UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
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Sacramento, California 95814-4700

February 28, 2014

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SWRCB EXECUTIVE

Mr. David Murillo
Regional Director
Bureau of Reclamation
2800 Cottage Way
Sacramento, California 95825

Mr. Mark Cowin
Director
California Department of Water Resources
1416 Ninth Street
Sacramento, California 95814

Re: Interim Contingency Plan for March Pursuant to Reasonable and Prudent Alternative Action I.2.3.C of the Biological and Conference Opinion on the Coordinated Long-term Operation of the Central Valley Project and State Water Project

Dear Mr. Murillo and Mr. Cowin:

This letter is in response to the U.S. Bureau of Reclamation's (Reclamation) February 27, 2014, letter, wherein Reclamation and the California Department of Water Resources (DWR) propose to extend through March the provisions of the Temporary Urgent Change (TUC) Petition[1] they submitted to the State Water Resource Control Board (SWRCB) on January 29, 2014, for the month of February. The SWRCB's revised Order approved modification to the Water Rights Decision 1641 (D-1641) permit terms related to the Delta outflow and Delta Cross Channel (DCC) standards described in D-1641, Table 3. Reclamation and DWR propose these same drought response actions as the interim drought contingency plan for March, per the drought exception procedures outlined in the biological and conference opinion on the long-term operation of the Central Valley Project (CVP) and State Water Project (SWP, CVP/SWP Opinion), reasonable and prudent alternative (RPA) Action I.2.3.C. Reclamation has requested NOAA's National Marine Fisheries Service's (NMFS) concurrence that these actions are consistent with the CVP/SWP Opinion.

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[1] The TUC Petition, Board's January 31, 2014 Order, and Board's February 7, 2014, revised Order, along with related documents, are available at: http://www.swrcb.ca.gov/waterrights/water_issues/programs/drought/tucp.shtml.

We understand that California is continuing to experience unprecedented drought conditions, entering its third straight year of below-average rainfall and very low snowpack. Calendar year 2013 was the driest year in recorded history for many parts of California, resulting in the low initial storage at the beginning of water year 2014. Water year 2014 is the driest to date. On January 17, 2014, the Governor of California announced an Emergency Proclamation, finding that "conditions of extreme peril to the safety of persons and property exist in California due to water shortage and drought conditions." NMFS stands ready to provide the assistance needed to manage through drought conditions in California. We realize that it is not possible to meet all needs during this very unusual water year, and we are committed to working with the operators of the CVP and SWP to protect health and safety while providing needed protections for listed anadromous fish species under the Endangered Species Act (ESA).

NMFS built flexible drought provisions into the current CVP/SWP Opinion. We anticipated drought conditions, when we wrote the CVP/SWP Opinion and its RPA. The RPA Action I.2.3.C (pages 26-27 of the 2009 RPA with 2011 amendments) provides drought exception procedures and requires that Reclamation develop and submit to NMFS a drought contingency plan. The rationale for this action explicitly recognizes that in drought conditions, there is potential for conflict between the need to maintain storage at Shasta Reservoir and other legal and ecological requirements in the Delta, including outflow and salinity standards. This RPA provision is triggered if the February forecast, based on 90 percent hydrology, shows that the Clear Creek temperature compliance point or 1.9 million acre feet end of September storage at Shasta Reservoir is not achievable.

On January 31, 2014, NMFS issued a letter to Reclamation, concurring that Reclamation's TUC Petition, as modified by the more specific DCC Gate closure criteria, was consistent with Action 1.2.3.C and met the specified criteria for a drought contingency plan (http://www.westcoast.fisheries.noaa.gov/publications/Central_Valley/Water%20Operations/20140131_nmfs_contingency_plan_response_letter_with_enclosures.pdf). Despite some rain events in early to mid-February which allowed Reclamation and DWR to temporarily meet Delta outflow and water quality standards requirements in D-1641, the 50 percent and 90 percent exceedance hydrology forecasts for February (enclosure 2 of Reclamation's letter) indicate that Reclamation will still be unable to meet 1.9 MAF of storage in Shasta Reservoir at the end of September 2014. Therefore, NMFS agrees that Action I.2.3.C is still in effect, and that a drought contingency plan is warranted.

Pursuant to Action I.2.3.C, Reclamation proposes to extend the plan submitted for February operations as the drought contingency plan for the month of March. NMFS finds that all required aspects of the contingency plan have been met, as follows:

- Reclamation commits to target a navigation control point at Wilkins Slough, based on minimum reservoir releases, not to exceed 4,000 cfs during the month of March. As seen since February 6, 2014, rain events and the associated unregulated flow entering the Sacramento River may result in flows at Wilkins Slough greater than 4,000 cfs (http://cdec.water.ca.gov/cgi-progs/queryDaily?WLK).
- On January 29, 2014, Reclamation and DWR filed a TUC Petition with the State Water Resources Control Board, indicating that there is not an adequate water supply to meet

water right permit obligations under D-1641 to support instream and Delta beneficial uses.

- When operating under the revised Order, exports have been, and will continue to be curtailed to the combined minimum health and safety rate of 1,500 cfs when Delta outflow requirements are not met.

Under the proposed drought contingency plan for March per RPA Action I.2.3.C, Reclamation and DWR will continue to maintain minimum releases during March from Shasta Reservoir, which should meet a Wilkins Slough flow not to exceed 4,000 cfs, and the minimum 3,000 cfs Delta outflow required by the SWRCB's revised Order. Modified operations of the DCC gates may still be required to maintain water quality standards in the Delta. Preliminary temperature modeling results show that, under the 90 percent forecast, a temperature compliance point above Clear Creek on the Sacramento River may be met through July, but the water temperature of releases from Keswick Dam may be greater than 56°C by mid-August. Reclamation will coordinate water temperature actions, as required by RPA Actions I.2.3.A, I.2.4, II.2, and III.1.2, by continuing to discuss precautionary initial temperature plans and updating these as in-season adjustments occur.

DCC operations

The recent dry hydrology and habitat conditions that juvenile winter-run and spring-run Chinook salmon (spring-run) are experiencing are anomalous, and winter-run and spring-run were rarely observed in the rotary screw trap locations downstream of the Glen-Colusa Irrigation District traps before the rain event in early February. Based on monitoring during February, members of the Delta Operations for Salmonids and Sturgeon group agree that at least 50% of the winter-run and young-of-the-year spring-run juveniles are currently in the Delta and that less than 5% have exited the Delta.

In an effort to balance water quality requirements with the needs of listed anadromous fish; an interagency team of fisheries biologists from NMFS, Reclamation, DWR, and California Department of Fish and Wildlife (DFW), in addition to an operator, have refined the set of operational criteria developed for DCC operations during February 2014. The revised criteria (Enclosure 1) include gate operations triggers based on catch of both winter-run sized (wild and hatchery origin) and spring-run sized (wild and hatchery origin) juvenile Chinook, wild juvenile steelhead, and on water quality conditions in the Delta. As was the case during February, the DCC gates will remain closed in March unless the conditions provided in the SWRCB's revised Order, and the water quality and fish monitoring thresholds in the revised criteria in Enclosure 1, allow gate opening.

Reclamation, in enclosure 3 of its February 27, 2014, letter, provided updated information on the current distribution of the listed anadromous salmonid species (as of February 21, 2014), and a general effects analysis of extending the provisions of the TUC Petition through March. NMFS agrees with Reclamation's assessments, but provides a more detailed analysis of the effects of the modified DCC gate operation on the listed anadromous fish species (Enclosure 2). That analysis is predicated on the underlying analysis of the CVP/SWP Opinion, in which DCC gates are closed in March, which concluded that implementation of the RPA is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, the Southern distinct population segment of North American green sturgeon, or Southern Resident killer whales. The modified DCC gate operation, proposed by Reclamation and revised by the interagency team's Matrix of Triggers for March (Enclosure 1), would only allow for the gates to be opened when salmon migration densities upstream of or in the vicinity of the DCC gates are low. The biological foundation for diurnal operations of the DCC gates (provided at the end of Enclosure 1) is based on evidence that both Chinook salmon and steelhead emigration behavior is influenced by environmental cues, including differential movements according to day and night periods, increasing river flows and stronger flood tidal flows, as well as increased turbidity.

Modified Monitoring

As outlined on page 4 of Enclosure 1, the DCC subgroup suggested that "during periods when the DCC gates are closed, consideration should be given to returning the increased Sacramento Trawl and beach seine efforts to baseline levels." The DCC subgroup also suggests that the additional Sacramento seine locations be continued through March 2014, and that daily monitoring resume at least 72 hours prior to a DCC gate opening. NMFS also expects daily monitoring when the DCC gates are open, and when the DCC gates are closed as an action response to a fish monitoring trigger. If the DCC gates are closed because the CVP and SWP are operating to D-1641 (and the DCC gates are expected to remain closed for four or more days), or because the CVP and SWP are operating to the drought contingency plan and revised Order but water quality is not of concern (and the DCC gates are expected to remain closed for four or more days), NMFS supports the following monitoring effort:

- The Sacramento trawl monitoring (at Sherwood Harbor) will occur 3 days per week;
- The Sacramento beach seine monitoring will occur once per week at all eight seine locations used to calculate the Sacramento Beach Seine Index[2]; and
- The rotary screw trap monitoring at Tisdale and Knights Landing will continue daily sampling on a 24 hours per day basis.

During any period in which Reclamation and DWR are operating the CVP/SWP under the February 7, 2014, revised Order, there will continue to be close coordination on current and projected operations on a weekly basis through existing meetings [DOSS group, Delta Conditions Team, Water Operations Management Team (WOMT), *etc.*]. NMFS will make determinations, as needed, regarding operations necessary to protect listed fish species under the RPA actions in the CVP/SWP Opinion, including any operations pursuant to a drought contingency plan under RPA Action I.2.3.C. NMFS determinations will be presented at the weekly WOMT call, as necessary. The DOSS will also continue to provide advice, as needed, to WOMT and NMFS.

In response to the January TUC Petition, the SWRCB's January 31, 2014, Order and February 7, 2014, revised Order, and the U.S. Fish and Wildlife Service's (USFWS') and NMFS' January 31, 2014, Endangered Species Act compliance documents, Reclamation and DWR has convened a team [Real-Time Drought Operations Team (RTDOT)] of managers from Reclamation, DWR, SWRCB, DFW, NMFS, and the USFWS in order to coordinate management of water supplies

[2] Verona, Elkhorn, Sand Cove, Miller Park, Sherwood Harbor, Discovery Park, American River, and Garcia Bend.

and protection of natural resources during the course of the declared drought emergency. Meeting weekly, this drought coordination team is needed to ensure effective coordination across all agencies and help guide development of a CVP/SWP operational strategy and corresponding contingency plan to address operations through the operating season if conditions fail to improve. The result of this effort will inform any future determinations pursuant to the CVP/SWP Opinion as well as any additional TUC Petitions to the SWRCB that may be submitted. The RTDOT should continue to meet on at least a weekly basis to address the potential for drought response actions for future months, and to discuss the process by which such actions will be presented to the SWRCB and the fish agencies (CDFW, NMFS, USFWS) for approval.

In conclusion, NMFS concurs that the proposed Interim Contingency Plan for March 2014, as modified by the revised DCC Gate closure criteria provided in Enclosure 1, is consistent with Action 1.2.3.C and meets the specified criteria for a drought contingency plan. We are making this finding based on both the real-time physical and biological data and monitoring information enclosed with Reclamation's letter, the supplemental analyses in Enclosures 1 and 2, and the underlying analysis of the CVP/SWP Opinion which concluded that implementation of the RPA is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, the Southern Distinct Population Segment of North American green sturgeon, and the Southern Resident killer whales, and will not result in the destruction or adverse modification of their designated critical habitats. Furthermore, the best available scientific and commercial data indicate that implementation of the interim contingency plan will not exceed levels of take anticipated for implementation of the RPA specified in the CVP/SWP Opinion.

NMFS may further refine the DCC gate operational triggers in March if real-time monitoring data suggest a change in risk to species or risk to water quality not accounted for by the current DCC gate operations triggers provided in Enclosure 1. In addition, the drought contingency plan will be reviewed and updated (if needed) based on data gathered through the monitoring efforts to ensure implementation of the plan continues to meet all ESA requirements.

NMFS expects that, if dry conditions persist, a drought contingency plan for April and beyond will need to be developed that will likely include consideration of actions in addition to the relaxation of Delta outflow requirements and the modification of DCC operations proposed for March. Therefore, NMFS encourages Reclamation and DWR to continue interagency planning and preparation for actions that may be considered in a subsequent contingency plan, for example:

- Temperature Management: Based on the current projected storage in Shasta Reservoir and associated preliminary temperature modeling, it is likely that temperatures will be problematic for Sacramento River winter-run Chinook salmon (winter-run) egg incubation and juvenile rearing in the upper Sacramento River, with potentially all available habitat below Keswick Dam reaching unsuitable temperatures by mid-August. Because winter-run fry are unlikely to have emerged from redds before temperature conditions are expected to become unsuitable for egg incubation, the loss of the entire winter-run year class is possible under forecasted river conditions. Further, without necessary infrastructure improvements at Livingston-Stone National Fish Hatchery (LSNFH), even hatchery operations for winter-run production and broodstock management will be disrupted. To address these issues, a subteam of the Interagency Ecological Program (IEP) winter-run Project Work Team (PWT) has been established (its first meeting was on January 29, 2014), to: (1) develop some alternative strategies based on different flow and temperature scenarios in the interest of preserving at least some fraction of this year's natural winter-run production; (2) discuss necessary infrastructure improvements and potential funding venues in support of LSNFH modifications necessary for the winter-run hatchery program; and (3) assess potential permitting needs for the different strategies.

- Drought Barriers: A "drought barriers" team has been meeting to discuss the necessity and processes to permit and install barriers at various locations in the Delta to maintain water quality in the Delta. These meetings and discussions should include Federal action and permitting agencies (*e.g.*, Reclamation, and the U.S. Army Corps of Engineers). A decision process should be developed to determine the need, timing, and duration of the construction and operation of any drought barriers in consideration of listed species life history and habitat needs.
- Monitoring: Continued interagency discussions regarding increased monitoring requirements during and throughout the spring.
- Clear Creek flows: Not being able to implement the Clear Creek pulse flow required in RPA Action I.1.1.

We look forward to continued close coordination with you and your staff throughout this extremely challenging water year.

If you have any questions regarding this letter, please contact me at will.stelle@noaa.gov, (206)526-6150, or contact Maria Rea at (916)930-3600, maria.rea@noaa.gov.

Sincerely,

William Stelle

William W. Stelle, Jr.
Regional Administrator

Enclosures:
1. Matrix of DCC gates operational criteria
2. NMFS' effects analysis for modified DCC gate operations in March 2014

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Enclosure 1

Matrix of Triggers for DCC Gate Operations
DCC Subgroup of DOSS
March 2014

The Triggers outlined in this matrix provide direction and a method which strives to balance water quality objectives while protecting fisheries resources. This matrix is for March DCC gate operations while operating under Reclamation's contingency plan and NMFS' response. The triggers are arranged in an upstream to downstream manner, but all triggers are independent of one another and do not need to occur sequentially.

Two to three separate catch indices, specific to species or age-classes, will be calculated at each monitoring location, as specified below. Exceedance of any catch index, at any location, will require implementation of the action specified for trigger exceedance at that monitoring location. If multiple trigger thresholds are exceeded, the action most protective for fish shall be implemented.

Trigger calculated based on:	**Knights Landing Catch Index (KLCI)[f]**	**Sacramento Trawl Catch Index (STCI)[f]**	**Sacramento Beach Seine Index (SBCI)[f]**
Winter-run trigger: "Older juveniles" and winter-run-sized hatchery Chinook[a]	Yes	Yes	Yes
Spring-run trigger: Young-of-year spring-run-sized Chinook, both natural-origin and hatchery[b]	Yes	Yes	Yes
Steelhead trigger: Natural origin steelhead[c]	No	Yes	Yes

Tisdale Catch Index (TCI) Rotary Screw Trap (RST) Alert

Catch @ RST	Water Quality Concern Levels Exceeded	Action to be Taken at DCC Gates
Any catch of fish	independent of WQ	No Action

Wilkins Slough flow increase Alert

Flow Increase	Water Quality Concern Levels Exceeded	Action to be Taken at DCC Gates
Flow increase over base flow by 45% within a 5-day time period, calculated using daily flow averages.	independent of WQ	No Action

Knights Landing Catch Index (KLCI) RST[f]

Catch @ RST	Water Quality Concern Levels Exceeded	Action to be Taken at DCC Gates: Closures to occur within 24 hours of trigger being met and NMFS providing notification or data are disseminated by fisheries agencies
N/A	N	Closed
< 3 fish per trap day	Y	Open
≥ 3 fish per trap day	Y	Closed until 3 consecutive days of catch < 3 fish per trap day; then open gates

Sacramento Beach Seine Catch Index (SBCI)[f]

Catch per day, standardized beach seines	Water Quality Concern Levels Exceeded	Action to be Taken at DCC Gates (Closures to occur within 24 hours of trigger being met and NMFS providing notification or data are disseminated by fisheries agencies.
<1 per day	N	Closed
<1 per day	Y	Open
≥ 1 per day	N	Closed
≥ 1per day	Y	Diurnal Operations[g] until catch <1 fish per day for three consecutive days; then open gates.

