Additional Scientific Information Related to Salmonids, Recommended Changes to the Bay-Delta Water Quality Control Plan, and Recommendations to Address Scientific Uncertainty and Changing Circumstances

Workshop 2: Bay-Delta Fishery Resources

Submitted by:
Trout Unlimited
&
The Bay Institute

Authored by:
Rene Henery, Ph.D
and
Jon Rosenfeld, Ph.D
(Exclusive Author of Section C (Delta Hydrodynamics) of this Submission)

Submitted to the State Water Resources Control Board on behalf of:
Trout Unlimited
The Bay Institute
Natural Resources Defense Council
Pacific Coast Federation of Fishermen's Associations

September 14, 2012

I. Response to Question 1: Additional Scientific Information and Recommended Changes to the Bay-Delta Water Quality Control Plan Regarding Salmonids

The State Water Resources Control Board (State Water Board) is requesting information related to the comprehensive Phase 2 review and update to the 2006 Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan). Specifically, the State Water Board seeks scientific and technical information that was not addressed in its 2009 Staff Report or its 2010 final report on "Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem" (hereafter 2010 Delta Flow Report or SWRCB 2010). We recognize that many different public trust resources are impacted by the conditions in the Sacramento-San Joaquin Delta (Delta); however this submittal focuses on new scientific and technical information related to anadromous species that rely on the Delta, mainly Chinook salmon (*Oncorhynchus tshawytscha)*.

Anadromous fish utilize the Delta for a number of critical functions including spawning, rearing, migration (both upstream as adults and downstream as juveniles) and foraging. However, they also utilize upstream riverine habitats to complete essential life functions. Therefore, Delta flow requirements (both inflow and outflow) must be sufficient to provide the contiguous habitat that is necessary to support the life cycle of Chinook salmon and other anadromous species. To truly understand what flow requirements are sufficient, it is necessary to understand not only the in-Delta requirements of Chinook salmon life history but also the upstream relationships between flow and Chinook salmon survival. The characteristics of inflow to the Delta are positively correlated with flow characteristics in the upstream watershed. Therefore, a range of flow characteristics in the upstream watershed drive a variety of processes that promote sustainable conditions for salmon and other anadromous fish species as well as the overall ecological health of the Delta.

The current Delta hydrograph has been dramatically altered over time by both water exports from the Delta and diversions throughout the watershed. These alterations have resulted in the significant deterioration of the ecological health of the Delta and the Public Trust resources it supports, including salmonids. Habitat alterations in the Delta limit salmon and steelhead production primarily through reduced survival during the outmigrant (smolt) stage. Decreased flow can delay juvenile migration events resulting in their increased exposure to unsuitable water temperatures, predation or entrainment. These lower survivals are associated with decreases in the magnitude of flow through the estuary, increases in water temperature, and water project diversions in the Delta.

An extensive amount of scientific information supports the concept that the magnitude, duration, frequency and timing of flow is critical to the restoration of natural anadromous fish resources in the Central Valley watershed. In addition to survival being higher with higher flows, Chinook salmon abundance has also been found to be higher with greater Sacramento River (and San Joaquin River) flow. Therefore, adequate freshwater flow both into the Delta and through the Delta is an absolute prerequisite to increasing salmon survival rates and restoring natural salmon production in the Central Valley.

Scientific literature and other technical information that has become available since 2010 strongly supports the State Water Board's 2010 Delta Flow Report finding that "*the best available science suggests that current flows are insufficient to protect public trust resources.*" (2010 Delta Flow Report, p.2). In the context of anadromous fish, the information reinforces the finding that Chinook salmon have diverse life histories and life cycles that require suitable conditions in the upper and lower watersheds, Delta and ocean. The information also supports the finding that the drastic changes to the quality and characteristics of historic salmonid habitat, largely caused by water diversion activities, have resulted in decreased Sacramento Valley Chinook salmon and steelhead stocks. Salmonids are adapted to the seasonally variable stream flows and diverse habitats of Central Valley rivers. Water management and diversion activities have helped create a system that deviates from these historical conditions. This deviation and associated decrease in the dynamism of the system has degraded habitat and created an environment conducive to alien species that compete with juvenile salmon for prey or predate upon them.

In this written submission, we review and summarize the findings of new publications, studies, and data and conclude that these new studies and publications support the following findings:

1. California's native fish communities are experiencing rapid decline with the majority at risk of extinction and trends in decline having accelerated markedly over the last three decades.
2. All Central Valley Chinook salmon populations as well as Central Valley steelhead populations are now sufficiently impacted to be endangered or at least vulnerable to extinction, with the most significant mechanisms of their decline being loss of access to upstream tributary spawning and downstream floodplain rearing habitats and large-scale flow alterations.
3. Delta inflow levels and patterns exert a strong influence over the growth, survival, movement, and life history diversity of migratory species that rely on them. Juvenile Central Valley Chinook salmon, specifically, are reliant on and affected by flow levels in the Delta.
4. The scientific literature strongly suggests that restoring floodplain connectivity and restoring flow regimes in both the Delta and its watershed are the restoration actions below major dams most likely to result in direct benefits to salmon and other species, by ameliorating flow and temperature changes (including effects of climate change), increasing habitat diversity and population resilience, improving juvenile survival and transport to marine environments, and facilitating efficient and timely return of adult salmonids to upstream spawning habitats.
5. Increased flows, improved habitat quality and connectivity, and increased access of fish to improved channel and floodplain habitat can all, individually and in concert, have a positive effect on survival.

These new studies and publications also support the State Water Board's findings in the 2010 Delta Flow Report that:

1. Existing flows are inadequate to protect Public Trust resources.

2. Winter/Spring inflows should be substantially increased, using a percentage of unimpaired flows approach.
3. Releases from upstream sources should be made proportionally to each stream and watershed to preserve ecological connectivity between the Delta and upstream watersheds, increase the spatial distribution (and hence, distribution of risk) of salmon spawning populations, and avoid concentrating impacts on a subset of source areas.
4. Limitations on reverse flows in Old and Middle River (OMR), closures of the Delta Cross Channel gates, inflow: export restrictions, and other objectives are necessary to provide adequate migratory pathways through the Delta for juvenile and adult salmonids.

The State Water Board should complement these changes to the Bay-Delta Plan objectives with the adoption and implementation of a clear, transparent, and fully-defined adaptive management strategy that establishes specific, measureable, achievable, relevant and time-bound targets for protection of fish and wildlife beneficial uses.

A. POPULATION STATUS OF CENTRAL VALLEY CHINOOK SALMON AND STEELHEAD RUNS

Overall, populations of important Delta anadromous fisheries have been greatly reduced from historic levels, are currently in decline, or both. They all remain highly vulnerable to collapse in response to short-term disturbances, as evident in the collapse of the Sacramento River fall run Chinook salmon in 2008-09, which resulted in the complete closure of the salmon fishery for the first time in California history, and which was attributed to poor oceanic conditions in combination with significantly depressed freshwater conditions. Populations of anadromous fish species (Chinook salmon, steelhead, and green and white sturgeon) remain severely depressed since the State Water Board published its Delta Flow Report (SWRCB 2010). Population responses to improved environmental conditions during their juvenile (freshwater) life stages among Chinook salmon runs are only evident 2-3 years later when these fish return to spawn; thus, flow improvements (relative to those at the end of the last decade) in 2010 and 2011 would only manifest as improved salmon escapement in 2012 and subsequent years. The current anticipated rebound of the fall run Chinook population reinforces that anadromous fish are also very sensitive to positive environmental conditions and have the potential for recovery.

1. New Information on the Risk of Extinction for Native Species

A recent quantitative protocol has determined that all runs of Sacramento Valley Chinook salmon are vulnerable to extinction within the next century and identifies estuary alteration and major dams as the two most significant impacts on anadromous populations.

> [Moyle, P.B., J.V.E. Katz, R.M. Quiñones. 2011. Rapid decline of California's native inland fishes: A status assessment. Biological Conservation (144) 2414–2423]

Moyle and others (2011) applied a quantitative protocol to assess conservation status of all 129 freshwater fishes native to California. Their results indicated that 83% of California's freshwater fishes are extinct or at risk of becoming so, representing a 16% increase since 1995 and a 21% increase since 1989. Additionally, of 31 species officially listed under federal and state endangered species acts (ESAs), 17 (55%) were rated as endangered by their criteria, while 12 (39%) were rated vulnerable (including Central Valley fall, winter and spring run Chinook salmon). Conversely, of the 33 species that received endangered rating by Moyle and others, only 17 (51%) were officially listed under the ESAs. This latter finding points to the insufficiency of the ESA listing as an indicator for collapse in fish populations and the urgent need for actions to promote their recovery.

> [Katz, J., P. B. Moyle. R.M. Quiñones, J. Israel and S. Purdy. 2012. Impending extinction of salmon, steelhead, and trout (Salmonidae) in California. Environ Biol Fish. DOI 10.1007/s10641-012-9974-8]

Katz et al (2012) developed a quantitative protocol to determine conservation status of all salmonids native to CA. Results indicate that if present trends continue, 25 (78%) of the 32 taxa native to California will likely be extinct or extirpated within the next century. As a component of this analysis, results classified Central Valley Late Fall Run Chinook Salmon populations as Endangered and all other Central Valley Chinook Salmon (Fall, Winter, Spring) and Steelhead populations as "Vulnerable" to extinction. Katz quantitative analysis identified major dams (43%) and estuary alteration (43%) as the two most significant ("Critical High") impacts on anadromous populations.

2. **New Information on Population Status of Central Valley Salmon and Steelhead runs**

Based on information from the sources identified below, the population status of Central Valley salmon and steelhead runs remain severely depressed.

> [Kormos, B., M. Palmer-Zwahlen, and A. Low. California Department of Fish and Game. March 2012. *Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement and Ocean Harvest in 2010*. Fisheries Branch Administrative Report 2012-02. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=44306]

> [National Marine Fisheries Service. February 10, 2012. Biological Opinion for the Department of Water Resources 2012 Georgiana Slough non-physical barrier study. File # 151422SWR2011SA00060 (TN 2011/05837). Available at: http://swr.nmfs.noaa.gov/bo/Georgiana_Slough_Barrier_Study_021012.pdf. ("NMFS 2012a")]

> [National Marine Fisheries Service. August 2011. *5-Year Review: Summary and Evaluation of Sacramento River Winter-run Chinook Salmon ESU*. Available at: http://swr.nmfs.noaa.gov/psd/fyr/Final_Winter-run_Chinook_5-year_Review_Report_082211.pdf ("NMFS 2011a")]

> [National Marine Fisheries Service. January 26, 2012. *Letter from Maria Rea to Ron Milligan regarding Winter Run Chinook JPE during water year 2012*. ("NMFS 2012b")]

[National Marine Fisheries Service. *Annual Report of Activities October 1, 2010, to September 30, 2011, Delta Operations for Salmonids and Sturgeon (DOSS) Technical Working Group*. October 2011. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/DOSS_Annual_Report_10_18-11_final.pdf ("NMFS 2011b")]

[National Marine Fisheries Service. *Delta Operations for Salmonids and Sturgeon (DOSS) Working Group. Presentation for the Independent Review Panel, 11-8-11, by Bruce Oppenheim (NMFS) and Thuy Washburn, USBR*. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/OCAP_2011_presentations_09_DOSS_ann_rev_11_7_11.pdf ("NMFS 2011c")]

[National Marine Fisheries Service. March 2012. Abundance-based Ocean Salmon Fisheries Management Framework for Sacramento River Winter-Run Chinook. Supplemental NMFS Report 2 to the Pacific Fishery Management Council. Available at: http://www.pcouncil.org/wp-content/uploads/G4c_SUP_NMFS_RPT2_MAR2012BB.pdf ("NMFS 2012c")]

[Pacific Fishery Management Council. April 2012. Preseason Report III: Council Adopted Management Measures and Environmental Assessment Part 3 for 2012 Ocean Salmon Fishery Regulations. Available at: http://www.pcouncil.org/wp-content/uploads/Preseason_Report_III_2012.pdf]

i. Winter Run Chinook Salmon

In recent years, escapement of winter run Chinook peaked in 2006 (the highest level since 1994), but since then, "*escapement estimates for 2007, 2008, 2009, 2010, and 2011 show a precipitous decline in escapement numbers based on redd counts and carcass counts*." (NMFS 2012a: 20). Brood year 2011 marked the fifth consecutive year of declining juvenile numbers and the fifth consecutive year in which the cohort replacement rate[1] was less than 1, indicating a negative growth rate and declining abundance. (NMFS 2012b: 1, NMFS 2012a: 20-21; *see* Fig. 1-2). The Department of

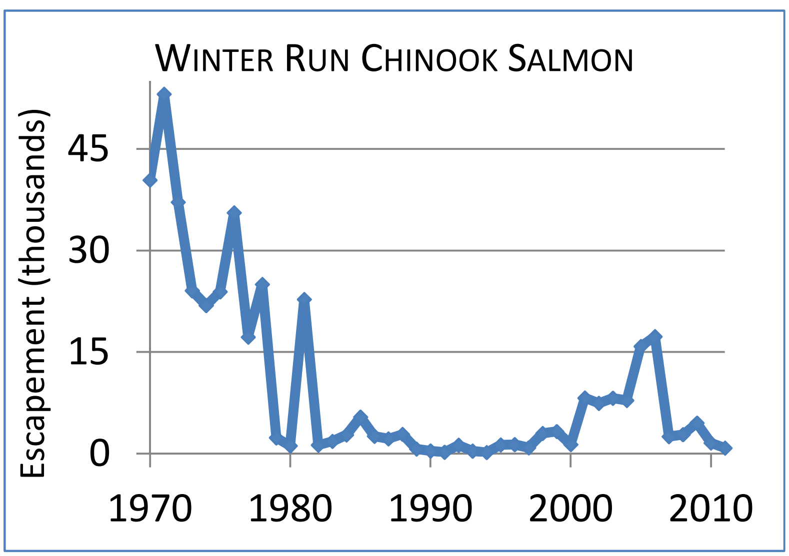

Fig. 1

[1] The cohort replacement rate is a measure of whether the population is increasing or decreasing. Because the majority of winter run spawners are three years old, the CRR is estimated by using the current brood year escapement divided by the escapement 3 years prior.

