Summary of Scientific Certainty Regarding San Joaquin Basin Chinook Salmon

Prepared for State Water Resources Control Board
Phase II Comprehensive Review Workshops
Workshop 2, "Bay-Delta Fisheries" to be held October 1-2, 2012

Prepared by
Doug Demko, Michael Hellmair, Matt Peterson, Shaara Ainsley,
Michele Palmer, and Andrea Fuller

On behalf of the
San Joaquin Tributaries Authority

September 14, 2012

Table of Contents

SPRING FLOWS

Scientific Certainty: High

- ***High, unmanaged spring flood flows (above 18,000 cfs), can increase smolt survival through the Delta.***
- ***Without the Head of Old River [Physical] Barrier in place, no significant relationship exists between spring flows in the managed range (below 7,000 cfs) and smolt survival through the Delta.***
- ***Flow related science relied upon by the SWRCB's Technical Report (2012) are flawed, have been discredited, are not the best available science, and should not be used as primary justification to modify flow objectives.***

Key Supporting Science

Existing scientific evidence does not support the conclusion that late winter and spring flow (February to June) in the San Joaquin River is the "primary limiting factor" to smolt survival and subsequent abundance.

- The VAMP independent scientific review panel determined that "simply meeting certain flow objectives at Vernalis is unlikely to achieve consistent rates of smolt survival through the Delta" (Dauble et al., 2010).
- NMFS (2009) states that "flows below approximately 5,000 cfs have a high level of variability in the adult escapement returning 2.5 years later, indicating that factors other than flow may be responsible for the variable escapement returns. Flows above approximately 5,000 to 6,000 cfs begin to take on a linear form and adult escapement increase in relation to flow."
- Baker and Morhardt 2001 indicates that there are no data points between 11,000-18,000 cfs, so there is no ability to identify a linear trend beginning at 5,000 cfs. Also, Baker and Morhardt (2001) state "when only the data below 10,000 cfs are considered, there appears to be a negative relationship between flow and smolt survival."
- "The complexities of Delta hydraulics in a strongly tidal environment, and high and likely highly variable predation, appear to affect survival rates more than flow, by itself, and complicate the assessment of flow effects of on survival rates." (Dauble et al. 2010).
- Choice of emigration route may be more important to survival than flow (Perry et al. 2010).
- The VAMP Peer Review (Dauble et. al 2010) indicates that consideration should be given regarding the role of Delta survival for the smolt life stage in the larger context of the entire life cycle of the fall-run Chinook (i.e., life cycle model), including survival in the upper watershed, the Bay and the ocean and fry rearing in the Delta.

The SWRCB's Technical Report's (2012) conclusion that higher spring flows result in increased adult abundance is based almost exclusively on analyses that are flawed and have been discredited (e.g., DFG 2005, 2010a; Mesick et al 2007; Mesick 2009), as well as similar non-peer-reviewed analyses (e.g., various Mesick documents, AFRP 2005, TBI & NRDC 2010a-c).

- The DFG's San Joaquin River Fall-run Chinook Salmon Population Model (SJRFRCS Model) (DFG 2005, DFG 2010a) has been found to be flawed through both peer and professional reviews (Demko et. al 2010).
- Mesick, TBI & NRDC 2010a-c and AFRP 2005 references have not been peer-reviewed and their analyses are the same/similar to those used in DFG's SJRFRCS Model.
- At least two Mesick documents have been rejected previously by FERC (2009a-b) due to
    - the "fallacy of focusing entirely on flow" and failure to consider the influence of other possible limiting factors (Tuolumne River Limiting Factors Analysis; Mesick et al. 2007); and
    - failing to consider other Central Valley populations, the effects of hatchery introductions on Tuolumne River Chinook salmon, and other potential factors (Tuolumne River Risk of Extinction Analysis; Mesick 2009).
- No factors other than flow were investigated in a rigorous fashion in the models suggesting a causal relationship between spring flow and adult returns.
- Bay Delta Conservation Program and Delta Stewardship Council are not using these analyses and an independent review panel recently recommended that NMFS develop a life cycle model for CV salmonids to examine water management and Biological Opinion Reasonable and Prudent Actions (Rose et. al. 2011).

FLOODPLAIN

Scientific Certainty: High

- ***Floodplains with characteristics like those shown to provide benefits to Chinook salmon (i.e., large, continuous expanses of shallow-water habitat) cannot be created through managed flows in the San Joaquin Basin.***
- ***Juvenile steelhead are not are not likely to use floodplains and thus would not benefit from floodplain inundation, regardless of the season.***

Scientific Certainty: Deficient

- ***Benefits of floodplain habitat on Chinook abundance have not been quantified.***

Key Supporting Science

Floodplains in the San Joaquin Basin have different characteristics than the Yolo and Cosumnes and will not provide similar salmon growth and survival benefits.

- Floodplains in the Yolo and Cosumnes bypasses consist of virtually one large, continuous expanse of mostly shallow-water habitat; while the San Joaquin Basin consists of several disconnected, smaller areas of largely deep-water habitat (oxbow features). This deep-water habitat is similar to isolated pond habitats in the Yolo Bypass where alien fish dominate and no Chinook salmon were found (Feyrer et al. 2004).
- San Joaquin Basin inundation zones estimated by the cbec analysis (cbec 2010) represent the maximum area available under a range of flows, not the quality of that habitat for salmon (i.e., depth and velocities). Even though these estimates are a best-case scenario and include areas which would not be considered beneficial to rearing salmon (i.e., deep ox-bows), the total area is still dwarfed in comparison to the Yolo Bypass or Cosumnes Preserve.
- Growth differences between juveniles rearing in floodplains versus in-river were found after a two-week period (Jeffres et al. 2008). There is no data that supports the conclusion that similar benefits occur if rearing is less than a two-week inundation period.
- Increased growth on floodplains is likely related to several factors including warmer water temperatures resulting from shallower depths and greater surface area than found in-river, as well as lower velocities and better food sources (Sommer et al. 2001). Shallow water floodplain habitat is not prevalent in the San Joaquin Basin.

<u>Juvenile steelhead are not likely to use floodplains and thus would not benefit from floodplain inundation, regardless of the season.</u>

- Juvenile steelhead are not likely to use floodplains known to rear in floodplain habitats to any great degree at any time of year (Bustard and Narver 1975, Swales and Levings 1989, Keeley et al. 1996, Feyrer et al. 2006, Moyle et al. 2007).

<u>Floodplain rearing may help increase the size/weight of Chinook outmigrants, but has not been shown to increase the *abundance* of outmigrants or the *number of adult returns*.</u>

- No clear evidence that juvenile floodplain rearing increases adult recruitment.