Sacramento Trawl Catch Index (STCI)[f]

Catch per day, standardized trawl	Water Quality Concern Levels Exceeded	Action to be Taken at DCC Gates (Closures to occur within 24 hours of trigger being met and NMFS providing notification or data are disseminated by fisheries agencies.
<1 per day	Y	Open
<3 per day	N	Closed
1 ≤ X ≤3 per day	Y	Diurnal Operations[g] Diurnal Operations until catch <1 fish per day for three consecutive days; then open gates.
3< X < 5 per day	Y	Closed until 3 consecutive days of daily catch <3 fish per day; then operate diurnally until catch <1 fish per day, then open gates (see above)
≥ 3 per day	N	Closed
≥ 5 per day	N	Closed
≥ 5 per day	Y	Closed until catch per day is < 5 fish

Footnotes:

a) Catch of older juvenile Chinook salmon and hatchery-produced Winter-run-sized Chinook will be the basis for one trigger criterion. The use of older juveniles is consistent with the triggers used in the Long Term Operations of the State Water Project and Central Valley Project biological opinion (NMFS June 4, 2009), reasonable and prudent alternative Action IV.2.3 Old and Middle River flow management. Older juvenile Chinook salmon are unclipped Chinook that are larger than the minimum Winter-run size criteria of the size at date river model for Chinook salmon. Older juveniles will include Winter-run Chinook salmon and older fish such as yearling Spring-run Chinook salmon and yearling Late Fall/Fall-run Chinook salmon as part of the catch considered for triggers. In addition, the work group decided to include hatchery Winter-run Chinook salmon as part of this trigger criterion. Hatchery-produced Winter-run-sized Chinook salmon will be distinguished by their missing adipose fin and their classification as winter-run based on the size-at-date table. While the CWTs will be verified as soon as possible, clipped fish will be included in the trigger calculation based on size-based, not CWT-confirmed, run assignment. At this time, no releases of hatchery-produced Chinook salmon should overlap with the sizes of the Living Stone National Fish Hatchery (LSNFH) Winter-run production release. Current hatchery produced Late Fall-run Chinook salmon from the Coleman National Fish Hatchery (CNFH) are considerably larger than the Winter-run production fish, thus there should be no mistaking one group of fish for the other. The average fork length at the time of release was 95mm; ad-clipped fish falling within the Winter-run size criteria of the size at date river model for Chinook salmon will be assumed to be hatchery Winter-run.

b) Natural origin (adipose fin present) Spring-run Chinook young-of-year (*not* yearlings) and hatchery origin (adipose fin absent) spring-run Chinook young-of-year identified using the size at date river model will be the basis for another trigger criterion until such time as the first release of hatchery Fall-run occurs (not expected until April 2014), after which time differentiation of natural origin Spring-run from unclipped hatchery Fall-run and hatchery origin spring-run from clipped hatchery-origin Fall-run becomes unreliable due to size overlap of the two runs.

In regards to young of the year Spring-run Chinook salmon, it is difficult to adequately distinguish between wild Spring-run and wild Fall-run Chinook salmon due to the overlap of the sizes of the fish emigrating downstream and the emergence timing of the fish from the spawning areas upstream of the monitoring efforts. Young of the year wild Spring-run are only slightly larger than the wild Fall-run Chinook salmon that are emerging from the gravel just a few weeks behind the wild Spring-run fish in streams and watersheds where they co-occur. For wild fish, this difference in the date of emergence from the gravel should allow for run discrimination based on size at date, assuming that ambient rearing conditions are similar for both groups of fish. However, run discrimination solely by length is further complicated by the large releases (tens of millions) of hatchery produced Fall-run Chinook salmon in river, typically in early April, that overlap with young-of-the-year Spring-run emigration. Seventy-five percent of the Fall-run hatchery release is not adipose fin clipped, and their larger sizes due to hatchery production techniques would overlap and swamp any wild produced Spring-run Chinook salmon production in the river, making the ability to distinguish runs by size at date unreliable. The DCC group believes that triggers using wild Spring-run Chinook salmon within the appropriate length at date size criteria can be implemented if the captures of these fish occur prior to the release of any hatchery produced fall run Chinook salmon. Furthermore, if hatchery production Fall-run Chinook salmon are trucked downstream to the Delta or bays, below the monitoring stations used in the Sacramento region beach seines and trawl, then the integrity of the size at date discrimination should still remain valid. It is not expected that hatchery produced Fall-run Chinook would subsequently ascend the Sacramento River from their downstream release locations and be present in the reaches where the monitoring efforts used in the DCC triggers are being conducted.

Hatchery origin Spring-run will also be included in the trigger criteria prior to any hatchery Fall-run release. For the past few years Feather River Fish Hatchery has released a portion of Spring-run production (all fish are clipped) into the Feather River and upstream of the confluence with the Sacramento River. Similar to hatchery origin Winter-run, these fish are distinguishable by their missing adipose fin and fork lengths and at the time of release are not expected to overlap with other production releases that have occurred to date. An in-river release may not be possible this year if conditions in the river deteriorate due to drought but providing protection for these fish if conditions allow is crucial.

c) Natural origin (adipose fin present) steelhead will also be used as the basis for a trigger criterion but only for the Sacramento Catch Indices (trawl and beach seines). Initially, the group did not come to a consensus regarding the use of steelhead as a potential trigger in the RST catches, beach seines or river trawls. Steelhead are considerably rarer than Chinook in the RST, trawl, or beach seine catches. Although any steelhead (with or without adipose fin) captured in the Tisdale or Knights Landing RSTs are assumed to be part of the California Central Valley steelhead DPS (because natural origin fish and hatchery fish from both hatcheries upstream of those sampling locations, Coleman National Fish Hatchery (CNFH) and the Feather River Fish Hatchery (FRFH), are considered to be part of the protected DPS), clipped steelhead captured below the confluence of the American River cannot be considered wholly fish from the protected DPS due to the potential input of fish from the Nimbus Fish Hatchery (NFH; *not* considered to be part of the protected DPS). All wild fish (intact adipose fin) are considered to be part of the protected DPS, and because all hatchery-produced steelhead are clipped, a trigger based on natural origin, unclipped, steelhead will include only fish that are part of the protected DPS. Given the unpredictability of steelhead downstream emigration, the group decided that only the Sacramento beach seine and trawl monitoring sites near the DCC gate location, and *not* the KLCI, should be used as indicators of steelhead being present in the vicinity of the gates and thus be vulnerable to entrainment into the DCC junction when gates are open. Capture of any wild steelhead in these beach seines or in the Sacramento River trawl will serve as a trigger for gate closures, using the same index thresholds as used for Chinook salmon.

d) The actions pertaining to the different sampling metrics are designed to protect both downstream migrating juvenile Chinook salmon and also those that may be rearing or holding in the Sacramento River near the DCC. With unidirectional river flow, catch data from Tisdale and Knights Landing provides an early warning of emigrating salmonids entering the Delta. Data from both the Sacramento River beach seine and trawl monitoring programs serves to further refine locational information on emigrating salmonids as well as provide information on salmonids rearing in the proximity of the DCC gates. The Tisdale and Knights Landing data provides information from discrete locations within the Sacramento River at the location of the RSTs. In comparison, the Sacramento River Trawl and the Sacramento River Beach Seines provides information from a broader suite of locations within the Sacramento River including mid-channel and river margin habitats that may harbor different life history strategies for juvenile salmonids (rearing versus emigration). In a 2012 NMFS Southwest Fisheries Science Center study using acoustically-tagged Winter-run Chinook hatchery smolts; the approximate travel time from the Knights Landing area to Georgiana Slough, which is downstream of the DCC, was approximately 2.5 days (unpublished data). Data from the aforementioned study and previous acoustic-tagged salmonid studies indicate that movement through the Delta is rapid. As such, the three-day closure period was deemed a reasonable balance between fisheries protection and providing operational flexibility for the operation of the DCC gates to ameliorate water quality issues in the central and southern Delta.

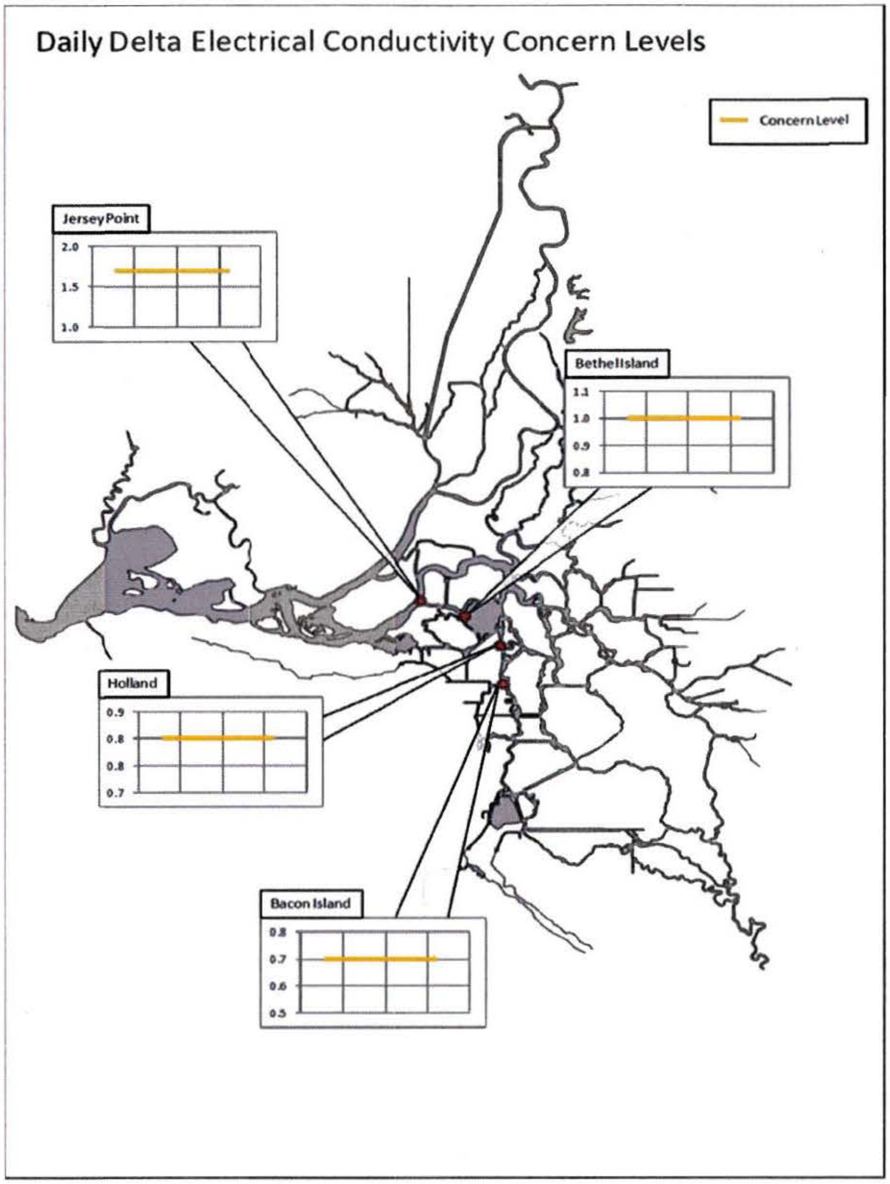
During periods when the DCC gates are closed, consideration should be given to returning the increased Sacramento Trawl and beach seine efforts to baseline levels. Historic baseline efforts are defined as follows. The Sherwood Harbor trawl will continue with sampling occurring 3 days per week through March 31st using a Kodiak trawl, then switching to a mid-water trawl on April 1st. The frequency of trawls will decrease in May and June to twice per a week, resuming to three days per week in July. Kodiak trawls will resume in October. The Lower Sacramento and North Delta beach seine sites will be sampled once per week year round. The special

Sacramento region beach seine sites, which includes portions of the Lower Sacramento and North Delta seine routes will be sampled weekly after February 1st, and will continue to include the three additional sites (Sand Cove, Sherwood Harbor, and Miller Park) for the duration of the emergency drought response. Tisdale and Knights Landing RSTs will continue to sample daily with an elevated level of effort until listed species are no longer observed in the monitoring effort. The Projects must notify the Real Time Drought Operations Management Team that water quality concerns levels may be reached within 5-7 days so that monitoring efforts can be increased to daily sampling no less than 72 hours prior to DCC gate opening, depending on fisheries catch indices. Having a complete set of data that maintains the frequency of sampling effort will provide substantial benefits in any retrospective analysis of this data for future operations of the DCC. If sampling effort is allowed to vary across time, then the analysis of fish presence and movement becomes much more difficult as "zero" could mean fish were either not present, or were missed on the off days that sampling did not occur. It should additionally be noted that determining where in the Sacramento River or Delta a majority of Winter-run and Spring-run out-migrating population is will be more difficult if sampling is discontinued.

e) The values for Jersey Point, Bethel Island, and Holland were adapted from the Chinook Salmon Decision Tree. Water Quality Concern Levels are exceeded when the electrical conductivity levels listed below are reached at one or more stations. The Chinook Salmon Decision Tree can be found at:
(https://www.usbr.gov/mp/cvo/OCAP/sep08_docs/Appendix_B.pdf).

Table1

Station	Water Quality Concern Level
Jersey Point	1.8 mmhos/cm
Bethel Island	1.0 mmhos/cm
Holland	0.8 mmhos/cm
Bacon Island	0.7 mmhos/cm



f) The Knights Landing rotary screw trap (RST) data are standardized to the number of older juvenile Chinook salmon (defined as fish larger than the minimum size length for winter-run Chinook salmon at date, *i.e.*, >95mm and hatchery winter-run Chinook) captured in one trap day (24 hours). The number of older juvenile fish captured in each RST is enumerated, and then the cumulative number of fish is divided by the number of hours the two RSTs were operated between sampling days divided by 24. For example, if the two traps are fished for 2 days there is a maximum of 96 hours that the 2 traps could have been fished: (2 days x 24 hours per day x 2 traps = 96 hours total time fished). If 100 fish were caught between both traps, then the catch per trap day is: 100 ÷ (96 hours/ 24 hours per day) = 25 fish per trap day. In a similar fashion the catch from the Sacramento trawl (STCI) and Sacramento area beach seines (SBCI) are standardized to one catch day with 10 tows per sampling day for the trawl data and eight hauls per day for the beach seine data. Data used to calculate the indices will represent the most current day of sampling, data from the Sacramento trawl and the Sacramento area beach seine Catch Indices sites will be reported on the day sampling occurs. Data collected from the Knights Landing RST, representing a 24 hour period, will include the previous daytime trap check (pm) and the current morning trap check (am).

g) Should diurnal operations[1] occur, operations of the gates will follow table 2 (DCC Gate Diurnal Operations):

Table 2: DCC Gate Diurnal Operations

Tidal Phase	Operational window. DCC gates will be closed during crepuscular periods and at night.
	Day is considered to be from sunrise to sunset (approximately 7am-7pm PST). Crepuscular periods are considered to be 1 hour after sunrise and 1 hour before sunset. Gate open window of operations for up to 6 hours within the daylight period.
Ebb Tide[2]	Period of operations for opening the DCC gates will occur during the ebb tidal phase during daylight periods. Periods of gate openings shall avoid the period of slack water surrounding the low tide and high tide changes (± 1 hour; bottom and top of the tides).
Slack[3]	Avoid the period of slack water surrounding the low tide and high tide changes (± 1 hour; bottom and top of the tides).
Flood Tide[4]	If Water Quality concern levels are being exceeded with DCC operations limited to the ebb tidal phase, the Real Time Drought Operations Team can request DCC operations to occur on the flood tide phase.

1 It has not been determined whether or not the necessary water quality benefits can be achieved through diurnal operations of the DCC gates. Additionally the design and wear of the gates may preclude successive openings and closings that may occur through diurnal operations.

2 This phase of the tide has been shown to create hydraulic conditions at junctions that enhance fish entrainment. Best to use period of the ebb tide with the strongest downstream flow. Avoid overlapping this phase of the tide with crepuscular period. Fish migratory movement is elevated during the crepuscular period.

3 Avoid the period of slack water surrounding the low tide and high tide changes (± 1 hour; bottom and top of the tides, as fish may be holding in the vicinity of the DCC and the increased movement by fish (milling behavior) will create conditions for greater exposure to entrainment.

4 This is a less optimal period of DCC gate operations for fish protection since flow convergence will occur with the water moving upstream on the flood tide meeting water still moving downstream at the beginning of the flood tide. This will send more water into an open DCC channel and extend the zone of entrainment across a significant proportion of the Sacramento River channel. If gates are opened 1 to 2 hours after flows change at the bottom of tide, there are likely fewer impacts due to opening during this period. Avoid crepuscular periods.