Fish and Game (DFG) estimated that adult winter run escapement in 2011 was only 824 spawners, including fish spawned at the hatchery. (NMFS 2012b: 1) This is the lowest level since 1994.

The National Marine Fisheries Service (NMFS) has suggested that the low 2011 escapement resulted from operations of Shasta Reservoir and dry conditions in 2008. (*See* NMFS 2011a: 20, 29-30). NMFS has also noted that the low abundance in recent years occurred despite the complete closure of the ocean fishery in 2008 and 2009, and very limited fishing season in 2010. (NMFS 2012: 30) Indeed, DFG concluded in a recent report that only 2 winter run Chinook salmon with coded wire tags were caught in the 2010 ocean fishery from brood years 2004, 2005, 2006, 2007, and 2008 (expanded count of 6). (Kormos et al 2012: 6 and Table 7)

Winter Run Chinook Salmon Population Estimates

Year	Population Estimate[a]	5-Year Moving Average of Population Estimate	Cohort Replacement Rate[b]	5-Year Moving Average of Cohort Replacement Rate	NMFS-Calculated Juvenile Production Estimate (JPE)[c]
1986	2,596				
1987	2,185				
1988	2,878				
1989	696		0.27		
1990	430	1,757	0.20		
1991	211	1,280	0.07		40,100
1992	1,240	1,091	1.78		273,100
1993	387	593	0.90	0.64	90,500
1994	186	491	0.88	0.77	74,500
1995	1,297	664	1.05	0.94	338,107
1996	1,337	889	3.45	1.61	165,069
1997	880	817	4.73	2.20	138,316
1998	2,992	1,338	2.31	2.48	454,792
1999	3,288	1,959	2.46	2.80	289,724
2000	1,352	1,970	1.54	2.90	370,221
2001	8,224	3,347	2.75	2.76	1,864,802
2002	7,441	4,659	2.26	2.26	2,136,747
2003	8,218	5,705	6.08	3.02	1,896,649
2004	7,869	6,621	0.96	2.72	881,719
2005	15,839	9,518	2.13	2.84	3,831,286
2006	17,296	11,333	2.10	2.71	3,739,050
2007	2,542	10,353	0.32	2.32	589,900
2008	2,830	9,275	0.18	1.14	617,783
2009	4,537	8,609	0.26	1.00	1,179,650
2010	1,596	5,760	0.63	0.70	332,012
2011	824[d]	2,466	0.29	0.34	NA[e]
median	2,364	2,218	1.05	2.26	412,507
mean[f]	3,814	4,113	1.63	1.90	
Last 10[g]	7,020	7,059	1.63	1.98	
Last 6[h]	4,938	7,966	0.63	1.37	

Figure 2 (reprinted from NMFS 2012a)

In 2010, NMFS issued a new biological opinion on the effect of the ocean salmon fishery on winter run salmon, and new measures to constrain take of winter run in the fishery were imposed. In 2011, NMFS released an analysis of the impacts of the fishery on winter run (O'Farrell 2011, Winship *et al* 2012) and its Winter Run Harvest Model to guide development of fishery measures to constrain impacts. NMFS concluded that ocean fishing is not adversely affecting winter run when populations are stable or increasing, but that measures were needed when the population was otherwise declining or at very low levels. (NMFS 2012c:1-2) The management strategy evaluation and life cycle model that it was based on found that, "*the most influential factors in winter-run population dynamics are related to variation in juvenile survival rates in the fresh water and marine environments (survival prior to age-2).*" (NMFS 2012c: 5) NMFS has also observed that "*Lindley et al. (2009) concluded that late-fall, winter and spring Chinook salmon in the Central Valley were not as strongly affected by recent changes in ocean conditions as the Sacramento River fall-run Chinook salmon*." (NMFS 2011: 30).

Since 2009, entrainment of winter run Chinook has been limited by the NMFS biological opinion, including OMR restrictions and an incidental take limit of entrainment at the CVP and SWP to less than 2% of the Juvenile Production Estimate (JPE). While entrainment has not exceeded this incidental take limit since 2009, incidental take of winter run exceeded 1% of the JPE in 2011. (NMFS 2011c: 50) In its presentation to the independent peer review panel organized by the Delta Science Program, NMFS examined the use of Smolt to Adult Ratios (SAR) to estimate the effect of juvenile incidental take on the abundance of adult winter run three years later, and estimated that the take in 2011 could be expected to reduce adult winter run populations in 3 years by 16-25%. (NMFS 2011d at 23; see Fig. 2)

Analysis of the population level effect of winter run losses at the Central Valley Project (CVP) and State Water Project (SWP) are ongoing.[2] However, in 2012 the independent peer review of the BDCP effects analysis cautioned against simply normalizing salvage to adult populations three years later:

> *A process to normalize observed salvage to mean population abundance of the species was described in order to account for some of the year to year variability in salvage associated with fish abundance.* ***Given the large and variable effect of survival at sea on adult salmon abundance, it seems that normalization of the juvenile salvage data to mean adult salmon abundance could introduce considerable error.*** *Was adult run size lagged back to the appropriate smolt year? Both normalized and non-normalized values of entrainment were provided, which is good.*

[Parker 2012: 41][3] (emphasis added)

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[2] Part of the debate over impacts focuses on the total number of fish impacted because run-identification of salvaged fishes is uncertain and because the number of fish salvaged is unquestionably only a small (though undetermined) fraction of the number of fish that are negatively impacted before they reach the SWP and CVP fish screening facilities.
[3] This peer review of the BDCP effects analysis was cited in the TBI et al submission for Workshop I:
[Parker, A., Simenstad, S., George, T., Monsen, N., Parker, T., Ruggerone, G., and Skalski, J. 2012. Bay Delta Conservation Plan (BDCP) Effects Analysis Phase 2 Partial Review, Review Panel Summary Report. Delta Science Program. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/BDCP_Effects_Analysis_Review_Panel_Final_Report_061112.pdf]

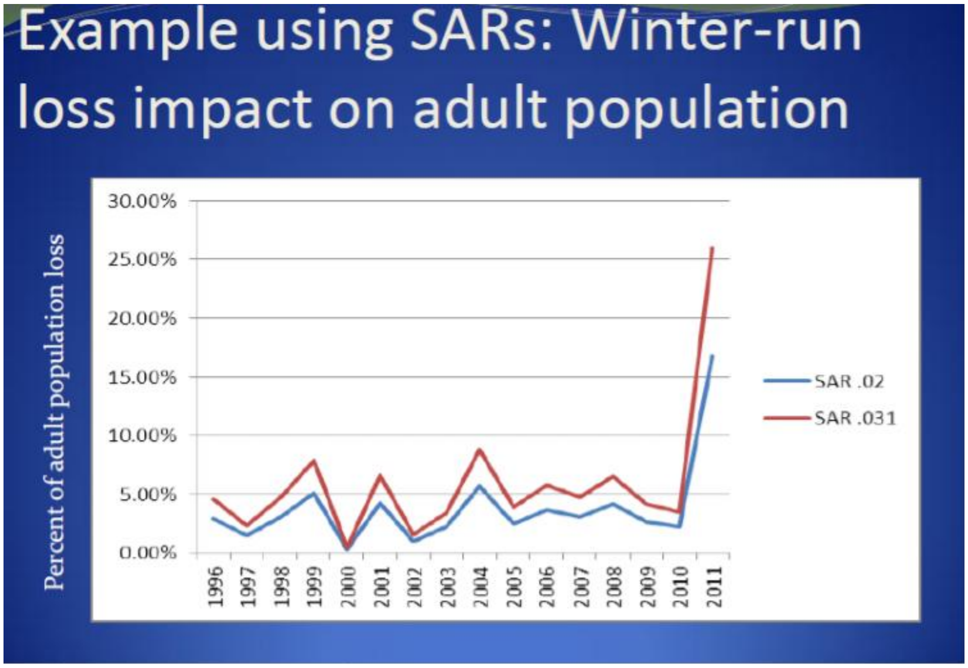

Fig. 3 (Reprinted from NMFS 2011c)

Furthermore, there is reason to believe that proportionate impacts of salmon entrainment that are expressed as a proportion of juvenile production would also significantly underestimate the population level effect of entrainment on Chinook salmon populations. DFG and NMFS have not updated the estimated survival to the Delta in the JPE calculation to account for recent acoustic tag data on survival to the Delta. (NMFS 2012b: 7) For instance, recent studies of late fall run Chinook salmon released in 2007-2007 with acoustic tags found that the average survival rate was only 3.9% for the migration from Battle Creek / upper Sacramento River release site to the ocean and that survival from the release site to the Delta was below 40% in all three years and was below 20% in 2007. (Michel 2010: 8 and Fig. 4)[4] Thus current estimates of entrainment at the pumps may substantially underestimate the fraction of the population that is taken, as well as the population level effects of this entrainment.

ii. Spring Run Chinook Salmon

Escapement of spring run Chinook salmon has been declining since 2005 in the Sacramento River basin and in most of the tributaries; since 2006, the cohort replacement rate has been less than 1 (indicating a negative growth rate and declining abundance) in the tributaries, and the CRR has been less than 1 in the basin since 2004. (NMFS 2012a: 26-27; *see* Fig. 4-5) Higher water temperatures and lower flows in 2007-2009 are generally associated with lower salmon abundance and may have contributed to recent declines.

The 2009 biological opinion does not establish an incidental take limit for spring run Chinook salmon based on observed salvage of spring run at the CVP/SWP. There currently is not a juvenile production estimate (JPE) for spring run, and there are difficulties in distinguishing spring and fall run fish in salvage. Currently, NMFS' biological opinion uses estimated salvage

[4] Michel 2010 is discussed in detail on page 20 of this submission.

of a few releases of late fall run hatchery salmon as surrogates for spring run take. (*See* NMFS 2011b: 51) There are substantial problems with this approach.

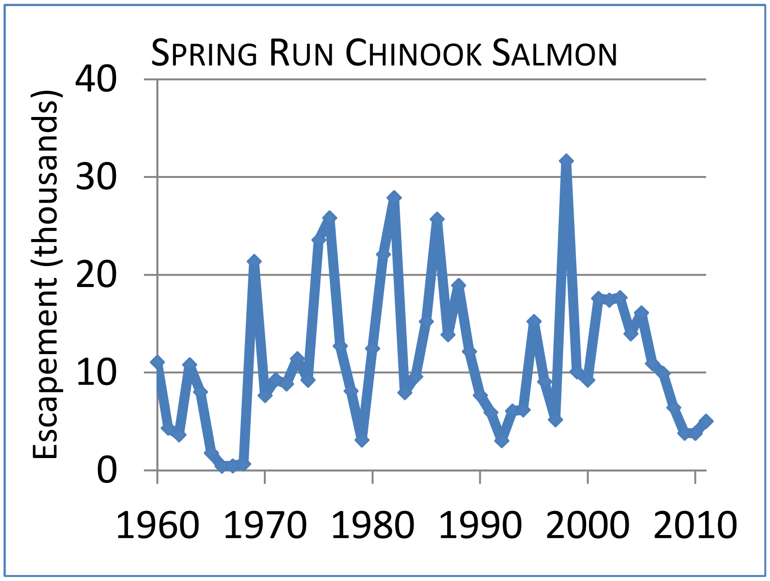

Fig. 4

Population numbers reveal only a part of the spring run's conservation status. Like winter run Chinook salmon, the spring run's geographic spawning range is severely restricted, making this unique species extremely susceptible to geographically isolated catastrophes (e.g. forest fires, mudslides, disease outbreaks). Geographic range restrictions represent a significant threat to fish populations (Rosenfield 2002) and to salmonids, in particular (McElhany et al 2000). Thus, current efforts to restore spawning populations of spring run Chinook salmon to watersheds in the San Joaquin River basin are considered essential to this species' persistence (NMFS 2008) in addition to the need to improve conditions and habitat availability in the Sacramento River basin waterways that support spring run spawning or could support it in the future.