<u>Floodplain inundation in the San Joaquin River tributaries only visually inferred from flow-area graphs by DFG (2010).</u>

- Wetted surface area increases more quickly between 3,000-5,000 cfs (Merced) and between 4,000-6,000 cfs (Tuolumne) indicating greater increases in width, which suggests bank overtopping or floodplain inundation; Stanislaus did not have a well-defined floodplain in the 100-10,000 cfs flow range examined (DFG 2010b, SWRCB Technical Report 2012).

<u>Tributary floodplain inundation thresholds exceed the SWRCB's Technical Report (2012) maximum monthly tributary target flows.</u>

- Maximum monthly target flows (i.e., median unimpaired) specified for each tributary in the SWRCB's Technical Report (2012) are 2,500 cfs for the Stanislaus River; 3,500 cfs for the Tuolumne River; and 2,000 cfs for the Merced River.
- Assuming minimum thresholds to begin inundating floodplains are 3,000 cfs for the Merced and Stanislaus Rivers, and 4,000 cfs for the Tuolumne River, all three of these minimums exceed the maximum flows proposed in the SWRCB's Technical Report (2012).

<u>SWRCB's Technical Report (2012) emphasizes the need for creating more floodplain in the San Joaquin Basin through higher flows, but "floodplain habitat" is not defined nor quantified for the San Joaquin Basin.</u>

- The attributes of "floodplain habitat," such as depth, velocity, cover, and water temperature, are not defined.
- No information/data is presented as to how much floodplain habitat exists in the San Joaquin Basin, how much could be gained at various flows, or what the benefit to Chinook salmon would be.

FLOW QUANTITY AND TIMING

<u>Scientific Certainty: High</u>

- ***Under specific conditions, salmon migration can be temporarily stimulated through flow management.***

<u>Scientific Certainty: Deficient</u>

- ***The benefit of temporary migratory stimulation on the survival of Chinook fry or smolts through the tributaries, lower San Joaquin River, and Delta is uncertain.***
- ***The importance of attraction flows to spawning migration and subsequent spawning success is uncertain.***

<u>Key Supporting Science</u>

<u>Juvenile Chinook migration out of the upper tributaries is ***temporarily*** stimulated by changes in flow, but long duration pulse flows do not "flush" fish out of the tributaries.</u>

- Juvenile Chinook migration can be stimulated by changes in flow, but the effect is short lived (few days) (Demko et al. 2001, 2000, 1996; Demko and Cramer 1995).

<u>Higher flows increase fry (but not necessarily parr or smolt) survival in the tributaries; benefits to adult escapement are uncertain.</u>

- Stanislaus River flows have a strong positive relationship with migration survival of Chinook fry, but weak associations with parr and smolt survival (Pyper and Justice 2006).
- Smolt survival (CWT) studies conducted by CDFG at flows ranging from 600 cfs to 1500 cfs and at 4,500 cfs have shown that smolt survival is highly variable and not improved by higher flows in the Stanislaus River (SRFG 2004; CDFG unpublished data).
- Smolt survival indices in the San Joaquin River from the Merced River downstream to Mossdale indicate little relationship to flow (TID/MID 2007).
- The contribution of fry emigrants (Feb/March) to total salmon production in the San Joaquin Basin is uncertain (Baker and Morhardt 2001; SRFG 2004; SJRGA 2008; Pyper and Justice 2006).

<u>Fall flow pulses ***temporarily*** stimulate upstream migration of Chinook salmon into San Joaquin Basin tributaries, but no evidence that attraction flows are needed.</u>

- Prolonged, high-volume fall pulse flows are not warranted, since equivalent stimulation of adult migration may be achieved through modest pulses (Pyper and others 2006).
    - Relatively modest pulse-flow event (increase of ~200 cfs for 3 days) was found to stimulate migration, but only for a short duration (increased for 2-3 days).
- Migration rate and timing are not dependent upon flows, exports, water temperature or dissolved oxygen concentrations (Mesick 2001; Pyper and others 2006).
- No evidence that low flows (1,000 to 1,500 cfs) in the San Joaquin River are an impediment to migration (Mesick 2001).

<u>Flow does not explain low Delta survival of juvenile Chinook observed since 2003, so more flow is not likely the solution.</u>

- Flood flows of approximately 10,000 cfs and 25,000 cfs during outmigration in 2005 and 2006 did not increase survival near levels when flows were moderately high (5,700 cfs) in 2000 (SJRGA 2007b).
- Since recent smolt survival has been far lower than it was historically, models based on historical data are not representative of recent conditions and should not be used to predict future scenarios (VAMP Technical Team 2009).

WATER TEMPERATURE

<u>**Scientific Certainty: High**</u>

- ***Water temperatures in the San Joaquin River and South Delta are controlled by air temperatures.***
- ***Releases from tributary reservoirs will not impact water temperatures in the San Joaquin River or South Delta.***
- ***San Joaquin River restoration flows will adversely affect water temperatures from the confluence of the Merced River downstream.***

Scientific Certainty: Deficient

- ***Salmon and steelhead survival benefits of releasing large quantities of water to decrease water temperatures in the tributaries are uncertain.***

Key Supporting Science

The dominant factor influencing water temperature is ambient air temperatures, not flow.

- Ambient air temperature is the primary factor affecting water temperature; by the end of May, water temperatures at Vernalis range between 65°F and 70°F regardless of flow levels between 3,000 cfs and 30,000 cfs. (SRFG 2004)

There is no evidence that water temperatures are unsuitable for adult Chinook upstream migration

- DFG demonstrated that pre-spawn mortality is quite low (i.e., 0%-4.5%) and appears to be density, not water temperature, dependent (Guignard 2005 through 2008).
- No associations between adult migration timing and conditions for water temperature, dissolved oxygen (DO), or turbidity (Pyper et. al 2006; Mesick 2001).
- San Francisco Bay water temperatures over 65°F in September when fish are migrating (CDEC; various stations) and water temperatures at Rough and Ready Island (RRI) are typically above 70°F during early migration season.

There is no evidence that water temperatures for juvenile rearing and migration need to be colder or maintained through June.

- Nearly all juvenile Chinook migrate prior to May 15, and <1% migrate after May 31, except in wet and above normal water years. 90-99% of non ad-clipped salvaged *O. mykiss* are encountered between January and May depending on water year type.
- Existing 7 Day Average Daily Maximum water temperatures are generally ≤68ºF (20°C) in the San Joaquin River and the eastside tributaries through May 15.

The restoration of the San Joaquin River upstream of the Merced River (San Joaquin River Restoration Program; SJRRP) will adversely affect water temperatures in the lower San Joaquin River during the spring and fall.