Biological Justification for Diurnal Delta Cross Channel Gate Operations.
Chapman *et al.* (2013) described a series of experiments conducted on the Sacramento River in which hatchery produced late-fall Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*) were released in the upper Sacramento River and tracked as they migrated downstream through the San Francisco Bay estuary and into the Pacific Ocean through the Golden Gate. From 2007 to 2010, during the months of December and January, a total of 1,110 Late-fall Chinook salmon and 1,100 steelhead trout were released into the upper Sacramento River. In 2007 the release was made in Battle Creek. From 2008 to 2010, releases were made at three different sites: 1) Jellys Ferry; 2) Butte City; and 3) Hamilton City within the upper and middle sections of the Sacramento River. Fish were released just after twilight at each site. Fish were tracked through 420 monitors placed at 186 different locations within the Sacramento and San Joaquin river systems and Delta, the San Francisco estuary, and coastal waters outside the Golden Gate. Receivers were deployed to provide coverage across river channels as single, dual, and multiple arrays to ensure complete coverage of the channel width.

This study found that within the upper river section, late-fall Chinook salmon traveled almost exclusively at night with 90.6 percent of detections recorded at night between sunset and sunrise. As the Chinook salmon smolts moved downstream, the proportion of movement during diurnal periods progressively increased, although movements at night still remained significantly greater than diurnal movements. Within the upper river reaches there were no significant differences in the timing of fish movement during the night, in particular movements were not concentrated within crepuscular periods, but were distributed relatively evenly throughout the nocturnal period. Movement ceased relatively quickly after sunrise and began shortly after sunset (. In contrast, as fish moved downstream into the middle and lower reaches, salmon movement did not stop abruptly at sunrise, but instead detections gradually decreased as light increased.

Tagged hatchery steelhead migrated more uniformly throughout the day in all regions of the river, estuary, and ocean compared to yearling late-fall Chinook salmon smolts. Like the Chinook salmon smolts, the proportion of detected movement at night decreased as fish migrated downstream. In the upper river 63.0 percent of detections occurred at night compared 90.6 percent for salmon smolts in the same reaches. Once these steelhead reached the estuary, the detections of night time movements decreased to 40.9 percent compared to 57.0 percent for late-fall Chinook salmon. In the upper river, there was a significant preference for nighttime movement. In the lower river, where Knights Landing is located, there is no significant difference between night time and day time movement, however in the middle river, Delta, and estuary there were significant preferences for daytime migration.

Chapman *et al.* (2013) found that more than 50 percent of Chinook salmon travelled at night in all of the study reaches, while steelhead were more variable. Chinook salmon also moved more during the day when river flows were increasing, regardless of flow direction (important in the tidal Delta and estuarine environment). In the estuary, incoming flood tides between zero and a flow of approximately -3500 cfs increased daytime detections. Similarly, downstream flows of approximately 12,300 cfs elicited daytime movements of Chinook salmon. Steelhead responded in a more muted manner. Incoming tides did not appear to stimulate more daytime movements in the estuary. In the riverine reaches of the study area, steelhead daytime movement was more likely when flows were 25,000 cfs or greater. Thus, both Chinook salmon and steelhead responded to increases in flow with increased daytime movements. However, Chinook salmon appear to be more sensitive to these higher flows, and also responded to the perceived higher flows of an incoming flood tide in the estuary.

The movement of both Chinook salmon smolts and steelhead were affected by increasing turbidity. In general, increasing turbidity reduced the percentage of nighttime movement, and stimulated daytime movement in fish. However, increasing turbidity is often associated with increasing flow and these two variables typically co-occur.

Plumb reported that in a U.S. Geological Survey (USGS) study the majority of acoustically tagged fish moving downstream past the location of the DCC did so at night. During the winter of 2008-2009 (November through March) 2,983 acoustically tagged Late-Fall Chinook salmon were released upriver from the DCC gate location. The release point was far enough upstream that fish were distributed in the river channel and were believed to be exhibiting normal migratory behavior and movements. Results indicated that 39 percent of the released fish (1,162 fish) were eventually detected in the vicinity of the DCC gates with approximately 5 percent of these detections believed to be fish within predators (154 fish). Of the arriving fish detected (1,008 fish), approximately 83 percent (840 fish) arrived at night, with the remainder (17 percent) arriving during the day (168 fish). Of the fish arriving at the DCC location (day and night), approximately 13 percent (143 fish) arrived when the gate was open. Of the 143 fish arriving at the gates when they were open, 20 percent (20 fish out of 100 fish) were entrained at night and 21 percent were entrained during the day (9 fish out of 43 fish). USGS performed an analysis of the data and calculated the joint probability of arriving at night and being subsequently entrained using different environmental covariates and determined that there was approximately a 19 percent chance of being entrained into the DCC at night. Conversely, the probability of being entrained during the day was approximately 6 percent. During the period of the study (November 2008 through March 2009), 73 percent of negative flood flows occurred during the day, and entrainment was more likely during these periods. Plumb *et al.* (2013 unpublished study) summarized that operation of the DCC gates during the day may allow for water diversion in to the interior Delta while minimizing the risk of entrainment of migrating Chinook salmon into the DCC.

Preliminary results from the 2012 Georgiana Slough non-physical barrier study (DWR 2013 draft) also help to illustrate the behavior of fish moving through this section of the river under different diel and flow conditions. Similar to the Plumb *et al.* 2013 and Chapman *et al.* (2013) studies, the majority of fish detected moving past the junctions of the DCC and Georgiana Slough channels with the main stem Sacramento occurred at night. In addition, data from tagged Late-Fall Chinook salmon passing through the Georgiana Slough junction indicate that greater numbers of fish passed through this study area at night than during the day. Furthermore, the passage of fish was also shown to be strongly influenced by tidal phase. During the night, more fish successfully passed the junction of the Georgiana Slough channel during a strong ebb phase than during the changing of the tide or a flood tide. During the changing of the tide from an outflowing tide to a flood tide, the flow of water increases into Georgiana Slough. It is during this transition that a converging flow situation sets up at the junction and 100 percent of the Sacramento River flow enters Georgiana Slough from both the upstream and downstream directions with little to no flow bypassing the junction. Under this specific scenario, all fish present across the width of the Sacramento River channel are vulnerable to entrainment into the junction. This is particularly true during nocturnal periods when fish are more likely to be moving rather than holding and thus become vulnerable to entrainment as they encounter the junction reach. During the day, more fish are holding, and move less in the region of the junction, thus reducing their vulnerability to entrainment, although not being becoming completely immune to entrainment.).

Summary:
Chapman *et al.* (2013) illustrates how Chinook salmon smolts emigrate primarily at night in the upper reaches of the Sacramento River but progressively increase movements during daytime periods as fish emigrate downstream towards the Delta and San Francisco Bay. Daytime movement is also increased by increasing river flows and stronger flood tidal flows, as well as increased turbidity. Steelhead smolts are more balanced in their use of daytime and night time periods for movements in all river reaches in comparison to Chinook salmon. They are less sensitive to changes in flow and turbidity in comparison to Chinook salmon, but still respond in the same manner: more flow and/or turbidity reduce the proportion of nocturnal movement and increases daytime movement.

The USGS analysis of Chinook salmon at the DCC junction indicates that Chinook salmon predominately arrive at night and are more susceptible to entrainment at night than during the day based on the joint probabilities of arriving at the DCC junction at night and subsequently being entrained into the DCC junction.

The analyses conducted in support of the 2012 Georgiana Slough non-physical barrier (DWR 2013 draft) finds that fish move more at night past the Georgiana Slough junction than during the day based on the number of detections at the non-physical barrier acoustic receiver array and that the behavior of the fish in the junction is strongly dependent on tidal phase and position in the channel cross section at the time of encountering the junction. Fish are more likely to successfully move downstream on a strong ebb tide past the Georgiana Slough junction and avoid entrainment into the Georgiana Slough channel than when downstream flow is weaker and the tides are changing from ebb to flood. The period of time when fish are most vulnerable to entrainment into the Georgiana Slough channel is during the period when flows are reversing and essentially all of the flow in the Sacramento River channel is directed into the channel of Georgiana Slough (converging flows). As negative flows increase and the flood tide strengthens, the vulnerability of entrainment lessens and fish were found to "mill' in the vicinity of the junction or move back upstream, avoiding the region surrounding the junction.

If the DCC gates are to be operated (*i.e.*, opened), then the option which minimizes the entrainment vulnerability to listed salmonids emigrating in the Sacramento River in the vicinity of the DCC gates would involve opening the gates on a diurnal cycle, and closing the gates during the night, thus avoiding the greater nocturnal presence of fish in the vicinity of the gates during fish movements. In addition, further reductions in entrainment vulnerability could be gained by operating the gates with recognition of the tidal phases in which the fish are more vulnerable to entrainment (*i.e.*, periods of tidal transition from ebb to flood and when upstream and downstream flows result in converging flow phases entering the DCC channel).

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Enclosure 2

Effects Analysis for Modified Delta Cross Channel gate operations in March 2014
February 28, 2014

Since the beginning of February 2014, increasing numbers of brood year 2013 winter run Chinook salmon (*Oncorhynchus tshawytscha*) have been emigrating downstream in the Sacramento River. A storm front moved into northern California starting February 7, 2014, which brought rain to the Sacramento Valley, causing flows on the Sacramento River to increase in response. del Rosario *et al.* (2013) demonstrated that juvenile winter-run Chinook salmon will increase their downstream movement past the Knights Landing rotary screw trap (RST) located at river kilometer (rkm) 141 in correlation to increases in flow at Wilkins Slough, located at rkm 190. Wilkins Slough is located several kilometers above the Knights Landing RST location and is continuously gaged for river flow. Specifically, when flows reached 400 m^3s^{-1} [≈14,200 cubic feet per second (cfs)] at Wilkins Slough, rapid increases in captures of juvenile winter-run sized Chinook salmon have occurred at the Knights Landing RST (see figures 1 and 2). These sudden spikes in flow correspond with at least the first 5 percent of the annual cumulative catch occurring at the Knights Landing RST, with 50% of the cumulative catch occurring within a few days of the flow spike. In dry precipitation years, such as water year 2014, the downstream emigration of winter-run Chinook is frequently delayed by weeks, even months, compared to wetter years (see table 1). For example, in water year 2009, 50 percent of the cumulative captures in the Knights Landing RST did not occur until February 24, 2009. This is almost 2 months behind the typical time of 50 percent cumulative catch of juvenile winter-run Chinook salmon (see table 2). The cumulative proportion of the population passing the Knights Landing RST location, as reflected in the catches in the RSTs, are presented in figures 3 and 4, for water years 2001 and 2009. These were both dry years and resemble the current water year in that precipitation events occurred later in the year than is typical.

To date, there has been very little precipitation in the Central Valley of California (see figures 5 and 6) as represented by the incremental precipitation at Oroville Dam and Shasta Dam. There was a significant lapse of any measurable precipitation from late November 2013, until the end of January 2014. The first significant precipitation event at Shasta Dam did not occur until February 6, 2014 (0.18 inches), and continued through February 10, 2014, with the heaviest rainfall occurring on February 8, 2014 (2.22 inches). Similarly, Oroville Dam received rainfall over the same period with slightly higher total accumulated amounts of precipitation. The weather forecast for the last week of February is for increased precipitation for the Central Valley as a storm track from the North Pacific has centered over Northern California, with several storms anticipated to move through the region. This should induce flows in the Sacramento and San Joaquin rivers to increase.

Flows at Wilkins Slough have remained low until the increased flows in the Sacramento River reached this location on February 7, 2014, in response to the aforementioned storm. Flows peaked at 13,838 cfs on February 11, 2014, and receded to pre-storm levels (4,284 cfs) by February 25, 2014 (see figure 7). Currently, real time data indicate that flows are increasing at Wilkins Slough as the next storm systems moves across Northern California (see figure 8). Guidance plots, which forecast precipitation and projected river discharges at selected locations, predict that the Sacramento River at the Fremont Weir (located a few kilometers downstream of Knights Landing, but upstream of the confluence of the Feather River at Verona), will increase to about 13,000 cfs with the current storm system through March 3, 2014 (see Figure 9). This predicted level of discharge for the Sacramento River is slightly lower than the previous storm cycle's influence, but would indicate that a second substantial pulse of water will be moving through the system. NMFS predicts that this second pulse of water will induce a second wave of winter-run Chinook salmon emigration past the Knights Landing monitoring site, as has been seen in the past (figures 1-4).

In response to the first increase in river discharge, pulses of winter-run Chinook salmon were detected moving through the system. Catches of winter-run Chinook salmon (as well as fall-run and spring-run Chinook salmon, and California Central Valley steelhead [*O. mykiss*]) increased at all monitoring sites from Red Bluff Diversion Dam (RBDD) downstream through the Delta to Chipps Island (see table 3 for delta monitoring sites, figure 10 for Knights Landing). Observations of increased numbers of multiple runs of Chinook salmon, as well as wild and tagged steelhead in the monitoring efforts throughout the system, indicate that a strong response to the environmental cue of increased river flows has occurred. This is the expected behavioral response of not only winter-run Chinook salmon, but of emigrating salmonids in general.

The increase in winter-run captures [a component of the older juveniles metric used in the Delta Cross Channel (DCC) gate operations matrix] exceeded the trigger criterion described in the matrix for DCC gate operations provided in NMFS' letter of January 31, 2014, to the United States Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) for several of the monitoring locations following the increase in Sacramento River flows (February 8, 2014). The first monitoring trigger exceeded was the catch index for the Sacramento Beach seines (daily catch index = 1) on February 8, 2014, which dictated that the DCC gates would be operated diurnally. Due to the increase in Sacramento River flows, and the conditions of the revised Order (February 7, 2014) from the State Water Resource Control Board (SWRCB) approving the Temporary Urgent Change Petition (TUC Petition), Reclamation chose to close the DCC gates completely (24 hours per day closure) on Monday, February 10, 2014, dependent on meeting Delta outflow standards and water quality parameters. Subsequently, on February 12, 2014, several triggers in the DCC gate operations matrix, which would have required complete closure of the DCC gates, were exceeded based on catch indices for Knights Landing, the Sacramento trawl, and the Sacramento region beach seines. However, since the DCC gates were already closed per Reclamation's decision, the triggers were not necessary to effect gate closures per the matrix operational actions. The DCC gates have remained closed since February 10, 2014, as Delta outflows and water quality issues have not required re-opening the gates to date.

The January 31, 2014, DCC gate operations matrix has provided the necessary response required to protect listed fish emigrating downstream, in the specific context of the extreme drought conditions this year, the Governor's emergency declaration, and the Temporary Urgency Change Petition approved, with some conditions, by the SWRCB. The detections of listed salmonids by the different monitoring efforts was successful in providing the structure for a rapid response to increasing presence of fish moving downstream into the Delta, and for listed salmonids rearing or present in the vicinity of the DCC gate location until the closure of the DCC gates on February

10, 2014. Since that time, the closed DCC is providing, the same level of protection that would have existed under the baseline operations (DCC closed) required in the 2009 biological opinion for the Long Term Operations of the State Water Project and Central Valley Project regarding diversion of fish into the interior of the Delta via the DCC junction.

In preparation for the next month of operations, NMFS management requested that the DCC Gates operation team include consideration of operations matrix triggers for hatchery-produced winter-run Chinook salmon released in-river, naturally-produced young-of-the-year spring-run Chinook salmon, and wild steelhead. As provided in footnote "a" of enclosure 1, the DCC Gates operation team decided to include winter-run Chinook hatchery production fish as part of the total older juvenile population used as one trigger criterion in the matrix. Inclusion of the winter-run hatchery fish within this broader population of older juveniles will provide protection to the winter-run hatchery production population.

Likewise, the team considered a trigger for the protection of young-of-the-year (YOY) naturally-produced and hatchery-produced spring-run Chinook salmon. As described in footnote "b" of enclosure 1, the DCC group believes that a triggers using wild and hatchery-produced Spring-run Chinook salmon within the appropriate length at date size criteria can be implemented if the captures of these fish occur prior to the release of any hatchery produced fall run Chinook salmon, or even after the fall-run hatchery release, if hatchery production Fall-run Chinook salmon are trucked downstream to the Delta or bays, below the monitoring stations used in the Sacramento region beach seines and trawl. Data using the Knights Landing RST captures of spring-run size at date show how these fish respond similarly to the increases in flow in their downstream emigration behavior. In addition, the sudden increase in "spring-run sized" fish following the release of the fall-run hatchery production is evident in the cumulative capture, with most purported spring-run captured after the release date of the hatchery fish (see figure 11, 12, and 13).

The team also considered triggers for steelhead. As described in footnote "c" of enclosure 1, some clipped steelhead (e.g. from Nimbus Fish Hatchery) are not part of the protected DPS. All wild fish (intact adipose fin) are considered to be part of the protected DPS, regardless of their parental lineage, and all hatchery-produced steelhead are clipped. Therefore, the team designed a trigger based on natural origin, unclipped, steelhead so that the trigger was based only on fish that were part of the protected DPS. Given the unpredictability of steelhead downstream emigration, the group decided that a steelhead trigger should be implemented only at the Sacramento beach seine and trawl monitoring sites. Movement of steelhead is also correlated to increases in Sacramento River flow (Chapman *et al.* 2013). Increased captures of both clipped and unclipped steelhead are observed at the Knights Landing RST (see figures 14 and 15) with increases in the flows at Wilkins Slough.

