.658	-0.657	2.753	2.352	0.227	-0.415
1987	254	306	477	649	176	137	-0.672	-0.738	-0.807	-0.593	-0.764	-0.849
1988	268	555	86	127	323	132	-0.657	-0.578	-1.068	-0.964	-0.636	-0.856
1989	205	102	181	1102	331	209	-0.726	-0.869	-1.005	-0.271	-0.629	-0.749
1990	125	280	192	108	168	218	-0.813	-0.755	-0.997	-0.977	-0.771	-0.736
1991	181	113	208	696	105	109	-0.752	-0.862	-0.986	-0.560	-0.826	-0.888
1992	216	182	814	376	177	92	-0.714	-0.818	-0.582	-0.787	-0.763	-0.912
1993	329	1639	1558	1811	1254	713	-0.591	0.120	-0.086	0.232	0.172	-0.044
1994	350	305	582	300	231	225	-0.568	-0.738	-0.737	-0.841	-0.716	-0.726
1995	273	3044	2062	5682	2572	2776	-0.652	1.025	0.250	2.979	1.316	2.836
1996	785	910	3594	2524	1190	1303	-0.096	-0.349	1.271	0.738	0.116	0.779
1997	2390	7432	3361	956	402	350	1.647	3.850	1.116	-0.375	-0.567	-0.552
1998	414	1950	6363	2961	2511	1901	-0.499	0.321	3.118	1.048	1.262	1.614
1999	1338	1077	2798	1957	1005	629	0.505	-0.242	0.740	0.335	-0.044	-0.161
2000	296	610	2664	2487	773	627	-0.626	-0.542	0.651	0.712	-0.246	-0.165
2001	170	431	554	663	346	275	-0.764	-0.657	-0.756	-0.583	-0.616	-0.657
2002	700	1097	341	481	338	384	-0.187	-0.229	-0.898	-0.712	-0.623	-0.504
2003	818	1457	839	447	624	1188	-0.060	0.003	-0.566	-0.736	-0.375	0.618
2004	676	910	1928	1594	623	352	-0.214	-0.349	0.161	0.078	-0.376	-0.549
2005	353	952	706	1092	847	1444	-0.565	-0.322	-0.654	-0.279	-0.182	0.976
2006	1213	4132	1476	3268	5081	2303	0.369	1.725	-0.141	1.266	3.493	2.175
2007	255	233	601	397	320	266	-0.671	-0.784	-0.724	-0.772	-0.639	-0.670

Exhibit DWR-1352

Water Year	Mean Delta Outflow (m^3s^{-1})						z-Scores					
	December	January	February	March	April	May	December	January	February	March	April	May
2008	203	695	683	346	270	233	-0.727	-0.487	-0.670	-0.808	-0.682	-0.716
2009	201	179	644	564	341	450	-0.729	-0.820	-0.695	-0.653	-0.621	-0.412
2010	180	763	849	485	697	586	-0.752	-0.443	-0.559	-0.710	-0.312	-0.223
2011	1363	1118	800	2949	2408	1333	0.532	-0.215	-0.592	1.039	1.173	0.820
2012	152	323	306	570	787	354	-0.783	-0.726	-0.921	-0.649	-0.234	-0.546
2013	1365	629	380	271	363	283	0.534	-0.530	-0.872	-0.861	-0.602	-0.645
Mean	873	1452	1687	1484	1056	745						
Standard Deviation	921	1553	1500	1409	1152	716						

Source: DAYFLOW database (https://www.water.ca.gov/Programs/Environmental-Services/Compliance-Monitoring-And-Assessment/Dayflow-Data)

Script B1. SAS Code Used to Calculate Principal Components from Historical Delta Outflow Data and Calculate Principal Components Inputs for Model Simulation

```
data dayflow; *these are the values from DAYFLOW (1956-2013) to reproduce
Nobriga and Rosenfield (2016);
input WY Jan Feb Mar Apr May Dec;
datalines;
1956  2.497892988 0.728011235 0.223499101 0.071789265 1.318906178 2.896130337
1957  -0.648197256      -0.662694939      0.22510573  -0.413313165
      0.253861395 -0.51974631
1958  -0.123884555      2.353256512 1.188962022 2.862931609 2.077757952 -
0.123094026
1959  -0.335195741      -0.016015846      -0.497709497      -0.630564671
      -0.75161188 -0.504008801
1960  -0.675319342      -0.193935835      -0.384877832      -0.501839817
      -0.549799112      -0.734590539
1961  -0.650730415      -0.332125848      -0.482318793      -0.587383576
      -0.701139875      -0.360947928
1962  -0.731797374      0.286595319 -0.098866709      -0.243604447      -
0.321809013 -0.451658547
1963  -0.55202425 0.822950523 -0.46715242 1.609328078 1.060155834 0.128627769
1964  -0.388416183      -0.730197562      -0.790890802      -0.690873034
      -0.653542873      -0.246110825
1965  1.537344245 -0.063176807      -0.493685143      0.482089138 0.239541223
      2.386505607
1966  -0.142441648      -0.437107657      -0.564658864      -0.451008554
      -0.651519911      -0.021303573
1967  0.204950967 0.463627791 0.078445379 0.992645704 1.907392929 0.910918958
1968  -0.492559701      -0.142111662      -0.24336025 -0.672561949      -
0.774000941 -0.317647212
1969  1.309915043 1.877920526 0.825745817 0.788403088 1.512513578 -
0.158263645
1970  2.585570386 0.97690051  0.071624012 -0.645640533      -0.614892311
      0.472293039
1971  0.235353576 -0.479432288      -0.409483638      -0.007968942
      0.003715654 1.676931094
1972  -0.54575133 -0.710305054      -0.689296466      -0.731292433      -
0.837148984 -0.210988814
1973  0.918841904 0.803924837 0.492121283 -0.371248709      -0.577814456
      -0.113644776
1974  1.593539443 -0.007724224      0.505555893 1.77574996  -0.03034434
      1.401359539
1975  -0.615922414      -0.042616336      0.289665902 -0.068258461
      0.098217055 -0.086447558
1976  -0.765020092      -0.984023829      -0.897102739      -0.702121353
      -0.884702619      -0.334386479
1977  -0.855199485      -1.03298438 -0.993195117      -0.843488893      -
0.885814865 -0.818369196
1978  0.271213531 -0.064741264      0.667216638 0.586754222 0.571247021 -
0.684410429
1979  -0.378347641      -0.25010919 -0.288128669      -0.560661238      -
0.509174058 -0.677958516
```

1980	1.220240165	1.171917633	0.939221948	-0.213042279	-0.217805048	-0.362837381
1981	-0.600682889	-0.725347397	-0.52134925	-0.630386075	-0.678889845	-0.563976379
1982	0.84571782	0.622476821	0.556064219	2.578081223	1.244355058	1.705170734
1983	0.701485948	2.193427673	4.305240494	1.985943617	2.860662054	1.785746742
1984	0.904627873	-0.341223603	-0.351868669	-0.556912345	-0.601776222	3.805175575
1985	-0.659105479	-0.830733132	-0.844410747	-0.748396761	-0.752114432	0.00728817
1986	-0.657490209	2.753408874	2.352099339	0.227158628	-0.415247913	-0.657959075
1987	-0.737525206	-0.806768617	-0.593048483	-0.763975643	-0.848817367	-0.671604796
1988	-0.577615739	-1.067706094	-0.9635814	-0.636044643	-0.856187275	-0.65722313
1989	-0.869031307	-1.004656919	-0.271214974	-0.629431647	-0.748637387	-0.72557869
1990	-0.754521713	-0.996933761	-0.976997856	-0.771090021	-0.735923084	-0.812647277
1991	-0.862302678	-0.986097874	-0.559615294	-0.825685744	-0.887686041	-0.751636284
1992	-0.817817165	-0.582086176	-0.7866687	-0.762840161	-0.911705206	-0.713538757
1993	0.120443545	-0.086208042	0.23207168	0.172027933	-0.044431094	-0.591158718
1994	-0.738090286	-0.736947306	-0.840686583	-0.716358302	-0.726391184	-0.56784951
1995	1.024601282	0.250150889	2.979138587	1.3158903	2.836488552	-0.651830502
1996	-0.34878295	1.271190057	0.738150161	0.116395857	0.77931745	-0.095938466
1997	3.849528394	1.115671892	-0.374794581	-0.567339775	-0.552074625	1.647442729
1998	0.320693624	3.117629301	1.048411141	1.262417771	1.61439254	-0.498581458
1999	-0.241648211	0.740469922	0.335351098	-0.044306831	-0.161428698	0.504620047
2000	-0.541981581	0.651499335	0.711831396	-0.245830353	-0.164716968	-0.626070459
2001	-0.65744258	-0.755623011	-0.582769427	-0.61634247	-0.656577315	-0.763530418
2002	-0.228711344	-0.897955557	-0.712313147	-0.623121774	-0.504448287	-0.187311633
2003	0.002962722	-0.565772108	-0.736482608	-0.374627301	0.617860603	-0.059756179
2004	-0.348895261	0.160564635	0.077930583	-0.375791457	-0.549078448	-0.214418593
2005	-0.321811395	-0.65432442	-0.278658763	-0.18171411	0.976156998	-0.565071369
2006	1.725183728	-0.140823101	1.265660738	3.493478173	2.175298898	0.368955317
2007	-0.784471552	-0.724157195	-0.772171432	-0.638777665	-0.669508455	-0.670590144

```
2008	-0.487032381	-0.669519325	-0.808023642	-0.682187332
	-0.715572292	-0.726973216
2009	-0.819772895	-0.695491218	-0.653126561	-0.620749222
	-0.412288725	-0.72919196
2010	-0.443376554	-0.558988298	-0.709512244	-0.311939833
	-0.222620106	-0.752026077
2011	-0.21514295 -0.59167466 1.03937369	1.173498697 0.820364699 0.532193172
2012	-0.72649056 -0.921243899	-0.649411474	-0.233904512	-
0.546430485 -0.782536037
2013	-0.529556872	-0.872009846	-0.861054077	-0.601957237
	-0.644533932	0.534054853
;
run;

*PCA to get similar values to Nobriga and Rosenfield (2016), outstat option
stores model coefficients for subsequent prediction;
proc princomp data = dayflow outstat=dayflowstat out=dayflow1;
	var jan--dec;
run;


*the scenario data to be analyzed;

*Existing Conditions model input data;

data outflow_existing; *these are z-scores of monthly mean Delta outflow from
CalSim, standardized to mean and standard deviation from DAYFLOW data for WY
1956-2013;
	input WY Jan Feb Mar Apr May Dec;
	datalines;
1922	-0.701035649	-0.377707791	-0.547777457	-0.225144399
	1.121148376 -0.665043022
1923	-0.40726753 -0.829565176	-0.846235931	-0.220943656	-
0.349904392 -0.072675322
1924	-0.784063153	-0.849814494	-0.879878484	-0.762921279
	-0.882230677	-0.809546788
1925	-0.787786765	0.265914121 -0.784753982	-0.206788098	-
0.392749086 -0.687481403
1926	-0.674433498	-0.234571238	-0.802075616	-0.246723381
	-0.648014819	-0.807791401
1927	-0.347571783	1.212429913 -0.278779887	0.353667273 0.002700611
	-0.504430767
1928	-0.551146236	-0.644813901	0.462355967 -0.256021707	-
0.650012405 -0.771561125
1929	-0.774501915	-0.847537389	-0.88906328 -0.714029716	-
0.759653983 -0.809546788
1930	-0.593551426	-0.797937596	-0.444950593	-0.627798297
	-0.702765176	-0.528566718
1931	-0.741615668	-0.919168468	-0.897091437	-0.724542626
	-0.855591638	-0.809546788
1932	-0.619637718	-0.825264942	-0.831452493	-0.626299619
	-0.500877878	-0.506511054
1933	-0.717249289	-0.9321111	-0.782166324	-0.687625112	-
0.739762976 -0.809546788
```

