APPENDIX I

Sample Sizes to Estimate Survival through the State Water Project

Prepared by:
Rebecca Buchanan
Columbia Basin Research
University of Washington
Seattle, WA

Prepared for:
Pat Brandes
U.S. Fish and Wildlife Service
Stockton, CA

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Summary

Maximum standard error on all parameters: 0.05
Using fish released only at Durham Ferry and in Old River (site B1, at the head of Old River):

- low survival from B1 to CCFB (0.20), through CCFB (0.11), from release sites to Chipps (0.5):
  - ≥ 800 fish are needed to estimate survival from the radial gates at CCFB to the trashrack
  - ≥5,000 fish are needed to estimate survival from trashrack to holding tank
  - ≥3,500 fish are needed to estimate survival from holding tank to release sites
  - ≥14,000 fish are needed to estimate survival from release sites to Chipps Island
- higher survival from B1 to CCFB (0.35), through CCFB (0.27), from release sites to Chipps (0.7):
  - ≥ 500 fish are needed to estimate survival from the radial gates to the trashrack
  - approximately 600 fish are needed to estimate survival from trashrack to holding tank
  - ≥800 fish are needed to estimate survival from holding tank to release sites
  - ≥4,000 fish are needed to estimate survival from release sites to Chipps Island

With 225 fish released at Durham Ferry, 150 fish released in Old River, and another supplemental release directly into CCFB:

- low survival from B1 to CCFB, through CCFB, and from release site to Chipps:
  - 60 fish should be released at CCFB to estimate survival from the radial gates to the trashrack
  - 970 fish should be released at CCFB to estimate survival from trashrack to holding tank
  - 640 fish should be released at CCFB to estimate survival from holding tank to release sites
  - 2700 fish should be released at CCFB to estimate survival from release site to Chipps
- higher survival from B1 to CCFB, through CCFB, and from release site to Chipps:
  - 50 fish should be released at CCFB to estimate survival the radial gates to the trashrack
  - 100 fish should be released at CCFB to estimate survival from trashrack to holding tank
  - 190 fish should be released at CCFB to estimate survival from holding tank to release sites
  - 1290 fish should be released at CCFB to estimate survival from release sites to Chipps

Relaxing the maximum standard error would require fewer fish, as would higher survival to the CCFB. With only 225 fish released at Durham Ferry and 150 fish released in Old River, the standard errors expected on estimates of transition and survival parameters range from 0.07 to 0.09 on the transition from the radial gates to the trashracks, 0.25 to 0.88 from the trashracks to the holding tanks, 0.24 to 0.49 from the holding tanks to the release sites, and 0.19 to 0.39 from the release sites to Chipps Island.

Methods

The release sizes necessary to estimate survival through different portions of Clifton Court Forebay and the State Water Project were analyzed in order to attain maximum standard errors of 0.05 for each segment survival. The main analysis considered only two releases: the initial release is at Durham Ferry, and a supplemental release is located at the first detection site in Old River (site B1). Parameters estimated are:

- Transition probability (joint probability of movement and survival) from site B1 to the radial gates at CCFB: $\phi_{B1,CCFB}$
- Transition probability from radial gates to trashrack: $\phi_{CCFB,TR}$
- Transition probability from trashrack to holding tanks: $\phi_{TR,HT}$
- Survival probability from holding tanks to release sites: $\sigma_{HT,Rel}$
- Transition probability from release sites to Chipps Island: $\phi_{Rel,Ch}$

Assumed parameter values were based on parameter estimates reported in the VAMP 2008 report (Holbrook et al. 2009), and the DWR 2009 report (Clark et al. 2009) (Table 1). At most two values were considered for each parameter, representing both high and low values based on available estimates from these two reports (Table 2)

University of Washington software SampleSize (http://www.cbr.washington.edu/paramest/samplesize/) was used to determine the release sizes needed at Durham Ferry and site B1 in Old River to estimate the 5 parameters with a maximum standard error of 0.05 on each. The minimum release size considered at Durham Ferry was 95. The minimum supplemental release size considered in Old River was 0. No consideration was given to estimating migration parameters through the San Joaquin downstream of the head of Old River, or through the CVP.

Another supplemental release made directly into Clifton Court Forebay at the radial gates was considered for the case with 225 fish released at Durham Ferry and 150 fish released in Old River at site B1.

