

**Delta Cross Channel Gates Operational Triggers with Supporting Information**

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		<b>Fish monitoring and physical information</b>	<b>Action to be taken</b>
Outmigrating Fish protection	Alert	Tisdale Rotary Screw trap catch index (CI) is $\geq 3$ winter-run per day standardized to catch per unit effort	<b><u>No action taken:</u></b> Alert to potential emigration event. Fish are expected to be entering the lower Sacramento River from upstream.
	Alert	Wilkins Slough flows increase over base flows by 45% within a 5-day time period. Current flows are approximately 3,692 cfs; 45% increase is equal to 5353 cfs	<b><u>No action taken:</u></b> Fish are expected to be entering the lower Sacramento River from upstream due to an increase in flows.
	Low trigger	Knights Landing Catch Index (KLCI) or Sacramento River trawl Catch Index (SCI) is $\geq 3$ fish per day, standardized to catch per unit effort. This signifies that a moderate increase in downstream migrating fish is currently occurring. These fish will be in the Delta within days.	<b><u>Action:</u></b> Within 24 hours of meeting the trigger criteria, the DCC gates will be closed for 4 consecutive days. Gates will reopen if the KCI or SCI remain below the trigger threshold for the entire 4-day period. If during the 4-day closure, the trigger is again exceeded, then a new 4-day closure will be initiated.
	High trigger	KLCI or SCI is $\geq 5$ fish per day, standardized to catch per unit effort. This signifies that a large increase in downstream migrating fish is currently occurring. These fish will be in the Delta within days. A KLCI or SCI $\geq 5$ fish per day typically correspond to the major emigration events of the year class, with a	<b><u>Action:</u></b> Within 24 hours of meeting the trigger criteria, the DCC gates will be closed for 7 consecutive days. Gates will reopen if the KCI or SCI remain below the trigger

		significant proportion of the annual emigrating population of winter-run Chinook salmon passing Knights Landing occurring during these events.	threshold for the entire 7-day period. If during the 7-day closure, the trigger is again exceeded, then a new 7-day closure will be initiated.
Protection of Rearing Fish in vicinity of the DCC Gates		Sacramento area standardized beach seines or SCI = 0 for winter-run Chinook salmon and no upstream triggers have been exceeded following previous gate closures.	<b><u>No action taken:</u></b> If no captures of fish occur in the SCI or Beach seines after triggers have been exceed and the required duration of gate closures have been met without exceeding the triggers again, then the DCC gates shall remain open until a trigger criterion has been exceeded.
	Low trigger	Sacramento area standardized beach seine or SCI is equal to 1 or 2 winter-run Chinook salmon. This indicates that although winter-run Chinook are in the area surrounding the location of the DCC gates, the fish are typically holding or rearing and not actively migrating downstream in large numbers.	<b><u>Action: Gates Operated Diurnally</u></b> After prior triggers are no longer exceeded, and the DCC gate closures have met their required duration without re-triggering gate closures, then the DCC gate will be operated diurnally to protect fish in the vicinity of the gates
	Alternative trigger	Standardized area beach seine catch is greater than 2 but no fish have been captured in the Sacramento River Trawl. This indicates that winter-run are still present in the vicinity of the DCC gates and are using the area to hold and rear.	<b><u>Action: Gates Operated Diurnally</u></b> After prior triggers are no longer exceeded, and the DCC gate closures have met their required duration without re-triggering

			gate closures, then the DCC gate will be operated diurnally to protect fish in the vicinity of the gates.
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Diurnal operations in response to tidal conditions

	Day (6am-6pm window) approximately up to 6 hour window for opening DCC gates within 12 hour diurnal period.	Night (6pm-6am)
Ebb	Preferred operations of DCC gates will occur during the ebb tidal phase during daylight periods. Periods of gate openings should avoid the period of slack water surrounding the low tide and high tide ( $\pm 1$ hour). 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 periods. Fish migratory movement is elevated during the crepuscular period	Do not open DCC.
Slack	Avoid this period of the tide, 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. Avoid crepuscular periods for reasons stated above.	Do not open DCC.
Flood	This 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 the change of flow direction at the bottom of the tide, you are likely to have less impact due to opening during this period. Avoid crepuscular periods	Do not open DCC.

### Supporting information

The U.S. Bureau of Reclamation (Reclamation) provided a current status of the species for Sacramento River Winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon, California Central Valley steelhead (*O. mykiss*), and Southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*) in its supporting analysis for the Temporary Urgency Change (TUC) Petition.

In response to Reclamation’s and the Department of Water Resources (DWR) request for the TUC Petition, an interagency group of fisheries biologists from NOAA’s National Marine Fisheries Service, Reclamation, California Department of Fish and Wildlife, and California Department of Water Resources (Interagency Team) met and developed the following proposed Delta Cross Channel (DCC) gate operational triggers, in consideration of their need to provide minimum health and safety supplies, conserve water for later protections of instream uses and water quality, and the need to protect the endangered winter-run Chinook salmon.