The actions pertaining to the different sampling metrics are designed to protect both downstream migrating juvenile Chinook salmon and also those that may be rearing or holding in the Sacramento River near the DCC. With unidirectional river flow, catch data from Tisdale and Knights Landing provides an early warning of emigrating salmonids entering the Delta. Data from both the Sacramento River beach seine and trawl monitoring programs serves to further refine locational information on emigrating salmonids as well as provide information on salmonids rearing in the proximity of the DCC gates. The Tisdale and Knights Landing data provides information from discrete locations within the Sacramento River at the location of the RSTs. In comparison, the Sacramento River Trawl and the Sacramento River Beach Seines provides information from a broader suite of locations within the Sacramento River stretching from Verona at the mouth of the Feather River to Garcia Bend south of Sacramento. The Sacramento River trawl and Sacramento area Beach seines sample various habitats including mid-channel and river margin habitats that may harbor different life history strategies for juvenile salmonids (rearing versus emigration). In a 2013, researchers from the NMFS Southwest Fisheries Science Center acoustically-tagged Winter-run Chinook hatchery smolts and released them into the upper river. Based on the movements of the fish past acoustic receivers located throughout the mainstem Sacramento River and downstream through the Delta to the Golden Gate, the approximate travel time from the Knights Landing area to Georgiana Slough, which is downstream of the DCC, was approximately 2.5 days (unpublished data). Movement from the upper river sections (Butte Bridge, rkm 357) downstream into the Delta was rapid once emigration behavior was exhibited. Prior to this rapid downstream migration, many of the released fish held for prolonged periods in river reaches above Butte Bridge for periods of up to 50 days following release. Data from the aforementioned study and previous acoustic-tagged salmonid studies indicate that movement through the Delta is rapid. As such, the three-day closure period was deemed a reasonable balance between fisheries protection and providing operational flexibility for the operation of the DCC gates to ameliorate water quality issues in the central and southern Delta (see figure 16).

In addition to assessing travel time, operations of the DCC gates on a diurnal basis were also evaluated to form a biological basis for such actions, with further attention paid to tidal influence on fish movement in this region of the Delta. Chapman *et al.* (2013) described a series of experiments conducted on the Sacramento River in which hatchery produced late-fall Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*) were released in the upper Sacramento River and tracked as they migrated downstream through the San Francisco Bay estuary and into the Pacific Ocean through the Golden Gate. From 2007 to 2010, during the months of December and January, a total of 1,110 Late-fall Chinook salmon and 1,100 steelhead trout were released into the upper Sacramento River. In 2007 the release was made in Battle Creek. From 2008 to 2010, releases were made at three different sites: 1) Jellys Ferry; 2) Butte City; and 3) Hamilton City within the upper and middle sections of the Sacramento River. Fish were released just after twilight at each site. Fish were tracked through 420 monitors placed at 186 different locations within the Sacramento and San Joaquin river systems and Delta, the San Francisco estuary, and coastal waters outside the Golden Gate. Receivers were deployed to provide coverage across river channels as single, dual, and multiple arrays to ensure complete coverage of the channel width.

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Tagged hatchery steelhead migrated more uniformly throughout the day in all regions of the river, estuary, and ocean compared to yearling late-fall Chinook salmon smolts. Like the Chinook salmon smolts, the proportion of detected movement at night decreased as fish migrated downstream. In the upper river 63.0 percent of detections occurred at night compared 90.6 percent for salmon smolts in the same reaches. Once these steelhead reached the estuary, the detections of night time movements decreased to 40.9 percent compared to 57.0 percent for late-fall Chinook salmon. In the upper river, there was a significant preference for nighttime movement. In the lower river, where Knights Landing is located, there is no significant difference between night time and day time movement, however in the middle river, Delta, and estuary there were significant preferences for daytime migration (see figure 18).

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In a study by the USGS (Dr. John Plumb, Ph.D., USGS, personal communication 1/29/14), it was found that the majority of acoustically tagged fish moving downstream past the location of the DCC did so at night. During the winter of 2008-2009 (November through March) 2,983 acoustically tagged late-fall Chinook salmon were released upriver from the DCC gate location. The release point was far enough upstream that fish were distributed in the river channel and were believed to be exhibiting normal migratory behavior and movements. Results indicated that 39 percent of the released fish (1,162 fish) were eventually detected in the vicinity of the DCC gates with approximately 5 percent of these detections believed to be fish within predators (154 fish). Of the arriving fish detected (1,008 fish), approximately 83 percent (840 fish) arrived at night, with the remainder (17 percent) arriving during the day (168 fish). Of the fish arriving at the DCC location (day and night), approximately 13 percent (143 fish) arrived when the gate was open. Of the 143 fish arriving at the gates when they were open, 20 percent (20 fish out of

100 fish) were entrained at night and 21 percent were entrained during the day (9 fish out of 43 fish). USGS performed an analysis of the data and calculated the joint probability of arriving at night and being subsequently entrained using different environmental covariates and determined that there was approximately a 19 percent chance of being entrained into the DCC at night. Conversely, the probability of being entrained during the day was approximately 6 percent. During the period of the study (November 2008 through March 2009), 73 percent of negative flood flows occurred during the day, and entrainment was more likely during these periods. Dr. Plumb and colleagues summarized that operations of the DCC gates during the day may allow for water diversion into the interior Delta while minimizing the risk of entrainment of migrating Chinook salmon into the DCC.

Preliminary results from the 2012 Georgiana Slough non-physical barrier study (DWR 2013 – draft) also help to illustrate the behavior of fish moving through this section of the river under different diel and flow conditions. Similar to the USGS study conducted by Dr. Plumb and colleagues and the Chapman *et al.* (2013) studies, the majority of fish detected moving past the junctions of the DCC and Georgiana Slough channels with the main stem Sacramento occurred at night (see figure 19 for a representation of DCC temporal passage). In addition, data from tagged late-fall Chinook salmon passing through the Georgiana Slough junction indicate that greater numbers of fish passed through this study area at night than during the day. Furthermore, the passage of fish was also shown to be strongly influenced by tidal phase. During the night, more fish successfully passed the junction of the Georgiana Slough channel during a strong ebb phase than during the changing of the tide or a flood tide. During the changing of the tide from an outflowing tide to a flood tide, the flow of water increases into Georgiana Slough. It is during this transition that a converging flow situation sets up at the junction and 100 percent of the Sacramento River flow enters Georgiana Slough from both the upstream and downstream directions with little to no flow bypassing the junction. Under this specific scenario, all fish present across the width of the Sacramento River channel are vulnerable to entrainment into the junction. This is particularly true during nocturnal periods when fish are more likely to be moving rather than holding and thus become vulnerable to entrainment as they encounter the junction reach. During the day, more fish are holding, and move less in the region of the junction, thus reducing their vulnerability to entrainment, although not being becoming completely immune to entrainment (see figure 20 and 21).

To summarize the biological foundation for diurnal operations of the DCC gates, Chapman *et al.* (2013) illustrates how Chinook salmon smolts emigrate primarily at night in the upper reaches of the Sacramento River but progressively increase movements during daytime periods as fish emigrate downstream towards the Delta and San Francisco Bay. Daytime movement is also increased by increasing river flows and stronger flood tidal flows, as well as increased turbidity. Steelhead smolts are more balanced in their use of daytime and night time periods for movements in all river reaches in comparison to Chinook salmon. They are less sensitive to changes in flow and turbidity in comparison to Chinook salmon, but still respond in the same manner: more flow and/or turbidity reduce the proportion of nocturnal movement and increases daytime movement.

The USGS analysis of Chinook salmon at the DCC junction indicates that Chinook salmon predominately arrive at night and are more susceptible to entrainment at night than during the day based on the joint probabilities of arriving at the DCC junction at night and subsequently being entrained into the DCC junction.

The analyses conducted in support of the 2012 Georgiana Slough non-physical barrier finds that fish move more at night past the Georgiana Slough junction than during the day based on the number of detections at the non-physical barrier acoustic receiver array and that the behavior of the fish in the junction is strongly dependent on tidal phase and position in the channel cross section at the time of encountering the junction. Fish are more likely to successfully move downstream on a strong ebb tide past the Georgiana Slough junction and avoid entrainment into the Georgiana Slough channel than when downstream flow is weaker and the tides are changing from ebb to flood. The period of time when fish are most vulnerable to entrainment into the Georgiana Slough channel is during the period when flows are reversing and essentially all of the flow in the Sacramento River channel is directed into the channel of Georgiana Slough (converging flows). As negative flows increase and the flood tide strengthens, the vulnerability of entrainment lessens and fish were found to "mill' in the vicinity of the junction or move back upstream, avoiding the region surrounding the junction (green regions in figures 4 and 5).

If the DCC gates are to be operated (*i.e.*, opened), then the option which minimizes the entrainment vulnerability to listed salmonids emigrating in the Sacramento River in the vicinity of the DCC gates would involve opening the gates on a diurnal cycle, and closing the gates during the night, thus avoiding the greater nocturnal presence of fish in the vicinity of the gates during fish movements. In addition, further reductions in entrainment vulnerability could be gained by operating the gates with recognition of the tidal phases in which the fish are more vulnerable to entrainment (*i.e.*, periods of tidal transition from ebb to flood and when upstream and downstream flows result in converging flow phases entering the DCC channel).

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Personal communication with Dr. John Plumb, Ph.D. United States Geological Survey, January 29, 2014. Power point presentation to NMFS staff on Wednesday, January 29, 2014. "Diel Activity Patterns of Juvenile Chinook Salmon with Implications for Operation of the Delta Cross Channel." Authored by: John Plumb, Noah Adams, Russell Perry, Theresa Liedtke, Jason Romine, and others, USGS, Western Fisheries Research Center, Cook, WA. 14 slides. Preliminary Draft findings.

Table 1: Recovery of winter-run and spring-run Chinook salmon at the Knights Landing Rotary Screw Trap for water years 2001 through 2012. Values are the percentage of cumulative capture for the water year, separated into quartiles. Colored cells indicate that the date has occurred after December 31st of each water year. The Magenta cells are included in the December category since they occurred within the first week of January.). Raw data courtesy of the California Department of Fish and Wildlife (CDFW), Knights Landing Monitoring Program, and compiled by NMFS.

Recovery of winter run and spring run sized fish in the Knights Landing RSTs

	Water Year												Percentage occuring before January
	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	
Water Year type	D	D	AN	BN	BN	W	D	C	D	BN	W	BN	
Date first WR @ KL	11/6/2000	11/16/2001	10/11/2002	10/6/2003	10/29/2004	10/11/2005	10/6/2006	12/12/2007	12/29/2008	10/15/2009	10/11/2010	10/10/2011	100
25% @ KL	1/19/2001	11/27/2001	12/17/2002	12/9/2003	12/11/2004	12/3/2005	12/15/2006	12/31/2007	1/26/2009	10/28/2009	12/8/2010	1/23/2012	75
50% @ KL	1/29/2001	12/11/2001	12/22/2002	12/11/2003	12/13/2004	12/6/2005	12/17/2006	1/12/2008	2/24/2009	1/20/2010	12/17/2010	1/25/2012	58
75% @ KL	2/23/2001	1/4/2002	1/4/2003	12/20/2003	1/5/2005	12/24/2005	12/30/2006	1/28/2008	2/27/2009	1/26/2010	12/23/2010	1/27/2012	58
100% @ KL	4/25/2001	4/24/2002	4/21/2003	4/5/2004	4/22/2005	4/18/2006	3/13/2007	3/3/2008	4/6/2009	4/16/2010	4/9/2011	4/11/2012	0
Date first SR @ KL	12/20/2000	11/27/2001	12/16/2002	12/10/2003	12/11/2004	11/14/2005	12/13/2006	10/19/2007	10/27/2008	10/26/2009	12/9/2010	10/24/2011	100
25% @ KL	2/26/2001	2/22/2002	12/19/2002	12/12/2003	1/4/2005	12/21/2005	12/12/2006	1/9/2008	3/19/2009	4/14/2010[a]	1/4/2011	3/30/2012	50
50% @ KL	3/28/2001	4/23/2002[a]	1/4/2003	12/24/2003	3/31/2005	2/7/2006	3/18/2007	1/13/2008	3/25/2009	4/15/2010[a]	2/27/2011	4/2/2012	17
75% @ KL	4/18/2001[a]	4/25/2002[a]	4/9/2003	3/22/2004	4/20/2005[a]	4/19/2006[a]	4/19/2007[a]	2/7/2008	4/14/2009[a]	4/16/2010[a]	4/7/2011	4/13/2012	0
100% @ KL	5/14/2001	5/14/2002	5/9/2003	5/12/2004	5/12/2005	5/6/2006	5/14/2007	5/15/2008	5/12/2009	5/17/2010	5/2/2011	5/10/2012	0
Date CNFH FR release	4/13/2001	4/4/2002	4/18/2003	4/16/2004	4/15/2005	4/14/2006	4/12/2007	4/23/2008	4/9/2009	4/8/2010	4/14/2011	4/19/2012	

Table 2: Recovery of winter-run and spring-run Chinook salmon at the Knights Landing Rotary Screw Trap for water years 2001 through 2012. Values are the percentage of cumulative capture for the water year, by the end of each month. Raw data provided by CDFW, Knights Landing Monitoring Program, and compiled by NMFS.

	Water Year												Mean	Range	Stdev
	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012			
% of Annual WR Cat	D	D	AN	BN	BN	W	D	C	D	BN	W	BN			
End of October	0	0	0.4	0.3	0.1	1.6	2.1	0	0	26.5	15	4.8	4.23	0 - 26.5	8.22
End of November	0.6	43	1.2	0.5	4.9	20.2	3.8	0	0	29.4	19.1	5.7	10.70	0-29.4	14.09
End of December	6.7	71.9	65.9	85.2	64.2	91.8	80.9	2.5	22.3	32.9	82.3	6.7	51.11	2.5-91.8	34.34
End of January	60	93	94.7	92.9	92	95.4	90.8	78.8	36.9	90	94.4	86.7	83.80	36.9-95.4	17.81
End of February	81.6	97	97.7	97.2	97.5	98.5	99.5	99.1	82.3	94.7	96.1	91.4	94.38	81.6-99.5	6.20
End of March	99	98.8	99.3	99.9	99.9	99.6	100	100	99.2	98.8	99.2	95.2	99.08	95.2-100	1.30
End of April	100	100	100	100	100	100	100	100	100	100	100	100	100.00	100-100	0.00
End of May	100	100	100	100	100	100	100	100	100	100	100	100	100.00	100-100	0.00
% of Annual SR Catch															
End of October	0	0	0	0	0	0	0	0.3	0.2	0.2	0	0.1	0.07	0-0.3	0.11
End of November	0	5.5	0	0	0	0.2	0	0.3	0.2	0.2	0	0.1	0.54	0-5.5	1.57
End of December	1	17.6	47.7	56	21.4	42.5	17.5	0.9	0.8	0.2	18.7	0.1	18.70	0.1-47.7	20.11
End of January	10.2	21.8	58.2	66	32.7	47.1	20.2	64.7	1.8	8.5	33.3	1.2	30.48	1.2-64.7	23.83
End of February	26	27.3	61	69.6	37	58.9	45.4	80.7	19.8	10.2	50.6	1.7	40.68	1.7-80.7	24.49
End of March	58.7	33.1	68.8	79.4	51.1	65.8	52.2	82.8	52.4	14.3	67.2	36.1	55.16	14.3-82.8	19.91
End of April	93.4a	92.2	99.8	98.7	99.1	98.9	96.4	97.8	99.4	99.5	99.6	99.2	98.24	92.2-99.8	2.23
End of May	100a	100	100	100	100	100	100	100	100	100	100	100	100.00	100-100	0.00

Table 3: Catches of listed and non–listed salmonids in the United States Fish and Wildlife Service's (USFWS) monitoring programs at Chipps Island, Sacramento River trawl (Sherwood Harbor) and the Sacramento Region beach seines for the period of January 26, 2014 to February 22, 2014. Raw data courtesy of the United States Fish and Wildlife Service, Delta Juvenile Fishes Monitoring Program, Stockton, California, and compiled by NMFS.

Date	Species/run	Sacramento Beach Seines	Sacramento River Trawl	Chipps Island Trawl	Jersey Point special trawl
	Fall-run CS	0	0	0	
	Spring-run CS	1	0	0	
	Late-Fall CS	0	0	0	
2/2 – 2/8	Winter-run CS	1	0	0	
	CS tagged	1	0	1	
	RBT	0	0	0	
	RBT clipped	4	52	1	
	Fall-run CS	11,698	7,684	0	1
	Spring-run CS	41	41	0	0
	Late-Fall CS	0	0	2	0
2/9 -2/15	Winter-run CS	41	41	1	1
	CS tagged	3	32	6	0
	RBT	0	7	1	0
	RBT clipped	28	196	11	0
	Fall-run CS	10,893	5,862	0	11
	Spring-run CS	32	49	0	0
	Late-Fall CS	2	0	0	0
2/16-2/22	Winter-run CS	21	2	5	0
	CS tagged	3	0	16	0
	RBT	1	0	0	0
	RBT clipped	7	12	20	0

Notes: CS = Chinook salmon
CS tagged = Chinook salmon tagged (adipose fin clipped) – hatchery release or study fish
RBT = Rainbow trout (steelhead) – natural / wild origin fish
RBT clipped = Rainbow trout (steelhead) adipose fin clipped – hatchery or study fish

Figure 1: Standardized catch of winter-run Chinook salmon at the Knights Landing RST during period between October 2000 and June 2001. Horizontal red lines indicate trigger levels of 3 and 5 fish per day (standardized trap days). Raw data provided by the California Department of Fish and Wildlife (CDFW), Knights Landing Monitoring Program, and compiled by NMFS.