- The lower San Joaquin River downstream of the Merced River confluence is identified as temperature impaired (USEPA 2010). According to water temperature modeling conducted by AD Consultants, SJRRP flows will be the same as the ambient temperature (SJRGA 2007a).

Releases from tributary reservoirs will not impact water temperatures in the San Joaquin River or South Delta.

- Increasing flows from the tributaries will not decrease water temperatures in the mainstem San Joaquin River downstream of the Merced confluence (SJRGA 2007a).

DISSOLVED OXYGEN

Scientific Certainty: High

- ***Low dissolved oxygen concentrations are limited to the DWSC and are the result of anthropogenic manipulation of channel geometry.***
- ***Existing DO concentrations do not impact salmon and steelhead migration.***

Key Supporting Science

Low dissolved oxygen (DO) concentrations are limited to the Deep Water Ship Channel (DWSC), and are the result of anthropogenic manipulation of channel geometry.

- The eastside rivers (Tuolumne, Stanislaus and Merced) discharge high-quality Sierra Nevada water which has low planktonic algal content and oxygen demand, and are not a major source of oxygen demand contributing to the low DO problem in the DWSC (Lee and Jones-Lee 2003).
- DO concentrations in the DWSC can be ameliorated by installation of the Head of Old River Barrier (Brunell et al. 2010).

Existing DO concentrations do not impact salmon and steelhead migration.

- Contrary to Hallock et al. (1970) indicating adult migration is prevented under low DO, migration has been observed at DO < 5mg/L (Pyper and others 2006). Adult upstream migration rate and timing is not dependent on DO concentrations (Pyper and others 2006).
- Smolt survival experiments indicate that juvenile salmon survival is not correlated with existing DO concentrations (SRFG 2004; SJRGA 2002 and 2003). Salmon and steelhead migrate in the upper portion of the water column where DO concentrations are highest (Lee & Jones-Lee 2003).

FOOD

Scientific Certainty: High

- ***Salmon and steelhead are not impaired by food availability in the San Joaquin Basin.***
- ***Projected food production from inundated areas will be realized in short inundation periods.***

<u>Key Supporting Science</u>

<u>Out-migrating Chinook smolts are not food-limited during their 3-15 day migration through the lower San Joaquin River below Vernalis and the South Delta.</u>

- The SWRCB's Technical Report (2012) provides evidence that, in other systems, unregulated rivers have more and better food resources than regulated rivers. However, the report does not provide any evidence that increasing flows in an already highly degraded system has the capability to return primary and secondary production quantity and quality to its pre-regulated state.
- Based on acoustic VAMP studies in 2008, Holbrook et al. (2009) found that smolts took 3-15 days (median 6-9 days) for migration through the lower San Joaquin River and South Delta, therefore the demand for food production over such a short duration is questionable.
- Increases in primary and secondary production due to restoration or changes in management likely occur over longer periods of time, rather than by short-term pulse flows.

CONTAMINANTS

<u>Scientific Certainty: Moderate</u>

- ***Influence of higher flows on contaminant concentrations is variable; dilution may occur in some instances but increase in others.***
- ***Providing a percent of unimpaired flows may increase contaminant concentrations.***

<u>Key Supporting Science</u>

<u>No evidence supports the idea that higher inflows reduce contaminant concentrations.</u>

- The SWRCB's Technical Report (2012, p. 3-29) states, "Higher inflows also provide better water quality conditions by reducing temperatures, increasing dissolved oxygen levels, and ***reducing contaminant concentrations***" but does not provide any references or further discussion to support this statement.
- The SWRCB's Technical Report (2012) may infer that higher flows act to dilute suspended contaminants. However, the influence of higher flows on contaminant concentrations is variable; dilution may occur in some instances but increases may occur in others.

<u>Unimpaired flows may increase contaminant concentrations.</u>

- High flows can increase contaminant concentrations through resuspension of contaminants in sediments (McBain and Trush, Inc 2002). These resuspended contaminants can enter the food web and have longer residence times in rivers and estuaries than water (Bergamaschi et al. 1997).
- Pesticides and herbicides were found in every sample of surface water sites along the

San Joaquin River and in the Old River before, during and after the VAMP month-long pulse flow and some contaminants increased throughout these three periods (Orlando and Kuivila 2005).

- "Perhaps the greatest risks to potential restoration actions within the San Joaquin River study reaches relate to uncertainties regarding remobilization of past deposits of […] pesticides, i.e., DDT and mercury" (McBain and Trush 2002).

TRANSPORT OF SEDIMENTS, BIOTA AND NUTRIENTS

Scientific Certainty: High

- ***Transport of sediment, biota, and nutrients benefits are closely linked to the availability and connectivity of floodplain habitat, and cannot be expected in a highly modified system such as the San Joaquin Basin.***

Key Supporting Science

Transport benefits from floodplain habitat are not realized in the South Delta and lower San Joaquin River because the majority of the floodplain in the lower San Joaquin River has been eliminated or is isolated behind levees.

- Transport of sediment, biota, and nutrients is directly related to the floodplains of a river-floodplain complex, which has nearly been eliminated from the lower San Joaquin River and its tributaries (cbec 2010; Williams 2006).
- "[F]ormer floodplains now behind manmade levees will remain isolated from the river, assuming no long-term changes in flood stages or flood protection policy" (Junk et al. 1989).
- "In unaltered large river systems with floodplains […], the overwhelming bulk of the riverine animal biomass derives directly or indirectly from production within the floodplains and not from downstream transport of organic matter produced elsewhere in the basin" (Junk et al. 1989).
- The FPC focuses on the lateral exchange of water, nutrients and organisms between the river channel and the connected floodplain. The floodplain is considered as an integral part of the system (Junk and Wantzen 2003).

Transport of sediment, biota, and nutrients differs between the large river-floodplain systems described by Junk et al. (1989) and the anthropogenic, leveed river channels of the South Delta.

- Under natural conditions, sediments would be downstream from upper tributaries, but dams limit natural sediment inputs such as gravels (Schoellhamer et al. 2007).
- Human activities (mining, urbanization and agriculture) have increased erosion and the supply of fine river sediments (Schoellhamer et al. 2007).
- Schoellhamer et al. (2007) states that the present day modified system, "would tend to

transport more sediment to the Delta because 1) the flood basins were a sink for fine sediments, and 2) the leveed channels will experience greater bed shear stress because more flow is kept in the channel. . . It follows that levee setbacks and floodplain restoration would tend to decrease sediment supply to the Delta by promoting floodplain deposition along upstream reaches."

