

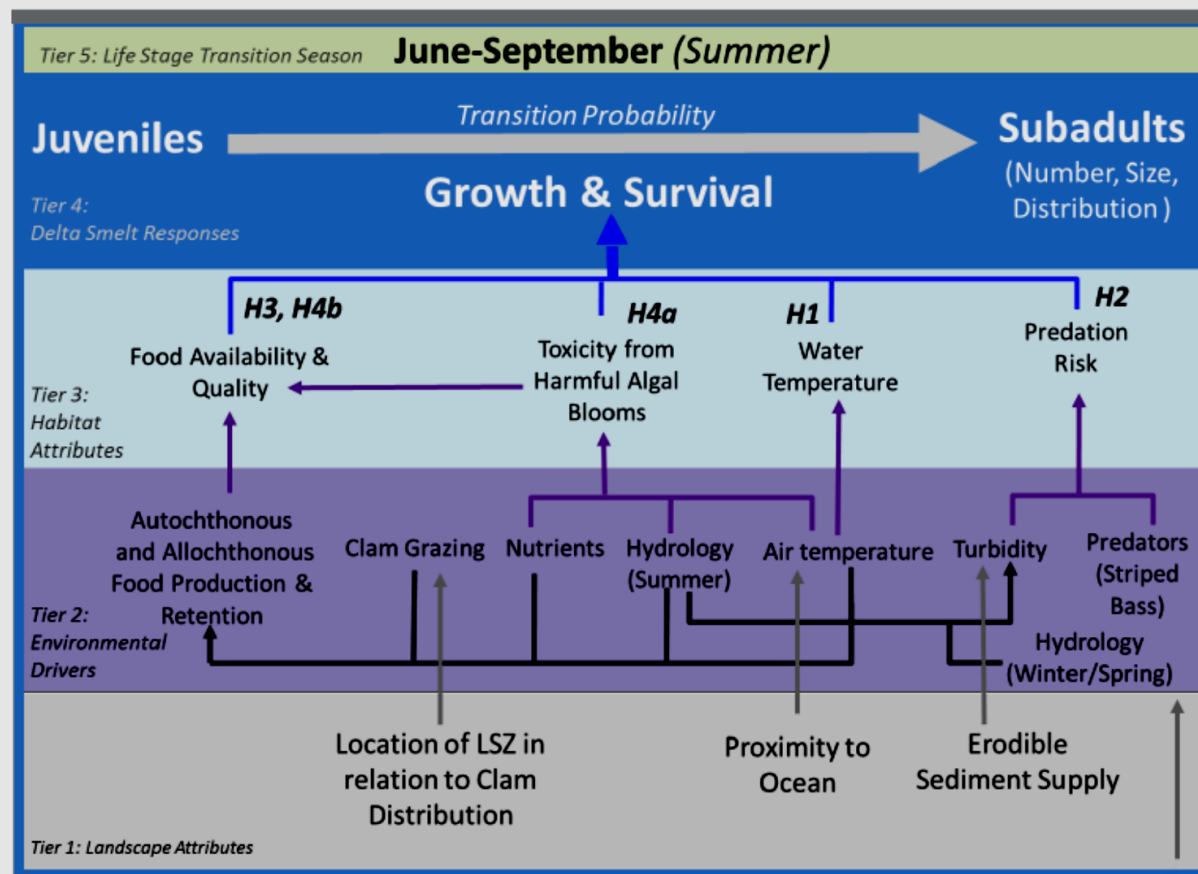
CDFW Rationale for Summer Delta Flow Augmentation

For Improving Delta Smelt Survival

(CDFW 7/8/16)