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1934	-0.665804899	-0.853280795	-0.840085556	-0.678910335	-0.762372418	-0.625488106
1935	-0.400337928	-0.922280743	-0.496001653	0.402027515	-0.238096871	-0.831943469
1936	-0.176157699	0.369879264	-0.494836417	-0.254037839	-0.367565878	-0.809546788
1937	-0.729976108	-0.217672258	-0.067648377	-0.219902135	-0.222151398	-0.809546788
1938	-0.404918274	1.441257016	2.315575877	0.995496903	1.663718757	1.069032042
1939	-0.806826963	-0.94186086	-0.836504859	-0.678910335	-0.685577023	-0.800409176
1940	-0.30820219	0.130001834	1.046938955	0.850646688	-0.309231512	-0.809546788
1941	0.846488664	1.03751106	0.726779388	0.980421272	0.863057557	0.10546366
1942	0.487446838	1.499179478	-0.560336512	0.423628002	0.489943276	0.330094221
1943	0.362238279	-0.034782218	0.687144485	-0.103661854	-0.272764405	-0.4989481
1944	-0.730112572	-0.644695818	-0.680395938	-0.629948927	-0.679237509	-0.795441973
1945	-0.76379455	-0.0764234	-0.626100801	-0.514585037	-0.455759005	-0.57767921
1946	-0.085849892	-0.82736874	-0.725318095	-0.485144075	-0.462977801	1.177113544
1947	-0.793168049	-0.809134068	-0.64719054	-0.608554829	-0.730532172	-0.680459645
1948	-0.697126104	-0.91466277	-0.782241441	-0.255810542	0.111185309	-0.805130794
1949	-0.795884934	-0.909419648	-0.13440808	-0.592228743	-0.582110694	-0.736789186
1950	-0.574622236	-0.440857149	-0.727093683	-0.388572353	-0.457477296	-0.809546788
1951	0.209765596	0.207828365	-0.49409279	-0.499605748	-0.332546028	1.845653926
1952	0.572878193	0.25566286	0.253108981	0.950527498	1.79109874	0.063122626
1953	0.840204994	-0.676891038	-0.691395863	-0.432654423	-0.052887518	-0.225794886
1954	-0.544424516	-0.09992865	-0.284893146	0.154508476	-0.548503465	-0.809546788
1955	-0.623875819	-0.932597572	-0.90016953	-0.63674188	-0.625758137	-0.536228909
1956	1.976445296	0.476801703	-0.28451621	-0.383194336	0.693477737	1.872473965
1957	-0.761618838	-0.77171977	-0.342979628	-0.570865294	-0.23263328	-0.79489776
1958	-0.213113062	2.10985545	0.891235981	1.648597927	0.9906632	-0.440949963
1959	-0.573046299	-0.275382894	-0.821725797	-0.665974581	-0.678622541	-0.791452293
1960	-0.76470734	-0.540190565	-0.738612671	-0.6073897	-0.698071783	-0.809546788
1961	-0.759737148	-0.480428091	-0.780453762	-0.698900057	-0.709252543	-0.607525728

1962	-0.825352548	-0.056410984	-0.655719456	-0.562156542	-0.582944102	-0.604588187
1963	-0.624596197	0.210033208	-0.56782856	1.433022007	0.088477344	-0.212905824
1964	-0.548612205	-0.916428732	-0.896974916	-0.687517633	-0.666441443	-0.809546788
1965	1.038307049	-0.445561488	-0.710410019	0.314241254	-0.254370873	1.479202426
1966	-0.479777197	-0.687956742	-0.70383295	-0.5731974	-0.642952622	-0.750926039
1967	-0.024440213	-0.10620752	0.039430855	0.533107204	1.115412943	0.0894805
1968	-0.541919216	-0.119998817	-0.435622071	-0.654780353	-0.646719778	-0.789514466
1969	1.224158199	1.532226609	0.308282274	0.558498681	1.272880437	-0.501453922
1970	2.864122507	0.353927597	-0.310688581	-0.613860361	-0.557642734	0.257608267
1971	-0.051810859	-0.714583541	-0.307800438	-0.348630733	0.104654888	0.589811803
1972	-0.717952079	-0.786061209	-0.548947129	-0.6071992	-0.650615481	-0.742429385
1973	0.53727344	0.455568561	0.031800822	-0.435516794	-0.29986272	-0.285742185
1974	1.473532169	-0.336794869	1.113617477	0.771505288	-0.123807001	0.813361655
1975	-0.758969757	-0.105670286	0.597305078	-0.274058692	0.182487999	-0.78331501
1976	-0.804118489	-0.943154696	-0.842638865	-0.706538607	-0.882230677	-0.793161034
1977	-0.737293705	-0.983077525	-0.908146861	-0.742156524	-0.882230677	-0.840293797
1978	0.290956714	-0.129890447	0.320040076	0.252835716	-0.059104702	-0.596123121
1979	-0.539142625	-0.444634457	-0.502232483	-0.4496135	-0.298666763	-0.792522088
1980	0.877373544	1.375766368	0.223678754	-0.373746097	-0.320065942	-0.59851253
1981	-0.580841287	-0.693383553	-0.668042819	-0.575621072	-0.695133711	-0.789701891
1982	0.462365707	0.822596434	0.583730037	2.517344188	0.789495941	1.497749598
1983	0.978536288	2.378227092	4.329164572	1.141581756	1.927076699	1.544398576
1984	0.223105648	-0.364357698	-0.361596395	-0.50370194	-0.517087241	3.839624359
1985	-0.750738623	-0.86569554	-0.818581058	-0.593527752	-0.664473088	-0.560725177
1986	-0.510373236	2.967166468	1.767365148	-0.27352293	-0.269152439	-0.601011926
1987	-0.757712621	-0.779197423	-0.59261013	-0.688469965	-0.731840631	-0.807414675
1988	-0.44726561	-0.873774815	-0.928634942	-0.670582534	-0.768550678	-0.541514752
1989	-0.771718276	-0.962038286	-0.104818081	-0.44029002	-0.600852756	-0.819354213

```
1990	-0.665540658	-0.897817963	-0.881739494	-0.684972778	-0.782057109	-0.809546788
1991	-0.770981913	-0.984406053	-0.362162624	-0.63551634 	-0.789582559 -0.835195896
1992	-0.811960828	-0.478172209	-0.711026613	-0.6745874	-0.803244605 -0.80966245
1993	0.250758406 -0.056021703	-0.32665651 0.053141397 0.11324769	-0.696402374
1994	-0.768274818	-0.710724033	-0.894452188	-0.66176419 -0.735247845 -0.788159136
1995	1.128966536 -0.233571853	3.149932729 0.766874343 2.400481605 -0.670874235
1996	-0.109377907	1.206578898 0.320704758 0.19443411	0.886332455 -0.463454672
1997	4.151556085 0.27368484	-0.603877428	-0.487734077	-0.506523535 1.210598718
1998	-0.057505096	3.041061395 0.615502434 0.671070428 1.353866315 -0.644486965
1999	-0.195931305	0.701899439 0.135658941 -0.181403246	-0.237696365 -0.048745081
2000	-0.537330787	0.810673729 0.172914695 -0.39122135 -0.318867436	-0.800936409
2001	-0.693670737	-0.619079505	-0.598570016	-0.601840073	-0.717289939	-0.798567959
2002	-0.054029169	-0.854402595	-0.709723117	-0.50500599 -0.530687099 -0.085358343
2003	0.197854765 -0.668951419	-0.685054487	-0.234890545	0.501870872 0.137912684
;
run;

*NAA model input data;

data outflow_naa; *these are z-scores of monthly mean Delta outflow from CalSim, standardized to mean and standard deviation from DAYFLOW data for WY 1956-2013;
	input WY Jan Feb Mar Apr May Dec;
	datalines;
1922	-0.698761675	-0.273383311	-0.427686862	-0.139829909	1.248596783 -0.661174424
1923	-0.413983198	-0.837994365	-0.844013374	-0.209258189	-0.403922201	0.017086187
1924	-0.785442396	-0.824823553	-0.870153123	-0.759207191	-0.882230677	-0.809546788
1925	-0.787992698	0.326269919 -0.767618775	-0.217922539	-0.423200961 -0.66457413
1926	-0.67641297 -0.218879633	-0.821526338	-0.349099003	-0.570288283 -0.809546788
1927	-0.341973423	1.39450525	-0.181967828	0.279663634 -0.118358856 -0.493501826
1928	-0.554049535	-0.656507558	0.481918334 -0.320120118	-0.625454205 -0.773064981
1929	-0.778276919	-0.851683013	-0.850455186	-0.723191077	-0.759653983	-0.809546788
```

1930	-0.593308796	-0.788256907	-0.446163918	-0.64201537	-0.731210062	-0.510066567
1931	-0.749427442	-0.897386033	-0.913339615	-0.724542626	-0.882230677	-0.809546788
1932	-0.617607993	-0.848856449	-0.827523634	-0.61350593	-0.532358241	-0.515530827
1933	-0.716635398	-0.931720307	-0.780412641	-0.678910335	-0.75416929	-0.761056233
1934	-0.667197235	-0.847913173	-0.833804595	-0.678910335	-0.759653983	-0.634661885
1935	-0.402207869	-0.927292126	-0.501641798	0.298672728	-0.374282342	-0.819733641
1936	-0.181974194	0.599962422	-0.475732953	-0.272122106	-0.437750109	-0.809546788
1937	-0.684885969	-0.170337455	-0.063995448	-0.239232849	-0.223596029	-0.809546788
1938	-0.407491575	1.993201579	2.532850952	1.070387541	1.778450913	1.117909217
1939	-0.808597806	-0.94266461	-0.842026981	-0.678910335	-0.640290912	-0.792246806
1940	-0.302288073	0.195201591	1.286169128	0.856013232	-0.419996259	-0.809546788
1941	0.936860768	1.298425295	0.803030565	0.958865235	0.76809599	0.44569757
1942	0.585207993	1.781734869	-0.519313124	0.419599206	0.431546665	0.536585608
1943	0.289664065	-0.018368843	0.645426344	-0.140143705	-0.367545335	-0.504735084
1944	-0.734497498	-0.647319297	-0.698827692	-0.641821102	-0.699548039	-0.809546788
1945	-0.77146112	-0.020641763	-0.592292392	-0.514458741	-0.501395192	-0.71554614
1946	-0.030685646	-0.819059994	-0.76730563	-0.482467331	-0.517983938	1.692396421
1947	-0.797062606	-0.800883238	-0.675697976	-0.682723045	-0.715666272	-0.768853587
1948	-0.697401648	-0.91466277	-0.781207555	-0.247064635	0.028298458	-0.809546788
1949	-0.797074105	-0.910437841	-0.143360333	-0.620681803	-0.608505807	-0.725961149
1950	-0.577011188	-0.434544794	-0.720019575	-0.419056228	-0.520789139	-0.809546788
1951	0.307814845	0.267365184	-0.487676082	-0.534892132	-0.462288886	2.043738408
1952	0.676110999	0.501494415	0.332295015	0.975192785	1.78127963	0.222450504
1953	0.884237104	-0.666089636	-0.675409169	-0.462273044	-0.131464029	-0.126659803
1954	-0.576065555	-0.119098707	-0.311193491	-0.04123126	-0.512172782	-0.799581469
1955	-0.628192851	-0.936278684	-0.889844504	-0.670892825	-0.67717509	-0.539213921
1956	2.272248551	0.613504795	-0.225929528	-0.377563584	0.49569431	2.053440291
1957	-0.762825685	-0.756106936	-0.390295675	-0.586670139	-0.287421633	-0.795602119

1958	-0.178929269	2.308149449	0.938318062	1.706410633	0.7896609	-0.401292267
1959	-0.58975814	-0.260894681	-0.830027009	-0.6667854	-0.666112335	-0.791452293
1960	-0.76721604	-0.516104417	-0.709218874	-0.584655477	-0.733560736	-0.809362606
1961	-0.762440753	-0.523511375	-0.741460144	-0.714261019	-0.695434824	-0.590261883
1962	-0.825352548	0.139681343	-0.638273225	-0.548950939	-0.602640127	-0.567651121
1963	-0.628799764	0.262834686	-0.559086366	1.503295524	0.044758194	-0.19909237
1964	-0.554730394	-0.918889341	-0.900433831	-0.686636946	-0.656396518	-0.809546788
1965	1.346866762	-0.432640578	-0.706124088	0.204933615	-0.379161701	1.715666862
1966	-0.480069207	-0.668407436	-0.693445694	-0.612891972	-0.608505807	-0.75002241
1967	0.009445089	-0.102137477	0.054922059	0.593146577	1.109360718	0.141750295
1968	-0.544927933	-0.226984981	-0.454729067	-0.665700364	-0.662735877	-0.789157618
1969	1.566506661	1.816509056	0.416114279	0.550519238	1.314227366	-0.472874667
1970	3.456019532	0.384315847	-0.303713338	-0.614146098	-0.569647829	0.348638751
1971	0.011328666	-0.70775088	-0.306667902	-0.313386592	0.012009782	0.694698498
1972	-0.721494137	-0.800984394	-0.709770774	-0.668330713	-0.707510312	-0.744229647
1973	0.542692115	0.546855302	0.122372432	-0.443158872	-0.384888099	-0.322936217
1974	1.574894286	-0.317326104	1.161251655	0.749659122	-0.266666307	1.086588825
1975	-0.757926004	-0.066458975	0.535386111	-0.259007014	0.122489287	-0.783069004
1976	-0.80551872	-0.944272569	-0.808820759	-0.704194621	-0.667426026	-0.793177759
1977	-0.82201628	-0.97943612	-0.908146861	-0.742156524	-0.882230677	-0.809546788
1978	0.354997904	0.033976531	0.447965972	0.226133757	-0.016088793	-0.563285286
1979	-0.540981308	-0.457963308	-0.502823483	-0.453202108	-0.390447607	-0.792938674
1980	0.957680157	1.609460589	0.284813779	-0.375184075	-0.334298415	-0.609165108
1981	-0.581936735	-0.679674234	-0.674858525	-0.605653335	-0.735856983	-0.789545513
1982	0.572985142	0.952250429	0.693098993	2.727549724	0.740170869	2.010406729
1983	1.100310077	2.804696344	4.807690869	1.220778263	1.824381339	1.646571367
1984	0.396130702	-0.295197498	-0.341680176	-0.506124652	-0.546127499	5.038439668
1985	-0.747429368	-0.862970979	-0.818224221	-0.584364651	-0.684016124	-0.618690405