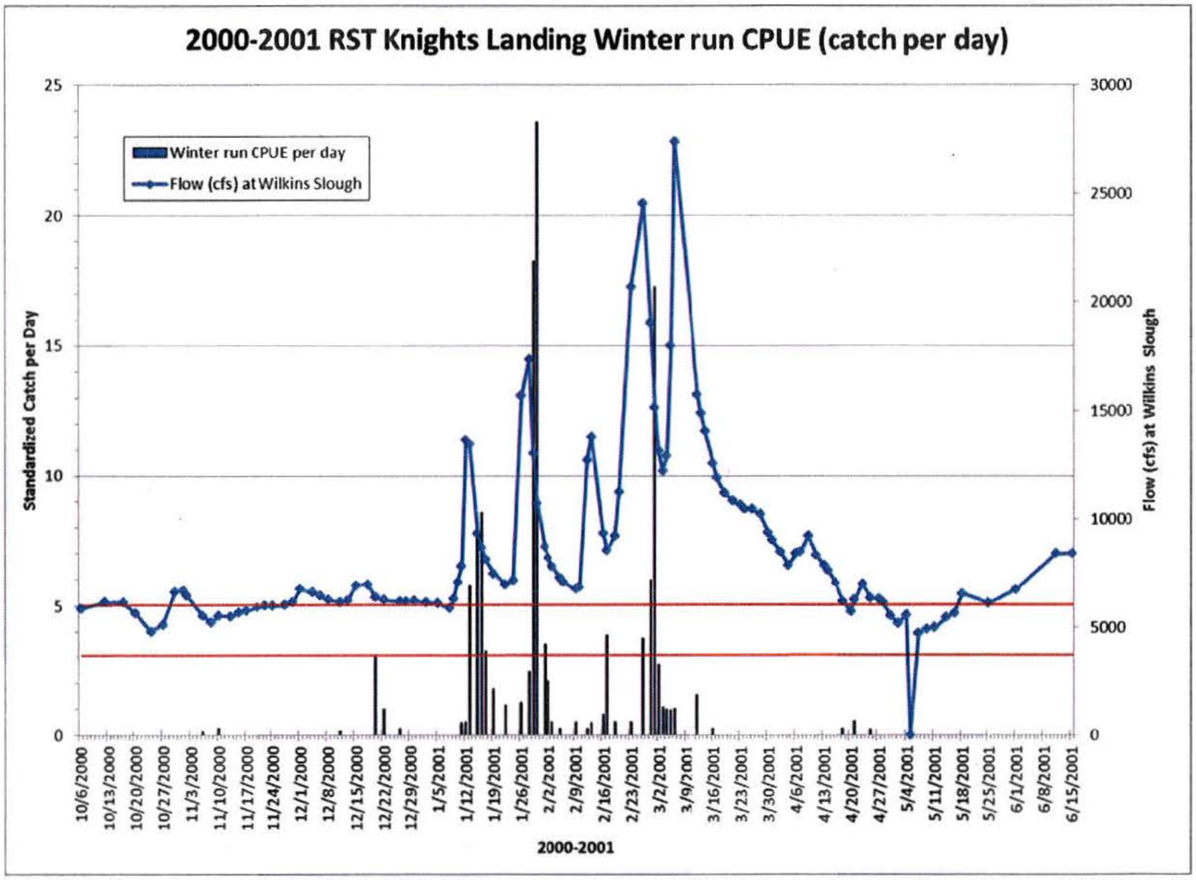

Figure 2: Standardized catch of winter-run Chinook salmon at the Knights Landing RST during period between October 2008 and June 2009. Horizontal red lines indicate trigger levels of 3 and 5 fish per day (standardized trap days). Raw data provided by CDFW, Knights Landing Monitoring Program, and compiled by NMFS.

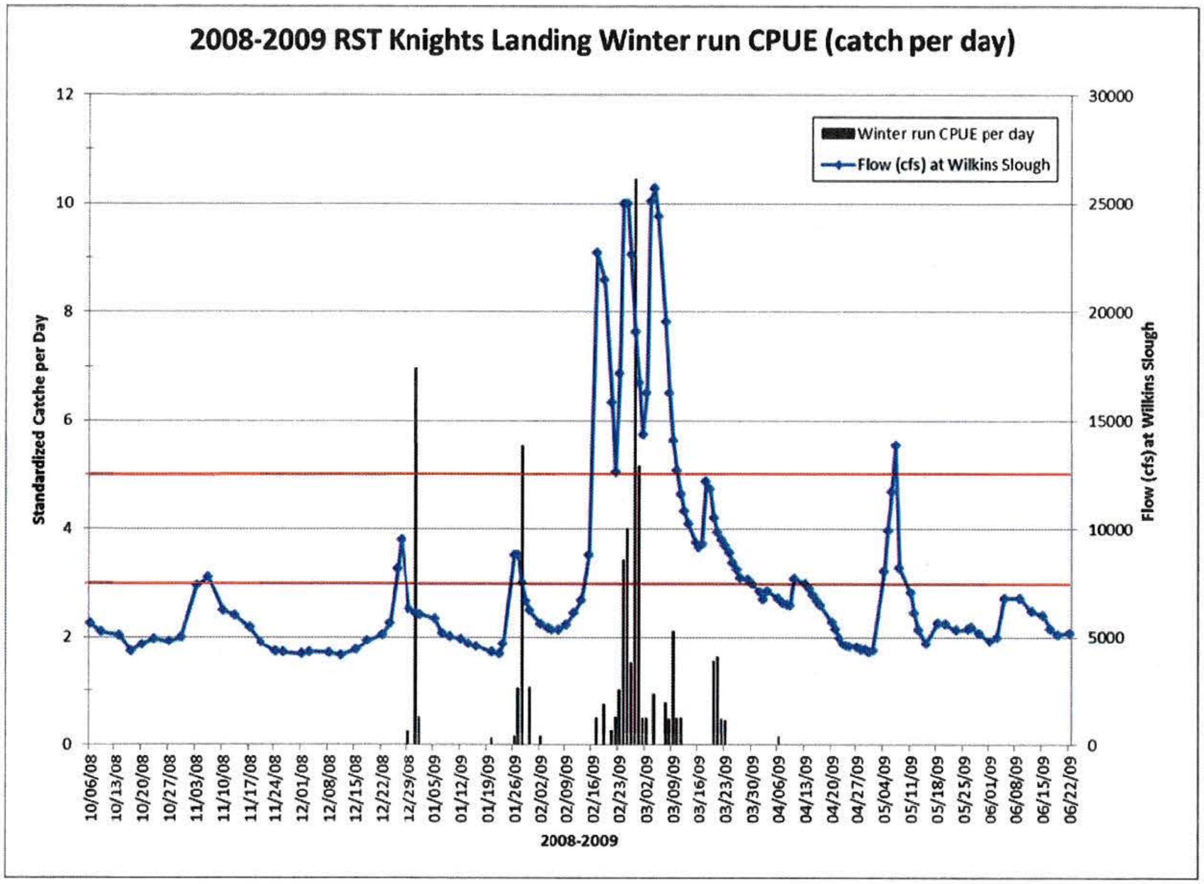

Figure 3: Cumulative percentile catch of winter-run Chinook salmon at the Knights Landing RST for the period of October 2000 to June 2001. Scale of the left hand vertical axis is 100 percent of annual catch is equal to 1.0. The red line is the daily discharge of the Sacramento River at Wilkins Slough in cubic feet per second. Raw data provided by CDFW, Knights Landing Monitoring Program, and compiled by NMFS.

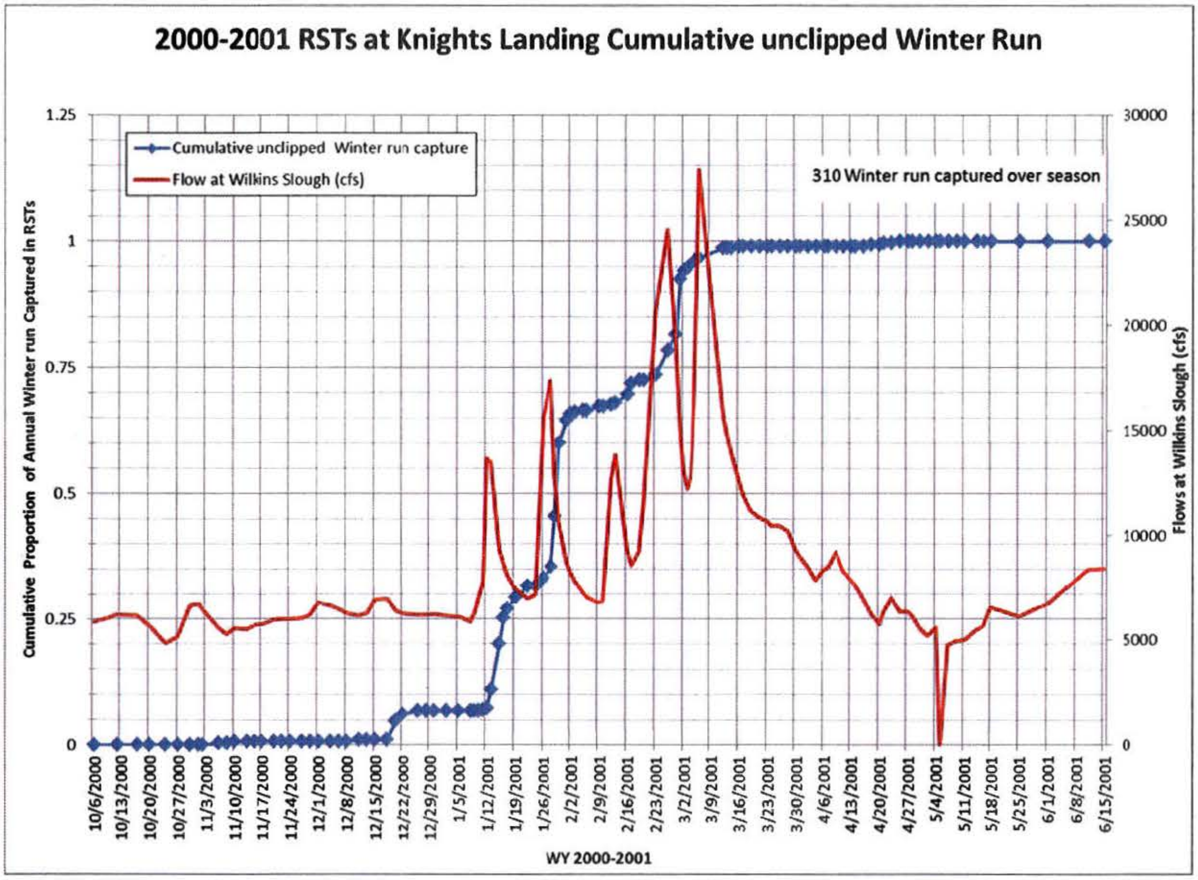

Figure 4: Cumulative percentile catch of winter-run Chinook salmon at the Knights Landing RST for the period of October 2008 to June 2009. Scale of the left hand vertical axis is 100 percent of annual catch is equal to 1.0. The red line is the daily discharge of the Sacramento River at Wilkins Slough in cubic feet per second. Raw data provided by CDFW, Knights Landing Monitoring Program, and compiled by NMFS.

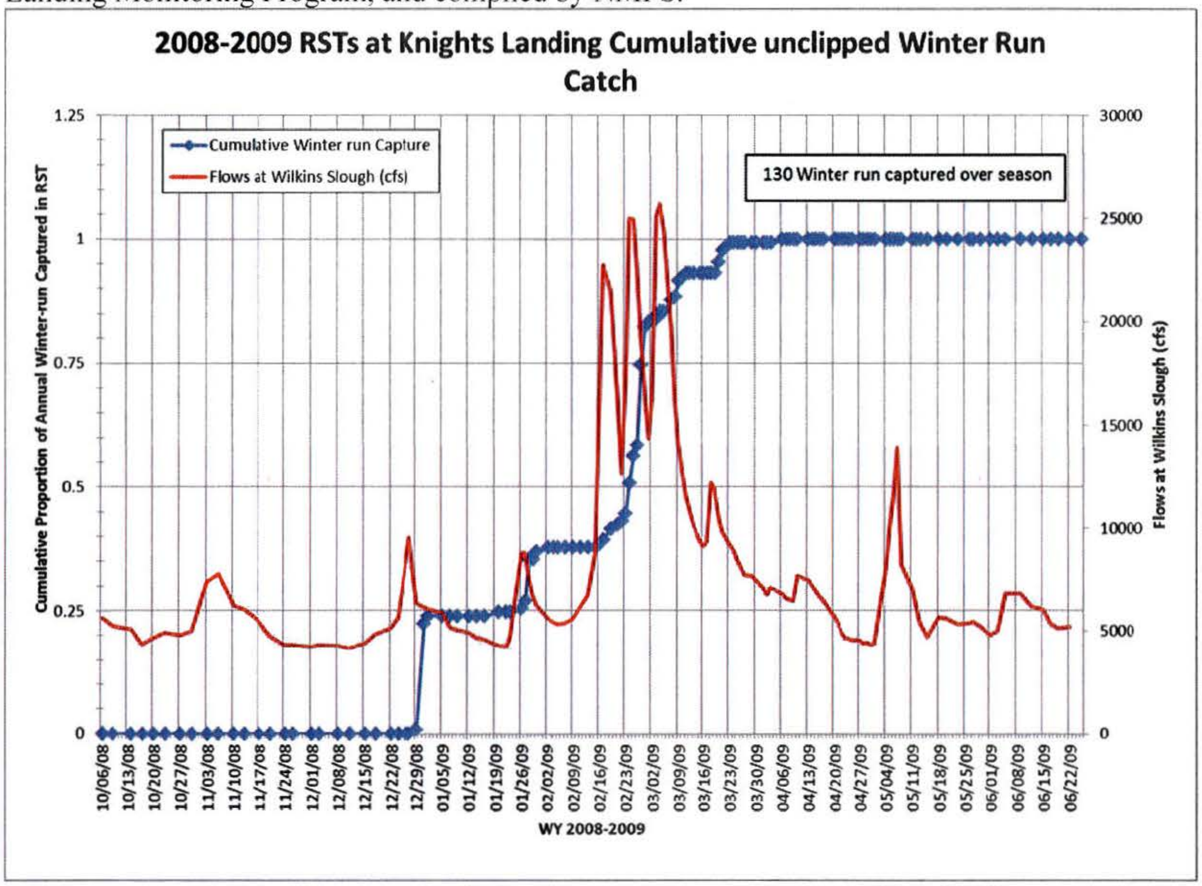

Figure 5: Oroville Dam (ORO) incremental precipitation for the water year 2014 (to date) from CDEC. Available at: http://cdec.water.ca.gov/cgi-progs/queryDaily?ORO.

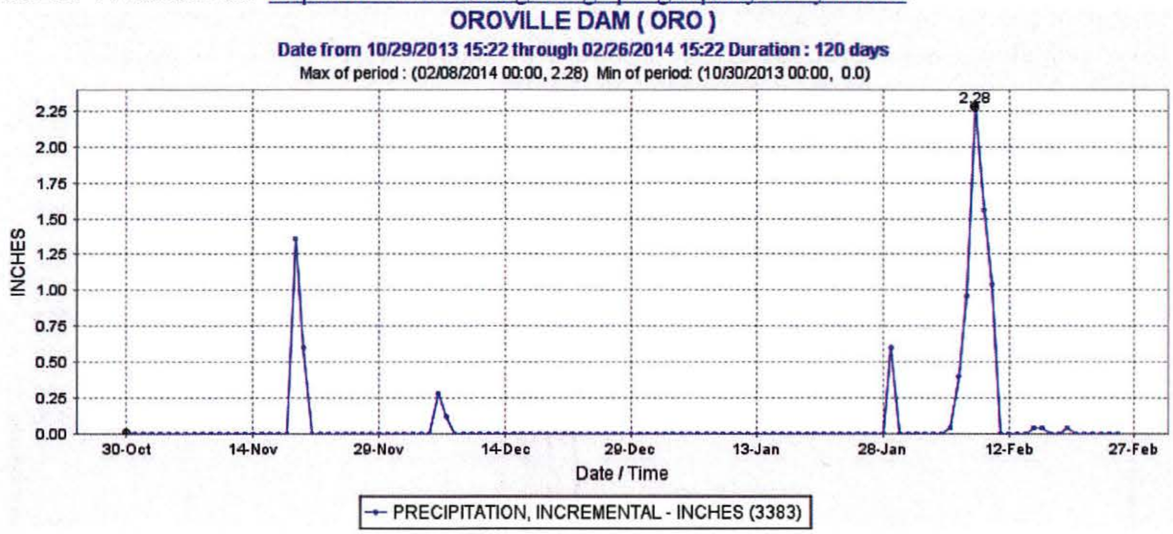

Figure 6: Shasta Dam (SHA) incremental precipitation for the water year 2014 (to date) from CDEC. Available at: http://cdec.water.ca.gov/cgi-progs/queryDaily?SHA.