The California Department of Fish and Wildlife (CDFW) has proposed augmenting summer Delta flows, in particular Delta outflow, in 2016 and future years to improve summer-period survival of Delta Smelt given the current depressed population. Although the details of the augmentation action (total volume, weekly rates, etc.) are still under discussion and may vary by year and Water Year-type, the action will likely involve augmenting July and August flows to achieve Delta outflow levels in those months similar to what is required by D-1641 for the month of June. The actual duration of the action would be limited by the total volume of water acquired for the purposes of the action. CDFW supports such an action as a management experiment, due to the severely degraded state of the Delta Smelt population, which has experienced year-over-year declines in abundance every year since 2011 and is now at record low abundance. What follows here is a brief biological rationale for CDFW's support of the action. Figure 48 (see below) from the 2015 IEP MAST updated Delta Smelt biology conceptual model provides a convenient framework for organizing a discussion of the potential benefits of summer flow augmentation. The general subject of Figure 48 is the through-summer (June-September) growth and survival of Delta Smelt. June through September is the species' transition period from juvenile life stage to the sub-adult life stage. Food availability and quality, Harmful Algal Bloom (HAB), water temperature, and predation risk are the four habitat attributes (stressors) identified as affecting summer growth and survival. Below each of these attributes we provide brief descriptions of how CDFW expects flow augmentation to influence the attribute.

Figure 48. Conceptual model of drivers affecting the transition from Delta Smelt juveniles to subadults. Hypotheses addressed in Chapter 7 are indicated by the “H-number” combinations.



Food Availability & Quality: The relatively high flows during spring 2016 should have reduced successful settlement of *Potamocorbula amurensis* in freshwater regions. The freshwater region moved downstream this year relative to 2012 and 2013. Moreover the higher the outflow maintained through the summer, the more habitat will be seasonally protected from *P. amurensis* settlement and subsequent feeding competition. In other words, starting early in the season high outflow can limit the next *P. amurensis* year-class from settling in the Delta and competing for food. There is also a possibility that reservoir releases contribute cladocerans to the system. There has been some research showing that transport of copepods, such as *Pseudodiaptomus*, from the Delta downstream into Suisun Bay supports the latter’s food web. This is a summer-flow related phenomena.

Harmful Algal Bloom Toxicity: Augmented summer outflow levels move the Low Salinity Zone (LSZ) seaward placing more of the principle Delta Smelt habitat into downstream areas where toxic blooms are less intense and common. Factors believed to be linked to more intense HABs include warmer water temperatures, lower flows, high nitrogen levels and relatively clear water

(IEP MAST 2015). Of these factors, direct flow augmentation will reduce residence time and dilute nitrogen levels reducing the chances for a bloom.

Water Temperature: Moving the LSZ seaward places some Delta Smelt habitat under greater influence of coastal marine air providing some water cooling effect, potentially reducing temperature stress and metabolic food demand.

Predation Risk: A greater overlap of the LSZ with eastern Suisun Bay places more of Delta Smelt habitat in a region where wind-driven re-suspension of sediment is common and summer turbidity higher. The higher levels of turbidity are likely to protect Delta Smelt from excessive predation. Also, predators of juvenile Delta Smelt are likely to occur at lower densities within LSZ as it moves seaward, due to the broader, open nature of the habitat and relative absence of SAV.

Beyond the conceptual model-based discussion provided above, CDFW advocacy of augmented summer flows to improve Delta Smelt survival is informed by recent (POD era) responses of the population to X2 position. Limited data are available from the POD era (2002-15) for assessing Delta Smelt population responses to flow conditions, but a cursory examination of the data suggest the survival response to higher flows is positive. During the POD era the Delta Smelt population experienced year-over-year increases in the Fall Midwater Trawl (FMWT) index in only the three wettest years (2003, 2006, and 2011) and the modestly wet 2010. In all of the years when average June through August X2 exceeded 80 the population experienced year-over-year declines in abundance. No years with an average June through August X2 greater than 80 experienced a year over year increase in the FMWT index. Also, using a general measure of summer survival (FMWT index divided by the Summer Townet Survey (STN) index), only the three wettest years achieved strong survival-index values, whereas survival indices for the remaining drier years varied widely at lower values, probably based on the relative effects of stressors discussed above. In early June 2016, X2 was positioned at approximately 76, which compares unfavorably with years of good Delta Smelt survival, indicating a need for flow augmentation in subsequent months.

Finally, flow augmentation could potentially slightly reduce contaminant concentrations in the fresher portions of the Delta and the LSZ through dilution.