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1986	-0.498781579	3.363327864 1.865599059 -0.24788059 -0.324291563
	-0.594139999
1987	-0.761478226	-0.739130808	-0.610236665	-0.678889837
	-0.706857733	-0.809546788
1988	-0.445405353	-0.824943664	-0.942404427	-0.675580054
	-0.759653983	-0.51988276
1989	-0.792242379	-0.962038286	-0.059299096	-0.447333117
	-0.570559354	-0.80299751
1990	-0.675957794	-0.906681535	-0.841517949	-0.684972778
	-0.803375816	-0.809546788
1991	-0.852695139	-0.896267515	-0.370142741	-0.640695528
	-0.805416129	-0.764935385
1992	-0.833182987	-0.469238957	-0.712504366	-0.699201108
	-0.748684578	-0.779188846
1993	0.292683427 -0.018749347	-0.120500306	0.077349216 0.011165986
	-0.635325378
1994	-0.771711351	-0.701120603	-0.900103894	-0.6687006	-
0.749826841 -0.788103767
1995	1.308173721 0.010998558 3.43403126  0.792430758 2.06673721	-
0.611008367
1996	-0.183921713	1.454701442 0.395546802 0.160894891 0.595195355 -
0.43920477
1997	4.69872405  0.397574852 -0.524575981	-0.500298383	-
0.511160126 1.562923649
1998	0.034833539 3.633512413 0.747902573 0.666817554 1.230636888 -
0.649781726
1999	-0.190504157	0.946970133 0.231169349 -0.173540162	-
0.358262421 0.012113879
2000	-0.547293459	0.964261198 0.264823208 -0.420123191	-0.4566959
	-0.802579963
2001	-0.698127117	-0.609374883	-0.604910803	-0.670369424
	-0.749198281	-0.809546788
2002	0.040661	-0.869091994	-0.714890189	-0.542676491	-
0.597473866 -0.02565696
2003	0.254149457 -0.652930496	-0.650402348	-0.228339479
	0.630378851 0.310955649
;
run;

*CWF H3+ model input data;

data outflow_cwf; *these are z-scores of monthly mean Delta outflow from
CalSim, standardized to mean and standard deviation from DAYFLOW data for WY
1956-2013;
	input WY Jan Feb Mar Apr May Dec;
	datalines;
1922	-0.674903555	-0.341808244	-0.423750702	-0.13980898
	0.979508659 -0.633772023
1923	-0.400470083	-0.837994365	-0.839139172	-0.20844569 -
0.395347084 -0.089812035
1924	-0.770356771	-0.833010124	-0.865290443	-0.756395319
	-0.882217731	-0.809546788
1925	-0.793238701	0.229989792 -0.681733822	-0.21717686 -
0.389783135 -0.663539752
```

1926	-0.68703019	-0.324541224	-0.802075616	-0.367566238	-0.554743006	-0.809546788
1927	-0.450150574	1.330685898	-0.169764079	0.283756274	-0.113698826	-0.543350775
1928	-0.572121564	-0.746931324	0.602692572	-0.322235178	-0.6230626	-0.718661932
1929	-0.753476531	-0.847581882	-0.855852769	-0.723741408	-0.759645198	-0.809546788
1930	-0.619653133	-0.8203074	-0.48942796	-0.641905107	-0.731210062	-0.541128313
1931	-0.758311595	-0.906503766	-0.906223287	-0.724542626	-0.882230677	-0.809546788
1932	-0.66099408	-0.846333204	-0.760672308	-0.60758308	-0.52341154	-0.399141238
1933	-0.725729533	-0.921253164	-0.787953032	-0.678910335	-0.754167919	-0.76199786
1934	-0.6744874	-0.85803007	-0.824508773	-0.678910335	-0.759653983	-0.650173961
1935	-0.452138822	-0.928659108	-0.592671291	0.224629823	-0.374030964	-0.71947338
1936	-0.326879601	0.593677873	-0.425012115	-0.271130844	-0.424180061	-0.809546788
1937	-0.688900203	-0.180931457	-0.102964805	-0.239263042	-0.223442268	-0.809391792
1938	-0.450106178	2.093115929	2.532753911	0.956722189	1.702155571	1.04265231
1939	-0.705572472	-0.922629218	-0.812278271	-0.678910335	-0.62930106	-0.809508414
1940	-0.353099971	0.102863172	1.239941258	0.681146163	-0.390103864	-0.809546788
1941	0.838000925	1.364917541	0.867608734	0.809065527	0.76970033	0.300406182
1942	0.4685645	1.750639895	-0.51916666	0.419749263	0.430952162	0.440287057
1943	0.397438447	-0.048694401	0.615635747	-0.138975263	-0.358359188	-0.508836837
1944	-0.638184485	-0.667155733	-0.73012199	-0.641952894	-0.678507123	-0.809546788
1945	-0.77806003	-0.061543031	-0.593249806	-0.499801744	-0.460929785	-0.589684806
1946	-0.136852725	-0.820958697	-0.668458422	-0.482294137	-0.504553982	1.514771911
1947	-0.770591533	-0.805288868	-0.66035669	-0.682715701	-0.716912698	-0.752095611
1948	-0.707523693	-0.91466277	-0.805380108	-0.236482324	0.043340361	-0.809546788
1949	-0.781091462	-0.894462997	-0.24876875	-0.609020938	-0.599878368	-0.740525893
1950	-0.586491235	-0.499820741	-0.617629041	-0.417368922	-0.519318172	-0.809546788
1951	0.394286643	0.267904188	-0.492016933	-0.5347727	-0.458047433	2.001075973
1952	0.612283281	0.529649204	0.387356115	0.873801417	1.556231539	0.163629915
1953	0.739157317	-0.702022078	-0.68141365	-0.464508928	-0.124447996	0.06369553

1954 -0.479313655 -0.223543924 -0.172092823 0.064603458 -
0.538480202 -0.809357246
1955 -0.62801726 -0.927237473 -0.889068796 -0.653235016 -
0.642206829 -0.503962926
1956 2.28073159 0.606011396 -0.224781369 -0.378305086 0.500520459
1.98488527
1957 -0.670312261 -0.743558712 -0.1921327 -0.60013983 -
0.263285563 -0.809541083
1958 -0.32402173 2.412779718 0.999643007 1.594411753 0.789961627 -
0.414103861
1959 -0.480888951 -0.330961409 -0.772891897 -0.68123332 -
0.646255868 -0.809541593
1960 -0.747676502 -0.587945588 -0.660499778 -0.613329255
-0.712141536 -0.809546788
1961 -0.769551731 -0.588995939 -0.784863565 -0.691158133
-0.704316267 -0.585482134
1962 -0.825352548 0.050518093 -0.521446963 -0.546610409 -
0.599983707 -0.603309874
1963 -0.644209966 0.206350602 -0.57957957 1.298961523 0.052374908 -
0.323265546
1964 -0.468747345 -0.911245204 -0.895275415 -0.676767049
-0.656574529 -0.809546202
1965 1.277566966 -0.443682053 -0.71474659 0.204094042 -0.372513043
1.49405131
1966 -0.340227663 -0.720977359 -0.617723217 -0.624332048
-0.608505807 -0.736142898
1967 -0.002019146 -0.1351821 0.093367348 0.463779346 0.815428881
0.134402961
1968 -0.45587073 -0.281040743 -0.616300304 -0.667232332 -
0.65767843 -0.809536354
1969 1.622961136 1.814850445 0.416275856 0.515549914 1.300745011 -
0.459136789
1970 3.380565944 0.355967229 -0.318386683 -0.610853476 -
0.560315798 0.384100982
1971 -0.011673644 -0.712881636 -0.167790208 -0.31373039
0.015369212 0.478234151
1972 -0.631664755 -0.826071051 -0.542060134 -0.636319502
-0.73232491 -0.719638886
1973 0.429651579 0.645282153 0.111399516 -0.443195066 -0.371826483
-0.36775815
1974 1.486175269 -0.366640501 1.128436933 0.566801376 -0.258169808
1.083680109
1975 -0.66452738 0.044524288 0.623709451 -0.257369391 0.135608437 -
0.763874013
1976 -0.711238459 -0.929152605 -0.815949649 -0.706358332
-0.651648872 -0.809546758
1977 -0.816990192 -0.97943612 -0.908146861 -0.742156524 -
0.882230677 -0.809546788
1978 0.227590972 -0.035949102 0.528302914 0.225775559 -0.01599303 -
0.580736315
1979 -0.51288676 -0.488520826 -0.404533121 -0.469729062 -
0.370830548 -0.809546788
1980 0.904439718 1.601032414 0.285051984 -0.374844022 -0.330891181
-0.450266577

```
1981	-0.593660334	-0.738320642	-0.665139563	-0.594369317
	-0.710852751	-0.787222448
1982	0.485648065 1.055304988 0.727637996 2.708916878 0.74023327	1.817136796
1983	1.174433419 2.822084027 4.80769715	1.221172656 1.807507274 1.523364739
1984	0.396189374 -0.295131635	-0.340669883	-0.506617547	-
0.529885739 5.048049069
1985	-0.658169854	-0.843346959	-0.817647511	-0.595213258
	-0.684016124	-0.619940193
1986	-0.532689276	3.405436876 1.859926409 -0.247522823	-
0.324190548 -0.61809246
1987	-0.66904197 -0.776083065	-0.554606902	-0.698091039	-
0.675805331 -0.809546788
1988	-0.531148514	-0.965821531	-0.906493545	-0.675556845
	-0.759653983	-0.544673226
1989	-0.798031559	-0.962038286	-0.159229416	-0.44919669 -
0.56258739	-0.805270702
1990	-0.683635668	-0.896019457	-0.836172517	-0.684972778
	-0.803287119	-0.809546788
1991	-0.852695139	-0.919431517	-0.451333737	-0.641235081
	-0.795517783	-0.755591778
1992	-0.831818216	-0.502716377	-0.728681589	-0.698248801
	-0.748684578	-0.768271586
1993	0.175458549 -0.044539244	-0.104037515	0.081266165 0.02749011
	-0.660535192
1994	-0.751789639	-0.737442289	-0.879418836	-0.669344656
	-0.749836707	-0.809393113
1995	1.238420636 -0.041669422	3.453088322 0.7031613	2.044971506 -
0.62845198
1996	-0.21847876 1.446323421 0.377755509 0.160846312 0.595136198 -
0.389612727
1997	4.673116005 0.379170524 -0.556915509	-0.496041141	-
0.535784318 1.732487398
1998	0.042815511 3.681763478 0.708300802 0.52827695	0.972477181 -
0.616181881
1999	-0.178982958	1.006533062 0.243624102 -0.174557682	-
0.352782844 -0.115975518
2000	-0.506084828	1.037303955 0.311900736 -0.419697068	-
0.447370356 -0.809545542
2001	-0.682172181	-0.675170251	-0.658501883	-0.657641596
	-0.742666469	-0.809545106
2002	-0.130823755	-0.871542535	-0.681159389	-0.531167243
	-0.577804021	-0.084012801
2003	0.125444393 -0.788562734	-0.576324345	-0.22455185 0.636876219
	0.164934861
;
run;

*get predictions of PC1 for Existing, based on PCA for observed data;
proc score data = outflow_existing score=dayflowstat out=existingpred
predict;
var jan--dec;
run;

*get predictions of PC1 for NAA, based on PCA for observed data;
```

```
proc score data = outflow_naa score=dayflowstat out=naapred predict;
var jan--dec;
run;