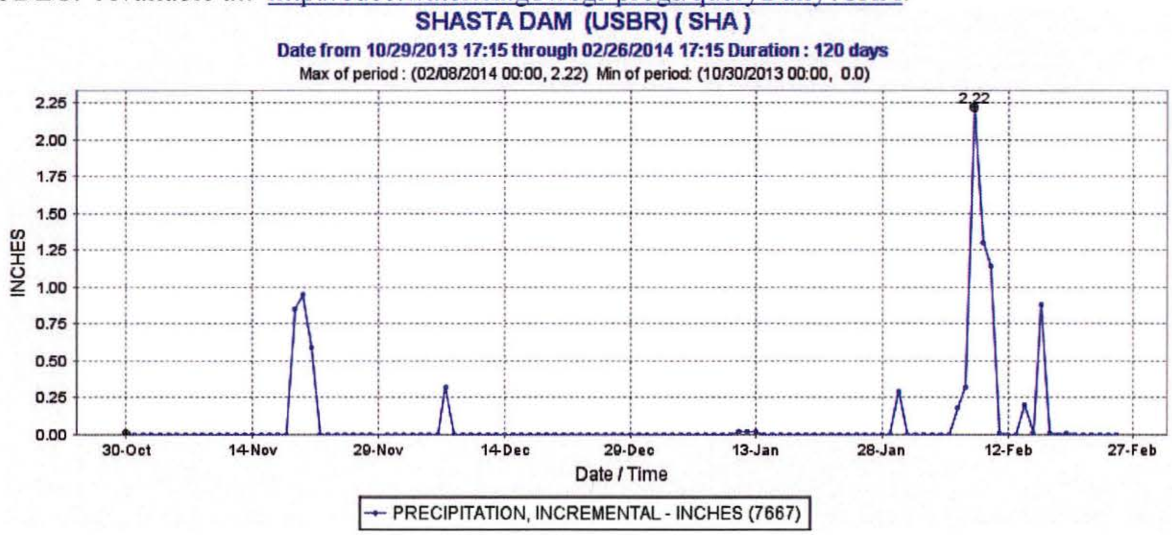

Figure 7: Daily Sacramento River discharges as measured at Wilkins Slough measured in cubic feet per second (cfs) for water year 2014. Available at: http://cdec.water.ca.gov/jspplot/jspPlotServlet.jsp?sensor_no=6284&end=02%2F26%2F2014+17%3A49&geom=medium&interval=151&cookies=cdec01.

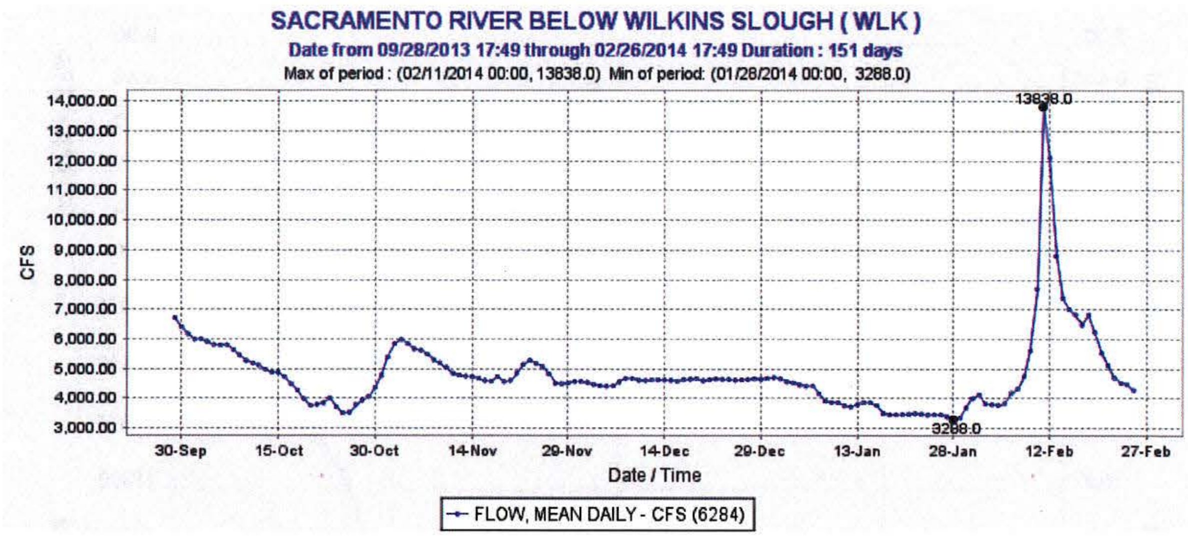

Figure 8: Real time Sacramento River discharges at Wilkins Slough for the week of February 23, 2014. Available at: http://cdec.water.ca.gov/cgi-progs/queryDaily?WLK

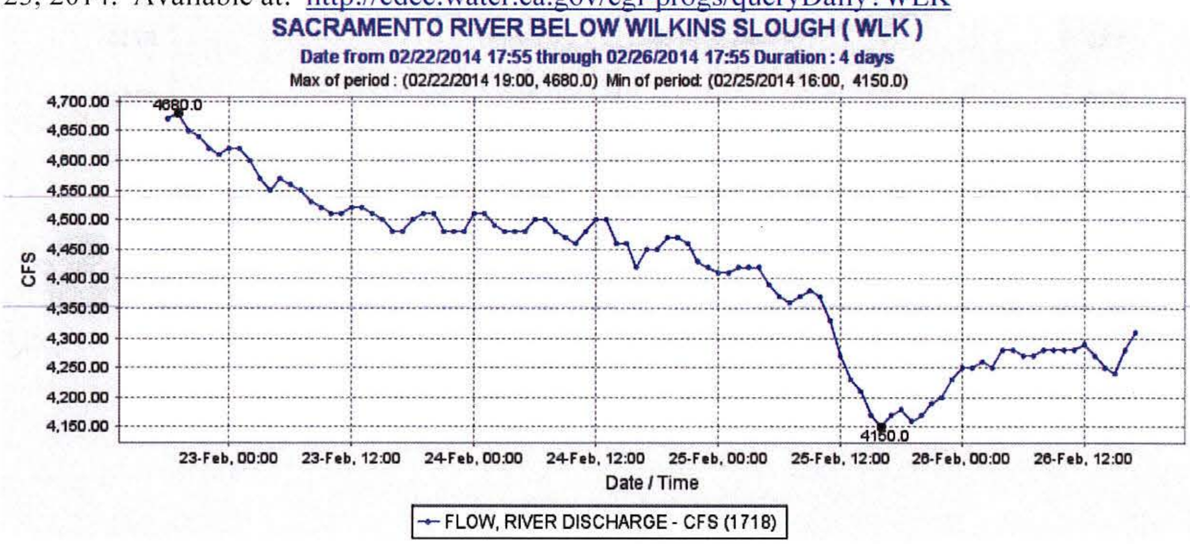

Figure 9: Guidance Plot forecast for Fremont Weir. Available at: http://cdec.water.ca.gov/guidance_plots/FRE_gp.html.

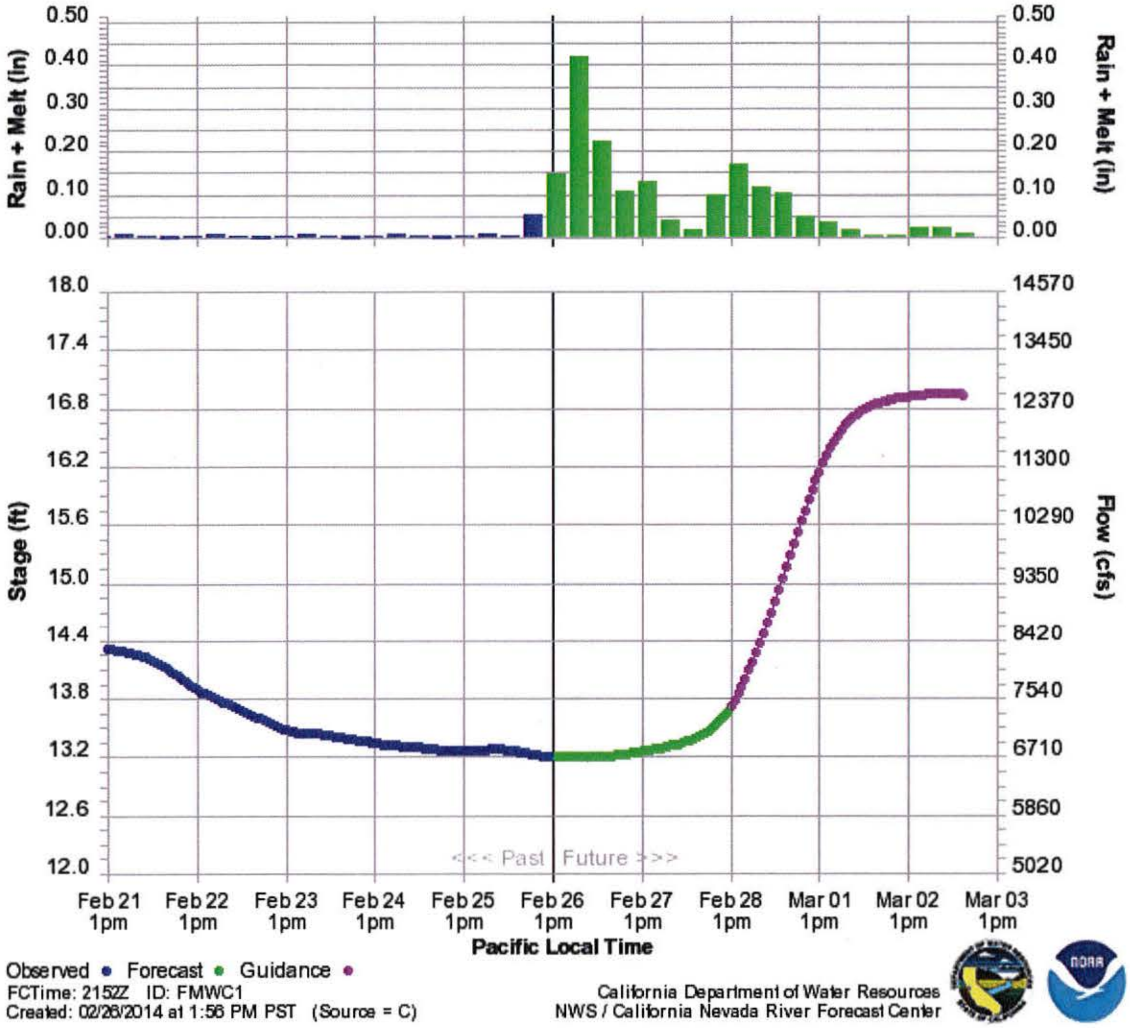

Figure 10: Knights Landing RST capture of winter-run Chinook salmon for water year 2014 (October 1, 2013 to February 26, 2014 inclusive). Raw data provided by CDFW, Knights Landing Monitoring Program, and compiled by NMFS.

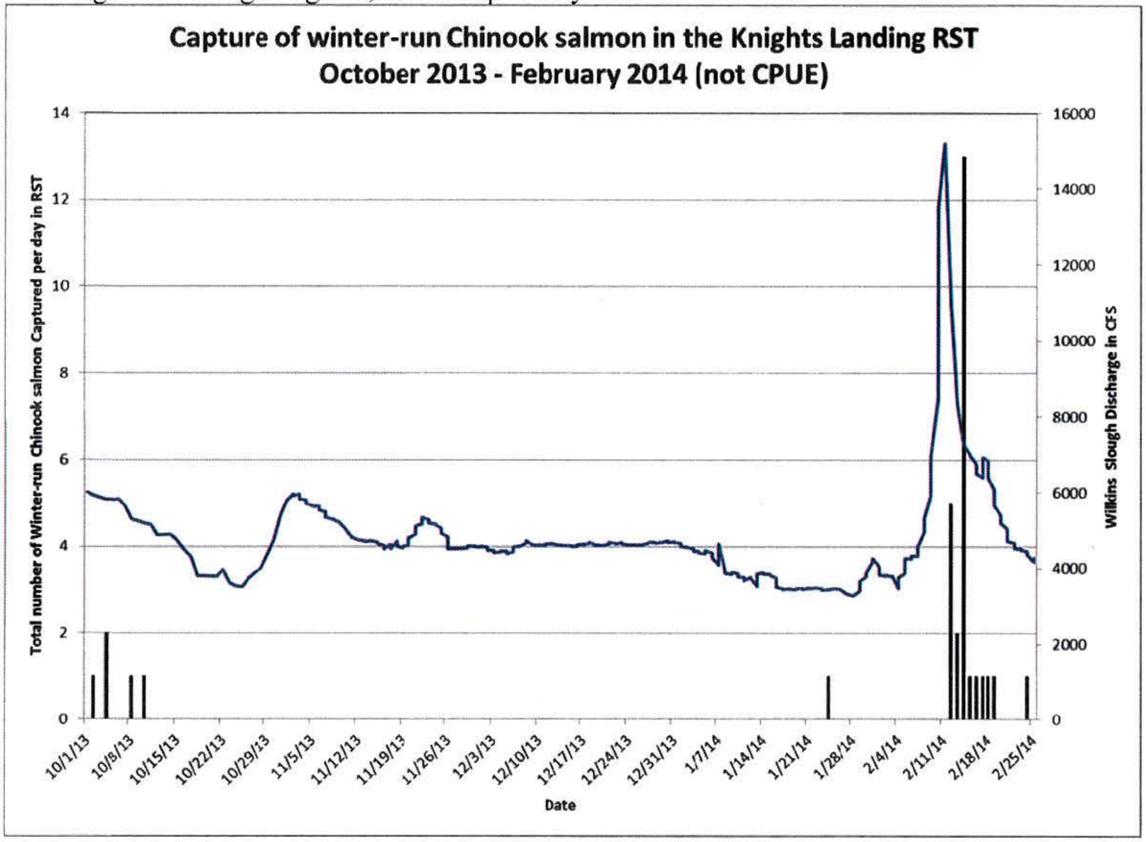

Figure 11: Cumulative capture of spring-run sized Chinook salmon at the Knights Landing RST for the period October 2008-June 2009. Vertical redline indicates the date of fall-run hatchery release from Coleman National Fish Hatchery. Raw data provided by CDFW, Knights Landing Monitoring Program, and compiled by NMFS.

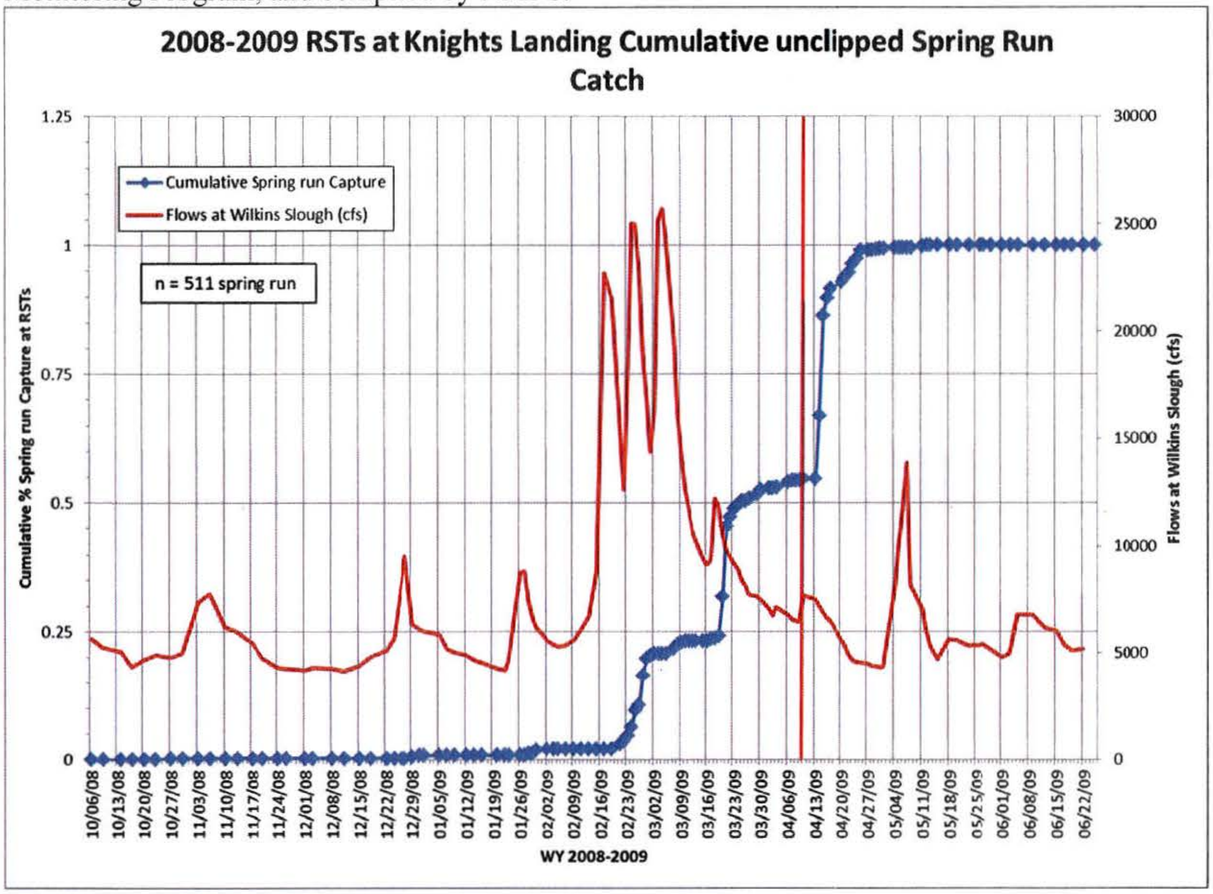

Figure 12: Cumulative capture of spring-run sized Chinook salmon at the Knights Landing RST for the period October 2009-June 2010. Vertical redline indicates the date of fall-run hatchery release from Coleman National Fish Hatchery. Raw data provided by CDFW, Knights Landing Monitoring Program, and compiled by NMFS.