CDFW considers it highly desirable that the flow augmentation actions in 2016 and future years be accompanied by a robust monitoring program to assess action performance and adaptively manage the actions. Ideally, monitoring would focus on the response of the Delta Smelt population, however two realities inhibit measurement of a Delta Smelt population response:

- 1) The relatively small scale of the likely actions (and thus the likely response), and
- 2) The present very low density of Delta Smelt, which will result in low monitoring sample sizes, and thus low strength of applied statistical analysis.

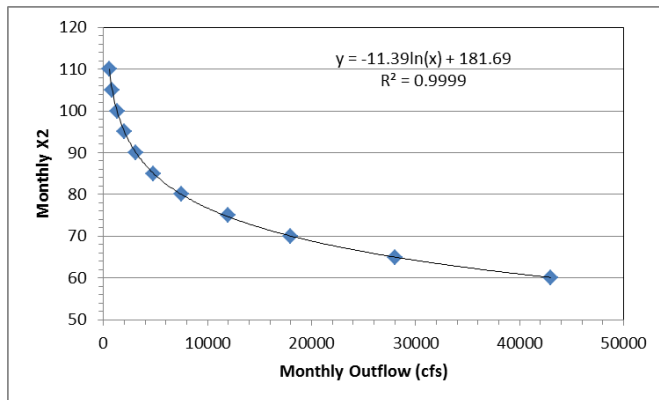
Given these fundamental population assessment limitations, CDFW expects that monitoring efforts will necessarily focus on measuring/assessing changes in key Delta Smelt habitat indicators likely to be affected by flow augmentation. These indicators would include:

- Basic flow conditions (inflow, outflow, X2 , etc.) associated with Delta Smelt habitat; values from CDEC
- The modeled location and extent of the LSZ
- Water temperatures within the LSZ and adjacent upstream areas from fish surveys (Bay Study, STN and FMWT surveys) and fixed locations (Mallard Island., Collinsville and Sacramento River at Decker Island)
- Turbidity within the LSZ and adjacent upstream areas from fish surveys (STN and FMWT surveys)) and fixed locations (Mallard Island and Sac River at Decker Island)
- Food (zooplankton) densities within LSZ and adjacent areas from the Environmental Monitoring Program and STN and FMWT surveys)
- Microcystis/cyanobacteria levels (visually ranked by STN and FMWT surveys)
- Fish condition (fish samples collected this year will allow assessment of body condition, length at date, otolith analysis and diet analysis).

As appropriate, monitoring results will be compared with similar data from past years within the POD period (2003 to present). Of particular interest will be comparing realized flow conditions and the attributes listed above with similar values during previous POD years to look for and tally improvements. In parallel, we propose to compare modelled “without augmentation” conditions with realized conditions to determine if distinguishable results should be expected.

BACKGROUND INFORMATION and ANALYSIS

The following are excerpted and original graphics addressing relationships between flow and habitat, and flow and Delta Smelt abundance



Isohaline positions (X2) measured at nominal distances (in kilometers) from the Golden Gate Bridge along the axis of the estuary. Adapted from Jassby et al. (1995).

Outflow (cfs)	X2
43000	60
28000	65
18000	70
12000	75
7500	80
4800	85
3100	90
2000	95
1300	100
840	105
540	110

. Flow requirements for steady state X2 values (From Table 2, Schubel et al. 1993).