Table 1. Parameters used in sample size analysis. At most two values were considered for each parameter, representing low and high values based on point estimates and 95% confidence intervals from the VAMP 2008 report and the DWR 2009 report.

Parameter	Definition	Values	Source
S_{RO}	Survival from Durham Ferry to head of Old River	0.5, 0.75	Preliminary VAMP 2009 results, and higher value
ψ_B	Proportion of fish at head of Old River that enter Old River	0.4, 0.7	VAMP 2008, and lower value if barrier is operating
$\phi_{DF,B1}$	Joint probability of moving from Durham Ferry to first detection site in Old River, and surviving to first site in Old River	0.3, 0.5	$=S_{RO} \cdot \psi_B$ (approximately)
$\phi_{B1,CCFB}$	Joint probability of moving from first site in Old River to CCFB (inside radial gates), and surviving to CCFB	0.2, 0.35	VAMP 2008
$\phi_{CCFB,TR}$	Joint probability of moving from radial gates at CCFB to trashrack at SWP, and surviving to trashrack	0.3, 0.4	VAMP 2008
$\phi_{TR,HT}$	Joint probability of moving from trashrack to holding tank, and surviving to holding tank	0.85	DWR 2009 (adjusted from acoustic-tagged steelhead fish guidance efficiency)
$\sigma_{HT,Rel}$	Probability of surviving from holding tank to salvage release sites	0.45, 0.8	$=\sigma_{B3}/(\phi_{TR,HT}\ \phi_{Rel,Ch})$, where σ_{B3} is from VAMP 2008
$\phi_{Rel,Ch}$	Joint probability of moving from release sites to Chipps, and surviving to Chipps	0.5, 0.7	VAMP 2008 (= $\sigma_{JPT,Chipps}$)
p_{B1}	Detection probability at first site on Old River	0.95	VAMP 2008 report
p_{CCFB}	Detection probability at CCFB (radial gates)	1	Discussions with DWR
p_{TR}	Detection probability at trashracks	0.95	Guess
p_{HT}	Detection probability in holding tanks	1	Assumption that all tanks are monitored
p_{Rel}	Detection probability at salvage release sites	0.95	Guess
p_{Ch}	Detection probability at Chipps Island dual array	0.76	Conservative guess based on VAMP 2008 estimates

Table 2. Parameter scenarios used in sample size analyses.

Scenario	$\phi_{DF,B1}$	$\phi_{B1,CCFB}$	$\phi_{CCFB,TR}$	$\phi_{TR,HT}$	$\sigma_{HT,Rel}$	$\phi_{Rel,Ch}$
1	0.3	0.2	0.3	0.85	0.45	0.5
2	0.5	0.35	0.4	0.85	0.8	0.7

Results

Releases only at Durham Ferry and Old River

The release sizes necessary to estimate the 5 parameters at the desired level of error (SE<=0.05) depend on the parameter to be estimated, and on the assumed parameter values (Table 3). To a lesser extent, the minimum release size required at Durham Ferry depends on the size of the supplemental release in Old River (Table 3), and vice versa (Table 4). However, in most cases the lowest total release size corresponds to releasing only 95 fish at Durham Ferry, with considerably more released in Old River. Recall that this analysis ignores the use of Durham Ferry releases for migration through the San Joaquin route or through the CVP.

Transition from B1 in Old River to CCFB ($\phi_{B1,CCFB}$ = 0.2 or 0.35)

Estimating the probability of getting from the first Old River site to the CCFB requires 270 fish released, with 95 released at Durham Ferry and 175 released in Old River.

Transition from radial gate at CCFB to Trashrack ($\phi_{CCFB,TR}$ = 0.3 or 0.4)

With low survival to and through the State Water Project, estimating the probability of getting from the radial gates at the CCFB to the trashrack requires 793 fish, with 95 released at Durham Ferry and 698 fish released into Old River. With higher survival, 501 fish are required, with 95 fish released at Durham Ferry and 406 fish released in Old River.

Transition from Trashrack to Holding Tank ($\phi_{TR,HT}$ = 0.85)

Estimating the probability of getting from the trashrack to the holding tank depends heavily on the underlying survival probabilities. If survival to the trashrack is low (0.06 from B1), then 5,195 fish are required, with 95 released at Durham Ferry and 5,100 released in Old River. If survival to the trashrack is higher (0.14 from B1), then only 582 fish are required, with 95 released at Durham Ferry and 487 released in Old River.