Spring Run Chinook Salmon Abundance Estimates

Year	Sacramento River Basin Escapement Run Size[a]	FRFH Population	Tributary Populations	5-Year Moving Average of Tributary Population Estimate	Trib CRR[b]	5-Year Moving Average of Trib CRR	5-Year Moving Average of Basin Population Estimate	Basin CRR	5-Year Moving Average of Basin CRR
1986	25,696	1,433	24,263						
1987	13,888	1,213	12,675						
1988	18,933	6,833	12,100						
1989	12,163	5,078	7,085		0.29			0.47	
1990	7,683	1,893	5,790	12,383	0.46		15,673	0.55	
1991	5,926	4,303	1,623	7,855	0.13		11,719	0.31	
1992	3,044	1,497	1,547	5,629	0.22		9,550	0.25	
1993	6,076	4,672	1,404	3,490	0.24	0.27	6,978	0.79	0.48
1994	6,187	3,641	2,546	2,582	1.57	0.52	5,783	1.04	0.59
1995	15,238	5,414	9,824	3,389	6.35	1.70	7,294	5.01	1.48
1996	9,083	6,381	2,702	3,605	1.92	2.06	7,926	1.49	1.72
1997	5,193	3,653	1,540	3,603	0.60	2.14	8,355	0.84	1.84
1998	31,649	6,746	24,903	8,303	2.53	2.60	13,470	2.08	2.09
1999	10,100	3,731	6,369	9,068	2.36	2.75	14,253	1.11	2.11
2000	9,244	3,657	5,587	8,220	3.63	2.21	13,054	1.78	1.46
2001	17,598	4,135	13,463	10,372	0.54	1.93	14,757	0.56	1.27
2002	17,419	4,189	13,230	12,710	2.08	2.23	17,202	1.72	1.45
2003	17,691	8,662	9,029	9,536	1.62	2.04	14,410	1.91	1.42
2004	13,982	4,212	9,770	10,216	0.73	1.72	15,187	0.79	1.35
2005	16,126	1,774	14,352	11,969	1.08	1.21	16,563	0.93	1.18
2006	10,948	2,181	8,767	11,030	0.97	1.29	15,233	0.62	1.20
2007	9,974	2,674	7,300	9,844	0.75	1.03	13,744	0.71	0.99
2008	6,420	1,624	4,796	8,997	0.33	0.77	11,490	0.40	0.69
2009	3,801	989	2,812	7,605	0.32	0.69	9,454	0.35	0.60
2010	3,792	1,661	2,131	5,161	0.29	0.53	6,987	0.38	0.49
2011	4967	1,900	3,067	4,021	0.64	0.47	5,790	0.77	0.52
Median	10,037	3,655	6,727	8,262	0.73	1.70	12,386	0.79	1.27
Average[c]	11,647	3,621	8,026	7,708	1.29	1.48	11,585	1.08	1.21
Last 10[d]	11,156	3,091	8,065	9,224	0.85	1.27	12,802	0.83	1.02
Last 6[e]	6,650	1,838	4,812	7,776	0.55	0.80	10,450	0.54	0.75

Fig. 5 (Reprinted from NMFS 2012a)

iii. Central Valley Steelhead

There is currently no abundance estimate for Central Valley steelhead. However, according to NMFS, the available evidence suggests a decline in the population of wild steelhead since 2005:

> *The most recent status review of the California Central Valley steelhead DPS (NMFS 2011c) found that the status of the population appears to have worsened since the 2005 status review (Good et al. 2005), when it was considered to be in danger of extinction. Analysis of data from the Chipps Island monitoring program indicates that natural steelhead production has continued to decline and that hatchery origin fish represent an increasing fraction of the juvenile production in the Central Valley (see Figure 14). Since 1998, all hatchery produced steelhead in the Central Valley have been adipose fin clipped (ad-clipped). Since that time, the trawl data indicates that the proportion of ad-clip steelhead juveniles*

> *captured in the Chipps Island monitoring trawls has increased relative to wild juveniles, indicating a decline in natural production of juvenile steelhead. In recent years, the proportion of hatchery produced juvenile steelhead in the catch has exceeded 90% and in 2010 was 95% of the catch. Because hatchery releases have been fairly consistent through the years, this data suggests that the natural production of steelhead has been declining in the Central Valley*.

(NMFS 2012a: 33) NMFS also found that salvage at the CVP and SWP indicated a decline in natural production, and they found that while small numbers of wild steelhead consistently return to the Coleman fish hatchery (200-300 fish per year), the number of hatchery fish has fluctuated significantly and have declined in recent years. (NMFS 2012a: 33-34)

Entrainment and low survival rates through the Delta remain a concern for steelhead from the San Joaquin River basin, Sacramento River basin, and eastside tributaries. Although there is no population estimates for Central Valley steelhead, the 2009 NMFS biological opinion continues use of an incidental take limit of 3,000 wild steelhead that is not based on a measure of steelhead abundance. (NMFS 2011b at 53-54) Salvage of wild steelhead in 2011 (738) was lower than in 2010 (1,029), with the highest monthly salvage of wild steelhead observed in June 2011. (NMFS 2011b: 54, 68) The seasonal salvage for hatchery steelhead in 2011 was the lowest observed in the past 11 years. (NMFS 2011b: 54)

iv. <u>Fall Run Chinook Salmon</u>

The Pacific Fishery Management Council (PFMC) has forecast that the 2012 Sacramento River Index is 819,400 adult Central Valley Fall run Chinook salmon, with escapement estimated at 245,820 spawners. (PFMC 2012:9-10) This is higher than the SI forecast of 729,900 fish in 2011, but the forecast of escapement in 2011 was substantially higher than actual escapement. (PFMC 2012:9) The PFMC adopted revisions to the fishery management plan until the stock is rebuilt, which includes an annual management target of 122,000 natural and hatchery adult spawners at moderate abundance, and lower fishing rates at low abundance. (PFMC 2012:4).

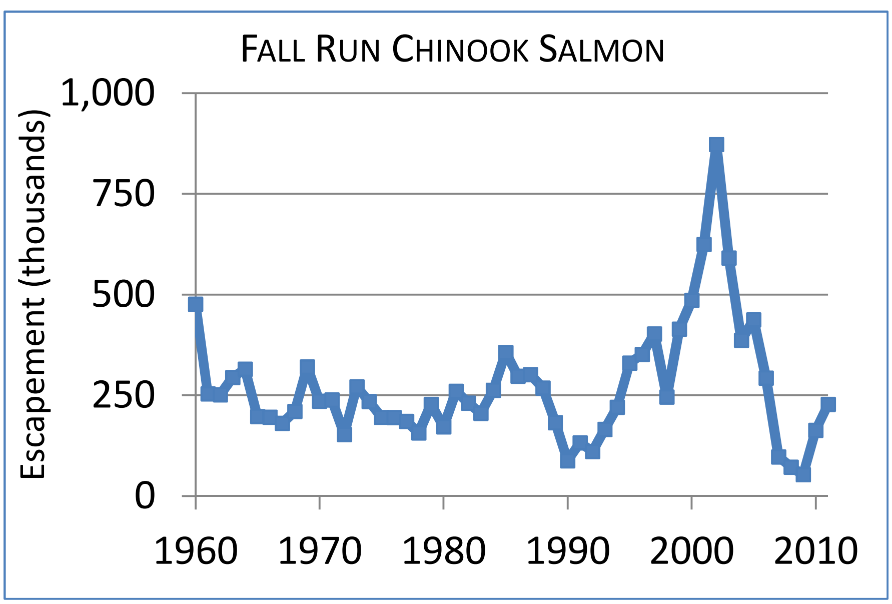

Fig. 6

The Central Valley Constant Fractional Marking Program (CFM) was initiated in 2007 to estimate in a statistically valid manner the relative contribution of hatchery production and to evaluate the various release strategies being employed in the Central Valley. Beginning with Brood

Year 2006 fall run Chinook, the program has marked and coded-wire tagged a minimum of 25 percent of releases from the Central Valley hatcheries each year. In 2012, biologists with the Department of Fish and Game released a report (Kormos et al (2012), *Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement and Ocean Harvest in 2010*) which evaluates the 2010 CV fall, spring, winter and late fall run Chinook CWT recovery data in an attempt to answer the following four questions with this first essentially complete year of recovery data:

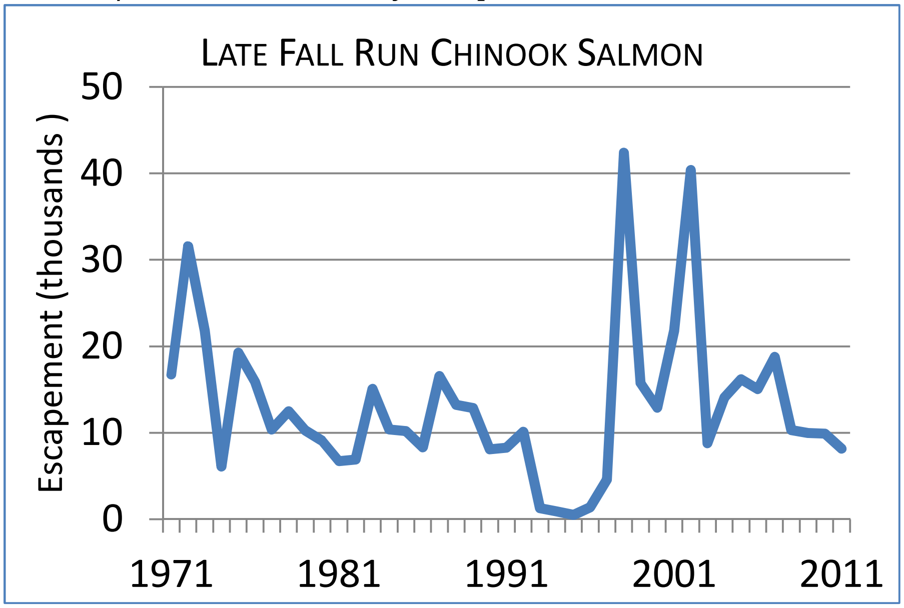

Fig. 7

1. What are the proportions of hatchery and natural-origin fish in spawning returns to CV hatcheries and natural areas, and in ocean harvest? Of the hatchery proportions, what proportions originated from in-basin versus out-of-basin CWT recoveries?
2. What are the relative recovery and stray rates for hatchery fish released in-basin versus salmon trucked to and released into the waters of the Carquinez Straits? The latter includes salmon acclimated in net pens that are pulled for several hours into San Pablo Bay before fish are released.
3. What are the relative recovery rates for fish acclimated in net pens and released in the bay versus salmon released directly into the waters of the Carquinez Straits?
4. What are the relative contribution rates of hatchery fish, by run and release type, to the ocean harvest?

General Recovery rates and age classes
Based on the findings presented in the report, during 2010, almost 27,000 CWTs were recovered from ad-clipped Chinook sampled in Central Valley natural area spawning surveys, at CV hatcheries, in CV river creel surveys, and in California ocean commercial and recreational fisheries. Almost all of the fall run Chinook CWTs recovered in the CV were tagged as part of the CFM program since most CV fish return at ages two, three, or four. Age five Chinook made up a very small fraction (0.01%) of the total CV fall run escapement in 2010.

24,838 valid CWTs recovered in the CV during 2010 were CV Chinook releases, with the majority originated from brood year 2006 through 2008. The specific breakdown of recoveries included more than 84% from fall run Chinook, followed by spring run (10%) and late fall run (6%). No Sacramento River winter run Chinook CWTs were recovered in 2010.

California ocean harvest recoveries in 2010 included 1846 of CV origin. Approximately 62% of all CWTs in the ocean harvest were fall run Chinook, followed by late fall run (30%), spring run (3%), and winter run (<1%). Only 2 winter run with CWTs (for an expanded count of 6) were caught in the ocean fishery in 2010.

Proportion of hatchery origin fish
Results indicate that the proportion of hatchery-origin fish on spawning grounds varied throughout the CV and by run. The lowest hatchery proportion (1%) was observed in the Butte Creek spring run Chinook mark-recapture survey, while the highest proportion (78%) was observed in the Feather River fall/spring run Chinook mark-recapture survey. The hatchery proportion of fall run Chinook returning to CV hatcheries ranged from 79% to 95%. Spring run Chinook return to FRH was 82% hatchery-origin fish whereas the late fall run return to CNFH approached 100% hatchery-origin. The majority of fish returning to spawn in the San Joaquin Basin and the Feather River were hatchery-origin, whereas the majority of fish returning to spawn in the Sacramento River were not.