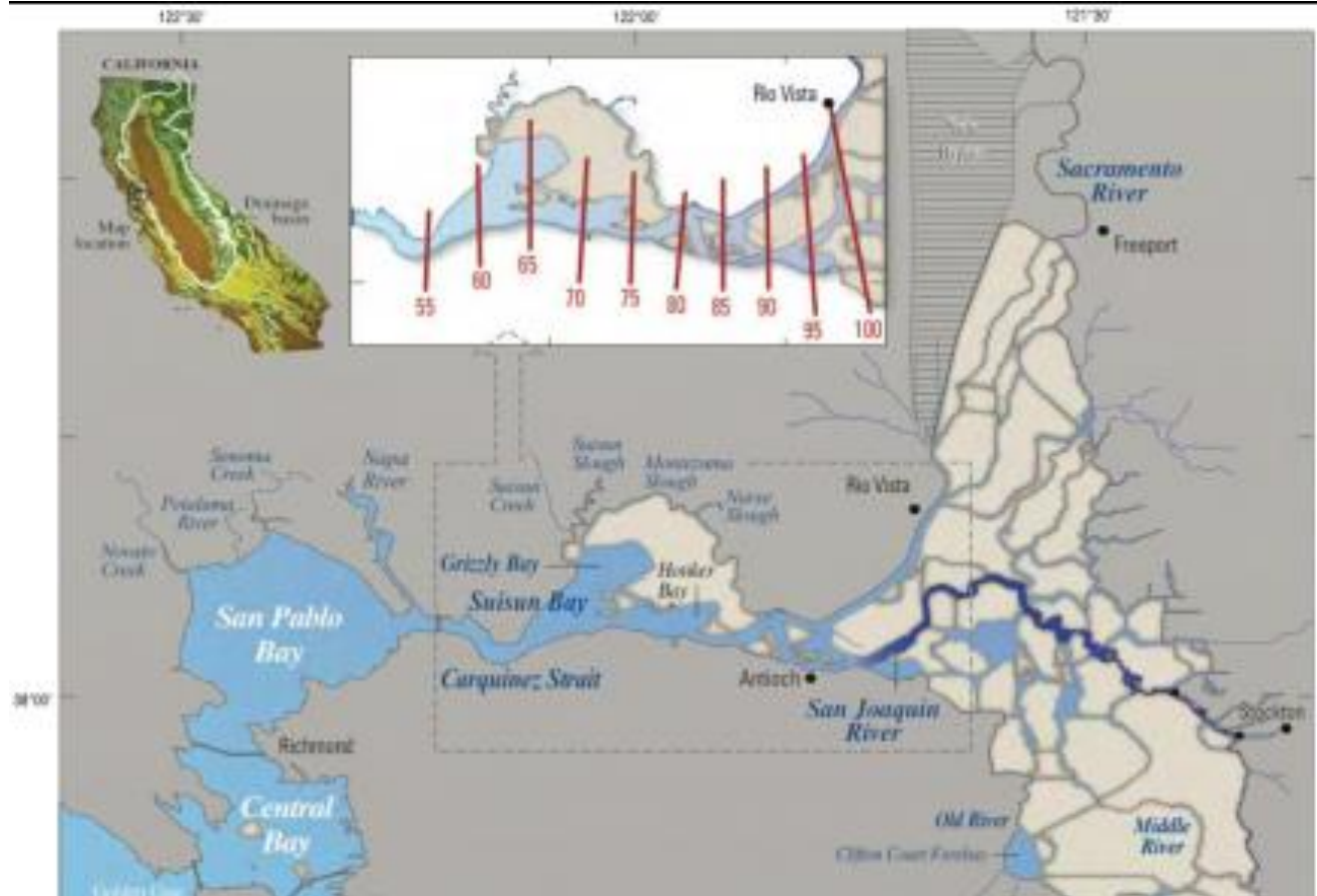
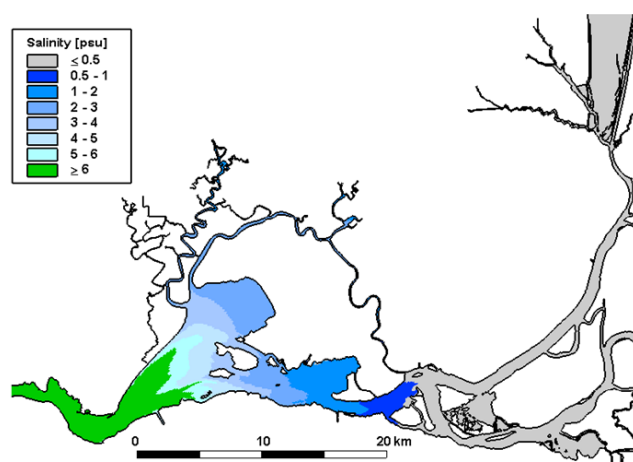
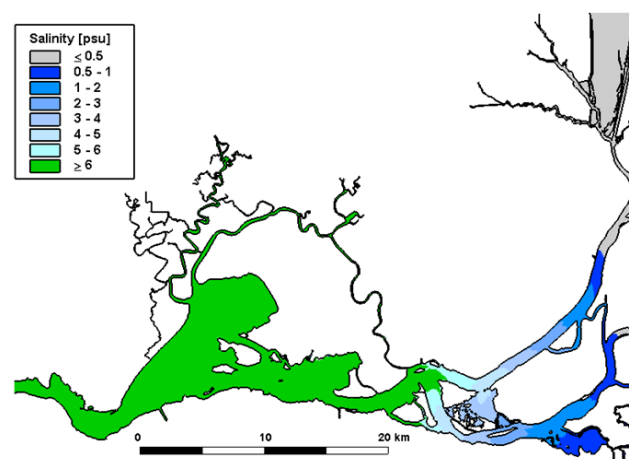


