Briefing on Six-year Study
June 26, 2018

Key Messages

Six-Year Study
- Four years of the total six years of studies have been written up as either final (2011-2013) or draft (2014) reports. Final reports just released in May/June 2018.
- Conditions during study years dominated by drought conditions.
- Survival results *(more details in Attachment 1, prepared by Jeff Stuart)*:
  - Through-Delta steelhead survival (for all routes combined) was highest in the Wet year (2011, and ranged from 15% (in 2013) to 54% (in 2011).
  - Absolute survival through the San Joaquin River route was better than the Old River route in three of the four analyzed study years (2011, 2012, and 2014) but not statistically significant (some power limitations?).
  - Reports do not provide analysis of survival as a function of the I:E ratio or OMR flow[1], though do evaluate total Delta survival as a function of Vernalis flow and some routing proportions as a function of local flows.
- Routing results:
  - Not surprisingly, the proportion of study fish in the San Joaquin River route was highest in the years when the HORB was installed.

SWFSC mini-project on Six-Year Study data
- Heads-up that SWFSC did a mini-analysis *(more details in Attachment 2, prepared by Caren Barceló)* to understand the relationship between detections at different receivers (detections being a surrogate for fish movement) and environmental variables (e.g. flow, turbidity, temperature, diel phase).
  - Preliminary results were that flow, conductivity and turbidity were the variables that most often had the strongest relationship (positive or negative) with the arrival rate of steelhead; associations differed for specific receivers.

Chinook releases in the San Joaquin River
- USFWS led studies of Chinook releases in the San Joaquin River, and measured through-Delta survival, in 2009-2015.
- For 2010-2013, through-Delta Chinook survival was <5% for all releases and survival was often higher in the Old River route (*see Attachment 3, prepared by Barb Byrne*).

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[1] The 2013 report notes, for example, that "[The NMFS 2009 BiOp] identified flow at Vernalis, export volume, and the ratio of Vernalis flow-to-export as variables to test during this study as priority variables. Separating the effects of these covariates is difficult because the variables are likely to be correlated."

Overview of Six-year Study

- Studies released acoustically tagged **hatchery steelhead** into the San Joaquin River at Durham Ferry (most releases were from **late March to late May**) and tracked them through the Delta system using multiple releases and multiple acoustic receiver locations throughout the lower San Joaquin River and Delta (Figure 1).
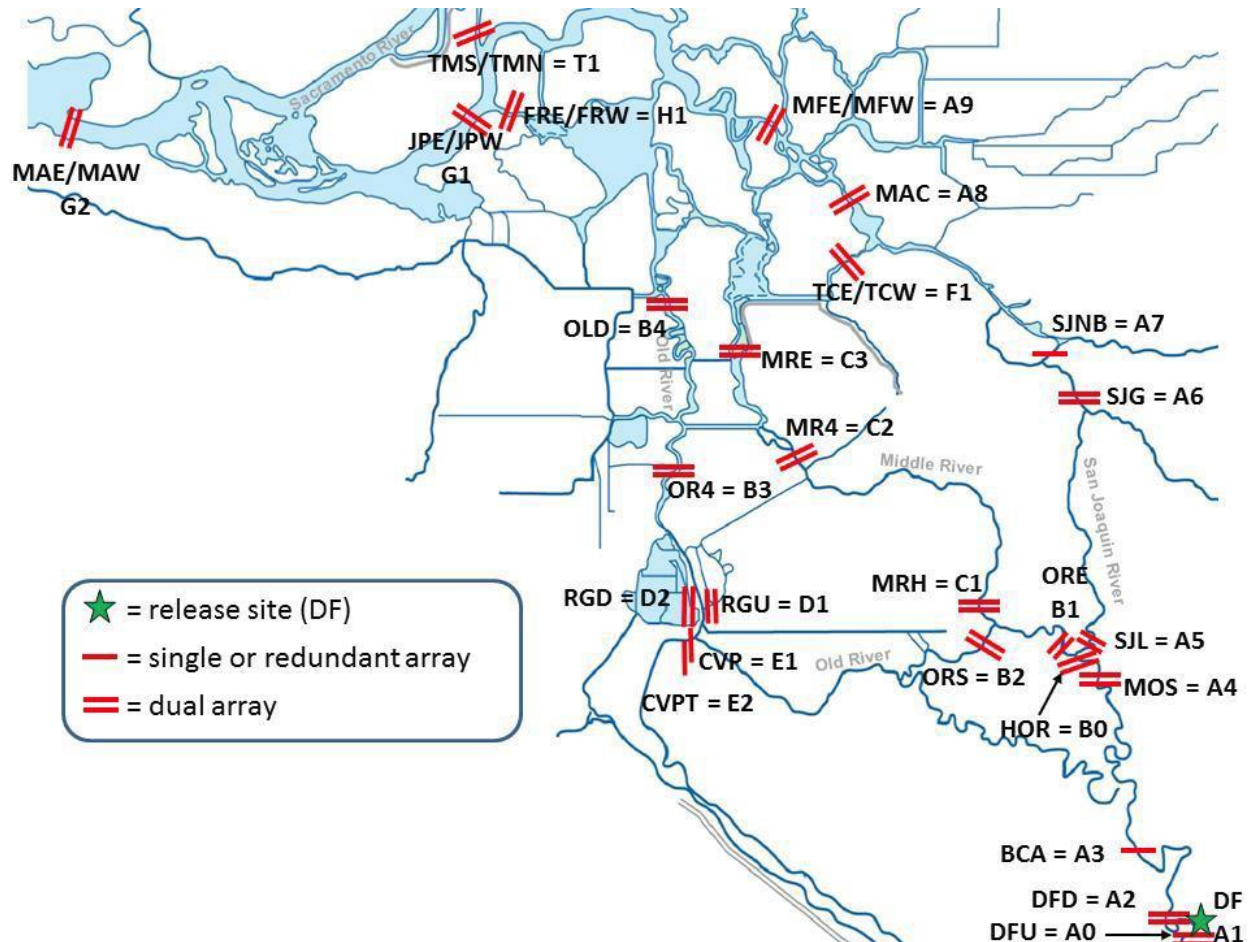