Survival from Holding Tank to Release Sites ($\sigma_{HT,Rel}$ = 0.45 or 0.8)

Estimating the probability of surviving from the holding tank to the release sites requires at least 3495 fish for the low survival scenario, with 95 fish released at Durham Ferry and 3400 fish released in Old River. If survival is higher throughout the system, then 843 fish are required, with 95 fish released at Durham Ferry and 748 released in Old River.

Transition from Release Sites to Chipps Island ($\phi_{Rel,Ch}$ = 0.5 or 0.7)

In the low survival scenario, estimating the probability of getting from the salvage release sites to Chipps Island requires over 10,000 fish, with 225 released at Durham Ferry and 13,380 fish released in Old River. In the high survival scenario, 3,995 fish are required, with 95 released at Durham Ferry and 3900 released in Old River.

Table 3. Minimum size of release at Durham Ferry needed in order to estimate parameters with SE <=0.05. Results for the previously recommended supplemental release size of 150 are in bold.

Scenario	Release Size in Old River	$\phi_{B1,CCFB}$	$\phi_{CCFB,TR}$	$\phi_{TR,HT}$	$\sigma_{HT,Rel}$	$\phi_{Rel,Ch}$
1	**150**	**165**	**1,920**	**16,270**	**10,848**	**44,140**
1	300	95	1,420	15,770	10,340	43,400
1	750	95	95	14,300	8,900	42,200
1	1000	95	95	14,000	8,100	41,300
1	2000	95	95	10,100	4,700	40,000
1	3000	95	95	6,800	1,400	35,000
2	**150**	**145**	**597**	**768**	**1,300**	**7,600**
2	300	95	296	467	1,000	7,250
2	750	95	95	95	95	6,400
2	1000	95	95	95	95	5,900
2	2000	95	95	95	95	3,900
2	3000	95	95	95	95	1,900

Table 4. Minimum size of supplemental release in Old River needed in order to estimate parameters with SE <=0.05. Results for the previously recommended release size of 225 are in bold. The sampling scheme with the smallest total release size is highlighted for each scenario and each parameter.

Scenario	Release Size at Durham Ferry	$\phi_{B1,CCFB}$	$\phi_{CCFB,TR}$	$\phi_{TR,HT}$	$\sigma_{HT,Rel}$	$\phi_{Rel,Ch}$
1	95	175	698	5,100	3,400	14,000
1	**225**	**135**	**658**	**4,970**	**3,340**	**13,380**
1	475	57	587	7,890	3,300	13,400
1	1000	0	426	4,730	3,200	13,200
1	2000	0	200	4,500	2,900	13,000
1	3000	0	0	4,200	2,600	12,600
2	95	175	406	487	748	3,900
2	**225**	**115**	**336**	**426**	**688**	**3,810**
2	475	0	215	296	567	3,690
2	1000	0	0	33	296	3,420
2	2000	0	0	0	0	3,000
2	3000	0	0	0	0	2,500

Releases at Durham Ferry, Old River, and Clifton Court Forebay

With an additional release made directly into Clifton Court Forebay, the total necessary release sizes generally decrease, ranging from 425 (50 at CCFB) to estimate survival from the radial gates to the trashrack if survival is relatively high, to 3075 (2700 at CCFB) to estimate survival from the release sites to Chipps Island if survival is low (Table 5).

Table 5. Minimum release size needed at Clifton Court Forebay to estimate parameters with maximum standard error of 0.05, with 225 fish released at Durham Ferry and 150 fish released at site B1 in Old River.

Scenario	$\phi_{CCFB,TR}$	$\phi_{TR,HT}$	$\sigma_{HT,Rel}$	$\phi_{Rel,Ch}$
1	60	970	640	2,700
2	50	100	190	1,290

References

Clark, K., M.D. Bowen, R. B. Mayfield, K. P. Zehfuss, J. D. Taplin, and C. H. Hanson. 2009. Quantification of Pre-Screen Loss of Juvenile Steelhead in Clifton Court Forebay. Technical report, CA Department of Water Resources, Sacramento, CA.

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