Relative recovery and stray proportions for hatchery-origin Chinook released in-basin versus hatchery-origin Chinook trucked and released into the waters of the Carquinez Strait (includes Chinook salmon acclimated in net pens and released into San Pablo Bay).
Results on relative recovery and stray proportions of in basin vs. trucked and released hatchery-origin fish were limited due to “lack of consistency” and “problem releases” among CV hatcheries. As a result, the report only presents results from direct comparisons for in a limited number of release groups. Overall results indicate that, Chinook that were trucked and released directly into the waters of Carquinez Strait or acclimated in bay area net pens had higher relative recovery rates than their respective in-basin releases (often at a 2:1 ratio or more). These releases also had higher stray proportions than their paired in-basin counterparts.

Though based only on a single year of recovery data, and so not necessarily indicative of larger scale trends in population dynamics, results from this report reinforce other research findings pointing to a) the severe impact of low juvenile outmigration survival rates on subsequent abundance, b) the increase in straying resulting from the alternative strategy of ocean release, c) the severely imperiled condition of winter run stocks and need for immediate action to recover them, d) the dominance of hatchery origin returns in the CV. This program should provide very useful information to managers in the future.

B. IMPORTANCE OF SACRAMENTO INFLOWS INTO THE DELTA

The magnitude, timing, duration, and frequency of Delta inflows[5] from source streams has changed dramatically from historical condition, particularly during the winter and early spring months. These reductions in flow have diminished the Delta's ability to support the viability of anadromous resources that rely on the Delta for food, habitat and migration.

1. The importance of a natural flow regime

New Information Summary:

Flow is a critical determinant of native fish success. Altered flow regimes, due to water management facilities and operation, are a significant cause of native fish declines. In addition, altered flow regimes are a significant predictor of spring run Chinook extirpation.

> [Nislow, K. H. and J. D. Armstrong. 2011. Towards a life-history-based management framework for the effects of flow on juvenile salmonids in streams and rivers. Fisheries Management and Ecology. DOI: 10.1111/j.1365-2400.2011.00810.x]

Nislow and Armstrong review the state of science concerning the influence of flow regime on juvenile salmonids and their habitats. Their findings indicate that a key consideration in the stage-specific impacts of flow is the extent to which flow-related losses or gains during early developmental stages can be compensated by increased growth or survival later in juvenile life history. Their recommendations include targeting specific aspects of flow regimes critical to multiple life-history stages, which can then serve as a basis for interim flow prescriptions and subsequent adaptive management. Findings from their assessment point not only to the importance of flow as a critical determinant of juvenile salmon success, but to the need for a management approach that integrates flow management in the upper and lower watershed as well as other factors promoting increased growth and survival access to productive floodplain habitat.

> [Zeug, S.C. 2010. Predictors of Chinook Salmon Extirpation in California's Central Valley. Fisheries Management and Ecology 18: 61-71.]

Zeug 2010 examined the relative strength of predictors for probability of extirpation of Chinook salmon in Central Valley streams and found that altered flow regime, habitat loss, and migration barriers were all significant predictors for extirpation of spring run Chinook salmon.

> [Mount, J., W. Bennett, J. Durand, W. Fleenor, E. Hanak, J. Lund, and P. Moyle. 2012. Aquatic Ecosystem Stressors in the Sacramento–San Joaquin Delta. Public Policy Institute of California, San Francisco, CA. 24p. Available at: http://www.ppic.org/content/pubs/report/R_612JMR.pdf]

[5] Because San Joaquin River inflows are being addressed in another Board proceeding, this submission focuses primarily on Sacramento River inflows.

This report synthesizes the stressors acting on the Delta into five key categories of like process and consequence relevant to management and decision-making:

> 1. ***Discharges**: Land and water use activities that directly alter water quality in the greater Delta watershed by discharging various contaminants that degrade habitat, disrupt food webs, or cause direct harm to populations of native species.*
> 2. ***Fisheries management**: Policies and activities that adversely affect populations of native species through harvest (commercial and sport) or hatcheries.*
> 3. ***Flow regime change**: Alterations in flow characteristics due to water management facilities and operations, including volume, timing, hydraulics, sediment load, and temperatures.*
> 4. ***Invasive species:** Alien (non-native) species that negatively affect native species by disrupting food webs, altering ecosystem function, introducing disease, or displacing native species.*
> 5. ***Physical habitat alteration**: Land use activities that alter or eliminate physical habitat necessary to support native species, including upland, floodplain, riparian, open water/channel, and tidal marsh. (p. 8)*

Additionally, the report explains that none of these stressors is entirely independent of the others, with significant interactions amplifying or suppressing the negative effects each has on native populations. As an example, Mount et al 2012 points to water operations that reduce flow intensifying the effects of agricultural and urban discharges that, in turn, promote conditions favorable to invasive species that alter food webs and ecosystem functions.

> [Moyle, P., W. Bennett, J. Durand, W. Fleenor, B. Gray, E. Hanak, J. Lund, and J. Mount. 2012. Where the Wild Things Aren't: Making the Delta a Better Place for Native Species. Public Policy Institute of California, San Francisco, CA. 55p. Available at: http://www.ppic.org/content/pubs/report/R_612PMR.pdf]

Moyle et al 2012 attributes harm to native species living in or passing through the Delta as well as the degradation of water quality and habitat to key stressors working singly and in combination. These stressors include alteration of flows, channelization of waterways, discharge of pollutants, introduction of non-native species, and the diversions of water from the system. Their analysis identifies five core premises that have strong scientific support including that the most restrictive physical and biological constraints on the system include limits on the availability of fresh water, and the domination of the ecosystem by invasive species. The report recommends five key components of a strategy for recovery and reoperation of the delta, the first of which is that natural processes place limits on all water and land management goals.

> [Miller, J.A., A. Gray, and J. Merz. 2010. Quantifying the contribution of juvenile migratory phenotypes in a population of Chinook salmon *Oncorhynchus tshawytscha*. Marine Ecology Progress Series 408:227–240].

This study documented contributions of three different life-history types to subsequent adult populations but noted that management activity is often disproportionately focused on particular life history strategies (e.g. big or fast-growing juveniles). They note:

> *The contribution of all 3 migratory phenotypes to the adult population indicates that management and recovery efforts should focus on maintenance of life-history variation rather than the promotion of a particular phenotype.* (Miller et al. 2012: 227).

This finding reinforces the need to identify the full seasonal duration of flows that benefit different fish species as flows constrained to narrow durations and particular calendar dates tend to reduce migratory species' viability by eroding natural life history diversity (McElhaney 2000). Miller et al (2010) is also quite valuable in that it demonstrates the potential to measure the differential migration success of various life-history types post-hoc, using advances in otolith microchemistry; such an approach, when combined with current tagging and recapture studies should be expanded to provide a more comprehensive and accurate image of juvenile survival patterns prior to, during, and after their Delta migration.

2. **Sacramento River inflow targets and Delta outflow targets can be achieved without compromising the ability of the reservoirs to meet existing upstream temperature and flow requirements**

New Information Summary:

Water temperature plays a critical role in the life history of native fishes, particularly salmonids. Water temperature requirements vary substantially by life stage and actual water temperatures vary significantly both temporally and spatially. Furthermore, temperature requirements for individual life stages can vary depending on habitat quality, nutrition, and antecedent conditions. Healthy fish with a variety of habitat options are more likely to survive stressful temperatures than unhealthy fish.

The State Water Board's 2010 Report notes that additional analysis and modeling will be needed to determine how best to apply the percentage of unimpaired to allow Sacramento inflow requirements to be met while ensuring cold water temperature protections for fish in upstream tributaries at key times of the year. The 2010 Delta Flows Report also recognizes that inflow requirements should be proportionally allocated among the mainstem Sacramento and San Joaquin Rivers and their key tributaries. A proportional allocation of releases to meet downstream criteria among all source streams is necessary to ensure the flow-related connectivity between the upstream and Delta that is necessary for migratory species to complete their life cycles. A disproportionate allocation can lead to adverse flow and temperature conditions below facilities that are disproportionately responsible for meeting the criteria.

Increasing Delta outflow need not come at the expense of upstream reservoir storage, as recent modeling has demonstrated. We strongly recommend that that State Water Board build on the CALSIM modeling done in development of BDCP Alternative 8 to ensure adequate upstream cold water pool protections. As the State Water Board is well aware, one of the significant limitations of the CALSIM model is that it is difficult to model reservoir carryover requirements in the model and the model is driven to maximize CVP/SWP exports within available constraints. As discussed at the September 6, 2012 workshop, recent modeling that purports to show that increasing delta outflow will necessarily reduce upstream storage does not incorporate existing reservoir storage criteria, and it may assume continued levels of diversions that drive reservoir storage lower. CALSIM modeling of Alternative 8 in the BDCP process, which seeks to increase Delta outflow per the SWRCB's request, has demonstrated that increased Delta outflow can be accomplished without impairing upstream reservoir storage. The approach to modeling Alternative 8 in CALSIM should be further refined, in consultation with the fish and wildlife agencies, to take account of minimum releases needed to meet downstream temperature compliance points in the spring and summer months, and this revised modeling analysis should be applied to a broader range of alternative outflow objectives in this proceeding.

> [National Marine Fisheries Service. 2009. Biological Opinion on proposed long term operations of the Central valley Project and State Water Project. Available at: http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf]

The 2009 NMFS biological opinion (pp. 592-603) imposes reservoir carryover storage and release requirements on Shasta Reservoir for the protection of winter and spring run Chinook salmon. This biological opinion establishes performance measures that require a minimum of 2.2 million acre feet (MAF) of storage in Shasta Reservoir at the end of September in 87% of years, with end of April storage of 3.8 MAF in 82% of years, and end of September storage of 3.2 MAF in 40% of years. (NMFS 2009: 592) In years when end of September storage falls below these targets, the biological opinion establishes decision-making processes to establish reservoir release schedules for fall, spring and summer months. (NMFS 2009: 592-603)

The amount of cold water storage at the end of September limits the geographic extent of suitable spawning habitat for salmon in the Sacramento River (known as the temperature compliance point), and 2.2 MAF of storage at the end of September is generally necessary to provide sufficient cold water to establish the temperature compliance point at Balls Ferry of the following year in 80% of years.[6] (NMFS 2009: 593) The biological opinion establishes the following performance standards relating to the temperature compliance point:

- Meet Clear Creek Compliance point 95 percent of time
- Meet Balls Ferry Compliance point 85 percent of time
- Meet Jelly's Ferry Compliance point 40 percent of time
- Meet Bend Bridge Compliance point 15 percent of time

(NMFS 2009: 592)[7]

[6] Balls Ferry is located approximately 23 miles upstream from the Red Bluff Diversion Dam. In Water Rights Order 90-5, the Board required the Bureau to maintain water temperatures below 56° F in the Sacramento River at Red Bluff Diversion Dam, except when factors beyond the control of the Bureau prevented meeting this temperature requirement. In recent years the temperature compliance point has been established at Balls Ferry or further upstream. (NMFS 2009 at 263)

[7] In its written summary submission to the State Water Board during the 2010 proceeding, NMFS provided a brief summary of storage objectives for Shasta Reservoir to protect listed salmon. Available online at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/exhibits/nmfs/nmfs_summary.pdf

The 2010 Public Trust Report briefly mentioned these requirements of the 2009 biological opinion and acknowledged that these reservoir storage requirements were (1) the minimum necessary to avoid jeopardy and were (2) constrained by water deliveries to senior water rights holders:

> *It is important to note that the flow protections described in the project description and RPA are the minimum flows necessary to avoid jeopardy. In addition, NMFS considered provision of water to senior water rights holders to be non-discretionary for purposes of the ESA as it applies to Section 7 consultation with the USBR, which constrained development of RPA Shasta storage actions and flow schedules.*

(SWRCB 2010: 23-24) (internal citations omitted)

The 2009 NMFS biological opinion also establishes minimum flow schedules and the following minimum temperature requirements:

River	Requirements	Reference
Clear Creek	60°F or lower at Igo gauge from June 1 to Sept 15 56°F or lower at Igo gauge from Sept 15 to Oct 31	Page 589
American River	65°F or lower at Watt Avenue Bridge from May 15 through October 31	Page 614
Stanislaus River	56°F or lower at Orange Blossom Bridge from 10/1 – 12/31 52°F or lower at Knights Landing and 56°F or lower at Orange Blossom Bridge from 1/1 – 5/31 55°F or lower at Orange Blossom Bridge from 1/1-5/31 65°F or lower at Orange Blossom Bridge from 6/1-9/30	Page 621

In addition, the biological opinion notes that non-flow measures can contribute to meeting these downstream water temperature requirements, including temperature control devices, temperature curtains, and other structural and operational modifications. (*See, e.g.,* NMFS 2009: 615-16)

However, it should be noted that these protections are principally designed to protect endangered and threatened runs; while these performance measures provide some protection for fall run Chinook salmon (which is not listed under the ESA), additional reservoir storage and downstream temperature requirements later in the year (October) should be considered to adequately protect fall run Chinook salmon in light of their different spawning and migration timing.