- Sediment inputs into the South Delta from the San Joaquin River are the result of increases in suspended sediments from run-off events and are generally not associated with managed flow pulses (SJRG 2004).

VELOCITY

Scientific Certainty: High

- ***No significant relationship exists between mean smolt migration time and San Joaquin River flow.***

Key Supporting Science

No evidence that higher spring flows "facilitate transport."

- The SWRCB's Technical Report (2012) did not define "facilitate transport so it is unclear by what mechanisms spring flows may facilitate transport of smolts, what the benefits are, and how the benefits may be influenced by factors such as flow level, duration, turbidity, etc. The SWRCB's Technical Report (2012) may be suggesting that increased flows result in increased ***velocity***, which may lead to decreased juvenile salmonid travel time through the region, thus 'facilitating transport'.

"It seems intuitively reasonable that increased flows entering the Delta from the San Joaquin River at Vernalis would decrease travel times and speed passage, with concomitant benefits to survival. The data, however, show otherwise" (Baker and Morhardt 2001).

- No significant relationships at the 95% confidence level between mean smolt migration times from three locations (one above and two below the HORB to Chipps Island) and San Joaquin River flow (average for the seven days following release), but
- Smolt migration rate increases with **size** of released smolts (Baker and Morhardt 2001).

Juvenile salmonids are actively swimming, rather than moving passively with the flow, as they migrate towards the ocean (Cramer Decl., Case 1:09-cv-01053-OWW-DLB Document 167, Peake McKinley 1998).

- Movements of juvenile salmonids depend on their species and size, water temperature and local hydrology, and many other factors (Cramer Decl., Case 1:09-cv-01053-OWW-DLB Document 167).

- Baker and Morhardt (2001) provide an example of a study which compared the speed of smolt passage to that of tracer particles (particle tracking model - PTM), "in which 80% of the smolts were estimated to have been recovered after two weeks, but only 0.55% of the tracer particles were recovered after two months."
- Chinook released at Mossdale traveled to Chipps Island 3.5 times faster than the modeled particles (Cramer Decl., Case 1:09-cv-01053-OWW-DLB Document 167).

<u>Results from VAMP studies (using acoustic tags) have generally shown short travel times between reaches, suggesting active swimming.</u>

- In 2009, mean travel times were reported for each reach, and all were under 2.5 days (SJRGA 2009).

<u>Increased flows may slightly increase velocity near the boundary of the Delta, but do not substantially increase velocity through the Delta.</u>

- Velocities at the Head of Old River may increase by about 1 ft/s with an additional 6,000 cfs San Joaquin River flow, but additional flow provides little to no change IN velocity (<0.5 ft/s) at other stations in the South Delta (Paulsen et al. 2008).

PHYSICAL HABITAT

<u>Scientific Certainty: High</u>

- ***Physical habitat has been substantially reduced by non-flow measures (e.g., land reclamation activities, levees).***
- ***Shallow water rearing habitat (important for almost all native fish), has virtually been eliminated from the Delta.***
- ***Restoring the Delta and mainstem San Joaquin River shallow water habitat cannot be accomplished through flow management.***
- ***Non-native species thrive in the highly altered San Joaquin Basin.***

<u>Key Supporting Science</u>

<u>Physical habitat for San Joaquin Basin and Delta native fishes has been substantially reduced and altered.</u>

- Diverse habitats historically available in the Delta have been simplified and reduced by development of the watershed (Lindley et al. 2009).
- Spawning and rearing habitat have been severely reduced, total abundance and salmon diversity reduced from past alterations (McEvoy, 1986; Yoshiyama et al., 1998, 2001; Williams 2006).
- Major change in system is loss of shallow rearing habitat (Lindley et al. 2009).
- 95% of wetlands/floodplains lost to levee construction and agricultural conversion since the mid 1800s (TBI 2003, Williams 2006).
- Only ~10% of historical riparian habitat remains, with half of the remaining acreage

disturbed or degraded (Katibah 1984).

- Shallow water habitats are essentially non-existent since the "current configuration of largely rip-rapped, trapezoidal channels in the Delta provides little habitat for covered species and contributes to a high degree of predation." (Essex 2009).

<u>Levees and off-channel oxbows restrict ability to create shallow water habitat with increased flows.</u>

- The primary purpose of levees is to provide flood protection and prevent high flows from entering adjacent floodplains. There are approximately 443 miles of levees in the lower San Joaquin River downstream of the Stanislaus River confluence and South Delta.
- Inundation of off-channel oxbows creates deep water instead of shallow water habitat.

<u>Habitat alterations are linked with invasive species expansions.</u>

- *Egeria densa* (Brazilian waterweed) expansion has increased habitat and abundance of largemouth bass and other invasive predators (Baxter et al. 2008).
- Current habitat structure benefits exotic predators more than natives (Brown 2003).

<u>Habitat influences growth, survival and reproduction.</u>

- Estuaries provide important rearing habitat for Chinook; salmon fry in Delta grew faster than in river (Healey 1991, Kjelson et al. 1982).
- Shallow water habitats support high growth of juvenile Chinook (Sommer et al. 2001; Jeffres et al. 2008; Maslin et al. 1997, 1998, 1999; Moore 1997). However, as mentioned above, there is little presently available.

<u>Water quality aspect of habitat is highly variable.</u>

- Variability in habitat likely causes regional differences in relationship between Delta smelt abundance and water quality (Baxter et al. 2008).
- Reduced pumping lowered salinity in Western Delta (as desired), but led (unexpected) result of increased salinity in Central Delta (Monsen et al. 2007).

<u>Improving habitat for increased abundance of native fishes.</u>

- Habitat quantity, quality, spatial distribution and diversity must be improved to promote life history diversity that will increase resilience and stability of salmon populations (Lindley et al. 2009).

GEOMORPHOLOGY

Scientific Certainty: High

- ***Managed flow range is insufficient to provide channel mobilizing flows in the San Joaquin River Basin.***
- ***In leveed systems, true channel mobilization flows are not possible because of flood control.***

Scientific Certainty: Deficient

- ***Releasing large quantities of water for channel mobilizing flows in the tributaries for uncertain benefits to salmon and steelhead.***

Key Supporting Science

Under natural conditions, channel formation and maintenance is directly influenced and modified by flow; however, the morphology of leveed rivers cannot be modified by flow (Jacobson and Galat 2006).

- The "five critical components of the ["natural," i.e., unaltered by humans] flow regime that regulate ecological processes in river ecosystems are the magnitude, frequency, duration, timing, and rate of change of hydrologic conditions (Poff et al. 1997, Poff and Ward 1989, Richter et al. 1996, Walker et al.1995).
- In [a highly modified] a system, flow-related factors like timing of floods, water temperature, and turbidity may be managed; but, in absence of a "naturalized morphology, or flow capable of maintaining channel-forming processes, the hydrologic pulses will not be realized in habitat availability."