Figure 1. Isohaline positions (X2) measured at nominal distances (in kilometers) from the Golden Gate Bridge along the axis of the estuary.



X2 = 74



X2 = 90

Figure 2: Differences in LSZ extent and location for X2 of approximately 74 and 90ⁱ. Low salinity zone graphs were developed from modeled mean monthly X2 from October 2011 and October 2014 as part of the current MAST drought synthesis (in preparation).

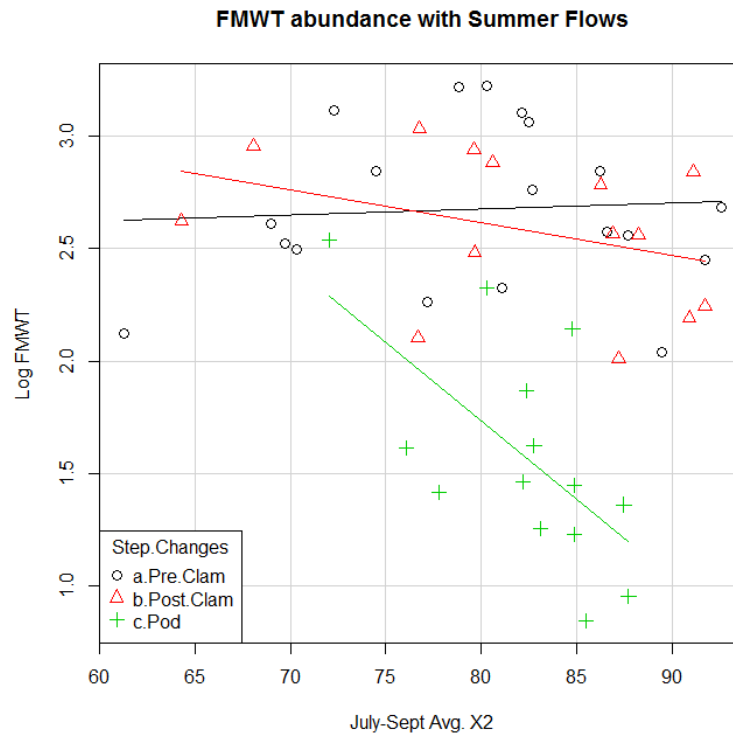


Figure 3: Fall Delta Smelt abundance (\log_{10} transformed) plotted against a July – September monthly mean X2 for three time periods: pre-clam (1967-1986), post-clam (1987-2015) and POD (2002-2015). Historically, summer flows did not appear to influence fall abundance (step changes a. & b.). However, since 2002 there is a significant ($r^2 = 0.3905$, $p = 0.016$) negative relationship between FMWT and X2 (i.e., more water, more Delta Smelt). Water year 2002 is associated with the start of the Pelagic Organism Decline and represents the approximate start of current ecological regime of the Delta ecosystem (see Baxter et al. 2010).