3. Relationship of increased flows to salmonid survival and migration

<u>New Information Summary:</u>

Several factors associated with increased flows influence salmonid migration rate and survival. In recent studies, migration rates of juvenile salmon were found to be fastest in the upper river region and slowest in the Delta. Additionally, survival of salmonid smolts migrating through the Sacramento River and through the Delta is extremely low, and a substantial number of the losses in the Delta can be attributed to the effects of the CVP and SWP operations.

[Michel, C.J., A.J. Ammann, E.D. Chapman, P.T. Sandstrom, H.E. Fish, M.J. Thomas, G.P. Singer, S.T. Lindley, A.P. Klimley and R.B. MacFarlane. 2012. The effects of environmental factors on the migratory movement patterns of Sacramento River yearling late-fall run Chinook salmon (*Oncorhynchus tshawytscha*). Environmental Biology of Fishes. DOI: 10.1007/s10641-012-9990-8]

Michel et al (2012) examined the migration patterns of acoustically tagged late fall run Chinook salmon yearling smolts during their outmigration through California's Sacramento River and San Francisco Estuary in 2007–2009. Migration rates (14.3 $km \cdot day^{-1}$ (± 1.3 S.E.) to 23.5 $km \cdot day^{-1}$ (± 3.6 S.E.)) were similar to rates published for other West Coast yearling Chinook salmon smolt emigrations. Migration rates were fastest through the upper river regions, and slowest in the Delta. Additionally, the study modeled the influence of different reach specific and environmental factors on movement rate and population spreading. Results suggested that several factors associated with increased flows positively influenced migration rate including (in order of importance), river width to depth ratio, river flow, water turbidity, river flow to mean river flow ratio, and water velocity. Water temperature did not improve model fit, suggesting, among other things, the specific significance of flow as opposed to temperature in fish distribution and migration.

[Michel, C. River and Estuarine Survival and Migration of Yearling Sacramento River Chinook Salmon (*Oncorhynchus Tshawytscha*) Smolts and the Influence of Environment. A thesis submitted in partial satisfaction of the requirements for the degree of Master of Arts in Ecology and Evolutionary Biology. December 2010.]

In this thesis, Michel summarized the results of three years of acoustic tagging results on salmon survival and migration rates. Michel (2010) concluded that the average survival rate for late fall run Chinook salmon released in 2007-2007 with acoustic tags was only 3.9% for the migration from Battle Creek / upper Sacramento River release site to the ocean and that survival from the release site to the Delta was below 40% in all three years and was below 20% in 2007. (Michel 2010 at 8 and Fig. 4). As the author notes, these three years were generally dry years with lower flows, so results may be different in higher flow years.

[del Rosario, R. B., Y. J. Redler, and P. Brandes. 2010. Residence of Winter-Run Chinook Salmon in the Sacramento-San Joaquin Delta: The role of Sacramento River hydrology in driving juvenile abundance and migration patterns in the Delta. Abstract submitted to the CalNeva conference (manuscript in preparation). Available at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/exhibits/nmfs/nmfs_exh7.pdf]

This study found that Sacramento River flow at Freeport was a statistically significant predictor of the abundance of winter run Chinook salmon caught at Chipps Island, with higher flow during the migration period corresponding to higher abundance. Abundance of juveniles in the Chipps Island trawl was not found to be correlated with prior year's adult escapement in a statistically significant way:

> *The hydrology of the Sacramento River drives winter-run smolt abundance and emigration patterns in the Delta. The annual cumulative winter run smolt abundance is highly dependent on the amount of flows in the Sacramento River, such that higher volume of water flowing in the river during the winter run emigration period results in greater abundance of winter run smolts both entering the Delta at Knights Landing (multiple regression, R2=0.76, F=12.6, p=0.003), and subsequently exiting the Delta at Chipps Island (multiple regression, R2=0.93, F=53.7, p<0.0001; Figure 1). This positive correlation between smolt abundance, expressed as annual cumulative CPUE at either sampling location, is not significantly correlated with annual spawner abundance (p>0.25).*

(del Rosario et al 2010: 4) Thus increased Sacramento River inflow resulted in higher survival rates for winter run salmon.

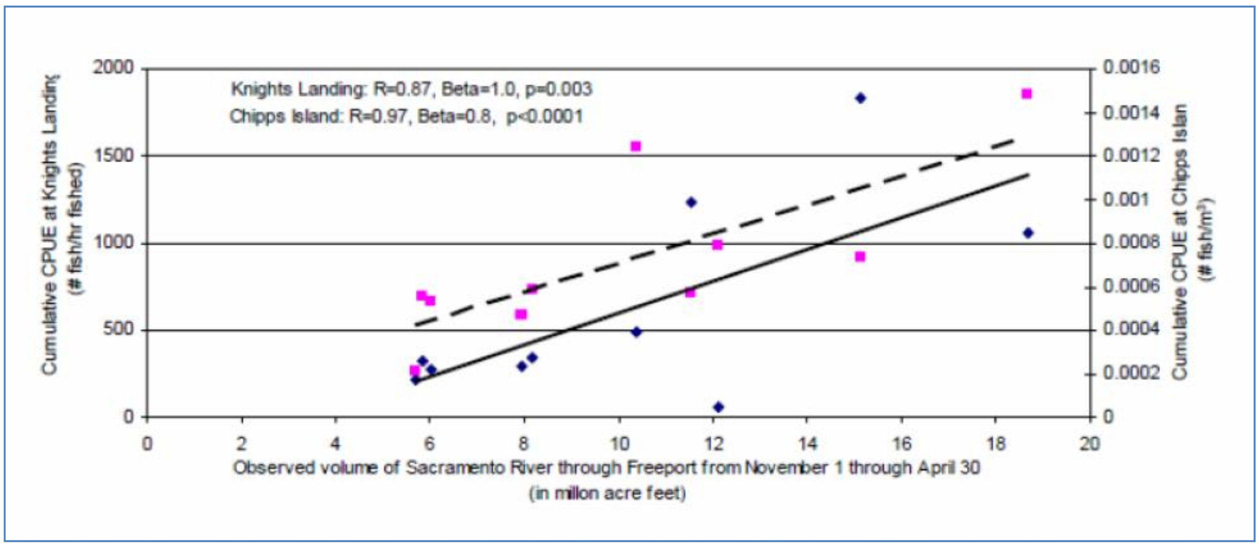

Fig. 8 Higher volume of flows during the winter run migration period results in greater abundance of winter run smolts entering the Delta at Knights Landing (diamonds, solid line) and subsequently exiting at Chipps Island (squares, dashed line), 1999-2008. (Reprinted from del Rosario et al 2010)

4. Importance of Inflow to Floodplains

Flood flows are essential for maintaining complex channel and floodplain features and, by inundating floodplains, provide essential spawning and rearing habitat for native fish. Pulse flows flush nutrients from inundated floodplains and create turbid habitat in the Delta improving growth and survival for native Delta species.

It is well established that juvenile Chinook salmon have faster growth rates on floodplains than in main-stem river channels (Sommer et al., 2001; Jeffres et al., 2008). Juvenile Chinook can enter and rear on floodplains during their downstream migration. Faster growth rates result in juveniles that are larger and have a higher likelihood of survival to adulthood. Although floodplain inundation provides important ecological benefits for salmon and the Delta generally, floodplain flows are relatively rare events along the Sacramento River due to levees and hydrologic alteration by dam. Loss of floodplain habitat has facilitated a less dynamic environment and one that is conducive to alien species that compete with juvenile salmon for prey in the limited habitat they do have or predate upon them. Due to the fact that many of these alien species are not capable of capitalizing on ephemeral floodplain innundation, the creation of additional floodplain habitat will serve the dual role of leveraging the evolutionary adaptations of central valley salmon to take advantage of the productivity of the flood pulse and reduce the concentration of predators and competitors in the existing habitat.

New Information Summary:

Information developed since 2010 reinforces the diverse benefits to salmonids of increased flows coupled with increased floodplain inundation and habitat availability. Specifically, new information emphasizes that juvenile salmon experience enhanced growth rates while utilizing floodplain habitat. Enhanced juvenile growth rates are correlated with higher juvenile survival rates. In addition, new information stresses the importance of floodplain habitat to combat the effects of climate change. (*See* climate change analysis below).

> [J. Katz. 2012. The Knaggs Ranch Experimental Agricultural Floodplain Pilot Study 2011-2012, Year One Overview. Available at http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/YBFE_Planning_Team_%E2%80%93_Knaggs_Ranch_Pilot_Project_Year_One_Overview_6-13-12.sflb.ashx]

The Knaggs Ranch is a cooperative project between U.C. Davis and the Department of Water Resources (and supported by various other agencies, landowners and organizations) that proposes to incrementally develop a flood-neutral management approach in the Yolo Bypass that will benefit agriculture, fish, and waterfowl. The Pilot Study was initiated to evaluate growth of juvenile Chinook salmon in flooded agricultural fields. The main result of the study, high juvenile salmon growth rates while utilizing floodplain habitat, reinforces existing literature that indicates juveniles experience faster growth rates on floodplains. The report states:

> "*The remarkable growth rates and condition of juvenile Chinook reared on the Knaggs experimental agricultural floodplain illustrate the potential for managing seasonally inundated habitat for Chinook salmon. Managed agricultural floodplain habitat appears to produce bio-energetically favorable rearing conditions, when compared to conditions in the Sacramento River. Our initial results provide strong evidence that juvenile Chinook permitted to access seasonally inundated floodplain on Yolo By-pass experience 1) more rapid growth, 2) substantially improved body condition, 3) delayed out-migration timing, and 4) a superior out-migration route. These floodplain benefits will results in higher quality out-migrants and likely improved rates of return. It is our conclusion that gaining access to floodplain rearing for millions of naturally produced fish is the first step in re-establishing self-sustaining stocks of Chinook salmon in the Central Valley.*" (p.10)

[Nislow, K. H. and J. D. Armstrong. 2011. Towards a life-history-based management framework for the effects of flow on juvenile salmonids in streams and rivers. Fisheries Management and Ecology. DOI: 10.1111/j.1365-2400.2011.00810.x]

See Nislow 2011 summary above finding that there is need for a management approach that integrates flow management in the upper and lower watershed as well as other factors promoting increased growth, survival and access to productive floodplain habitat.

5. Importance of Inflow to Maintain Flow Corridors

As noted above, anadromous fish utilize the Delta for a number of critical functions including migrating (both upstream as adults and downstream as juveniles). Therefore, Delta inflow requirements must be sufficient to provide contiguous habitat between the upstream tributaries and the Delta. The State Water Board should consider whether its flow requirements will protect upmigrating adults coming into the Bay Delta Estuary in addition to helping juveniles migrate from their natal streams through the Estuary to the ocean. The State Water Board's 2010 Report identified the absence of a migratory corridor for returning adult salmon as an issue requiring attention.

New Information Summary:

Flow measures should be considered that both assist juveniles in route through the estuary and adults upmigrating through the Delta. Recent information notes that regulatory processes to date have not considered measures specific to assisting adult upmigration.

[Environmental Protection Agency. August 2012. Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, EPA's Action Plan. Available at: http://www.epa.gov/sfbay-delta/pdfs/EPA-bayareaactionplan.]

[Environmental Protection Agency. February 2011. Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, Unabridged Advance Notice of Proposed Rulemaking. Available at: http://www.epa.gov/sfbay-delta/pdfs/BayDeltaANPR-fr_unabridged.pdf]

In August 2012, after releasing its advanced notice of proposed rulemaking (ANPR) in February 2011, the United States Environmental Protection Agency (EPA) released its "Action Plan" for the Delta after assessing the effectiveness of current regulatory mechanisms in place to protect water quality in the Delta. Generally, EPA concludes that "…*Clean Water Act (CWA) programs currently are not adequately protecting aquatic resources of the Bay Delta Estuary*." The Action Plan proceeds to recommend various actions to address water quality concerns in the Delta.