Due to land use changes, higher flows do not necessarily provide the channel maintenance that would occur under natural conditions.

- In leveed systems, true channel mobilization flows are not possible because of flood control. In fact, higher flows can result in increased detrimental incision in upstream tributary areas (like the Stanislaus River) where existing riparian encroachment is armored and cannot be removed by high flow events, limiting "river migration and sediment transport processes" (Kondolf et al. 2001, page 39).
- Urban and agricultural developments have encroached down to the 8,000 cfs line, "effectively limiting the highest flows to no more than the allowable flood control" (i.e., 8,000 cfs, Kondolf et al. 2001).
- Where flood pulses are not available to provide maintenance of channel habitat, "mimicking certain geomorphic processes may provide some ecological benefits" (Poff et al. 1997) [e.g., gravel augmentation, stimulate recruitment of riparian trees like cottonwoods with irrigation].

In the absence of floodplain connectivity, the functions attributed to higher “pulse flows” cannot be achieved.

- Historically, the San Joaquin River was a channel connected with its floodplain. Flood pulses in the winter and spring would have provided the beneficial functions of floodplains identified by Junk et al. (1989) and by Junk and Wantzen (2003). However, anthropomorphic changes in the lower river (e.g., levees), particularly below Vernalis (the focus of the 2012 Technical Report), have substantially reduced this floodplain connectivity and the region can no longer be considered a “large river-floodplain system.”

HEAD OF OLD RIVER BARRIER

Scientific Certainty: High

- ***Salmon smolt survival can be increased through installation of the Head of Old River Barrier (HORB).***

Key Supporting Science

Operation of a rock barrier at the Head of Old River improves salmon smolt survival through the Delta by 16-61% (Newman 2008).

- HORB reduces entrainment into Old River from more than 58% to less than 1.5%.
- Physical (rock) HORB increases San Joaquin River flow.
- Installation of the HORB doubles through-Delta survival by directing juvenile salmonids through the San Joaquin River mainstem (compared to the Old River route, NMFS 2012).

In the absence of a rock barrier at the Head of Old River, a statistically significant relationship between San Joaquin River flow and salmon survival does not exist (Newman 2008).

- HORB cannot be installed or operated during high flow events
    - Temporary rock barrier requires flows less than 5,000 cfs for installation and flows less than 7,000 cfs for operation (SJRTC 2008).

Head of Old River Barrier Predation and “Hot Spots”.

- Mean predation rate at HORB was 27.5% in 2009 and 23.5% in 2010.
- 2007 telemetry tracking found that 20% of released fish were potentially consumed by predators at three “hot spots”: Stockton Water Treatment Plant, Tracy Fish Facility trashracks and Old River / San Joaquin River split.

PREDATION

Scientific Certainty: High

- ***Predation by non-native species (especially striped bass)) is a major impediment to salmon smolt survival through the lower San Joaquin River and Delta more than river flow.***
- ***Evidence from other basins (i.e., Columbia) indicates that predation can be easily and cost-effectively reduced.***

Key Supporting Science

The VAMP review panel concluded that "high and likely highly variable impacts of predation appear to affect survival rates more than the river flow" (Dauble et al. 2010).

- ➢ All fishery agencies have acknowledged that striped bass are a major stressor on Chinook populations in the Central Valley and recovery will not occur without significant reduction in their populations and/or predation rates (DFG 2011).

Recent San Joaquin Basin VAMP studies conducted from 2006–2010 provide direct evidence of high predation rates on Chinook salmon in the lower San Joaquin River and South Delta.

- ➢ In 2007, 20% of released fish were potentially consumed by predators at three "hotspots" (Stockton Treatment Plant, Tracy Fish Facility trashracks, and the HOR).
- ➢ In 2009, mortality rates (likely due to predation) between Durham Ferry and the HOR ranged from 25.2% to 61.6% (mean 40.8%), and predation rates at HOR ranged from 11.8% to 40% (mean 27.5) (Bowen et al. 2009).
- ➢ In 2010, mortality rates (likely due to predation) between Durham Ferry and the HOR ranged from 2.8% to 20.5% (mean 7.8%) and predation rates at HOR ranged from 17% to 37% (mean 23.5%) (Bowen and Bark 2010).

Reducing striped bass predation on juvenile Chinook is the simplest, fastest, and most cost-effective means of increasing outmigration survival.

- ➢ High predation occurs at "hot spots," which can be the focus of a control program.
- ➢ Encouraging increased angling pressure on salmonid predators has successfully increased the number of adult returns in other basins on the West Coast (Radtke et al. 2004).
- ➢ Columbia River predator suppression program has cut predation on juvenile salmonids by 36% (Porter 2011).
- ➢ California Fish and Game Commission (CFGC 2012) rejected DFG's recommendation to amend striped bass sport fishing regulations, which included increasing bag limits and decreasing size limits.

REFERENCES

AFRP (Anadromous Fish Restoration Program). 2005. Recommended Streamflow Schedules to Meet the AFRP Doubling Goal in the San Joaquin River Basin. September 27, 2005.

Baker P. F. and J. E. Morhardt. 2001. Survival of Chinook Salmon Smolts in the Sacramento-San Joaquin Delta and Pacific Ocean. In: Brown RL, editor. Fish Bulletin 179: Contributions to the biology of Central Valley salmonids. Volume 2. Sacramento (CA): California Department of Fish and Game. www.stillwatersci.com/resources/2001BakerMorhardt.pdf

Baxter, R., R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, M. Gingras, B. Herbold A. Mueller-Solger, M. Nobriga, T. Sommer, K. Souza. 2008. Pelagic Organism Decline Progress Report: 2007, Synthesis of Results. Interagency Ecological Program for the San Francisco Estuary. http://www.science.calwater.ca.gov/pdf/workshops/POD/IEP_POD_2007_synthesis_report_031408.pdf

Bergamaschi, B.A., K.L. Crepeau, and K.M. Kuivila. 1997. Pesticides associated with suspended sediments in the San Francisco Bay Estuary, California U.S. Geological Survey Open-File Report 97-24.

Bowen, Mark, D., et al. 2009. 2009 Effectiveness of a Non-Physical Fish Barrier at the Divergence of the Old and San Joaquin Rivers (CA), Technical Memorandum 86-68290-09-05, September 2009. U.S. Bureau of Reclamation.