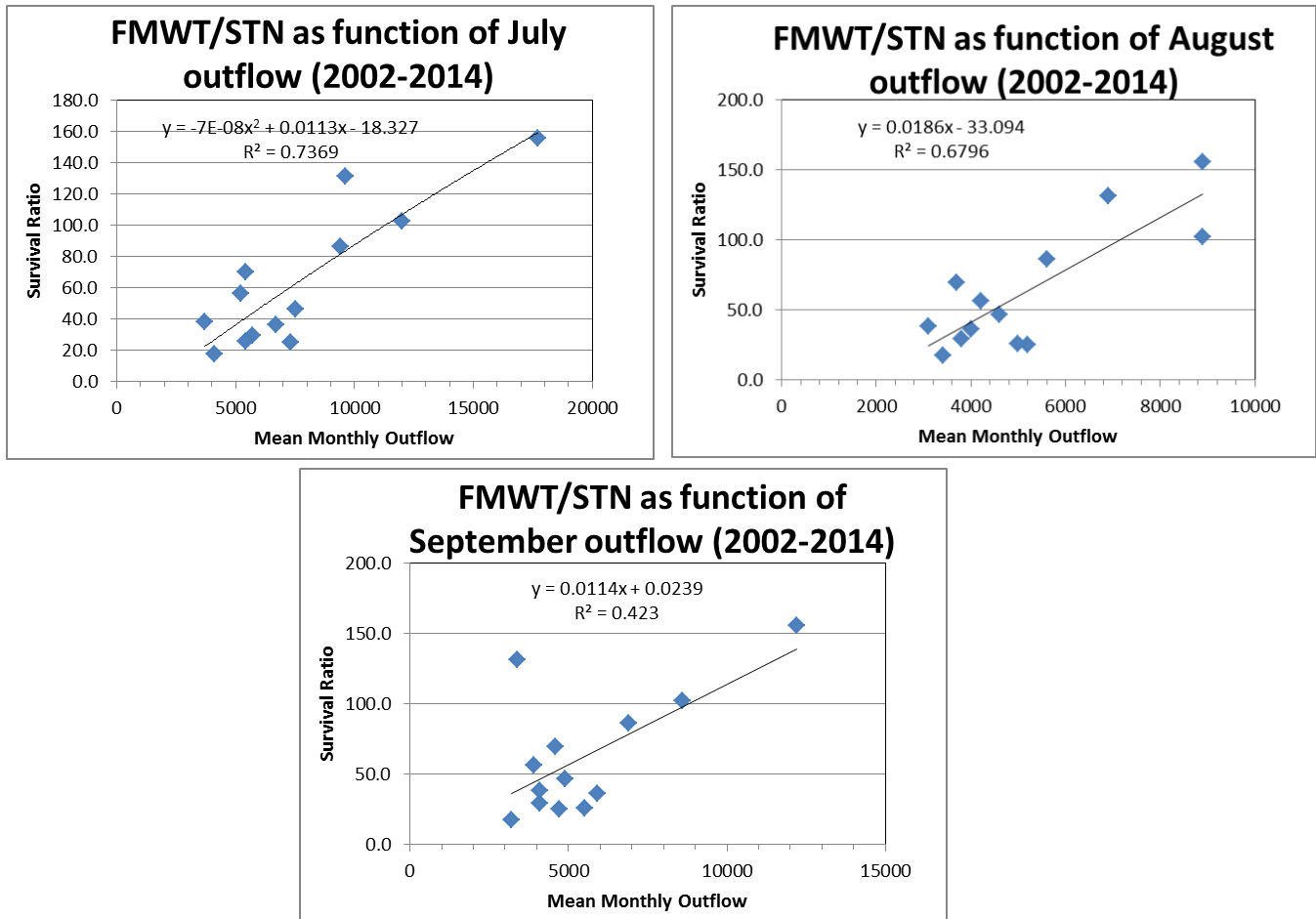


Figure 4: Survival – fall abundance (FMWT) divided by summer abundance (STN) – plotted against a monthly mean outflow (cfs), for July (top left), August (top right) and September (bottom).

Similar to Figure 2, years occurring before 2002 showed no significant relationship to summer time flows (not shown). In years following 2002, monthly outflow for July, August, and September was strongly correlated to summer survival (Figure 3). This relationship was strongest in the July and August months (r^2 of 0.736 and 0.679 respectively) and weakest in September ($R^2 = 0.423$). However, alternative regression analyses using first-difference data for each of these months also indicated significant association between the summer to fall Delta Smelt survival and mean Delta outflow. This emphasizes the consistent year-to-year co-variation between survival and summer Delta outflow.

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