*get predictions of PC1 for CWF H3+, based on PCA for observed data;
proc score data = outflow_cwf score=dayflowstat out=cwfpred predict;
var jan--dec;
run;
```

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Table B2. Historical Delta Outflow Data Principal Component 1: Comparison of Reproduced and Original Values from Nobriga and Rosenfield (2016)

Water Year	Reproduced	Original (Nobriga and Rosenfield 2016, Table 2)
1956	2.73	2.77
1957	-0.62	-0.627
1958	3.72	3.74
1959	-1.12	-1.14
1960	-1.18	-1.19
1961	-1.28	-1.29
1962	-0.57	-0.575
1963	1.21	1.21
1964	-1.48	-1.5
1965	1.28	1.3
1966	-1.00	-1.02
1967	1.90	1.91
1968	-1.10	-1.12
1969	2.64	2.68
1970	0.89	0.928
1971	0.16	0.152
1972	-1.58	-1.6
1973	0.41	0.442
1974	1.96	1.97
1975	-0.11	-0.123
1976	-1.91	-1.93
1977	-2.20	-2.23
1978	0.71	0.722
1979	-1.05	-1.05
1980	1.04	1.08
1981	-1.51	-1.5
1982	3.03	3.04
1983	5.83	5.91
1984	0.54	0.492
1985	-1.65	-1.67
1986	1.70	1.71
1987	-1.79	-1.81

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Water Year	Reproduced	Original (Nobriga and Rosenfield 2016, Table 2)
1988	-1.95	-1.97
1989	-1.68	-1.7
1990	-2.04	-2.06
1991	-1.96	-1.98
1992	-1.85	-1.88
1993	0.00	0.006
1994	-1.77	-1.79
1995	3.54	3.59
1996	1.13	1.2
1997	1.58	1.6
1998	3.08	3.11
1999	0.42	0.414
2000	0.04	0.036
2001	-1.61	-1.61
2002	-1.35	-1.35
2003	-0.46	-0.468
2004	-0.51	-0.514
2005	-0.29	-0.235
2006	3.82	3.79
2007	-1.71	-1.73
2008	-1.66	-1.67
2009	-1.55	-1.57
2010	-1.16	-1.17
2011	1.21	1.21
2012	-1.51	-1.53
2013	-1.36	-1.38

Table B3. CalSim-II Mean Delta Outflow (Cubic Meters Per Second) for Existing Conditions, No Action Alternative, and California WaterFix CWF H3+ Scenarios

Water Year	Month	Existing	NAA	CWF H3+
1922	12	260.508	264.071	289.308
1922	1	363.021	366.553	403.616
1922	2	1120.870	1277.328	1174.710
1922	3	712.689	881.880	887.425
1922	4	796.722	895.016	895.040
1922	5	1547.970	1639.241	1446.536
1923	12	806.057	888.724	790.275
1923	1	819.374	808.942	829.933
1923	2	443.209	430.568	430.568
1923	3	292.201	295.333	302.200
1923	4	801.561	815.025	815.961
1923	5	494.488	455.804	461.945
1924	12	127.426	127.426	127.426
1924	1	234.042	231.899	255.334
1924	2	412.841	450.320	438.043
1924	3	244.804	258.505	265.356
1924	4	177.126	181.405	184.644
1924	5	113.267	113.267	113.277
1925	12	239.843	260.940	261.893
1925	1	228.258	227.938	219.788
1925	2	2086.125	2176.642	2032.249
1925	3	378.821	402.962	523.962
1925	4	817.871	805.042	805.901
1925	5	463.805	441.997	465.929
1926	12	129.042	127.426	127.426
1926	1	404.346	401.271	384.778
1926	2	1335.536	1359.069	1200.605
1926	3	354.417	327.014	354.417
1926	4	771.860	653.908	632.631
1926	5	280.999	336.662	347.795
1927	12	408.426	418.491	372.582
1927	1	912.108	920.805	752.757
1927	2	3505.637	3778.700	3682.988
1927	3	1091.669	1228.064	1245.258
1927	4	1463.596	1378.333	1383.048
1927	5	747.003	660.307	663.645
1928	12	162.409	161.024	211.127
1928	1	595.866	591.356	563.282
1928	2	720.285	702.748	567.137
1928	3	2135.828	2163.389	2333.543
1928	4	761.147	687.296	684.859
1928	5	279.568	297.156	298.868
1929	12	127.426	127.426	127.426

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Water Year	Month	Existing	NAA	CWF H3+
1929	1	248.895	243.031	281.557
1929	2	416.256	410.039	416.189
1929	3	231.864	286.257	278.653
1929	4	233.456	222.901	222.266
1929	5	201.050	201.050	201.056
1930	12	386.198	403.236	374.629
1930	1	529.992	530.369	489.444
1930	2	490.642	505.160	457.093
1930	3	857.558	855.848	794.895
1930	4	332.807	316.427	316.554
1930	5	241.790	221.419	221.419
1931	12	127.426	127.426	127.426
1931	1	299.982	287.847	274.046
1931	2	308.829	341.497	327.823
1931	3	220.553	197.662	207.687
1931	4	221.343	221.343	221.343
1931	5	132.345	113.267	113.267
1932	12	406.510	398.203	505.394
1932	1	489.468	492.621	425.223
1932	2	449.658	414.278	418.062
1932	3	313.029	318.564	412.749
1932	4	334.533	349.274	356.097
1932	5	386.370	363.825	370.233
1933	12	127.426	172.084	171.217
1933	1	337.834	338.787	324.660
1933	2	289.419	290.005	305.703
1933	3	382.467	384.937	374.314
1933	4	263.878	273.918	273.918
1933	5	215.294	204.977	204.978
1934	12	296.937	288.488	274.202
1934	1	417.750	415.587	404.262
1934	2	407.642	415.692	400.520
1934	3	300.866	309.715	322.812
1934	4	273.918	273.918	273.918
1934	5	199.103	201.050	201.050
1935	12	106.799	118.044	210.380
1935	1	830.139	827.234	749.669
1935	2	304.161	296.646	294.596
1935	3	785.634	777.687	649.439
1935	4	1519.313	1400.234	1314.926
1935	5	574.558	477.030	477.210
1936	12	127.426	127.426	127.426
1936	1	1178.391	1169.355	944.252
1936	2	2242.044	2587.105	2577.680
1936	3	787.275	814.189	885.648

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Water Year	Month	Existing	NAA	CWF H3+
1936	4	763.432	742.597	743.739
1936	5	481.840	431.578	441.296
1937	12	127.426	127.426	127.569
1937	1	318.063	388.108	381.873
1937	2	1360.879	1431.868	1415.980
1937	3	1389.125	1394.271	1339.369
1937	4	802.761	780.490	780.455
1937	5	585.977	584.943	585.053
1938	12	1857.527	1902.541	1833.232
1938	1	823.023	819.026	752.826
1938	2	3848.814	4676.579	4826.422
1938	3	4746.761	5052.872	5052.736
1938	4	2203.075	2289.360	2158.401
1938	5	1936.527	2018.691	1964.053
1939	12	135.841	143.358	127.461
1939	1	198.680	195.929	355.973
1939	2	274.797	273.591	303.639
1939	3	305.911	298.131	340.043
1939	4	273.918	273.918	273.918
1939	5	254.099	286.530	294.401
1940	12	127.426	127.426	127.426
1940	1	973.267	982.454	903.520
1940	2	1882.294	1980.076	1841.594
1940	3	2959.426	3296.468	3231.339
1940	4	2036.187	2042.370	1840.898
1940	5	523.616	444.292	465.700
1941	12	970.116	1283.459	1149.651
1941	1	2767.018	2907.406	2753.833
1941	2	3243.307	3634.606	3734.326
1941	3	2508.365	2615.792	2706.774
1941	4	2185.706	2160.870	1988.280
1941	5	1363.140	1295.134	1296.283
1942	12	1176.992	1367.163	1278.476
1942	1	2209.265	2361.132	2179.933
1942	2	3935.682	4359.437	4312.803
1942	3	694.995	752.791	752.997
1942	4	1544.200	1539.559	1539.731
1942	5	1095.938	1054.117	1053.692
1943	12	413.476	408.146	404.368
1943	1	2014.760	1902.020	2069.442
1943	2	1635.164	1659.779	1614.299
1943	3	2452.525	2393.749	2351.778
1943	4	936.687	894.655	896.001
1943	5	549.731	481.855	488.433
1944	12	140.416	127.426	127.426

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Water Year	Month	Existing	NAA	CWF H3+
1944	1	317.851	311.040	460.657
1944	2	720.462	716.528	686.778
1944	3	525.847	499.879	455.790
1944	4	330.329	316.650	316.499
1944	5	258.639	244.094	259.162
1945	12	340.967	213.997	329.910
1945	1	265.528	253.619	243.367
1945	2	1572.714	1656.371	1595.030
1945	3	602.342	649.973	648.624
1945	4	463.245	463.390	480.277
1945	5	418.681	385.999	414.978
1946	12	1957.066	2431.622	2268.036
1946	1	1318.679	1404.374	1239.449
1946	2	446.503	458.964	456.117
1946	3	462.558	403.403	542.666
1946	4	497.165	500.249	500.448
1946	5	413.512	374.119	383.737
1947	12	246.310	164.903	180.336
1947	1	219.898	213.848	254.969
1947	2	473.850	486.224	479.617
1947	3	572.629	532.466	554.080
1947	4	354.978	269.525	269.534
1947	5	221.905	232.551	231.658
1948	12	131.493	127.426	127.426
1948	1	369.094	368.666	352.942
1948	2	315.586	315.586	315.586
1948	3	382.361	383.818	349.762
1948	4	761.390	771.466	783.659
1948	5	824.693	765.335	776.107
1949	12	194.433	204.405	190.991
1949	1	215.677	213.830	238.658
1949	2	323.450	321.923	345.880
1949	3	1295.069	1282.457	1133.951
1949	4	373.788	341.006	354.441
1949	5	328.196	309.293	315.471
1950	12	127.426	127.426	127.426
1950	1	559.397	555.686	540.959
1950	2	1026.164	1035.630	937.735
1950	3	460.057	470.023	614.277
1950	4	608.429	573.307	575.251
1950	5	417.451	372.111	373.164
1951	12	2572.766	2755.195	2715.904
1951	1	1777.902	1930.217	2064.546
1951	2	1999.013	2088.301	2089.110
1951	3	788.323	797.363	791.248

Water Year	Month	Existing	NAA	CWF H3+
1951	4	480.503	439.848	439.985
1951	5	506.919	414.005	417.042
1952	12	931.122	1077.857	1023.685
1952	1	2341.978	2502.345	2403.192
1952	2	2070.751	2439.430	2481.655
1952	3	1841.028	1952.590	2030.164
1952	4	2151.264	2179.682	2062.865
1952	5	2027.749	2020.717	1859.551
1953	12	665.039	756.339	931.649
1953	1	2757.256	2825.658	2600.284
1953	2	672.178	688.377	634.489
1953	3	510.350	532.873	524.413
1953	4	557.640	523.515	520.939
1953	5	707.194	650.922	655.947
1954	12	127.426	136.603	127.600
1954	1	606.308	557.155	707.454
1954	2	1537.462	1508.712	1352.073
1954	3	1083.057	1046.003	1241.977
1954	4	1234.136	1008.616	1130.553
1954	5	352.263	378.281	359.441
1955	12	379.141	376.392	408.857
1955	1	482.884	476.178	476.451
1955	2	288.689	283.168	296.728
1955	3	216.216	230.763	231.856
1955	4	322.502	283.156	303.500
1955	5	296.938	260.116	285.158
1956	12	2597.466	2764.130	2700.993
1956	1	4522.346	4981.860	4995.038
1956	2	2402.398	2607.415	2596.177
1956	3	1083.588	1166.128	1167.746
1956	4	614.625	621.113	620.259
1956	5	1241.697	1100.056	1103.512
1957	12	140.917	140.268	127.431
1957	1	268.908	267.033	410.748
1957	2	529.961	553.376	572.195
1957	3	1001.221	934.559	1213.743
1957	4	398.402	380.192	364.673
1957	5	578.471	539.235	556.519
1958	12	466.890	503.413	491.614
1958	1	1120.983	1174.085	948.692
1958	2	4851.527	5148.913	5305.830
1958	3	2740.061	2806.394	2892.792
1958	4	2955.541	3022.150	2893.111
1958	5	1454.524	1310.578	1310.793
1959	12	144.090	144.090	127.431

Water Year	Month	Existing	NAA	CWF H3+
1959	1	561.845	535.884	705.007
1959	2	1274.329	1296.058	1190.977
1959	3	326.733	315.038	395.533
1959	4	288.822	287.888	271.242
1959	5	259.080	268.039	282.259
1960	12	127.426	127.595	127.426
1960	1	264.110	260.213	290.567
1960	2	877.191	913.314	805.572
1960	3	443.828	485.240	553.878
1960	4	356.320	382.513	349.477
1960	5	245.151	219.736	235.075
1961	12	313.480	329.379	333.781
1961	1	271.831	267.631	256.585
1961	2	966.818	902.205	803.997
1961	3	384.880	439.816	378.667
1961	4	250.887	233.189	259.807
1961	5	237.144	247.040	240.679
1962	12	316.185	350.203	317.362
1962	1	169.901	169.901	169.901
1962	2	1602.727	1896.811	1763.091
1962	3	560.613	585.192	749.785
1962	4	408.435	423.650	426.347
1962	5	327.599	313.494	315.396
1963	12	676.910	689.631	575.273
1963	1	481.765	475.235	451.296
1963	2	2002.319	2081.507	1996.796
1963	3	684.439	696.756	667.884
1963	4	2707.167	2788.132	2552.710
1963	5	808.431	777.122	782.577
1964	12	127.426	127.426	127.426
1964	1	599.803	590.298	723.868
1964	2	312.938	309.248	320.712
1964	3	220.717	215.844	223.112
1964	4	264.001	265.016	276.388
1964	5	267.803	274.997	274.869
1965	12	2235.278	2453.053	2248.953
1965	1	3064.997	3544.329	3436.675
1965	2	1019.109	1038.486	1021.927
1965	3	483.562	489.600	477.452
1965	4	1418.171	1292.233	1291.266
1965	5	562.904	473.536	478.297