Bowen, M.B., R. Bark,. 2010. (DRAFT) 2010 Effectiveness of a Non-Physical Fish Barrier at the Divergence of the Old and San Joaquin Rivers (CA). U.S. Department of Interior/Bureau of Reclamation. Technical Memorandum 86-68290-10-07.

Brown, L. R. 2003. Will Tidal Wetland Restoration Enhance Populations of Native Fishes? In: Larry R. Brown, editor. Issues in San Francisco Estuary Tidal Wetlands Restoration. San Francisco Estuary and Watershed Science. Vol. 1, Issue 1 (October 2003), Article 2. http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art2

Brunell, M., G.M. Litton, J.C. Monroe & ICF International. 2010. Effects of the Head of Old River Barrier on flow and water quality in the San Joaquin River and Stockton Deep Water Ship Channel. Report to the Department of Water Resources. http://baydeltaoffice.water.ca.gov/sdb/af/docs/HORB_Report_Final_3-17-2010.pdf

Bustard, D.R. and D.W. Narver. 1975. Aspects of the winter ecology of juvenile coho salmon (*Oncoryhnchus kisutch*) and steelhead trout (*Salmo gairdneri*). *Journal of the Fisheries Research Board of Canada* 32:667-680.

cbec. 2010. San Joaquin Floodplain inundation mapping. cbec, Inc, Sacramento, California. 24pp. Report provided as Attachment 4 in *Comments pertaining to the "Scientific Basis for Developing Alternate San Joaquin River Delta Inflow Objectives" described in the State Water Resources Control Board's October 29, 2010, Draft Technical Report on the Scientific Basis for Alternative San Joaquin*

River Flow and Southern Delta Salinity Objectives submitted on December 6, 2010 to the State Water Source Control Board by Demko et al. on behalf of the San Joaquin River Group Authority.

CFGC [California Fish and Game Commission]. 2012. Agenda item 9- Request for authorization to publish notice of commission intent to amend striped bass sport fishing regulations. Staff Summary, Meeting of February 2, 2012. State of California Fish and Game Commission, Sacramento, California.

Dauble, D., Hankin, D., Pizzimenti J.J., and Smith P. 2010. The Vernalis Adaptive Management Program (Vamp): Report of The 2010 Review Panel. http://www.sjrg.org/peerreview/review_vamp_panel_report_final_051110.pdf

Demko, D.B. and S.P. Cramer. 1995. Effects of pulse flows on juvenile Chinook migration in the Stanislaus River. Annual Report for 1995. Prepared by S.P. Cramer & Associates, Inc. for the Oakdale Irrigation District, Oakdale, CA, and South San Joaquin Irrigation District, Manteca, CA.

Demko, D.B. and others. 1996. Effects of pulse flows on juvenile Chinook migration in the Stanislaus River. Annual Report for 1996. Prepared by S.P. Cramer & Associates, Inc. for the Oakdale Irrigation District, Oakdale, CA, and South San Joaquin Irrigation District, Manteca, CA.

Demko, D.B., A. Phillips and S.P. Cramer. 2000. Effects of pulse flows on juvenile Chinook migration in the Stanislaus River. Annual Report for 1999. Prepared by S.P. Cramer & Associates for the Tri-Dam Project.

Demko, D.B., A. Phillips and S.P. Cramer. 2001. Effects of pulse flows on juvenile Chinook migration in the Stanislaus River. Annual report for 2000 prepared for Tri-Dam project.

DFG. 2005. Final Draft. San Joaquin River Fall-run Chinook Salmon Population Model. San Joaquin Valley Southern Sierra Region. 87 pages.

DFG. 2010a. Flows Needed in the Delta to Restore Anadromous Salmonid Passage from the San Joaquin River at Vernalis to Chipps Island. http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/exhibits/dfg/dfg_exh3.pdf.

DFG. 2010b. California Department of Fish and Game Comments on the Draft Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives. http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_pla n/water_quality_control_planning/comments120610/carl_wilcox.pdf

DFG. 2011. Report and Recommendation to the Fish and Game Commission in Support of a Proposal to Revise Sportfishing Regulations for Striped Bass.

Essex Partnership. 2009. DRERIP Evaluations of BDCP Draft Conservation Measures – Summary Report. http://www.science.calwater.ca.gov/pdf/workshops/workshop_eco_052209_BDCP-DRERIP_Summary_with_Appendices1.pdf

Feyrer, F., T.R. Sommer, S.C. Zeug, G. O'Leary, and W. Harrell. 2004. Fish assemblages of perennial floodplain ponds of the Sacramento River, California (USA), with implications for the conservation of native fishes. *Fisheries Management and Ecology* 11: 335-344.

Feyrer, F, T.R. Sommer, W. Harrell. 2006. Importance of flood dynamics versus intrinsic physical habitat in structuring fish communities: evidence from two adjacent engineered floodplains on the Sacramento River, California. *North American Journal of Fisheries Management* 26: 408-417.

Feyrer, F., M. Nobriga, and T. Sommer. 2007. Multi-decadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, U.S.A. Canadian Journal of Fisheries and Aquatic Sciences 64:723-734. http://iep.water.ca.gov/AES/FeyrerNobrigaSommer2007.pdf

Guignard, J. 2005. Stanislaus River Fall Chinook Salmon Escapement Survey 2004. California Department of Fish and Game. Prepared for United States Bureau of Reclamation Contract # R0440003.

Guignard, J. 2006. Stanislaus River Fall Chinook Salmon Escapement Survey 2005. California Department of Fish and Game. Prepared for United States Bureau of Reclamation Contract #R0540004.

Guignard, J. 2007. Stanislaus River Fall Chinook Salmon Escapement Survey 2006. California Department of Fish and Game. Prepared for United States Bureau of Reclamation Contract # R0640001.

Guignard, J. 2008. Stanislaus River Fall Chinook Salmon Escapement Survey 2007. California Department of Fish and Game. Prepared for United States Bureau of Reclamation Contract #R0740005.

Hallock, R.J., R.F. Elwell, and D.H. Fry Jr. 1970. Migrations of Adult King Salmon *Onchorhynchus tshawytscha* in the San Joaquin Delta as Demonstrated by the Use of Sonic Tags. Fish Bulletin 151.

Healey MC. 1991. Life history of Chinook salmon (*Oncorhynchus tshawytscha*). In: Groot C, Margolis L, editors. Pacific salmon life histories. Vancouver (BC): University of British Columbia Press. p 311-394.

Holbrook, C.M., Perry, R.W., and Adams, N.S., 2009, Distribution and joint fish-tag survival of juvenile Chinook salmon migrating through the Sacramento-San Joaquin River Delta, California, 2008: U.S. Geological Survey Open-File Report 2009-1204, 30 p. http://www.sjrg.org/technicalreport/2009/2008-USGS-Fish-Survival-Report.pdf

Jacobson, R.B. and D.L. Galat. 2006. Flow and form in rehabilitation of large-river ecosystems: An example from the Lower Missouri River: *Geomorphology* 77 (2006) 249-269.