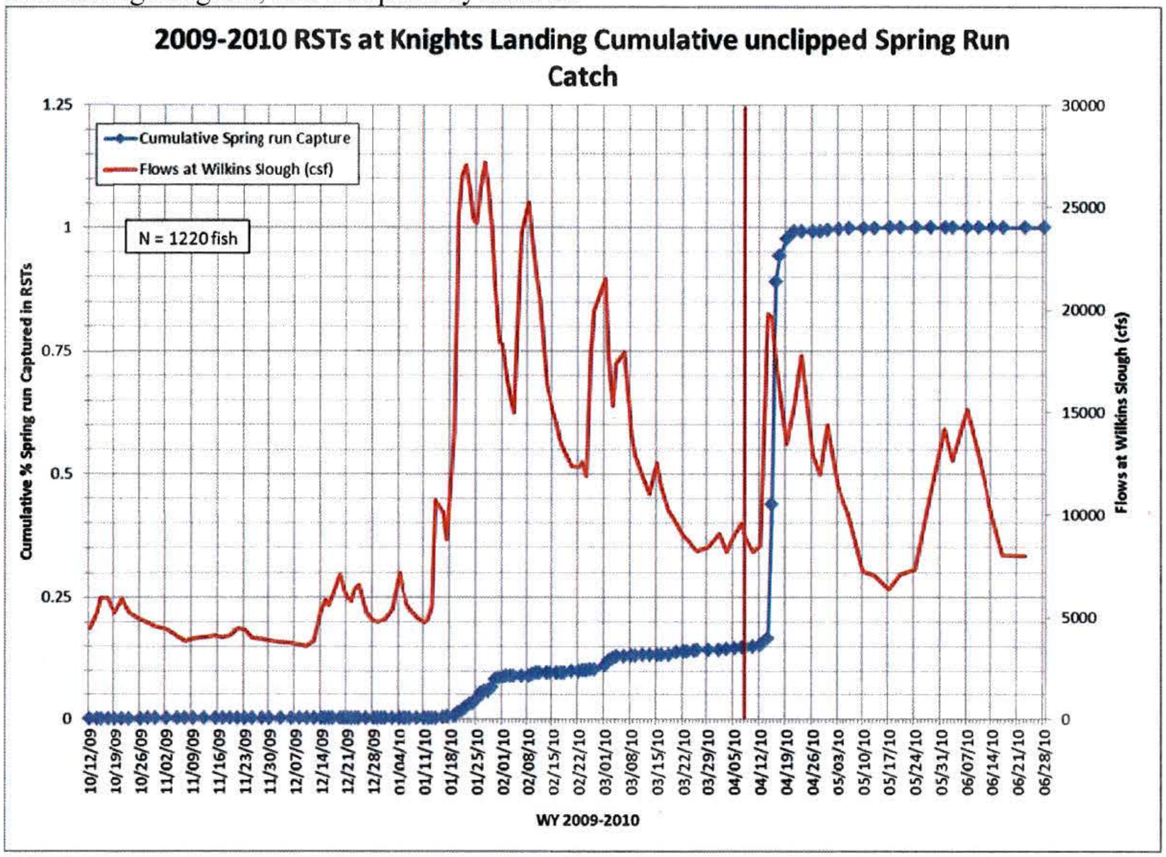

Figure 13: Catch per unit effort for spring-run sized Chinook salmon from the Knights Landing RST for the period October 2008 – June 2009. Vertical red line indicated the date of hatchery release of fall-run Chinook salmon from Coleman National Fish Hatchery. Raw data provided by CDFW, Knights Landing Monitoring Program, and compiled by NMFS.

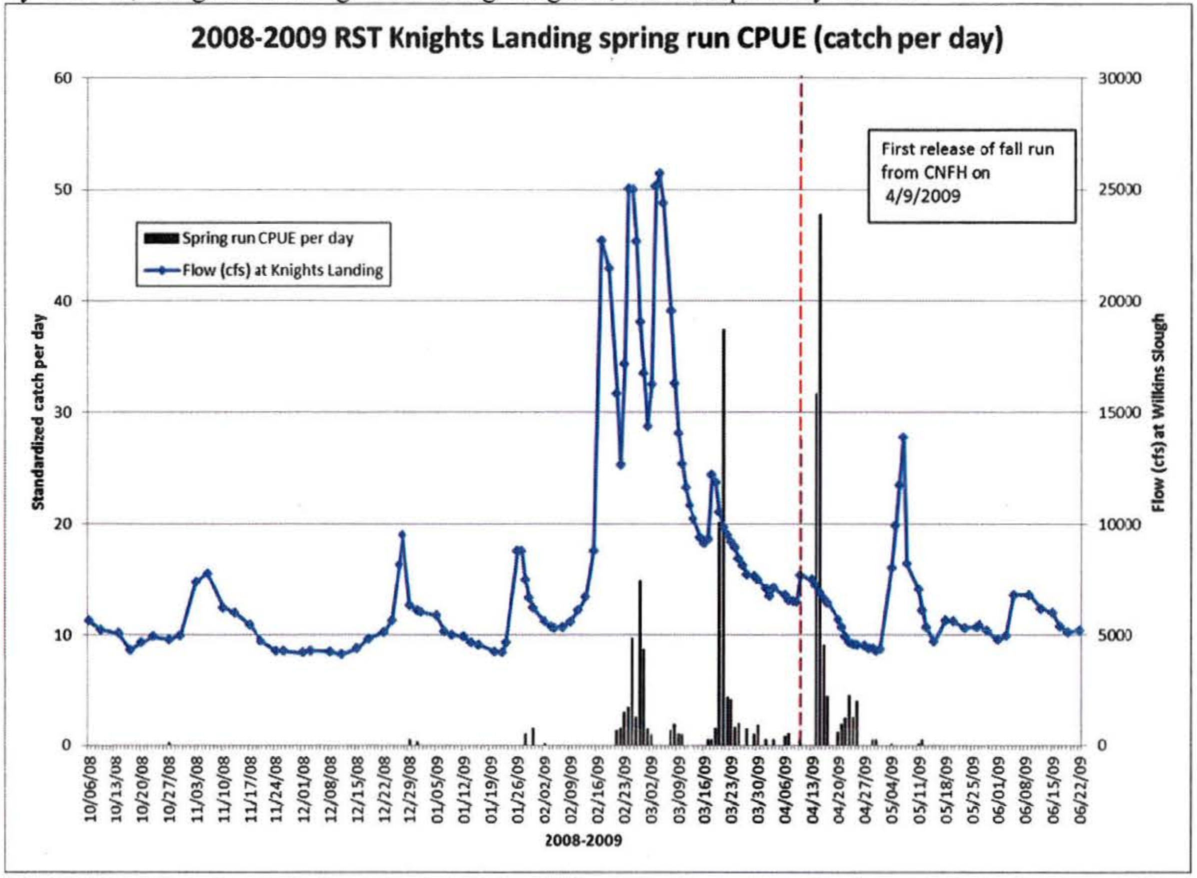

Figure 14: Catch of clipped and unclipped steelhead from the Knights Landing RST for the period October 2005 – June 2006. Vertical red line indicated the date of hatchery release of clipped steelhead from Coleman National Fish Hatchery. Water year 2006 is a wet year. Raw data provided by CDFW, Knights Landing Monitoring Program, and compiled by NMFS.

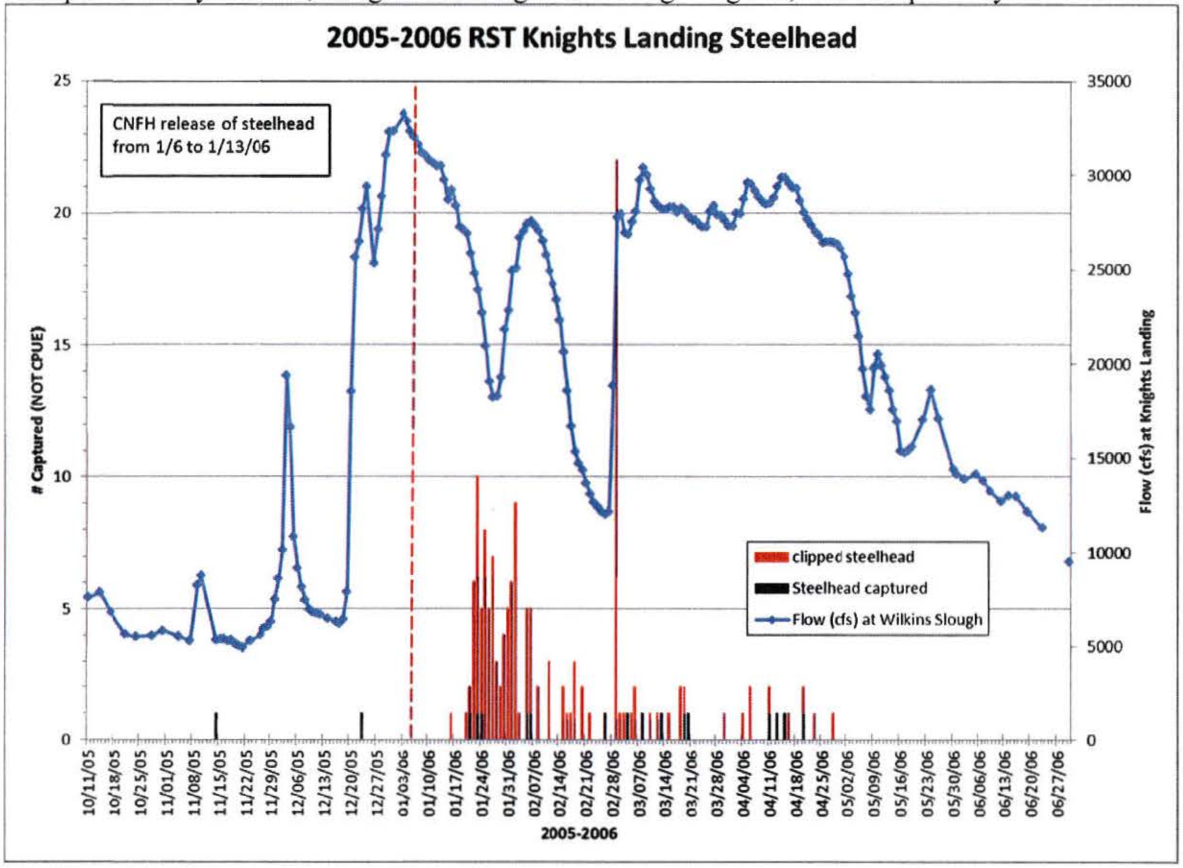

Figure 15: Catch of clipped and unclipped steelhead from the Knights Landing RST for the period October 2008 – June 2009. Vertical red line indicated the date of hatchery release of clipped steelhead from Coleman National Fish Hatchery. Water year 2009 is a dry year. Raw data provided by CDFW, Knights Landing Monitoring Program, and compiled by NMFS.

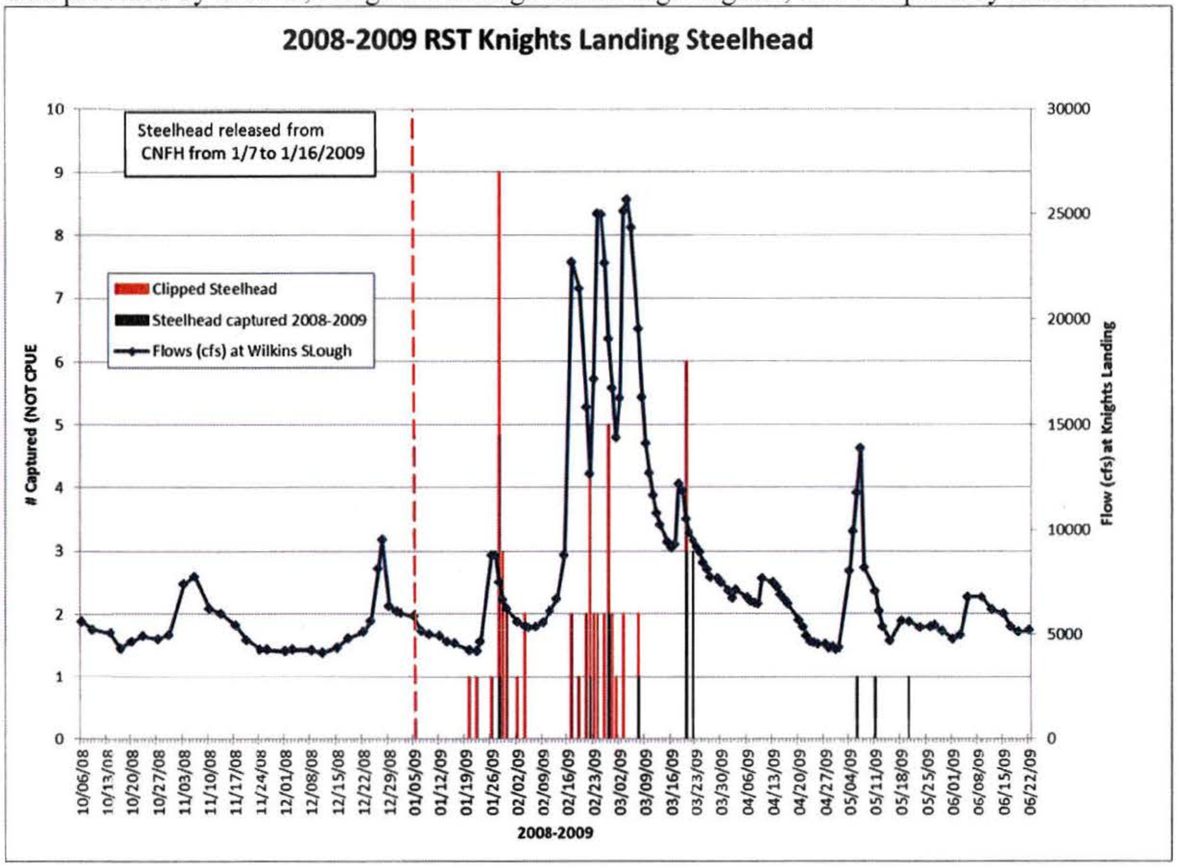

Figure 16: Travel time of acoustically tagged hatchery winter-run Chinook salmon released from Livingston Stone National Fish Hatchery in 2013. Red box is a 5-day window that covers the transit time from Knights Landing to Georgiana Slough. Data from poster presented by Hassrick *et al.* (2013) at the State of the Estuary Meeting.