1966	12	181.413	182.246	195.028
1966	1	706.734	706.280	923.517
1966	2	655.583	684.901	606.061
1966	3	492.828	507.462	614.145

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Water Year	Month	Existing	NAA	CWF H3+
1966	4	395.715	349.981	336.800
1966	5	284.624	309.293	309.293
1967	12	955.396	1003.535	996.768
1967	1	1414.076	1466.715	1448.906
1967	2	1528.046	1534.150	1484.592
1967	3	1539.985	1561.810	1615.974
1967	4	1670.336	1739.510	1590.460
1967	5	1543.862	1539.528	1329.031
1968	12	145.875	146.203	127.435
1968	1	610.200	605.526	743.871
1968	2	1507.362	1346.913	1265.844
1968	3	870.700	843.781	616.149
1968	4	301.719	289.138	287.373
1968	5	281.926	270.457	274.078
1969	12	411.168	437.488	450.140
1969	1	3353.707	3885.528	3973.227
1969	2	3985.244	4411.589	4409.101
1969	3	1918.760	2070.680	2070.908
1969	4	1699.591	1690.397	1650.108
1969	5	1656.631	1686.241	1676.586
1970	12	1110.236	1194.071	1226.731
1970	1	5901.305	6820.786	6703.573
1970	2	2218.121	2263.695	2221.180
1970	3	1046.714	1056.541	1035.869
1970	4	348.865	348.536	352.330
1970	5	345.718	337.121	343.804
1971	12	1416.183	1512.779	1313.424
1971	1	1371.557	1469.641	1433.908
1971	2	615.650	625.897	618.202
1971	3	1050.783	1052.379	1248.039
1971	4	654.448	695.054	694.658
1971	5	820.017	753.670	756.076
1972	12	189.238	187.580	210.228
1972	1	336.742	331.240	470.785
1972	2	508.453	486.072	448.449
1972	3	711.041	484.462	720.743
1972	4	356.540	286.108	322.989
1972	5	279.137	238.392	220.621
1973	12	609.830	575.576	534.297
1973	1	2286.668	2295.086	2119.483
1973	2	2370.554	2507.459	2655.072
1973	3	1529.235	1656.838	1641.379
1973	4	554.342	545.538	545.496
1973	5	530.325	469.435	478.789
1974	12	1622.064	1873.696	1871.017

Exhibit DWR-1352

Water Year	Month	Existing	NAA	CWF H3+
1974	1	3741.097	3898.557	3760.737
1974	2	1182.228	1211.426	1137.468
1974	3	3053.367	3120.477	3074.245
1974	4	1945.005	1919.835	1709.157
1974	5	656.406	554.098	560.183
1975	12	151.584	151.811	169.489
1975	1	273.023	274.645	419.734
1975	2	1528.851	1587.657	1754.102
1975	3	2325.953	2238.718	2363.153
1975	4	740.365	757.707	759.594
1975	5	875.756	832.789	842.184
1976	12	142.516	142.501	127.426
1976	1	202.887	200.712	347.171
1976	2	272.856	271.180	293.856
1976	3	297.269	344.914	334.871
1976	4	242.087	244.787	242.294
1976	5	113.267	267.098	278.396
1977	12	99.109	127.426	127.426
1977	1	306.696	175.084	182.892
1977	2	212.983	218.444	218.444
1977	3	204.977	204.977	204.977
1977	4	201.050	201.050	201.050
1977	5	113.267	113.267	113.267
1978	12	323.981	354.223	338.152
1978	1	1904.028	2003.513	1805.593
1978	2	1492.528	1738.283	1633.414
1978	3	1935.325	2115.555	2228.738
1978	4	1347.423	1316.659	1316.246
1978	5	702.742	733.547	733.616
1979	12	143.105	142.721	127.426
1979	1	614.513	611.657	655.300
1979	2	1020.499	1000.509	954.681
1979	3	776.855	776.023	914.500
1979	4	538.101	533.966	514.925
1979	5	531.182	465.453	479.502
1980	12	321.780	311.970	458.309
1980	1	2814.996	2939.748	2857.042
1980	2	3750.597	4101.073	4088.433
1980	3	1799.565	1885.696	1886.031
1980	4	625.511	623.854	624.246
1980	5	515.857	505.664	508.104
1981	12	145.702	145.846	147.986
1981	1	549.736	548.035	529.823
1981	2	647.444	668.004	580.051
1981	3	543.251	533.649	547.341

Exhibit DWR-1352

Water Year	Month	Existing	NAA	CWF H3+
1981	4	392.922	358.321	371.322
1981	5	247.255	218.092	235.998
1982	12	2252.359	2724.497	2546.503
1982	1	2170.303	2342.145	2206.471
1982	2	2920.995	3115.440	3269.993
1982	3	2306.828	2460.914	2509.574
1982	4	3956.461	4198.648	4177.180
1982	5	1310.460	1275.136	1275.181
1983	12	2295.321	2389.419	2275.950
1983	1	2972.147	3161.316	3276.463
1983	2	5254.010	5893.596	5919.673
1983	3	7583.632	8257.810	8257.819
1983	4	2371.386	2462.632	2463.086
1983	5	2125.128	2051.584	2039.499
1984	12	4409.138	5513.202	5522.052
1984	1	1798.625	2067.411	2067.502
1984	2	1140.892	1244.613	1244.712
1984	3	974.992	1003.051	1004.475
1984	4	475.783	472.992	472.424
1984	5	374.762	353.965	365.596
1985	12	356.581	303.197	302.046
1985	1	285.810	290.951	429.611
1985	2	389.024	393.110	422.540
1985	3	331.163	331.666	332.479
1985	4	372.291	382.848	370.349
1985	5	269.213	255.217	255.217
1986	12	319.479	325.807	303.748
1986	1	659.205	677.212	624.538
1986	2	6137.256	6731.389	6794.541
1986	3	3974.408	4112.806	4104.814
1986	4	740.983	770.526	770.938
1986	5	552.318	512.831	512.903
1987	12	129.389	127.426	127.426
1987	1	274.976	269.126	412.721
1987	2	518.747	578.836	523.418
1987	3	649.525	624.692	703.067
1987	4	262.904	273.942	251.819
1987	5	220.968	238.859	261.097
1988	12	374.273	394.196	371.364
1988	1	757.239	760.129	626.931
1988	2	376.907	450.140	238.862
1988	3	176.113	156.713	207.307
1988	4	283.513	277.755	277.782
1988	5	194.678	201.050	201.050
1989	12	118.394	133.457	131.364

Exhibit DWR-1352

Water Year	Month	Existing	NAA	CWF H3+
1989	1	253.219	221.336	212.343
1989	2	244.536	244.536	244.536
1989	3	1336.758	1400.888	1260.100
1989	4	548.843	540.728	538.581
1989	5	314.774	336.468	342.177
1990	12	127.426	127.426	127.426
1990	1	418.160	401.978	390.051
1990	2	340.849	327.556	343.546
1990	3	242.182	298.848	306.379
1990	4	266.933	266.933	266.933
1990	5	185.006	169.739	169.802
1991	12	103.804	168.511	177.116
1991	1	254.363	127.426	127.426
1991	2	210.991	343.174	308.435
1991	3	974.194	962.952	848.565
1991	4	323.914	317.947	317.326
1991	5	179.617	168.277	175.366
1992	12	127.319	155.384	165.439
1992	1	190.704	157.737	159.857
1992	2	970.201	983.599	933.392
1992	3	482.693	480.611	457.819
1992	4	278.899	250.540	251.638
1992	5	169.833	208.905	208.905
1993	12	231.628	287.877	264.660
1993	1	1841.582	1906.711	1724.608
1993	2	1603.310	1659.209	1620.531
1993	3	1024.218	1314.664	1337.857
1993	4	1117.347	1145.238	1149.750
1993	5	826.170	753.066	764.756
1994	12	147.123	147.174	127.567
1994	1	258.568	253.230	284.177
1994	2	621.438	635.841	581.368
1994	3	224.271	216.309	245.451
1994	4	293.673	285.681	284.939
1994	5	218.528	208.087	208.080
1995	12	255.138	310.272	294.207
1995	1	3205.832	3484.221	3375.863
1995	2	1337.034	1703.822	1624.835
1995	3	5922.256	6322.512	6349.361
1995	4	1939.669	1969.114	1866.263
1995	5	2464.153	2225.145	2209.557
1996	12	446.164	468.497	514.169
1996	1	1282.130	1166.330	1112.647
1996	2	3496.862	3868.977	3856.413
1996	3	1936.261	2041.703	2016.638

Water Year	Month	Existing	NAA	CWF H3+
1996	4	1280.136	1241.494	1241.438
1996	5	1379.808	1171.313	1171.271
1997	12	1987.904	2312.382	2468.544
1997	1	7901.265	8751.261	8711.481
1997	2	2097.779	2283.580	2255.978
1997	3	633.651	745.376	699.814
1997	4	494.181	479.705	484.610
1997	5	382.327	379.006	361.372
1998	12	279.440	274.563	305.508
1998	1	1362.711	1506.155	1518.554
1998	2	6248.078	7136.591	7208.954
1998	3	2351.591	2538.124	2482.331
1998	4	1829.289	1824.390	1664.771
1998	5	1714.628	1626.379	1441.500
1999	12	828.096	884.145	766.179
1999	1	1147.674	1156.104	1174.002
1999	2	2739.983	3107.521	3196.849
1999	3	1675.557	1810.118	1827.665
1999	4	847.118	856.177	855.005
1999	5	574.845	488.503	492.427
2000	12	135.356	133.842	127.427
2000	1	617.328	601.851	665.867
2000	2	2903.114	3133.453	3242.997
2000	3	1728.045	1857.532	1923.857
2000	4	605.377	572.078	572.569
2000	5	516.715	418.010	424.689
2001	12	137.537	127.426	127.427
2001	1	374.462	367.539	392.324
2001	2	758.879	773.434	674.759
2001	3	641.129	632.195	556.693
2001	4	362.714	283.759	298.423
2001	5	231.388	208.537	213.215
2002	12	794.376	849.359	795.615
2002	1	1368.111	1515.207	1248.815
2002	2	405.960	383.930	380.255
2002	3	484.529	477.250	524.772
2002	4	474.281	430.879	444.139
2002	5	365.022	317.193	331.280
2003	12	1000.000	1159.367	1024.887
2003	1	1759.399	1846.850	1646.914
2003	2	684.085	708.112	504.702
2003	3	519.284	568.104	672.470
2003	4	785.493	793.040	797.404
2003	5	1104.479	1196.509	1201.162

Table B4. Principal Components Inputs for Model Simulation

Water Year	Existing	NAA	CWF H3+
1922	-0.40952	-0.21179	-0.34872
1923	-1.15217	-1.15213	-1.17049
1924	-2.00733	-1.99131	-1.98601
1925	-0.98301	-0.96313	-0.95058
1926	-1.33171	-1.34523	-1.38559
1927	0.28391	0.31802	0.24926
1928	-0.89012	-0.90538	-0.88028
1929	-1.92751	-1.91746	-1.90976
1930	-1.50126	-1.51232	-1.56283
1931	-1.9993	-2.01265	-2.01638
1932	-1.59331	-1.61213	-1.55716
1933	-1.8738	-1.86197	-1.8644
1934	-1.80435	-1.80105	-1.80797
1935	-0.90654	-1.01923	-1.08371
1936	-0.64008	-0.57837	-0.60206
1937	-0.80451	-0.77682	-0.79998
1938	3.02578	3.45438	3.37297
1939	-1.90155	-1.88151	-1.82353
1940	0.43303	0.51993	0.37729
1941	1.93401	2.14889	2.06339
1942	1.0606	1.25937	1.17883
1943	0.10584	0.00615	0.02143
1944	-1.65399	-1.68369	-1.6626
1945	-1.18613	-1.20987	-1.16921
1946	-0.81176	-0.68948	-0.72599
1947	-1.71236	-1.77432	-1.756
1948	-1.26335	-1.29903	-1.30151
1949	-1.46468	-1.49183	-1.5214
1950	-1.32555	-1.3641	-1.34748
1951	0.06782	0.10792	0.12658
1952	1.7087	1.9338	1.78012
1953	-0.58367	-0.57943	-0.59271
1954	-0.77002	-0.87017	-0.78478

Water Year	Existing	NAA	CWF H3+
1955	-1.74189	-1.78076	-1.74239
1956	1.43111	1.57783	1.56108
1957	-1.33114	-1.37922	-1.25179
1958	2.29912	2.35829	2.3245
1959	-1.52285	-1.52084	-1.48894
1960	-1.65082	-1.63468	-1.63922
1961	-1.63366	-1.63093	-1.67254
1962	-1.30113	-1.20423	-1.19688
1963	0.2508	0.29069	0.12865
1964	-1.82538	-1.82498	-1.78508
1965	0.29209	0.36443	0.27307
1966	-1.5401	-1.52907	-1.46979
1967	0.75433	0.81376	0.6146
1968	-1.25375	-1.32048	-1.38827
1969	1.9172	2.22746	2.22811
1970	0.53916	0.78094	0.75189
1971	-0.40093	-0.37379	-0.38046
1972	-1.61168	-1.74604	-1.64044
1973	-0.02556	0.00143	-0.00804
1974	1.38971	1.45344	1.30712
1975	-0.29835	-0.33044	-0.19971
1976	-2.00653	-1.89073	-1.85285
1977	-2.0585	-2.078	-2.07625
1978	0.11238	0.27758	0.23485
1979	-1.16292	-1.21413	-1.17611
1980	0.49591	0.63879	0.66261
1981	-1.5979	-1.62829	-1.63509
1982	2.69727	3.05374	3.01982
1983	5.12244	5.57367	5.56492
1984	0.35682	0.7727	0.78324
1985	-1.7269	-1.7455	-1.71118
1986	1.4369	1.63843	1.63525
1987	-1.73524	-1.7122	-1.66475
1988	-1.75212	-1.7293	-1.80897

Water Year	Existing	NAA	CWF H3+
1989	-1.42755	-1.39884	-1.44329
1990	-1.90453	-1.90387	-1.89965
1991	-1.73334	-1.71881	-1.75783
1992	-1.70887	-1.6904	-1.70771
1993	-0.19792	-0.09535	-0.13723
1994	-1.82934	-1.83901	-1.84422
1995	2.99145	3.15533	3.06182
1996	0.98518	0.95164	0.94182
1997	1.1691	1.53706	1.54338
1998	2.28848	2.56674	2.3974
1999	0.0787	0.18987	0.19098
2000	-0.32025	-0.29649	-0.22787
2001	-1.59986	-1.64937	-1.68645
2002	-1.19576	-1.20305	-1.25054
2003	-0.35099	-0.19804	-0.30229

Appendix C – R Code Used for Model Simulation to Compare Scenarios

Script C1. R Code Used for Model Simulation to Compare Scenarios