Jeffres, C.A., J.J. Opperman, and P.B. Moyle. 2008. Ephemeral floodplain habitats provide best growth conditions for juvenile Chinook salmon in a California river. *Environmental Biology of Fishes* 83:449-458.

Junk, W.J., P.B., Bayley, and R.E. Sparks. 1989. The Flood Pulse Concept in River-Floodplain Systems. Special publication. *Canadian Journal of Fisheries and Aquatic Science* 106:110–127.

Junk, W.J. and K.M. Wantzen. 2003. The flood pulse concept: New aspects, approaches and applications-an update. Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries: Volume II. 23 pp.

Katibah, E.F. 1984. A brief history of the riparian forests in the central valley of California. In: Warner, R.E.; Hendrix, K.M., editors. California riparian systems:

ecology conservation and productive management. Berkeley, CA: University of California Press; 23-29.

Keeley, E.R. , P.A. Slaney and D. Zaldokas. 1996. Estimates of production benefits for salmonid fishes from stream restoration initiatives. Watershed Restoration Management Report No. 4. Watershed Restoration Program, Ministry of Environment, Lands and Parks and Ministry of Forests, British Columbia. 20 pp.

Kjelson, MA, Raquel, PF, Fisher, FW. 1982. Life history of fall-run juvenile Chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin Estuary, California. In: Kennedy, VS, editor. Estuarine comparisons. New York: Academic Press. p. 393-411.

Kondolf, G.M., A. Falzone, and K.S. Schneider. 2001. Reconnaissance-level assessment of channel change and spawning habitat on the Stanislaus River below Goodwin Dam. USFWS, March, 2002.

Lee, G. F. and A. Jones-Lee. 2000. Issues in developing the San Joaquin River Deep Water Ship Channel DO TMDL. Report to Central Valley Regional Water Quality Board, Sacramento, CA, August 2000.

Lindley, S. T., C. B. Grimes, M. S. Mohr, W. Peterson, J. Stein, J. T. Anderson, L.W. Botsford, , D. L. Bottom, C. A. Busack, T. K. Collier, J. Ferguson, J. C. Garza, A. M. Grover, D. G. Hankin, R. G. Kope, P. W. Lawson, A. Low, R. B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F. B. Schwing, J. Smith, C. Tracy, R. Webb, B. K. Wells, and T. H. Williams. March 18, 2009. What caused the Sacramento River fall Chinook stock collapse? Pre-publication report to the Pacific Fishery Management Council. http://swr.nmfs.noaa.gov/media/SalmonDeclineReport.pdf

Maslin, P, Lenox, M, Kindopp, J, McKinney, W. 1997. Intermittent streams as rearing habitat for Sacramento River Chinook salmon (*Oncorhynchus tshawytscha*). California State University Chico, Dept. of Biological Sciences.

Maslin, PLM, Kindopp, J. 1998. Intermittent streams as rearing habitat for Sacramento River Chinook salmon (*Oncorhynchus tshawytscha*): 1998 update. California State University Chico, Dept. of Biological Sciences.

Maslin, P, Kindopp, J, Storm, C. 1999. Intermittent streams as rearing habitat for Sacramento River Chinook salmon (*Oncorhynchus tshawytscha*): 1999 update. California State University Chico, Dept. of Biological Sciences.

McBain and Trush, Inc. editor. 2002. San Joaquin River Restoration Study background report. Prepared for Friant Water Users Authority. Lindsay, California and Natural Resources Defense Council, San Francisco, California. Arcata, California. December 2000.

McEvoy, A. F. 1986. The fisherman's problem: ecology and law in the California fisheries. Cambridge University Press, New York, New York.

Mesick, C. 2001. The effects of the San Joaquin River flows and Delta export rates during October on the number of adult San Joaquin Chinook salmon that Stray. In: R.L. Brown (ed.) Contributions to the Biology of Central Valley Salmonids. California Department of Fish and Game. Fish Bulletin 179(2): 139-162.

Mesick, C.F. and D. Marston. 2007. Provisional Draft: Relationships Between Fall-Run Chinook Salmon Recruitment to the Major San Joaquin River Tributaries and Stream Flow, Delta Exports, the Head of the Old River Barrier, and Tributary Restoration Projects from the Early 1980s to 2003.

Monsen, N.E., J.E. Cloern, and J.R. Burau. 2007. Effects of flow diversions on water and habitat quality; examples from California's highly manipulated Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 5, Issue 3, Article 2. http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1119&context=jmie/sfews

Moore, TL. 1997. Condition and feeding of juvenile Chinook salmon in selected intermittent tributaries of the upper Sacramento River [ms thesis]. California State University, Chico.

Moyle, P.B., P.K. Crain, and K. Whitener. 2007. Patterns in the Use of a Restored California Floodplain by Native and Alien fishes. *San Francisco Estuary and Watershed Science* 5:1–27. http://repositories.cdlib.org/jmie/sfews/vol5/iss3/art1

Newman, K. B. and D. G. Hankin. 2004. Statistical Procedures for Detecting the CVPIA Natural Chinook Salmon production Doubling Goal and Determining Sustainability of Production Increases. Prepared for CH2M Hill (subcontract 73603). June 21, 2004.

NMFS. 2009. Biological opinion and conference opinion on the long-term operations of the Central Valley Project and State Water Projects. NMFS Endangered Species Act, Section 7 Consultation. 844 pp.

NMFS. 2012. Summary of the expected benefits to salmonid survival of a rock barrier at the Head of Old River & preferential use of the Central Valley Project export facility. http://baydelta.files.wordpress.com/2012/01/2012_horb_survival-benefits_nmfs.pdf

Orlando, J.L., and K. M. Kuivila. 2005. Concentrations of organic contaminants detected during managed flow conditions, San Joaquin River and Old River, California, 2001: U.S. Geological Survey Data Series 120, 13 pp.

Paulsen, S. and E.J. List. 2008. Effect of increased flow in the San Joaquin River on stage, velocity, and water fate, Water Years 1964 and 1988. Prepared by Flow Science, Inc., for San Joaquin River Group Authority. 107 pages.

Peake, S. and R.S. McKinley. 1998. A re-evaluation of swimming performance in juvenile salmonids relative to downstream migration. *Canadian Journal of Fisheries and Aquatic Sciences* 55: 682-687.