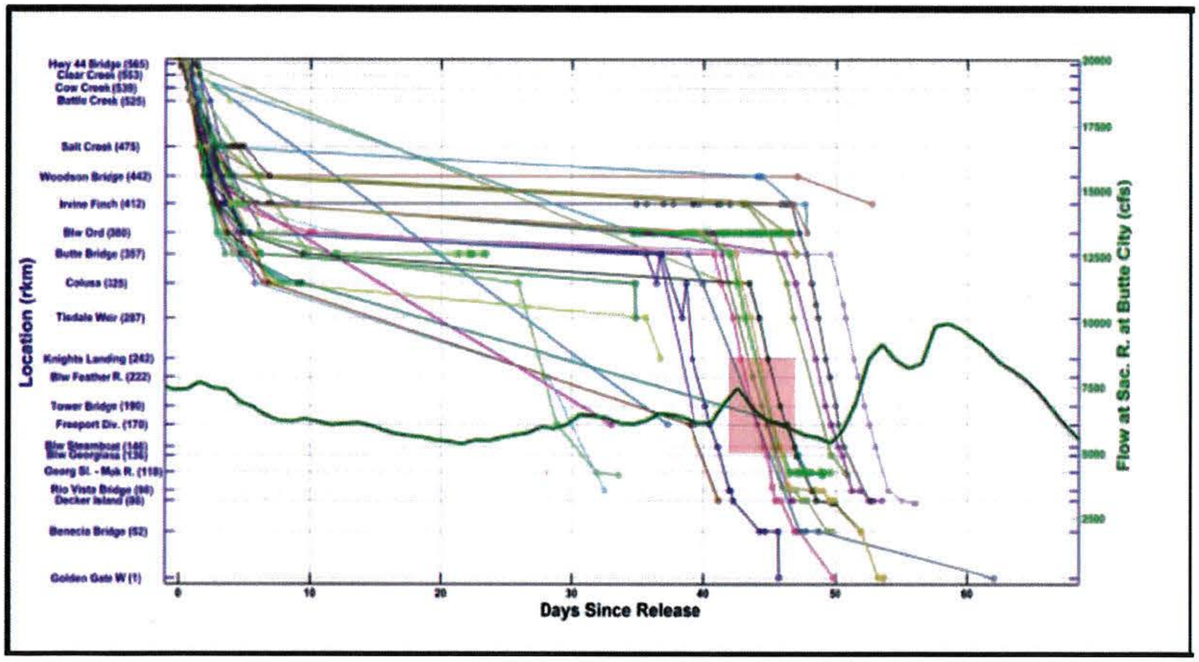

Figure 17: Percentage movement of late-fall Chinook salmon detected hourly over a 24 hour period. (Taken from figure 2 in Chapman *et al.* 2013)

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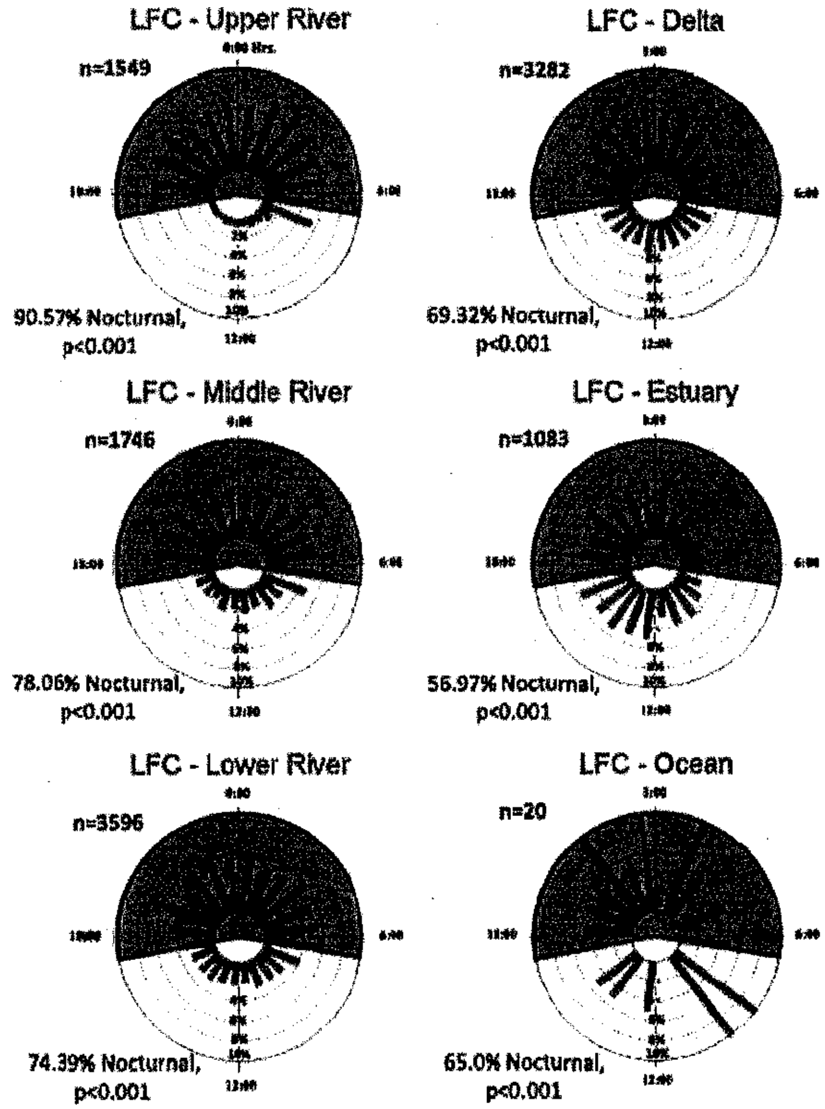


Fig. 2 Circular histograms with the percentages of late fall run Chinook salmon smolts detected each hour during a 24 h day (all monitors combined in each reach). The top represents midnight and the bottom represents noon; the clear area depicts daytime and the shaded area depicts nighttime. The arrow (r vector) denotes the mean time that all fish were detected. In all reaches, except for the Estuary, there is a significant preference for night migration. Note the shift from predominately nighttime detections in the upper river to less nighttime detections with each successive reach downriver. The percent nighttime detections increase again once the smolts enter the ocean. The statistics were based on 14 h of darkness and 10 h of daylight

Figure 18: Percentage movement of California Central Valley steelhead detected hourly over a 24 hour period. (Taken From figure 3 in Chapman *et al.* 2013)

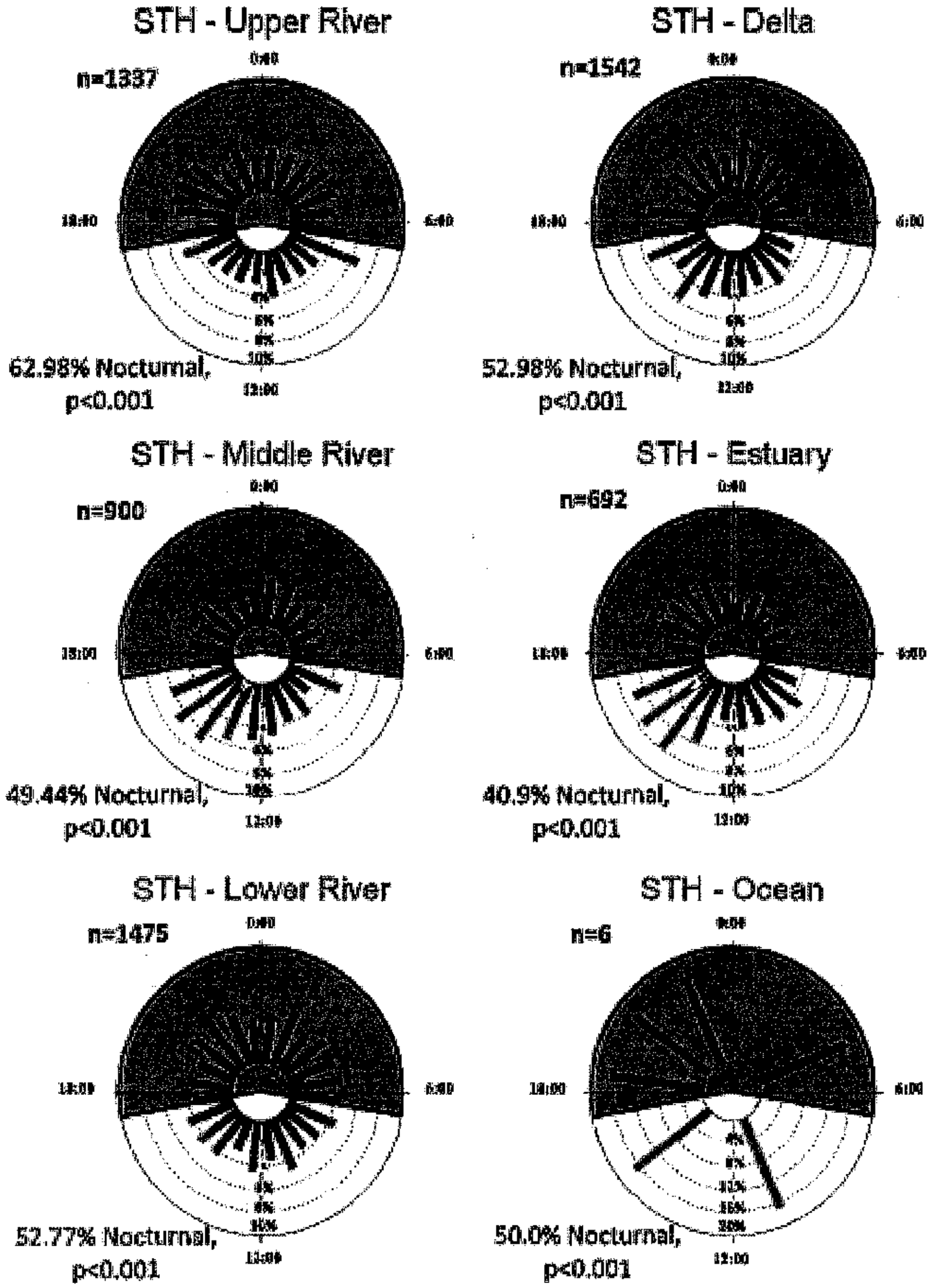


Fig. 3 Circular histograms with the percentages of steelhead smolts detected each hour during a 24 h day (all monitors combined in each reach). The top indicates midnight and the bottom indicates noon; the clear area signifies daytime and the shaded area signifies nighttime. The arrow (r vector) denotes the mean time that all fish were detected. There was significance for nocturnal migration in the upper river; in the middle river, Delta, and Estuary there was significance for diurnal migration; in the lower river there was no preference for day or night migration. The statistics were based on 14 h of darkness and 10 h of daylight

Figure 19: Histogram showing the frequency distribution of the hour each fish track entered the 2008 Walnut Grove Array above the DCC with representative light signal (DWR 2013 draft).

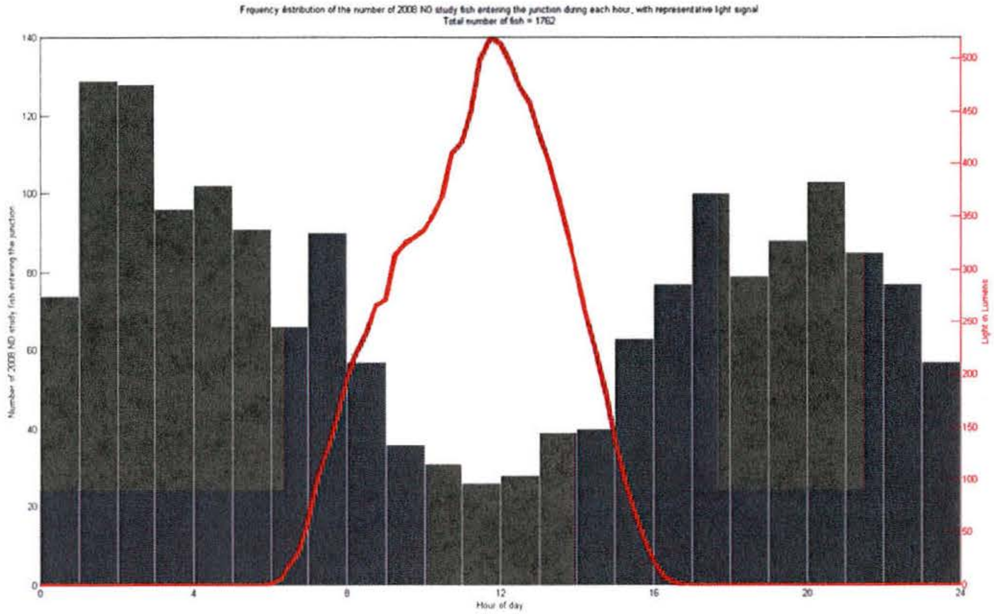
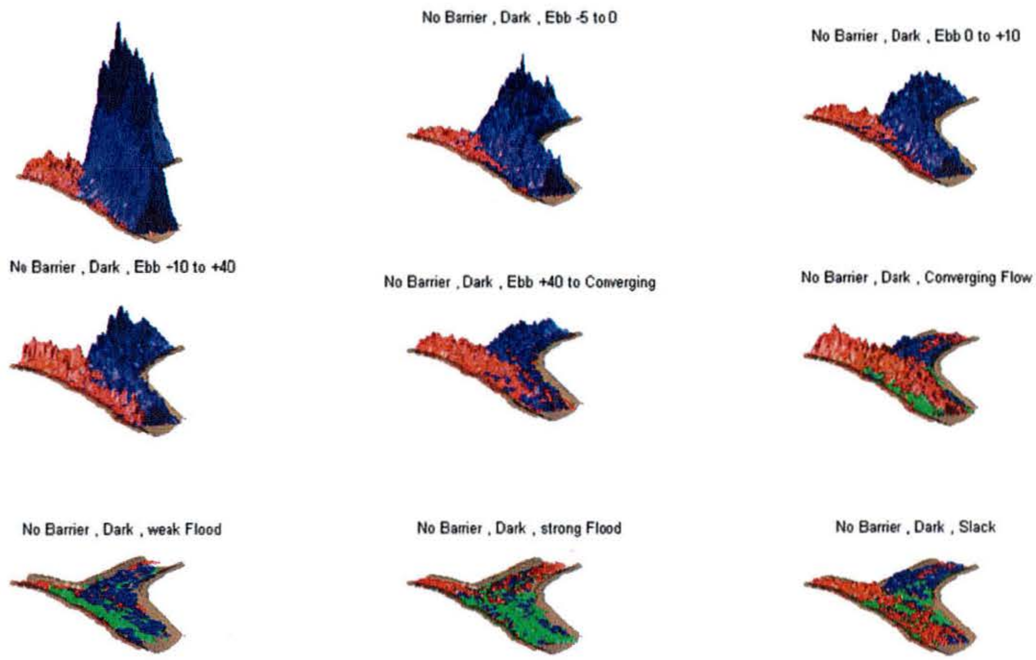
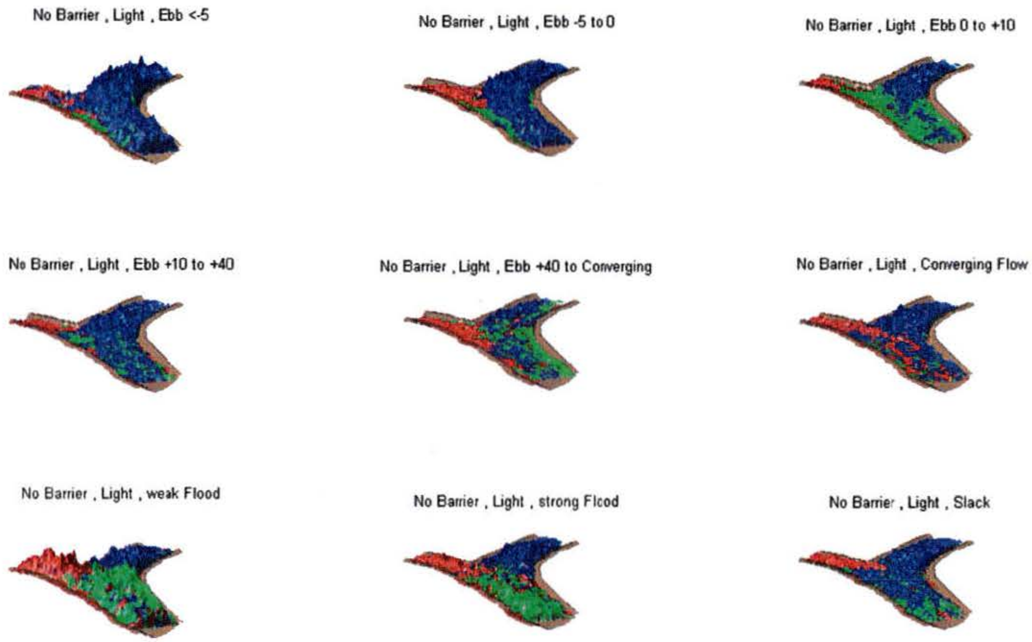


Figure 20: Spatial distribution of fish entering the Georgiana Slough junction during dark periods with the barrier out (DWR 2013 draft).



Notes: Empirical fish density distributions for each junction fate: The height of the red surface indicates the number of fish that exited the junction via Georgiana Slough in each portion of the junction, the height of the blue surface indicates the number of fish that exited the junction moving downstream in the Sacramento River in each portion of the junction, and the height of the green surface indicates the number of fish that exited the junction moving upstream in the Sacramento River in each portion of the junction. The junction bathymetry is represented by the brown surface. For clarity, the green surface showing the spatial distribution of upstream exiting fish is not show for the Ebb conditions, so that the near-bank distribution of Georgiana Slough exiting fish is easier to see. It is likely that the near-shore mass of fish exiting the junction moving upstream during dark ebb conditions is caused by predators, or juveniles displaying holding behavior during crepuscular periods.

Figure 21: Spatial distribution of fish entering the Georgiana Slough junction during light periods with the barrier out (DWR 2013 draft).



Notes: Empirical fish density distributions for each junction fate. The height of the red surface indicates the number of fish that exited the junction via Georgiana Slough in each portion of the junction, the height of the blue surface indicates the number of fish that exited the junction moving downstream in the Sacramento River in each portion of the junction, and the height of the green surface indicates the number of fish that exited the junction moving upstream in the Sacramento River in each portion of the junction. The junction bathymetry is represented by the brown surface.