Figure 1: Locations of Acoustic Receivers for the 2012 study. Each year's study had a small number of additional/ removed or relocated acoustic receiver locations but the release location at Durham Ferry (DF) and westernmost receivers near Chipps Island (MAE & MAW) were consistent throughout.

- Studies occurred during a Wet year (2011) and five Dry or Critical years (2012-2016), as summarized in Table 1.

Table 1: *Overview of hydrologic conditions and report status for the Six-year Study*

Water Year	HORB status	San Joaquin yeartype	I:E ratio in effect	14-day OMR range (in cfs, 4/1-5/31)	Vernalis flow range (in cfs, 4/1-5/31)	Status of report
2011	Out	Wet	Vernalis flow offramp 4/1-5/10; 4:1 from 5/11-5/31	2,391 to 9,520	9635 to 28,575	Final (May 2018)
2012	In	Dry	Joint Stipulation Study* in lieu of I:E ratio	-4,218 to -1,710	1,577 to 4,418	Final (May 2018)
2013	Out	Critical	1:1	-4,050 to -130	859 to 4,176	Final (June 2018)
2014	In	Critical	1:1	-4,750 to -1,650 *(based on Index)*	510 to 3,035	Draft (May 2018)
2015	In	Critical	1:1	-1,860 to -1,170 *(based on Index)*	254 to 1,433	*No report available*
2016	In	Critical	1:1	-3,720 to -1,860 *(based on Index)*	733 to 3,215	*No report available*

*OMR requirements in Joint Stipulation Study ranged from -1,250 cfs to -5,000 cfs.

- Survival and routing estimates (Table 2) show that:
  - Through-Delta steelhead survival (for all routes combined) was highest in the Wet year (2011, and ranged from 15% (in 2013) to 54% (in 2011). See Figure 2.
  - Absolute survival through the San Joaquin River route was better than the Old River route in three of the four study years (2011, 2012, and 2014) but not statistically significant[2].
  - Not surprisingly, the proportion of study fish in the San Joaquin River route was highest in the years when the HORB was installed.