Perry, R.W., J.R. Skalski, P.L. Brandes, P.T. Sandstrom, A.P. Klimley, A. Ammann, and B. MacFarlane. 2010. Estimating survival and migration route probabilities of Chinook salmon in the Sacramento-San Joaquin River delta. North American Journal of Fisheries Management 30: 142-156.

Poff, N.L. and J.V. Ward. 1989. Implications of streamflow variability and predictability for lotic community structure- a regional-analysis of streamflow patterns. *Canadian Journal of Fisheries and Aquatic Sciences* 46: 1805-1818.

Poff, N.L., J.K. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The Natural Flow Regime. *Bioscience* 47: 769-784.

Porter, R. 2011. Report on the predation index, predator control fisheries, and program evaluation for the Columbia River Basin experimental Northern Pikeminnow management program. 2011 Annual Report by R. Portern for the Pacific States Marine Fisheries Commission.

Pyper, B, J.B. Lando, and C. Justice. 2006. Analyses of Weir Counts and Spawning Surveys of Adult Chinook Salmon in the Stanislaus River. September 2006.

Pyper, B. and C. Justice. 2006. Analyses of rotary screw trap sampling of migrating juvenile Chinook salmon in the Stanislaus River, 1996-2005. August 2006.

Radtke, H.D., C.N. Carter, and S.W. Davis, 2004. Economic evaluation of the Northern Pikeminnow Management Program. Pacific States Marine Fisheries Commission, June, 2004.

Richter, B.D., J.V. Baumgartner, J. Powell, and D.P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. *Conservation Biology*. 10: 1163-1174. Blackwell Publishing Ltd. (RBI 2007)

Rose, K., J. Anderson, M. McClure and G. Ruggerone. 2011. Salmonid Integrated Life Cycle Models Workshop. Report of the Independent Workshop Panel. Prepared for the Delta Stewardship Council.

Schoellhamer, D., S. Wright, J. Drexler and M. Stacy. 2007. Sedimentation conceptual model. Sacramento, (CA): Delta Regional Ecosystem Restoration Implementaiton Plan.

SRFG Stanislaus River Fish Group. 2004. A Summary of Fisheries Research In The Lower Stanislaus River (Working Draft), 10 March 2004. Source: http://www.delta.dfg.ca.gov/srfg/restplan/Fisheries_Research_03-08-04.doc

SJRGA 2003. 2002 Annual Technical Report on the Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. January 2003. 125 pgs. Source: http://www.sjrg.org/technicalreport/2002/2002_sjrg_report.pdf

SJRGA. 2002. 2001 Annual Technical Report on the Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. January 2002. 125 pgs. Source: http://www.sjrg.org/technicalreport/default.htm

SJRGA. 2007a. San Joaquin River Group Authority Written Comments to Proposal by Central Valley Regional Water Quality Control Board to List the San Joaquin, Tuolumne, Merced and Stanislaus Rivers as Impaired Bodies of Water for Temperature Pursuant to Section 303(D). 19 November 2007.

SJRGA San Joaquin River Group Authority. 2007b. 2006 Annual Technical Report on the Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. January 2007. 137 pgs. Source: http://www.sjrg.org/technicalreport/default.htm <http://www.sjrg.org/technicalreport/default.htm>

SJRGA San Joaquin River Group Authority. 2008. 2007 Annual Technical Report on the Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan. January 2008. 127 pgs. Source: http://www.sjrg.org/technicalreport/default.htm

SJRGA. 2009. San Joaquin River Agreement Vernalis Adaptive Management Plan 2007 Annual Technical Report. Prepared for California Water Resource Control Board in compliance with D-1641. http://www.sjrg.org/technicalreport/2009/2009-SJRGA-Annual-Technical-Report.pdf

SJRTC (San Joaquin River Technical Committee), 2008, Summary Report of the Vernalis Adaptive Management Plan (VAMP) for 2000-2008, Report prepared for the Advisory Panel Review conducted by the Delta Science Program, December 22, 2008, 84 p.

Sommer, T.R., M.L. Nobriga, W.C. Harrell, W. Batham, and W.J. Kimmerer. 2001. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. *Canadian Journal of Fisheries and Aquatic Sciences* 58: 325-333.

[SRFG] Stanislaus River Fish Group. 2004. A Summary of Fisheries Research In The Lower Stanislaus River (Working Draft), 10 March 2004. Source: http://www.delta.dfg.ca.gov/srfg/restplan/Fisheries_Research_03-08-04.doc

Swales, S. and C.D. Levings. 1989. Role of off-channel ponds in the life-cycle of coho salmon (*Oncorhynchus kisutch)* and other juvenile salmonids in the Coldwater River, British Columbia. *Canadian Journal of Fisheries & Aquatic Sciences* 46: 232-242.

SWRCB. 2012. Technical report on the scientific basis for alternative San Joaquin river flow and Southern Delta salinity objectives. 202 pp.

TBI and NRDC [The Bay Institute and Natural Resources Defense Council]. 2010a. Exhibit 1 - Written Testimony of Jonathan Rosenfield. Ph.D., Christina Swanson, Ph.D., John Cain, and Carson Cox Regarding General Analytical Framework.

TBI & NRDC. 2010b. Exhibit 2 -Written Testimony of Jonathan Rosenfield, Ph.D., and Christina Swanson, Ph.D., Regarding Delta Outflows.

TBI & NRDC. 2010c. Exhibit 3 -Written Testimony of Christina Swanson, Ph.D., John Cain, Jeff Opperman, Ph.D., and MarkTompkins, Ph.D. Regarding Delta Inflows.

TID/MID. 2007. 2006 Lower River Annual Report. United States of America Before the Federal Energy Regulatory Commission FERC 2299 Report. March 2007. Source: http://www.tuolumnerivertac.com/Documents

VAMP Technical Team. 2009. Summary report for the Vernalis Adaptive Management Plan (VAMP) for the experimental determination of juvenile chinook salmon survival within the lower san Joaquin River in response to river flow and State Water Project (SWP) and Central Valley Project (CVP) exports (2000-2008).

Walker, K.F., F. Sheldon, and J.T. Puckridge. 1995. A perspective on dryland river ecosystems. *Regulated Rivers* 11: 85-104.

Williams, J.G. 2006. Central Valley Salmon: A Perspective on Chinook and Steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science, 4-3.

Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical abundance and decline of Chinook salmon in the Central Valley region of California. North American Journal of Fisheries Management 18:487–521.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 2001. Historic and present distribution of chinook salmon in the Central Valley drainage of California. In Fish Bulletin 179: Contributions to the biology of Central Valley salmonids., R. L. Brown, editor, volume 1, pages 71–176. California Department of Fish and Game, Sacramento, CA.