Appendix 1 of the Action Plan specifically identifies the issue of fragmented fish migration corridors in the Delta. The Plan notes:

> *"Migratory fish rely on diverse habitats during different life stages and they require appropriate cues and connections to guide them to those habitats. Juvenile salmon use flow as the primary cue to maneuver from their spawning grounds through the rivers to the estuary. Salinity gradients and tidal action can then guide them to the ocean. Adult fish follow the unique chemical signature of their natal stream, although straying is common. Along these migratory paths, contaminants, high temperatures, low dissolved oxygen, physical barriers, and predators may interfere with migratory success. Thus, salmon management requires a watershed approach to ensure a connected and unblocked migratory corridor."* (EPA 2012: 26)

The EPA Plan notes that regulatory response to date has focused on helping juveniles make it through the estuary and to the ocean. Little attention has been paid to measures that may aid adults upmigrating through the Delta to their natal streams. The EPA notes:

> *"Migratory passage along the San Joaquin River is a beneficial use that may not be adequately protected. Outmigrating juveniles have some protection; adults migrating back to their natal streams have little protection. The absence of migratory cues for returning adult San Joaquin fish has not been comprehensively addressed in a regulatory framework.*
>
> *Although critical, the remediation of temperature and dissolved oxygen alone is unlikely to restore depleted salmon stocks unless water from the San Joaquin River and its tributaries supports a migratory corridor to and from the Estuary during both the season of adult upmigration and young outmigration."* (p.27)

Similarly, in the February 2011 ANPR, EPA found that,

> *Retrospective analysis of earlier sonic tagging data found significant impairment of adult salmon migration to San Joaquin tributaries when total state and federal exports exceeded three times the volume of water entering from the San Joaquin River at Vernalis."* (p. 58) (internal footnotes omitted)

The EPA analysis focuses on the San Joaquin River but clearly states that the problem is one that is central to the comprehensive Delta plan proceedings.

> "*EPA supports the work of the SWRCB to establish objectives for the San Joaquin River and the Delta that result in conditions which establish a migratory corridor for both juvenile and adult salmon*." (p.28**)**

The EPA urges the State Water Board to be mindful of the evolving science related to migratory corridors in the Delta such as sonic tagging studies.

In its BDCP Red Flag comments cited above, DFG echoed concerns about San Joaquin flows and Delta hydrodynamics during the adult migratory period:

> *The continuation of zero and [negative] SJR flows at Antioch is not protective of San Joaquin Basin fish. While the PP_ELT and PP_LLT [modeling of effects of the proposed project in the early and late long term periods] show an increase in OMR and SJR flows due to a reduction in south Delta exports, the continuation of low flows in August and September followed by 0 cfs in October and November and [negative] 2000 cfs in December is not protective. Positive SJR flows during this time are important and necessary to cue upstream adult migration, reduce straying, and to help address water quality concerns (e.g., DO and temperature).* (p.4)

C. DELTA HYDRODYNAMICS & SALMON SURVIVAL

New Information Summary:

Substantial research is underway to examine the effects of CVP/SWP exports, river flows, DCC gate operations, and other factors on the survival of salmon and steelhead through the Delta (and in upstream reaches). While data from 2006-2010 have been analyzed and published, results of studies and monitoring associated with operations in 2011 (a wet year with positive OMR for part of the spring) and 2012 (a below normal year with the Head of Old River Barrier (HORB) installed) are not yet available. However, recent studies continue to show very low survival rates through the Delta and show that current protections in D-1641 are inadequate to protect migrating salmonids.

> [Perry, R. W., P. L. Brandes, J. R. Burau, A. P. Klimley, B. MacFarlane, C. Michel, and J. R. Skalski. 2012. *Sensitivity of survival to migration routes used by juvenile Chinook salmon to negotiate the Sacramento-San Joaquin River Delta*. Environ. Biol. Fish. DOI 10.1007/s10641-012-9984-6]

In order to evaluate the relative benefit of management approaches that alter survival rates versus diverting fish away from low-survival routes and towards high-survival routes, Perry et al 2012 examine a 3-year data set of route-specific survival and movement of juvenile Chinook salmon in the Sacramento-San Joaquin Delta to quantify the sensitivity of survival to changes in migration routing at two major river junctions in the Sacramento River. Their results indicate that management actions that influence only migration routing were less effective at creating increased survival than actions that altered both migration routing and route-specific survival. They observed significant variation in survival rates among fish released between 2006 and 2009, with survival rates of less than 50% in every year except for the January 2007 release:

> *Although rankings of route-specific survival vary somewhat across release groups, one pattern remained consistent: survival probabilities for the Sacramento River were always greater than survival for migration routes through the interior Delta (via Georgiana Slough and the Delta Cross Channel; Fig. 3). (Perry et al 2012:7)*

The authors concluded that because overall survival rates are low in all routes, increasing survival through the Delta "*would require management actions that affect not only migration* *routing, but also survival within migration routes*." (p. 9) The authors also noted several limitations of this study. For instance, their analysis assumed that management actions only alter migration routing but not route-specific survival; however, as they note, changes in flow has been observed to change route-specific survival, and changes in the abundance of salmon in each route may change survival from predation. (p. 11) As a result, the authors cautioned that, "*absolute changes in survival should be interpreted with caution*," but relative changes in survival between routes should provide stronger information for managers. (p. 11) Finally, because physical barriers change flow levels as well as migration routing, and nonphysical barriers only change migration routing, the authors caution that,

> *under the assumption of constant route-specific survival, non-physical barriers would realize only a fraction of the maximum possible increase in population survival. With respect to route-specific survival, physical barriers may yield a larger change in survival than non-physical barriers because physical barriers alter discharge and hydrodynamics of each migration route.*

(Perry et al 2012:11-12)

> [Singer, G., A. R. Hearn, E. D. Chapman, M. L. Peterson, P. E. LaCivita, W. N. Brostoff, A. Bremner, and A. P. Klimley. 2012. *Interannual variation of reach specific migratory success for Sacramento River hatchery yearling late-fall run Chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Oncorhynchus mykiss).* Environ Biol Fish DOI 10.1007/s10641-012-0037-y]

This paper presents results from studies of migratory survival of salmon and steelhead that were released in 2009 and 2010 with acoustic tags. The DCC gates remained closed during the releases in both years, and the study did not evaluate the effects of flow or exports on survival. The authors calculated route specific survival rates and the proportion of fish using each route, in order to estimate the proportion of fish surviving the migration through the Delta using each route. The authors observed that, "*Although overall migratory success to the Golden Gate was similar between 2009 and 2010, reach specific success was very different between years*." (p. 9) Overall survival from Elkhorn Landing (near Sacramento) to the Golden Gate Bridge was estimated as follows for each year and species:

	2009	2010
Salmon	19.2%	23.6%
Steelhead	14.6%	13.8%

(p. 9) However, as compared to 2009, in 2010 survival was lower through the Delta but higher through San Francisco Bay. (pp. 9-10) With respect to survival through the Delta, the authors noted that,

> *Success for both species in the Delta was above 60 % in 2009, yet dropped to below 45 % in 2010. Conversely, successful migration through San Francisco Bay was only around 50 % in 2009, yet increased to over 75 % in 2010. This apparent reversal in the relative success rates (which might be assumed to reflect mortality) may be counterintuitive, given that flows were higher in 2010, and*

> *increased flows are often associated with increased survival (Sims and Ossiander 1981). Survival of salmonid smolts in the Delta is positively correlated (r=0.95) with volume of flow and that the survival rate changed greatly as the flow changed. The survival was nearly 100 % when the flows were above 708 m3 s−1 (25 000 cfs), but less than 20 % when the flows were near 283 m3 s−1 (10 000 cfs) (Fischer et al. 1991). The paradox we observed may have resulted from indirect effects of climate and flow– the 2010 releases occurred in March, 1 month later than in 2009.*

(pp. 10-11) Consistent with Perry et al 2010, the authors concluded that survival rates through the East Delta were lower than other routes, even with the DCC closed:

> *It has been suggested that fish entrained in the East Delta have lower survival rates than other routes (Perry et al. 2010), although it is important to note that Perry defined "survival" as migration to Chipps Island. This was consistent with our results - throughout the duration of our study, fish migrating through the East Delta had lower overall survival than fish choosing either the West Delta or the mainstem Sacramento River, with the exception of West Delta steelhead in 2009 (Fig. 6).*

(p. 15) Although their study did not directly examine why survival was lower in the East Delta routes, the authors note that migratory survival is generally inversely related to migratory distance, and note that fish entrained into the East Delta have a longer route to the ocean and potentially encounter the CVP and SWP pumps, and they also noted that,

> *Additionally, the Operations Criteria and Plan (OCAP) Biological Assessment (BA) (USBR 2008) contains regressions of monthly steelhead salvage at the Central Valley Project and State Water Project pumping facilities, which shows a significant relationship between number of steelhead salvaged and the amount of water exported during the months of January through May, the same time that our tagged fish where in the Sacramento River Watershed. Our study suggests that entrainment in the east delta was negatively correlated with success to the ocean.*

(p. 15)

Table 2 Number and proportion of fish that used each route though the Delta, and their success to the Golden Gate Bridge

		Chinook		Steelhead	
		2009	2010	2009	2010
West Delta	# of fish	93	137	72	60
	Prop utilizing route	0.21	0.316	0.231	0.288
	# to Golden Gate	28	42	7	18
	Prop. Success to ocean	0.30	0.31	0.10	0.30
East Delta	# of fish	68	62	53	59
	Prop utilizing route	0.154	0.143	0.17	0.188
	# to Golden Gate	6	10	10	6
	Prop. Success to ocean	0.09	0.16	0.19	0.10
Mainstem	# of fish	281	234	187	109
	Prop utilizing route	0.636	0.54	0.599	0.524
	# to Golden Gate	55	61	46	36
	Prop. Success to ocean	0.20	0.26	0.25	0.33
Total fish in delta		442	433	312	208

Fig. 9 (Reprinted from Singer et al 2012)

[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 Juvenile Chinook Salmon in the Sacramento–San Joaquin River Delta*. North American Journal of Fisheries Management 30:142–156. DOI: 10.1577/M08-200.1]

This study reports results of acoustic tag survival studies for salmon released in migration years 2007-2009. The overall survival through the Delta (the fraction surviving through all routes) averaged less than 33% for migration years 2007–2009. Survival was substantially lower for fish that were entrained into the interior Delta, including fish entrained through the Delta Cross Channel Gates; salmon migrating along the Sacramento River were between 1.5 and 6.6 times more likely to reach Chipps Island. The study showed that low flows in the Sacramento River (as well as opening the Delta Cross Channel gates) increase the chances of fish being entrained into the interior Delta, with lower survival rates.

[National Research Council. 2012. Sustainable water and environmental management in the California Bay-Delta. National Research Council. The National Academies Press, Washington, DC. Available at: https://download.nap.edu/catalog.php?record_id=13394]

In their 2012 report, the National Academy of Sciences concluded that, "*The committee accepts the conclusion that pump operations pose a risk to juvenile salmonids. The survival of salmonid smolts migrating through the Delta is low. Several studies make this point.*" (p. 81) For instance, the NAS report reviewed Michel 2010 and found it supported the conclusion that survival to the Bay was, "*an order of magnitude less than that typically reported for yearling Chinook smolts migrating past eight dams in the Snake Columbia River system*," and that 20-30% of smolts died in the Delta and that, "*[t]hese losses are substantive and are at least in part attributable to pump operations that alter current patterns into and through the channel complex, drawing smolts into* *the interior waterways and toward the pumps*." (p. 81) The committee also acknowledged that salmon survival from the San Joaquin River in recent years has been estimated to be between 5 and 8 percent. (p. 81) But the committee warned that "*delta-specific management actions may not yield the large survival benefits as some might expect. Migrating smolts incur substantial levels of mortality outside of passage through the Delta including mortality directly and indirectly associated with SWP and CVP pump operations*." (p. 81)

> [Cavallo, B., J. Merz, and J. Setka. 2012. Effects of predator and flow manipulation on Chinook salmon (*Oncorhynchus tshawytscha*) survival in an imperiled estuary. Environ. Biol. Fish. DOI 10.1007/s10641-012-9993-5]

Cavallo et al (2012) examined the effects of predator control and increased flow (resulting from opening the Delta Cross Channel gates) on survival rates for juvenile salmon migrating through the Delta from the Mokelume River. Their evaluation of removal of non-native, piscivorous fish found that migratory salmon survival after predator reduction improved in half of the treatments (there were significant improvements in survival after the first predator reduction treatment (from <0.80 to >0.99) but there was no apparent improvement in survival as a result of the second predator reduction treatment (survival decreased to pre-impact levels)). The authors suggested that daily (rather than weekly) predator removals, or removals across a broader geographic area, may be necessary to see any benefits for salmon survival. They also acknowledged that, "*we cannot rule out that observed changes in impact reach salmon survival occurred for reasons other than reduced predation pressure*." (p. 9) Increased flow and decreased tidal effect, however, resulted in decreased emigration time and increased survival in juvenile salmon. These results demonstrate that habitat manipulation through increased flow in the Delta tidal transition zone can be an effective approach to enhance salmon survival.