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[2] Power to detect survival differences between routes (excerpt from p.11 of the 2012 Report): "Buchanan (2010) recommended a sample size of 475 for estimating survival to Chipps down the Old River and San Joaquin routes if survival in the Old River route was low (0.05). Additionally, if survival between Durham Ferry and Chipps Island was higher (0.15) and survival between Durham Ferry and the Old River junction was high (0.9), a release of 475 at Durham Ferry would be able to detect a 50% difference between survival in the San Joaquin River and Old River routes. Thus, a release group of 475 at Durham Ferry was expected to provide accurate information about route entrainment and survival for examining biotic and abiotic factors influencing juvenile steelhead survival."

Table 2: *Summary of hatchery steelhead survival estimates from Six-Year Study: 2011 - 2014*

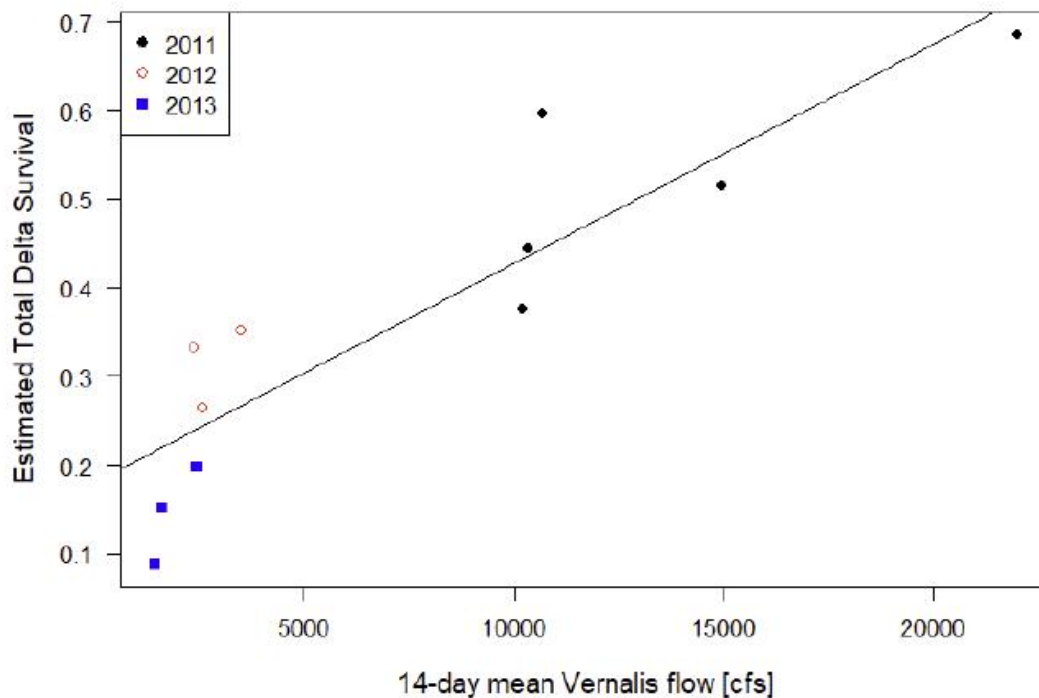| Study Year	Proportion using Route		Survival Probability Estimate			HORB Status	Water Year Type
	San Joaquin River route	Old River route	San Joaquin River Route	Old River route	Total Survival (any route)		
2011	0.51	0.49	0.55	0.52	0.54	Out	Wet
2012	0.94	0.06	0.33	0.07	0.32	In	Dry
2013	0.12	0.88	0.11	0.15	0.15	Out	Critical
2014	0.92	0.08	0.25	0.19	0.24	In	Critical

Figure 27. Estimated total delta survival (Mossdale to Chipps Island) for acoustic-tagged steelhead in the 2011, 2012, and 2013 Six-Year Study, versus 14-day mean San Joaquin River flow at Vernalis. Survival and flow data are from Tables 26 and 27. The line is the best fit linear predictor of survival as a function of 14-day Vernalis flow for these data ($r^2 = 0.8007$).

Figure 2: *Estimated total Delta survival for hatchery steelhead from the 2011-2013 study years. (Figure 27 from the 2013 report)*

- Other details available in Attachment 1:
    - Water temperatures were elevated (59 degrees F or higher) in three out of the four analyzed study years (2012-2014) during the fish releases.
    - Survival estimates by release group are provided in "heat-map" tables.
    - Releases are plotted along Vernalis flows and Mossdale water temperatures.