```
# Load packages ---------------------------------------------------------


if (!require("pacman"))
    install.packages("pacman")

## Loading required package: pacman

library(pacman)
# p_load checks if package is installed, installs if necessary, then loads

p_load(tidyverse, readxl, arm)

# Load longfin data from Nobriga & Rosenfield ----------------------------

datNR <- read.csv(
    'data/nobriga-rosenfield-2016-data.csv',
    na.strings = '',
    header = TRUE
)

# Add the lagged data and step decline indicator
datNR$lag2BayAge0 <- lag(datNR$BayAge0, n = 2)

# Step decline in survival begins in 1987, shows up in 1989 Age 2
datNR$Step1989 <- ifelse(datNR$WaterYear < 1987, 0, 1)
# Step shows up in 1991 Age 2
datNR$Step1991 <- ifelse(datNR$WaterYear < 1991, 0, 1)


# Build Models ----------------------------------------------------------
#  models use flow data from N&R, not CalSim

# naming model parameters for clarity and conciseness

# alpha
#  RPS in model 1abc; Age0 per Age 0
a1 <- log(datNR$BayAge0 / datNR$lag2BayAge0)
#  RPS in models 2; Age0 per Age2
a2 <- log(datNR$BayAge0 / datNR$BayAge2)

# S; survival from Bay Age 0 to Bay Age 2. Only in model 2
S02 <- (datNR$BayAge2 / datNR$lag2BayAge0)
```

```
#  outflow
#  Using PC1 reported in N&R
pc1 <- datNR$DeltaOutflowPC1
pc1.sqrd <- (datNR$DeltaOutflowPC1) ^ 2


# step decline year
step89 <- datNR$Step1989
step91 <- datNR$Step1991

# birth year FMWT
byFMWT <- (lag(datNR$FMWT, n = 2))


# Survival -----------------------------------------------------------

#  Model2abc: Survival
##  as modeled in N&R
surv.NR <- glm(log(S02) ~ log(byFMWT) + step91,
               family = gaussian(link = 'identity'))

# confirm coefficients are same as reported in N&R 2016
display(surv.NR)

## glm(formula = log(S02) ~ log(byFMWT) + step91, family = gaussian(link = "i
dentity"))
##             coef.est coef.se
## (Intercept)  3.19     1.03
## log(byFMWT) -0.63     0.11
## step91      -1.68     0.47
## ---
##   n = 32, k = 3
##   residual deviance = 28.0, null deviance = 57.9 (difference = 29.8)
##   overdispersion parameter = 1.0
##   residual sd is sqrt(overdispersion) = 0.98

# Recruitment --------------------------------------------------------

# Model2abc: Recruitment
rps.NR <- lm(a2 ~ pc1.sqrd + pc1)

# confirm coefficients are same as reported in N&R 2016
display(rps.NR)

## lm(formula = a2 ~ pc1.sqrd + pc1)
##             coef.est coef.se
## (Intercept)  2.94     0.30
## pc1.sqrd    -0.15     0.05
```

```
## pc1          0.95     0.15
## ---
## n = 34, k = 3
## residual sd = 1.29, R-Squared = 0.58

# FUNCTIONS ---------------------------------------------------------------


# castarray fxn -----------------------------------------------------------
# function builds empty arrays to be used for simulating longfin population.

castarray <- function(df = dat,
                      n.sims = 10,
                      cast = 'hindcast',
                      hindcast.yrs = df[, 1],
                      n.forecast.yrs = 50) {
    # array columns
    Acols <- list(
        'Year',
        'of',
        'of.sqrd',
        'BayAge0_preDD',
        'BayAge0',
        'BayAge2',
        'rps',
        'survival',
        'Step91'
    )
    if (cast == 'hindcast') {
        #  Hindcast array
        n.yrs <- length(hindcast.yrs)

        # array dimensions
        dims <- c(n.yrs, length(Acols), n.sims)
        dim.names <- list(NULL, Acols, simulation = 1:n.sims)
        hind.array <-
            array(data = NA,
                  dim = dims,
                  dimnames = dim.names)

        #  fill Years
        hind.array[, 'Year', ] <- hindcast.yrs

        return(hind.array)
    }

    if (cast == 'forecast') {
        #  Forecast array
```

```
        Year.start <- max(df$WaterYear) - 1
        Year.end <- Year.start + n.forecast.yrs
        foreYear <- Year.start:Year.end

        # array dimensions
        dims <- c(length(foreYear), length(Acols), n.sims)
        dim.names <- list(NULL, Acols, simulation = 1:n.sims)
        fore.array <-
            array(data = NA,
                  dim = dims,
                  dimnames = dim.names)

        #  fill Years
        fore.array[, 'Year', ] <- foreYear

        return(fore.array)
    }

}



# popsim fxn ---------------------------------------------------------------
# fxn to simulate longfin pop'n dynamics under different flow scenarios

popsim <- function(mat,
                   outflow,
                   fmwt = 798,
                   clam,
                   rps = rps.NR,
                   surv = surv.NR,
                   Beta = -0.00077,
                   method = 'NR',
                   sigma = TRUE,
                   truncate = TRUE,
                   seed = NULL,
                   ...) {
    if (is.null(seed))
        seed = as.numeric(Sys.time())
    mat[1:2, 'BayAge0', ] <- fmwt
    mat[, 'Step91', ] <- clam
    mat[, 'of', ] <- outflow
    mat[, 'of.sqrd', ] <- outflow ^ 2

    n.sims = dim(mat)[3]

    #  progress bar
```

```
pb_j <- txtProgressBar(min = 0,
                       max = n.sims,
                       style = 3)

for (j in 1:n.sims) {
    for (i in 3:nrow(mat)) {
        # start in year 3
        if (mat[i - 1, 'BayAge0', j] < 1)
            break  # stop loop, population is extinct
        if (is.na(mat[i, 'of', j]))
            break  # stop loop, end of flow data time series
        if (is.na(mat[i, 'Step91', j]))
            break  # stop loop, end of clam data time series

        mat[i, 'rps', j] <-
            pred.rps(
                rps,
                mat[i, 'of.sqrd', j],
                mat[i, 'of', j],
                method = method,
                sigma = sigma,
                seed = seed + j
            )

        mat[i, 'survival', j] <-
            surv02(
                surv,
                mat[i - 2, 'BayAge0', j],
                mat[i, 'Step91', j],
                method = method,
                truncate = truncate,
                sigma = sigma,
                seed = seed + j
            )

        mat[i, 'BayAge2', j] <-
            mat[i, 'survival', j] * mat[i - 2, 'BayAge0' , j]
        mat[i, 'BayAge2', j] <-
            ifelse(mat[i, 'BayAge2', j] < 1, 0, mat[i, 'BayAge2', j])
        mat[i, 'BayAge0_preDD', j] <-
            mat[i, 'rps', j] * mat[i, 'BayAge2', j]
        mat[i, 'BayAge0', j] <-
            ricker(mat[i, 'rps', j], mat[i, 'BayAge2', j], B = Beta)

        mat[i, 'BayAge0', j] <-
            ifelse(mat[i, 'BayAge0' , j] < 1, 0, mat[i, 'BayAge0' , j])
```

```
        }
        #  update progress bar
        setTxtProgressBar(pb_j, j)
    }
    close(pb_j)
    return(mat)
}


# ricker fxn -----------------------------------------------------------
# for calculating recruits per spawner assuming a Ricker SR model
# used in pred.rps fxn, not called directly

ricker <- function(alpha, S, B = -0.00077) {
    R = alpha * S * exp(B * S)
    return(R)
}


# pred.rps fxn ---------------------------------------------------------
# predict recruits per spawner using different methods for handling uncertain
ty
# not called directly, used in popsim fxn

pred.rps <- function(fit,
                     b1,
                     b2,
                     method = c('NR', 'sim', 'mean'),
                     sigma = TRUE,
                     seed = NULL) {
    #  set seed if comparison between methods is desired
    set.seed(seed)
    stopifnot(length(b1) == length(b2))
    #  make matrix of Intercept (1) and predictor 1 and predictor 2
    X.pred <- cbind(rep(1, length(b1)), b1, b2)
    colnames(X.pred) <- c('intercept',
                          all.vars(as.formula(fit))[2],
                          all.vars(as.formula(fit))[3])
    n.pred <- dim(X.pred)[1]
    #  G&H simulation method
    if (method == 'sim') {
        sim.rps <- sim(fit, n.pred)
        y.pred <- X.pred[, 1] * sim.rps@coef[, 1] + # intercept
            X.pred[, 2] * sim.rps@coef[, 2] + # outflow squared
            X.pred[, 3] * sim.rps@coef[, 3]   # outflow PC1
        if (sigma == FALSE) {
            #  No model uncertainty
```