D. <u>RECENT SALMONID LIFE CYCLE MODELS</u>

New Information Summary

NMFS is developing a new life cycle model for Central Valley salmon runs. The 2011 independent peer review panel found that no existing life cycle models (including the IOS model) were adequate for evaluating the effects of the RPAs, and instead recommended that NMFS develop its own model. New life cycle models should help inform future management actions to restore listed salmon and steelhead runs.

> [Rose, K., J. Anderson, M. McClure, and G. Ruggerone. June 14, 2011. *Salmonid Integrated Life Cycle Models Workshop: Report of the Independent Workshop Panel. Delta Science Program*. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/Salmonid_ILCM_workshop_final_report.pdf]

This report summarized an independent panel review of existing salmon life cycle models, including the SALMOD, Shiraz, IOS, Delta Passage submodel, and OBAN models. The panel recommended that instead of using any of these existing models, NMFS should develop its own life cycle model, stating that:

> *The Panel recommends that NMFS develop a model (or models) from the beginning. NMFS should use the existing models as guidance and the foundation, but should not try to modify one of the existing models to use for evaluating water management and the RPA actions. None of the models reviewed was completely appropriate alone for the needed life cycle model. Furthermore, none of the codes from the existing models, including SLAM, which is a general model, should be used for the NMFS model.*

(Rose 2011:8; see pp. 12-13, 9, 18). In addition, the panel identified concerns with using several of the models:

> *Several of the models presented at the workshop (IOS, Shiraz, SALMOD, and OBAN) use the same approach of representing life stage survivals as Beverton-Holt (or Ricker) like functions (density-dependence). Environmental covariates (e.g., water temperature, flow) are then added to these functions based on correlation analyses. The Panel had several cautions about using this approach for a model designed to address water management and RPA actions.*

(Rose 2011: 13-14). The panel also suggested that NMFS' life cycle model should explicitly consider the impacts of degraded freshwater habitat and competition with hatchery fish as a source of density dependence, even at low abundances (p. 16), and emphasized that the life cycle model should be developed to include life history variation and spatial distribution elements of the Viable Salmonid Population frameworks, instead of only modeling abundance (p. 16-17).

> [Zeug, S., P. S. Bergman, B. J. Cavallo, and K. S. Jones. 2012. *Application of a Life Cycle Simulation Model to Evaluate Impacts of Water Management and Conservation Actions on an Endangered Population of Chinook Salmon*. Environ. Model Assess. DOI 10.1007/s10666-012-9306-6]

This paper describes sensitivity analysis of the IOS life cycle model for winter run Chinook salmon. The paper reports that, "Delta survival, water year, and egg mortality were significant drivers of variability in age 3 escapement" (p. 10) and that "harvest may have a profound effect on salmon population dynamics" (p. 10). The model predicted that escapement was very sensitive to increases in water temperature, with a 10% increase in temperature producing a 95.7% reduction in escapement, with escapement less sensitive to changes in flow and not sensitive to changes in exports or ocean conditions. (p. 11) However, the authors also acknowledged some of the limitations of the model, for instance stating that:

> *several of the relationships in the IOS model are based on limited data that influence the estimate of input parameters and the form of uncertainty distributions associated with those estimates. For example, river migration survival has been hypothesized to be influenced by flow,* ***yet survival during the river migration stage is not influenced by flow in our model because the values we used to inform the relationship were***

> ***taken from a field study conducted over three low-flow years.*** (p. 11) (footnotes omitted) (emphasis added).

They also acknowledged that, "*The lack of significant changes in escapement with a 10% change in flow, exports and ocean conditions may reflect the type of data used to parameterize these relationships*." (p. 11) The model used uniform random variables for ocean conditions and smolt to age 2 survival, which the authors indicated could significantly affect model output.

E. CLIMATE CHANGE CONSIDERATIONS

The State Water Board's 2010 Flow Report did not specifically analyze the projected impacts of climate change on native species or their habitat. The report does suggest that the current criteria may not be appropriate in the future given the uncertainty associated with climate change effects.

> "*The numeric criteria are all short term criteria that are only appropriate for the current physical system and climate. There is uncertainty in these criteria even for the current physical system and climate, and therefore for the short term. Long term numeric criteria, beyond five years, for example, and assuming a modified physical system, are highly speculative. Only the underlying principles for the proposed numeric criteria and the other measures are advanced as long term determinations*." (p.128)

The 2010 Flow Report appears to anticipate that climate change will be considered in the context of an adaptive management program.

New Information Summary:

Recent literature finds that many native California fish, including salmonids, are vulnerable to extirpation in the near future. Climate change effects enhance that vulnerability. The effects of climate change can be ameliorated by restoring floodplain connectivity and stream flow regimes, re-aggrading incised channels and developing regional management plans that focus on restoring native fish.

> [Beechie, T., H. Imaki, J. Greene, A. Wade, H. Wu, G. Pess, P. Roni, J. Kimball, J. Stanford, P. Kiffney and N. Mantua. 2012. Restoring salmon habitat for a changing climate. River Research and Applications. DOI: 10.1002/rra.2590]

Beechie et al (2012) developed a decision support process for adapting salmon recovery plans that incorporates (1) local habitat factors limiting salmon recovery, (2) scenarios of climate change effects on stream flow and temperature, (3) the ability of restoration actions to ameliorate climate change effects, and (4) the ability of restoration actions to increase habitat diversity and salmon population resilience. Through the application of this process to systems in the pacific northwest, their findings indicated that restoring floodplain connectivity, restoring stream flow regimes, and re-aggrading incised channels were the restoration actions most likely most likely to ameliorate stream flow and temperature changes and increase habitat diversity and population resilience. Additionally, the potential benefits associated with this suite of actions stood in contrast with in-stream rehabilitation actions, which they found were unlikely to ameliorate climate change effects.

> [United States Environmental Protection Agency. August 2012. Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, EPA's Action Plan. Available at: http://www.epa.gov/sfbay-delta/pdfs/EPA-bayareaactionplan.]

As noted above, in August 2012, the EPA released its "Action Plan" for the Delta after assessing the effectiveness of current regulatory mechanisms in place to protect water quality in the Delta. Generally, EPA concludes that "…Clean Water Act (CWA) programs currently are not adequately protecting aquatic resources of the Bay Delta Estuary." (p.2) The Action Plan notes that adverse effects from the loss of functional floodplain habitat in the Delta are likely to be exacerbated by climate change.

> *"Beginning in the 1850s, settlers diked, drained, and converted the floodplains, riparian corridors, and wetlands of the Bay Delta watershed into farms, cities and suburbs. (See Figure 3) A diversity of unique natural communities were destroyed and displaced, along with the fish and wildlife they supported. The losses include approximately 313,000 acres of wetlands in the Delta, 637,000 acres of riparian forest along the Sacramento River, and 329,000 acres of riparian forest along the San Joaquin River. Throughout the watershed, levees were built near creeks and rivers, thereby disconnecting them from their historical floodplains. Consequently, the floodplains that once provided valuable rearing and foraging habitat for fishes when seasonally inundated were converted to other uses. In addition, the loss of wetlands, floodplains, and riparian corridors greatly diminished the ability of these areas to accommodate flooding and recharge groundwater aquifers. Anticipated effects of climate change – including rising sea levels and more intense rainfall events – may exacerbate the ecological and flood control problems associated with the conversion of these aquatic habitats."*(p.100)

This excerpt highlights the importance of floodplain habitat in the Delta to ameliorate the effects of climate change.

> [BDCP "Red Flag" Documents [California Department of Fish and Game; US Fish and Wildlife Service; and National Marine Fisheries Service. April 2012 BDCP EA (Ch. 5) Staff "Red Flag" Review Comprehensive List. Available at: http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Effects_Analysis__Fish_Agency_Red_Flag_Comments_and_Responses_4-25-12.sflb.ashx]

In their review of the February 2012 BDCP draft effects analysis, the state and federal fish and wildlife agencies observed significant adverse effects from the combination of CVP/SWP operations under BDCP and climate change, which could lead to the extinction of several salmon runs. For instance, the National Marine Fisheries Service wrote that,

> *The analysis indicates that the cumulative effects of climate change along with the impacts of the PP may result in the extirpation of mainstem Sacramento River populations of spring-run and winter-run Chinook salmon over the term of the permit.*

(p.28) Similarly, DFG found that:

> *Winter-run redd dewatering and lower weighted usable spawning habitat in the Sacramento River under the preliminary proposal is not acceptable. This would lead to a significant decline in the population (as estimated by the JPE).*
>
> *Spring-run egg mortality in the mainstem of the Sacramento River is near 100 percent during dry and critical dry years. This type of egg mortality could lead to the extirpation of spring-run Chinook salmon from the mainstem of the Sacramento River during one drought cycle.*

(p. 3-4) Because of these concerns, NMFS recommended that operational criteria be developed that would ensure the protection of suitable habitat in the upper Sacramento River.

> [Moyle, P.B., R.M. Quinones, J. Kiernan. 2012. Effects of Climate Change on Inland Fishes of California: With Emphasis on the San Francisco Estuary Region. California Energy Commission White Paper. Available at: http://uc-ciee.org/downloads/Effects%20of%20Climate%20Change%20on%20the%20Inland%20Fishes%20of%20California.pd]

In 2003, the California Energy Commission created its Climate Change Center to document climate change research relevant to the state. The Center commissioned a report to analyze the effects of climate change on inland fishes in California. The report notes that anadromous fish will be especially affected by climate change:

> "*California's native inland fish fauna is in steep decline, a pattern which is reflected in the status of fishes native to streams flowing into the San Francisco Estuary and in the estuary itself. Climate change will further reduce the distribution and abundance of these mostly endemic fishes and expand the distribution and abundance of alien fish species. The decline and likely extinction of many native fishes reflects dramatic shifts in the state's aquatic ecosystems; shifts which are being accelerated by climate change. Fishes requiring cold water, such as salmon and trout, will especially suffer from climate change impacts of warmer water and reduced summer flows. Additionally, desirable species living in the San Francisco Estuary and the lower reaches of its streams will have to contend with the effects of rising sea level along with changes in flows and temperature.*" (p.5)

The report includes both dams and alien species among the top factors negatively affecting native species. The report notes that many native aquatic species will disappear in the future without regional management strategies in place that incorporate measures for, among other things, obtaining and preserving habitat that can act as a climate change refugia and managing coldwater pools in reservoirs to favor native fish.

II. RECOMMENDED CHANGES TO THE BAY-DELTA WATER QUALITY CONTROL PLAN AND PROGRAM OF IMPLEMENTATION

A. Recommendations for New and Revised Objectives in the Bay Delta Water Quality Control Plan

We recommend that the State Water Board consider the following measures in its update of the water quality control plan, consistent with the potential objectives identified in the 2009 staff report:

1. Sacramento River Inflow and Delta Outflow Objectives: Increase winter/spring inflow and outflow objectives to improve migratory survival of juvenile salmonids into and through the Delta sufficient to achieve the SWRCB's narrative salmon doubling objective and other specific targets to restore and maintain natural, self-sustaining, and ecologically and commercially viable anadromous fish populations (see below). Releases from upstream sources should be made proportionally to each stream and watershed as a fraction of unimpaired flow to preserve ecological connectivity between the Delta and upstream watersheds and to avoid concentrating impacts on a subset of source areas.

2. Floodplain Habitat Flow Objectives: Establish Sacramento River inflow and structural modifications objectives such that flows from the Sacramento River inundate floodplains for 15-120 days between December and May every year or twice in every three years.

3. Reverse Flow Objectives/Export:Inflow Objectives: Establish objectives limiting reverse flows in Old and Middle River (OMR) and/or other restrictions on hydrodynamics and exports (e.g., I:E ratios) that reduce juvenile entrainment and improve migratory survival in the winter and spring months in order to achieve specific survival and other targets (see below). In addition, establish objectives that provide adequate migratory corridors through the Delta for both juveniles and adults, including pulse flow releases and restrictions on exports during fall months to allow for successful upmigration of adults, particularly those coming into the San Joaquin River.

4. Maintain Adequate Upstream Temperature Conditions: Build on the CALSIM modeling done for BDCP Alternative 8 to ensure that upstream reservoirs maintain adequate end of April and end of September storage (cold water pools) and release sufficient flows to maintain temperature compliance points downstream from these reservoirs while meeting Delta flow objectives.

B. Recommendations for the Program of Implementation to Address Climate Change and Changed Circumstances

We provide the following recommendations to account for climate change and changed circumstances:

(1) Develop and implement a robust adaptive management program tied to clearly defined biological outcome metrics that clearly define success.
(2) Develop and implement protective flow objectives that will enhance species' natural resiliency to habitat disturbances (e.g., through increased spatial distribution of populations) and increase diversity of life history stages.