```
            return(exp(y.pred))
        }
        else if (sigma == TRUE) {
            #  With model uncertainty
            y.pred_sigma <- rnorm(n.pred, y.pred, sim.rps@sigma)
            return(exp(y.pred_sigma))
        }
    }
    #  N&R method, no model uncertainty
    if (method == 'NR') {
        log_a =
            X.pred[, 1] * rnorm(n = n.pred,
                                mean = coef(fit)[1],
                                sd = se.coef(fit)[1]) + # intercept
            X.pred[, 2] * rnorm(n = n.pred,
                                mean = coef(fit)[2],
                                sd = se.coef(fit)[2]) +  # outflow squared
            X.pred[, 3] * rnorm(n = n.pred,
                                mean = coef(fit)[3],
                                sd = se.coef(fit)[3])  # outflow PC1
        return(exp(log_a))
    }
    if (method == 'mean') {
        y.mean = predict(fit, newdata = as.data.frame(X.pred))
        return(exp(y.mean))
    }
}


# sumsims fxn ------------------------------------------------------------
# function for summarising alternative flow scenario simulations

sumsims <-
    function(mat,
             INDEX = 'BayAge0',
             # age class to summarise data by
             ref = NULL,
             ...) {
        #  years for which we have outflow (deals with CalSimII ending in 200
3)
        years <- mat[!is.na(mat[, 'of', 1]), 'Year', 1]
        #  number of simulations
        n.sims = dim(mat)[3]
        summat <- data.frame(
            Year = years,
            medIndex = NA,
            loIndex = NA,
```

```
            hiIndex = NA,
            pExtinct = NA,
            medDiff = NA,
            loDiff = NA,
            hiDiff = NA,
            pDiffExt = NA
        )
        for (i in 1:length(years)) {
            summat$medIndex[i] = quantile(mat[i, INDEX, ], probs = 0.5, na.rm
 = TRUE)
            summat$loIndex[i] = quantile(mat[i, INDEX, ], probs = 0.025, na.r
m = TRUE)
            summat$hiIndex[i] = quantile(mat[i, INDEX, ], probs = 0.975, na.r
m = TRUE)
            summat$pExtinct[i] =  (sum(is.na(mat[i, INDEX,])) / n.sims)
            if (is.null(ref))
                next
            if (is.na(ref[i, 'of', 1]))
                break
            summat$medDiff[i] = quantile((mat[i, INDEX, ] - ref[i, INDEX, ]),
 probs = 0.5, na.rm = TRUE)
            summat$loDiff[i] = quantile((mat[i, INDEX, ] - ref[i, INDEX, ]),
probs = 0.025, na.rm = TRUE)
            summat$hiDiff[i] = quantile((mat[i, INDEX, ] - ref[i, INDEX, ]),
probs = 0.975, na.rm = TRUE)
            summat$pDiffExt[i] =  (sum(is.na(mat[i, INDEX,])) - sum(is.na(ref
[i, INDEX,]))) /
                n.sims
        }
        #  Year 3 is when simulations begin
        return(summat[3:length(years), , ])
    }


# surv02 fxn ------------------------------------------------------------
# function for simulating longfin age-0 to age-2 survival

surv02 <- function(fit,
                   b1,
                   b2,
                   method = c('NR', 'sim', 'mean'),
                   truncate = TRUE,
                   sigma = TRUE,
                   seed = NULL) {
    #  set seed if comparison between methods is desired
    set.seed(seed)
    stopifnot(length(b1) == length(b2))
```

```
#  make matrix of Intercept (1) and predictor 1 and predictor 2
X.pred <- cbind(rep(1, length(b1)), b1, b2)
colnames(X.pred) <- c('intercept',
                      all.vars(as.formula(fit))[2],
                      all.vars(as.formula(fit))[3])
n.pred <- dim(X.pred)[1]
#  G&H simulation method
if (method == 'sim') {
    sim.surv <- sim(fit, n.pred)
    y.pred <- X.pred[, 1] * sim.surv@coef[, 1] + # intercept
        log(X.pred[, 2]) * sim.surv@coef[, 2] + # log(byFMWT)
        X.pred[, 3] * sim.surv@coef[, 3]   # step91
    if (sigma == FALSE) {
        if (fit$family[[2]] == 'logit') {
            survival = invlogit(y.pred)
        }
        if (fit$family[[2]] == 'identity') {
            survival = exp(y.pred)
        }
    }
    if (sigma == TRUE) {
        #  With model uncertainty
        y.pred_sigma <- rnorm(n.pred, y.pred, sim.surv@sigma)
        if (fit$family[[2]] == 'logit') {
            survival = invlogit(y.pred_sigma)
        }
        if (fit$family[[2]] == 'identity') {
            survival = exp(y.pred_sigma)
        }
    }
    if (truncate == TRUE) {
        return(ifelse(survival > 1, 1, survival))
    }
    else if (truncate == FALSE) {
        return(survival)
    }
}

if (method == 'NR') {
    log_survival =
        X.pred[, 1] * rnorm(n = n.pred,
                            mean = coef(fit)[1],
                            sd = se.coef(fit)[1]) + # intercept
        log(X.pred[, 2]) * rnorm(n = n.pred,
                                 mean = coef(fit)[2],
                                 sd = se.coef(fit)[2]) + # log(byFMWT)
        X.pred[, 3] * rnorm(n = n.pred,
```

```
                                   mean = coef(fit)[3],
                                   sd = se.coef(fit)[3])   # step91

        if (fit$family[[2]] == 'logit') {
            survival = invlogit(log_survival)
        }
        if (fit$family[[2]] == 'identity') {
            survival = exp(log_survival)
        }
        if (truncate == TRUE) {
            return(ifelse(survival > 1, 1, survival))
        }
        else if (truncate == FALSE) {
            return(survival)
        }
    }
    if (method == 'mean') {
        y.mean = predict(fit, newdata = as.data.frame(X.pred))
        if (fit$family[[2]] == 'logit') {
            survival = invlogit(y.mean)
        }
        if (fit$family[[2]] == 'identity') {
            survival = exp(y.mean)
        }
        if (truncate == TRUE) {
            return(ifelse(survival > 1, 1, survival))
        }
        else if (truncate == FALSE) {
            return(survival)
        }
    }
}



# BEGIN ANALYSIS ----------------------------------------------------------

# Load flows --------------------------------------------------------------

inputflows <-
    read_excel('data/LFS_inputs_to_CPhillis_06152018.xlsx',
               sheet = 'inputs',
               skip = 2)
# PC1 Loadings
pc1flows <- inputflows %>%
    dplyr::select(WY, Existing, NAA, `CWF_H3+`)
```

```
# CalSim Mean Dec - May Delta outflows
simflows <- inputflows %>%
    dplyr::select(year, Existing__1, NAA__1, `CWF_H3+__1`)

# make common column names for both
names(simflows) <- names(pc1flows)


# Run N&R simulations -----------------------------------------------------
--

sims <- 1000 # number of simulations

hind.array.NR <- castarray(datNR, n.sims = sims)

# starting value for FMWT. Using median 1967-2013 FMWT Index following N&R 20
16
fmwt_start <- median(datNR$FMWT, na.rm = TRUE)

# Beta is the density dependence parameter. It is not reported in
# Nobriga & Rosenfield 2016. Matt Nobriga provided me the
# parameter estimate they used in their paper
Beta.NR <- -0.00077

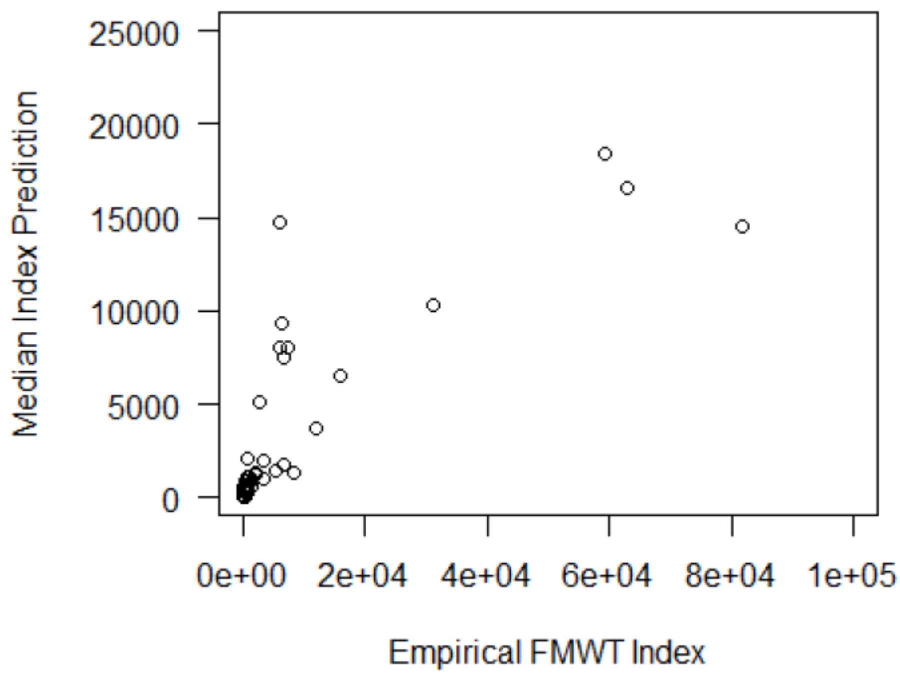
NR <- popsim(
    hind.array.NR,
    pc1,
    fmwt = fmwt_start,
    clam = step91,
    rps = rps.NR,
    method = 'NR',
    Beta = Beta.NR
)

sum.NR <- sumsims(NR)
```

```
# recreate figure 6d in N&R 2016 -----------------------------------------

par(las = 1,
    oma = c(0, 0, 0, 0),
    mar = c(5, 6, 2, 2))
plot(
    datNR$FMWT[3:58],
    sum.NR$medIndex,
    xlim = c(0, 100000),
```

```
    ylim = c(0, 25000),
    xlab = 'Empirical FMWT Index',
    ylab = ''
)
mtext(
    side = 2,
    'Median Index Prediction',
    las = 3,
    line = 4.5
)
```




```
# Run simulations with alternative flows ---------------------------------

# Combine longfin data and alternative flow scenarios
dat <- left_join(pc1flows, datNR, by = c('WY' = 'WaterYear'))

# assign "good" survival (pre-clams) value for CalSim years before N&R data
dat$Step1991[is.na(dat$Step1991)] <- 0
dat$Step1991[is.na(dat$Step1989)] <- 0

CalSim.yrs <- dat$WY

#  array with 82-year CalSim time series
hind.array <-
```

```
    castarray(dat, hindcast.yrs = CalSim.yrs, n.sims = sims)

# Common Random Number (CRN) for all scenarios. Ensures differences observed
# are due to differences in scenario, not differences in random inputs
myseed <- 42

# NAA, good survival ---------------------------------------------------------

NAA.good <- popsim(
    hind.array,
    dat$NAA,
    fmwt = fmwt_start,
    clam = 0,
    rps = rps.NR,
    method = 'NR',
    Beta = Beta.NR,
    seed = myseed
)

# NAA poor survival ----------------------------------------------------------

NAA.poor <- popsim(
    hind.array,
    dat$NAA,
    fmwt = fmwt_start,
    clam = 1,
    rps = rps.NR,
    method = 'NR',
    Beta = Beta.NR,
    seed = myseed
)

# NAA observed survival ------------------------------------------------------
--

NAA.obs <- popsim(
    hind.array,
    dat$NAA,
    fmwt = fmwt_start,
    clam = dat$Step1991,
    rps = rps.NR,
    method = 'NR',
    Beta = Beta.NR,
    seed = myseed
)

# CWF_H3+, good survival ----------------------------------------
```

```
H3.good <- popsim(
    hind.array,
    dat$`CWF_H3+`,
    fmwt = fmwt_start,
    clam = 0,
    rps = rps.NR,
    method = 'NR',
    Beta = Beta.NR,
    seed = myseed
)

# CWF_H3+, poor survival -------------------------------------------

H3.poor <- popsim(
    hind.array,
    dat$`CWF_H3+`,
    fmwt = fmwt_start,
    clam = 1,
    rps = rps.NR,
    method = 'NR',
    Beta = Beta.NR,
    seed = myseed
)

# CWF_H3+, observed survival -------------------------------------------

H3.obs <- popsim(
    hind.array,
    dat$`CWF_H3+`,
    fmwt = fmwt_start,
    clam = dat$Step1991,
    rps = rps.NR,
    method = 'NR',
    Beta = Beta.NR,
    seed = myseed
)

# Existing CalSim conditions, good survival ---------------------

existing.good <- popsim(
    hind.array,
    dat$Existing,
    fmwt = fmwt_start,
    clam = 0,
    rps = rps.NR,
    method = 'NR',
    Beta = Beta.NR,
```

```
    seed = myseed
)

# Existing CalSim conditions, poor survival ----------------------

existing.poor <- popsim(
    hind.array,
    dat$Existing,
    fmwt = fmwt_start,
    clam = 1,
    rps = rps.NR,
    method = 'NR',
    Beta = Beta.NR,
    seed = myseed
)

# Existing CalSim conditions, observed survival ---------------------

existing.obs <- popsim(
    hind.array,
    dat$Existing,
    fmwt = fmwt_start,
    clam = dat$Step1991,
    rps = rps.NR,
    method = 'NR',
    Beta = Beta.NR,
    seed = myseed
)

# summarise simulations ---------------------------------------------------

ref.scenario <-
    NAA.poor #  select the reference flow and survival scenario
sum.NAA.poor <- sumsims(NAA.poor, ref = ref.scenario)
sum.NAA.poor <- sum.NAA.poor %>%
    mutate(
        flow_scenario = 'NAA',
        survival_scenario = 'poor',
        scenario = 'NAA_poor'
    )

sum.NAA.good <- sumsims(NAA.good, ref = ref.scenario)
sum.NAA.good <- sum.NAA.good %>%
    mutate(
        flow_scenario = 'NAA',
        survival_scenario = 'good',
        scenario = 'NAA_good'
    )
```

```
sum.NAA.obs <- sumsims(NAA.obs, ref = ref.scenario)
sum.NAA.obs <- sum.NAA.obs %>%
    mutate(
        flow_scenario = 'NAA',
        survival_scenario = 'observed',
        scenario = 'NAA_observed'
    )

sum.H3.good <- sumsims(H3.good, ref = ref.scenario)
sum.H3.good <- sum.H3.good %>%
    mutate(
        flow_scenario = 'CWF_H3+',
        survival_scenario = 'good',
        scenario = 'CWF_H3+_good'
    )

sum.H3.poor <- sumsims(H3.poor, ref = ref.scenario)
sum.H3.poor <- sum.H3.poor %>%
    mutate(
        flow_scenario = 'CWF_H3+',
        survival_scenario = 'poor',
        scenario = 'CWF_H3+_poor'
    )

sum.H3.obs <- sumsims(H3.obs, ref = ref.scenario)
sum.H3.obs <- sum.H3.obs %>%
    mutate(
        flow_scenario = 'CWF_H3+',
        survival_scenario = 'observed',
        scenario = 'CWF_H3+_observed'
    )

sum.existing.good <- sumsims(existing.good, ref = ref.scenario)
sum.existing.good <- sum.existing.good %>%
    mutate(
        flow_scenario = 'existing',
        survival_scenario = 'good',
        scenario = 'existing_good'
    )

sum.existing.poor <- sumsims(existing.poor, ref = ref.scenario)
sum.existing.poor <- sum.existing.poor %>%
    mutate(
        flow_scenario = 'existing',
        survival_scenario = 'poor',
        scenario = 'existing_poor'
```

```
    )

sum.existing.obs <- sumsims(existing.obs, ref = ref.scenario)
sum.existing.obs <- sum.existing.obs %>%
    mutate(
        flow_scenario = 'existing',
        survival_scenario = 'observed',
        scenario = 'existing_observed'
    )

summarised.scenarios <- bind_rows(
    sum.NAA.good,
    sum.NAA.poor,
    sum.NAA.obs,
    sum.H3.good,
    sum.H3.poor,
    sum.H3.obs,
    sum.existing.good,
    sum.existing.poor,
    sum.existing.obs
)



# END ---------------------------------------------------------------------
```

Exhibit DWR-1352

Appendix D – Detailed Simulation Model Outputs

Table D1. Longfin Smelt Fall Midwater Trawl Index: Median and 95% Interval of Predictions, With Proportion of Simulations Giving Quasi-Extirpation (Index < 1) for Existing Conditions, No Action Alternative, and California WaterFix H3+ Operational Scenarios Based on Reproduction of Nobriga and Rosenfield (2016) 2abc Model With Post-1991 Juvenile Survival Function.

Water Year	Existing				NAA				CWF H3+			
	Median	Lower 95%	Upper 95%	Prop. Quasi-Extirp.	Median	Lower 95%	Upper 95%	Prop. Quasi-Extirp.	Median	Lower 95%	Upper 95%	Prop. Quasi-Extirp.
1924	78	3	1230	0	80	3	1257	0	81	3	1266	0
1925	338	19	4481	0.01	346	19	4589	0.009	352	19	4663	0.009
1926	92	2	3209	0.01	91	2	3174	0.009	86	2	3024	0.009
1927	1031	35	19219	0.032	1065	36	19808	0.031	1010	34	18704	0.031
1928	188	6	5408	0.032	183	6	5320	0.031	186	6	5439	0.031
1929	104	3	1484	0.043	107	3	1501	0.043	106	3	1536	0.043
1930	108	3	2672	0.043	105	3	2642	0.043	99	3	2495	0.043
1931	41	1	1313	0.043	40	1	1291	0.043	40	1	1319	0.043
1932	81	3	2540	0.057	79	3	2471	0.057	84	3	2644	0.058
1933	39	1	1652	0.06	40	1	1670	0.061	39	1	1667	0.062
1934	57	3	1896	0.083	57	3	1892	0.083	57	3	1862	0.083
1935	151	7	5629	0.083	132	6	4905	0.083	121	5	4531	0.083
1936	246	11	7658	0.088	262	12	8202	0.088	257	12	7989	0.088
1937	280	13	6369	0.088	277	13	6523	0.088	261	12	6342	0.088
1938	3403	82	123159	0.088	3393	64	154702	0.088	3424	68	146906	0.088
1939	74	3	1723	0.088	75	4	1747	0.088	80	4	1866	0.088
1940	2153	67	18898	0.088	2267	49	20197	0.088	2016	49	17877	0.088
1941	1876	67	72666	0.092	1966	70	81192	0.095	1979	70	78678	0.095
1942	3939	131	40390	0.092	4467	140	46675	0.095	4115	135	43805	0.095

Exhibit DWR-1352

Water Year	Existing				NAA				CWF H3+			
	Median	Lower 95%	Upper 95%	Prop. Quasi-Extirp.	Median	Lower 95%	Upper 95%	Prop. Quasi-Extirp.	Median	Lower 95%	Upper 95%	Prop. Quasi-Extirp.
1943	1445	54	14567	0.092	1331	53	13072	0.095	1338	56	13292	0.095
1944	283	10	2241	0.096	278	10	2198	0.099	283	10	2254	0.099
1945	384	16	4466	0.096	362	15	4291	0.099	379	16	4554	0.099
1946	354	14	5802	0.096	410	17	6640	0.099	386	16	6487	0.099
1947	114	5	2193	0.096	101	4	2014	0.099	106	5	2079	0.099
1948	209	9	3776	0.096	205	9	3628	0.099	202	9	3580	0.099
1949	106	5	2875	0.096	96	5	2772	0.099	95	5	2677	0.099
1950	159	7	3498	0.096	149	7	3357	0.099	153	7	3418	0.099
1951	637	29	15867	0.096	627	29	16411	0.099	631	29	16664	0.099
1952	2154	79	62336	0.096	2291	83	71339	0.099	2198	80	65230	0.099
1953	578	25	7765	0.096	568	25	7819	0.099	563	25	7718	0.099
1954	631	28	5855	0.096	553	26	5241	0.099	623	29	5769	0.099
1955	124	5	2139	0.096	117	5	2050	0.099	124	5	2148	0.099
1956	3094	112	47226	0.096	3258	116	48903	0.099	3316	118	50693	0.099
1957	131	6	3384	0.096	116	6	3165	0.099	142	7	3710	0.099
1958	7484	159	75958	0.096	7679	157	77516	0.099	7619	158	75453	0.099
1959	99	5	2720	0.096	95	5	2707	0.099	106	5	2844	0.099
1960	328	10	2251	0.096	336	11	2309	0.099	337	11	2295	0.099
1961	77	4	2389	0.098	76	4	2394	0.1	75	4	2287	0.099
1962	200	8	3329	0.098	226	9	3763	0.1	233	9	3806	0.099
1963	623	30	18880	0.098	639	31	19596	0.1	566	27	16731	0.099
1964	74	3	1867	0.098	78	3	1850	0.1	83	4	1963	0.099
1965	1365	59	18693	0.098	1457	63	19828	0.1	1284	56	18213	0.099

Exhibit DWR-1352

Water Year	Existing				NAA				CWF H3+			
	Median	**Lower 95%**	**Upper 95%**	**Prop. Quasi-Extirp.**	**Median**	**Lower 95%**	**Upper 95%**	**Prop. Quasi-Extirp.**	**Median**	**Lower 95%**	**Upper 95%**	**Prop. Quasi-Extirp.**
1966	82	4	2598	0.098	84	4	2613	0.1	93	5	2845	0.099
1967	2567	101	27849	0.098	2724	106	29388	0.1	2286	90	24719	0.099
1968	122	6	3695	0.098	112	6	3405	0.1	106	5	3156	0.099
1969	6012	157	63000	0.098	6890	158	76944	0.1	6418	154	77201	0.099
1970	958	45	25133	0.098	1103	51	30395	0.1	1063	50	29840	0.099
1971	1570	54	9056	0.098	1619	56	9271	0.1	1526	55	9180	0.099
1972	172	7	2271	0.098	147	6	1947	0.1	165	7	2184	0.099
1973	1465	58	15619	0.098	1541	61	16019	0.1	1518	60	15972	0.099
1974	1924	72	42944	0.098	1877	70	41180	0.1	1820	69	38618	0.099
1975	1065	44	10432	0.098	1052	43	10116	0.1	1201	49	11547	0.099
1976	122	5	1406	0.098	150	6	1619	0.1	157	6	1682	0.099
1977	95	4	1383	0.098	91	4	1362	0.1	95	4	1330	0.099
1978	712	31	11983	0.098	850	37	14500	0.1	832	36	14420	0.099
1979	152	7	3960	0.098	138	7	3628	0.1	150	7	3837	0.099
1980	1686	69	23112	0.098	1986	79	24966	0.1	2020	80	25400	0.099
1981	94	5	2464	0.098	88	4	2356	0.1	89	4	2341	0.099
1982	6441	130	103038	0.098	7272	124	119337	0.1	7336	125	117823	0.099
1983	1421	10	259158	0.098	1096	5	274362	0.1	1112	5	278807	0.099
1984	2928	100	18261	0.098	3924	133	25101	0.103	3908	130	25329	0.101
1985	132	3	1900	0.098	122	3	1864	0.103	127	3	1944	0.101
1986	5233	151	51943	0.116	6380	175	58396	0.118	6318	165	58248	0.117
1987	74	3	1506	0.116	75	3	1541	0.118	81	4	1668	0.117
1988	253	9	1972	0.116	272	10	2039	0.118	240	8	1840	0.117

Exhibit DWR-1352

Water Year	Existing				NAA				CWF H3+			
	Median	**Lower 95%**	**Upper 95%**	**Prop. Quasi-Extirp.**	**Median**	**Lower 95%**	**Upper 95%**	**Prop. Quasi-Extirp.**	**Median**	**Lower 95%**	**Upper 95%**	**Prop. Quasi-Extirp.**
1989	90	5	2471	0.116	94	5	2610	0.118	90	5	2509	0.117
1990	71	3	1338	0.116	74	3	1343	0.118	71	3	1308	0.117
1991	64	3	1839	0.116	66	3	1892	0.118	61	3	1799	0.117
1992	61	3	1812	0.116	64	3	1819	0.118	61	3	1755	0.117
1993	371	19	11599	0.116	413	22	12921	0.118	387	20	12329	0.117
1994	47	3	1645	0.116	47	3	1554	0.118	46	2	1532	0.117
1995	3739	96	111501	0.116	4029	101	123017	0.118	3850	98	115963	0.117
1996	920	45	32238	0.116	903	44	32070	0.118	887	43	31749	0.117
1997	4353	138	34235	0.116	5351	164	44388	0.118	5348	156	44626	0.117
1998	4510	131	79597	0.116	4828	143	92022	0.118	4606	132	85156	0.117
1999	2236	82	16357	0.116	2707	92	17113	0.118	2687	92	17145	0.117
2000	1475	57	9802	0.116	1529	58	10025	0.118	1609	63	10693	0.117
2001	242	9	2475	0.116	243	9	2383	0.118	229	9	2256	0.117
2002	365	15	4278	0.116	371	15	4263	0.118	353	15	4011	0.117
2003	536	24	10195	0.116	630	29	11669	0.118	551	25	10487	0.117