We recommend that the State Water Board develop a robust adaptive management program that establishes targets and defines desired outcomes for public trust values and beneficial uses of the Bay Delta system that are specific, measureable, achievable and relevant to the particular goals that characterize the plan's overarching purpose (protecting the public trust values and beneficial uses of the Delta ecosystem) and timebound (S.M.A.R.T.), and evaluates the performance of the WQCP objectives over time toward achieving these targets. The State Water Board should establish quantitative targets when possible, such as survival, abundance, and spatial distribution metrics, as opposed to narrative outcomes. For instance, outcomes for Chinook salmon should include metrics identifying quantifiable improvements in the survival of outmigrating juveniles and metrics identifying increased abundance targets sufficient to meet the State Water Board's narrative salmon doubling objectives and other targets for restoring and maintaining natural, self-sustaining, and ecologically and commercially viable anadromous fish populations. For a more detailed description of this process, please see the TBI et al August 17, 2012 submission for Workshop 1. The flow objectives and adaptive management program should be sufficient to achieve greater diversity of life history strategies for salmonid populations and enhance the resiliency of those populations. In other words, the State Water Board should identify objectives that will increase and sustain salmonid life history diversity to ensure a more resilient population that is better able to respond to future climatic disturbances.

Literature Cited

Beechie, T., H. Imaki, J. Greene, A. Wade, H. Wu, G. Pess, P. Roni, J. Kimball, J. Stanford, P. Kiffney and N. Mantua. 2012. Restoring salmon habitat for a changing climate. River Research and Applications. DOI: 10.1002/rra.2590]

BDCP "Red Flag" Documents California Department of Fish and Game; US Fish and Wildlife Service; and National Marine Fisheries Service. April 2012 BDCP EA (Ch. 5) Staff "Red Flag" Review Comprehensive List. Available at: http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/Effects_Analysis__Fish_Agency_Red_Flag_Comments_and_Responses_4-25-12.sflb.ashx

Cavallo, B., J. Merz, and J. Setka. 2012. Effects of predator and flow manipulation on Chinook salmon (*Oncorhynchus tshawytscha*) survival in an imperiled estuary. Environ. Biol. Fish. DOI 10.1007/s10641-012-9993-5

del Rosario, R. B., Y. J. Redler, and P. Brandes. 2010. Residence of Winter-Run Chinook Salmon in the Sacramento-San Joaquin Delta: The role of Sacramento River hydrology in driving juvenile abundance and migration patterns in the Delta. Abstract submitted to the CalNeva conference (manuscript in preparation). Available at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/exhibits/nmfs/nmfs_exh7.pdf

Environmental Protection Agency. August 2012. Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, EPA's Action Plan. Available at: http://www.epa.gov/sfbay-delta/pdfs/EPA-bayareaactionplan.

Environmental Protection Agency. February 2011. Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, Unabridged Advance Notice of Proposed Rulemaking. Available at: http://www.epa.gov/sfbay-delta/pdfs/BayDeltaANPR-fr_unabridged.pdf

Jeffres, C., J. Opperman and P. Moyle (2008), "Ephemeral floodplain habitats provide best growth conditions for juvenile Chinook salmon in a California river," *Environmental Biology of Fishes* 83 (4): 449-458.

Katz, J., P. B. Moyle. R.M. Quiñones, J. Israel and S. Purdy. 2012. Impending extinction of salmon, steelhead, and trout (Salmonidae) in California. Environ Biol Fish. DOI 10.1007/s10641-012-9974-8

Katz, J. 2012. The Knaggs Ranch Experimental Agricultural Floodplain Pilot Study 2011-2012, Year One Overview. Available at http://baydeltaconservationplan.com/Libraries/Dynamic_Document_Library/YBFE_Planning_Team_%E2%80%93_Knaggs_Ranch_Pilot_Project_Year_One_Overview_6-13-12.sflb.ashx

Kormos, B., M. Palmer-Zwahlen, and A. Low. California Department of Fish and Game. March 2012. *Recovery of Coded-Wire Tags from Chinook Salmon in California's Central Valley Escapement and Ocean Harvest in 2010*. Fisheries Branch Administrative Report 2012-02. Available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=44306

McElhany, P., M. H. Rucklelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. NOAA Technical Memorandum NMFS-NWFSC-42. Available at: http://www.nwfsc.noaa.gov/publications/techmemos/tm42/tm42.pdf

Michel, C.J., A.J. Ammann, E.D. Chapman, P.T. Sandstrom, H.E. Fish, M.J. Thomas, G.P. Singer, S.T. Lindley, A.P. Klimley and R.B. MacFarlane. 2012. The effects of environmental factors on the migratory movement patterns of Sacramento River yearling late-fall run Chinook salmon (*Oncorhynchus tshawytscha*). Environmental Biology of Fishes. DOI: 10.1007/s10641-012-9990-8

Michel, C. River and Estuarine Survival and Migration of Yearling Sacramento River Chinook Salmon (*Oncorhynchus Tshawytscha*) Smolts and the Influence of Environment. A thesis submitted in partial satisfaction of the requirements for the degree of Master of Arts in Ecology and Evolutionary Biology. December 2010.

Miller, J.A., A. Gray, and J. Merz. 2010. Quantifying the contribution of juvenile migratory phenotypes in a population of Chinook salmon *Oncorhynchus tshawytscha*. Marine Ecology Progress Series 408:227–240.

Mount, J., W. Bennett, J. Durand, W. Fleenor, E. Hanak, J. Lund, and P. Moyle. 2012. Aquatic Ecosystem Stressors in the Sacramento–San Joaquin Delta. Public Policy Institute of California, San Francisco, CA. 24p. Available at: http://www.ppic.org/content/pubs/report/R_612JMR.pdf

Moyle, P.B., J.V.E. Katz, R.M. Quiñones. 2011. Rapid decline of California's native inland fishes: A status assessment. Biological Conservation (144) 2414–2423

Moyle, P.B., R.M. Quinones, J. Kiernan. 2012. Effects of Climate Change on Inland Fishes of California: With Emphasis on the San Francisco Estuary Region. California Energy Commission White Paper. Available at: http://uc-ciee.org/downloads/Effects%20of%20Climate%20Change%20on%20the%20Inland%20Fishes%20of%20California.pdf

Moyle, P., W. Bennett, J. Durand, W. Fleenor, B. Gray, E. Hanak, J. Lund, and J. Mount. 2012. Where the Wild Things Aren't: Making the Delta a Better Place for Native Species. Public Policy Institute of California, San Francisco, CA. 55p. Available at: http://www.ppic.org/content/pubs/report/R_612PMR.pdf

National Marine Fisheries Service. 2009. Biological Opinion on proposed long term operations of the Central valley Project and State Water Project. Available at:

http://www.swr.noaa.gov/ocap/NMFS_Biological_and_Conference_Opinion_on_the_Long-Term_Operations_of_the_CVP_and_SWP.pdf

National Marine Fisheries Service. February 10, 2012. Biological Opinion for the Department of Water Resources 2012 Georgiana Slough non-physical barrier study. File # 151422SWR2011SA00060 (TN 2011/05837). Available at: http://swr.nmfs.noaa.gov/bo/Georgiana_Slough_Barrier_Study_021012.pdf. ("NMFS 2012a")

National Marine Fisheries Service. August 2011. *5-Year Review: Summary and Evaluation of Sacramento River Winter-run Chinook Salmon ESU*. Available at: http://swr.nmfs.noaa.gov/psd/fyr/Final_Winter-run_Chinook_5-year_Review_Report_082211.pdf ("NMFS 2011a")

National Marine Fisheries Service. January 26, 2012. *Letter from Maria Rea to Ron Milligan regarding Winter Run Chinook JPE during water year 2012*. ("NMFS 2012b")

National Marine Fisheries Service. *Annual Report of Activities October 1, 2010, to September 30, 2011, Delta Operations for Salmonids and Sturgeon (DOSS) Technical Working Group.* October 2011. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/DOSS_Annual_Report_10_18-11_final.pdf ("NMFS 2011b")

National Marine Fisheries Service. *Delta Operations for Salmonids and Sturgeon (DOSS) Working Group. Presentation for the Independent Review Panel, 11-8-11, by Bruce Oppenheim (NMFS) and Thuy Washburn, USBR*. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/OCAP_2011_presentations_09_DOSS_ann_rev_11_7_11.pdf ("NMFS 2011c")

National Marine Fisheries Service. March 2012. Abundance-based Ocean Salmon Fisheries Management Framework for Sacramento River Winter-Run Chinook. Supplemental NMFS Report 2 to the Pacific Fishery Management Council. Available at: http://www.pcouncil.org/wp-content/uploads/G4c_SUP_NMFS_RPT2_MAR2012BB.pdf ("NMFS 2012c")

National Research Council. 2012. Sustainable water and environmental management in the California Bay-Delta. National Research Council. The National Academies Press, Washington, DC. Available at: https://download.nap.edu/catalog.php?record_id=13394

Nislow, K. H. and J. D. Armstrong. 2011. Towards a life-history-based management framework for the effects of flow on juvenile salmonids in streams and rivers. Fisheries Management and Ecology. DOI: 10.1111/j.1365-2400.2011.00810.x

O'Farrell, Michael R., Michael S. Mohr, Allen M. Grover, and William H. Satterthwaite. 2012. Sacramento River winter Chinook cohort reconstruction: analysis of ocean fishery impacts. U.S. Department of Commerce, NOAA Technical Memorandum NMFS, NOAA-TM-NMFS-SWFSC-491, 68 p. Available at: http://swfsc.noaa.gov/publications/FED/01220.pdf

Pacific Fishery Management Council. April 2012. Preseason Report III: Council Adopted Management Measures and Environmental Assessment Part 3 for 2012 Ocean Salmon Fishery Regulations. Available at: http://www.pcouncil.org/wp-content/uploads/Preseason_Report_III_2012.pdf

Parker, A., Simenstad, S., George, T., Monsen, N., Parker, T., Ruggerone, G., and Skalski, J. 2012. Bay Delta Conservation Plan (BDCP) Effects Analysis Phase 2 Partial Review, Review Panel Summary Report. Delta Science Program. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/BDCP_Effects_Analysis_Review_Panel_Final_Report_061112.pdf

Perry, R. W., P. L. Brandes, J. R. Burau, A. P. Klimley, B. MacFarlane, C. Michel, and J. R. Skalski. 2012. *Sensitivity of survival to migration routes used by juvenile Chinook salmon to negotiate the Sacramento-San Joaquin River Delta*. Environ. Biol. Fish. DOI 10.1007/s10641-012-9984-6

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 Juvenile Chinook Salmon in the Sacramento–San Joaquin River Delta*. North American Journal of Fisheries Management 30:142–156. DOI: 10.1577/M08-200.1

Rose, K., J. Anderson, M. McClure, and G. Ruggerone. June 14, 2011. *Salmonid Integrated Life Cycle Models Workshop: Report of the Independent Workshop Panel. Delta Science Program*. Available at: http://deltacouncil.ca.gov/sites/default/files/documents/files/Salmonid_ILCM_workshop_final_report.pdf

Rosenfield, J.A. 2002. Pattern and process in the geographic ranges of freshwater fishes. Global Ecology and Biogeography 11:323-332.

Singer, G., A. R. Hearn, E. D. Chapman, M. L. Peterson, P. E. LaCivita, W. N. Brostoff, A. Bremner, and A. P. Klimley. 2012. *Interannual variation of reach specific migratory success for Sacramento River hatchery yearling late-fall run Chinook salmon (Oncorhynchus tshawytscha) and steelhead trout (Oncorhynchus mykiss).* Environ Biol Fish DOI 10.1007/s10641-012-0037-y

Sommer, T., B. Harrell, M. Nobriga, R. Brown, P. Moyle, W. Kimmerer and L. Schemel 2001. California's Yolo Bypass: Evidence that flood control can be compatible with fisheries, wetlands, wildlife and agriculture. Fisheries 26 (8): 6-16.

Sommer, T., M. L. Nobriga, B. Harrell, W. Batham, & 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.

Winship, Arliss J., Michael R. O'Farrell, and Michael S. Mohr. 2012. Management Strategy Evaluation for Sacramento River winter Chinook salmon. Report to the U.S. National Marine Fisheries Service, Southwest Region, Long Beach, California. 85 p.

Zeug, S.C. 2010. Predictors of Chinook Salmon Extirpation in California's Central Valley. Fisheries Management and Ecology 18: 61-71.

Zeug, S., P. S. Bergman, B. J. Cavallo, and K. S. Jones. 2012. *Application of a Life Cycle Simulation Model to Evaluate Impacts of Water Management and Conservation Actions on an Endangered Population of Chinook Salmon*. Environ. Model Assess. DOI 10.1007/s10666-012-9306-6