Because of the anomalous dry hydrology in water year 2014 (WY2014) and lack of sufficient precipitation driven pulse flows in the Sacramento River to trigger behavioral responses in juvenile winter-run Chinook salmon that stimulates downstream migration, some believe that the majority of juvenile winter-run are still rearing in the upper Sacramento River, awaiting the appropriate environmental cues to migrate. However, others believe that the winter-run juveniles are slowly migrating downstream in persistent low numbers towards the Delta. As a result, Reclamation’s assessment of the current status and distribution of winter-run Chinook salmon has indicated that there are from <5% to >30% of the winter-run population currently in the Delta, with the remainder above the monitoring locations of the Tisdale Weir and Knights Landing rotary screw traps (RSTs). In previous dry years, migration past the Knights Landing location has been delayed into late January or February, awaiting a pulse event (see Table 1).

Table 1. Percentage of annual recovery of Winter-run Juveniles at Knight Landing by date

	Water Year												
	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	
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	
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	
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	
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	

In most years, precipitation events trigger emigration events. Recovery of winter-run juveniles at Knights Landing increases with these precipitation events that increase flows in the Sacramento River. These flows fluctuations have been typically measured at Wilkins Slough where a monitoring gage is located. Wilkins Slough is located upstream of the Knights Landing RST location and provides real time measurements of flow. A team of scientist from multiple federal and state agencies was convened in 1994 and over the course of more than 10 years developed the Salmon Decision Tree, to provide a framework for making operational decisions using the Knights Landing catch data and physical measurements such as the Wilkins Slough river flow data to determine when older juveniles, which include winter-run Chinook salmon juveniles, are entering the Delta and may need protection from water operations. This decision tree was modified in the 2009 NMFS biological opinion for the long term operations of the

Central Valley Project (CVP) and State Water Project (SWP, CVP/SWP Opinion). The Salmon Decision Tree team developed triggers based on standardized numbers of fish captured in the Knights Landing RSTs as well as monitoring efforts occurring downstream of that location in the Delta (Sacramento River trawls and beach seines). During the development of the Salmon Decision Tree criteria, the timing and magnitude of the passage of older juvenile Chinook salmon, *i.e.*, those fish larger than the minimum winter run Chinook salmon size criteria, were assessed from the Knights Landing RST monitoring data. In addition to the presence of the salmonids, physical data such as water temperature and river discharge were examined. The Knights Landing RST data have been collected since the fall of 1995 by CDFG staff using paired traps. The monitoring study has been conducted annually, collecting data to develop information on timing, composition (race and species) and relative abundance of juvenile Chinook salmon and steelhead emigrating from the upper Sacramento River. The traps have typically been placed in the river from early October through June of each year to coincide with the periods of salmonid out migration from the Sacramento River basin, however in some years the traps have been run for a longer period of time. The Salmon Decision Tree group also used data from the monitoring efforts conducted by the U.S. Fish and Wildlife Service (FWS) in the Sacramento River near the City of Sacramento as part of the Juvenile Salmon Monitoring Program/Delta Juvenile Fish Monitoring Program. The FWS conducts a river trawl using either a mid-water trawl or Kodiak trawl to sample fish (Sacramento trawl) and a beach seine at several shore locations in the Sacramento region (Sacramento Area beach seines). During the salmon emigration period, the sampling effort is intensified to 3 times per week.

The Salmon Decision Tree work group used data from these monitoring studies to develop the trigger criteria for the Decision Tree. The Knights Landing data was 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.*, >70mm) 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:  $100 \div (96 \text{ hours} / 24 \text{ hours per day}) = 25 \text{ fish per trap day}$ . In a similar fashion, the catch from the Sacramento trawl and Sacramento area beach seines 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. The daily catch data is adjusted so that the effort per day is always equivalent, taking into account any variance in the number of tows or hauls actually completed each day. These data are then referred to as the Knights Landing Catch Index (KLCI) or the Sacramento Catch Index (SCI) respectively. The Salmon Decision Tree work group found that the older juvenile Chinook salmon arrived at the Knights Landing RST location in “pulses” that were associated with precipitation driven increases in the river flow at Knights Landing (see Figure 1). The work group developed numerical criteria that served as the thresholds for closure of the DCC gates, and are the basis for the threshold triggers used in the current operations table. In addition to the numerical values for the Knights Landing and Sacramento Catch indices that trigger operational responses, the work group developed physical hydrological triggers that indicated that older juvenile salmonid migration was imminent. This included a flow criterion at Wilkins Slough of 7,500 cfs and a water temperature of 13.5°C. In a recent paper by del Rosario *et al.* (2013),

analysis of the Knights Landing data suggest that catch spikes of as little as 5% cumulative catch are observable and are nearly coincident with rapid increases in flow greater than 14,125 cfs. In light of the very dry hydrology for 2014, flows of this magnitude are unlikely, barring a significant precipitation event. The Interagency Team decided, based on professional judgment, that a lower flow might serve as an alert for active downstream migration, in this case, and developed a standard in which flow increases of 45% over a period of 5 days at Wilkins Slough would signify a physical trigger for indicating movement of fish downstream past Knights Landing. Past data regarding small pulses of less than 10,000 cfs at Wilkins Slough from low flows indicated that there was movement of fish, but not as pronounced as the larger flows.

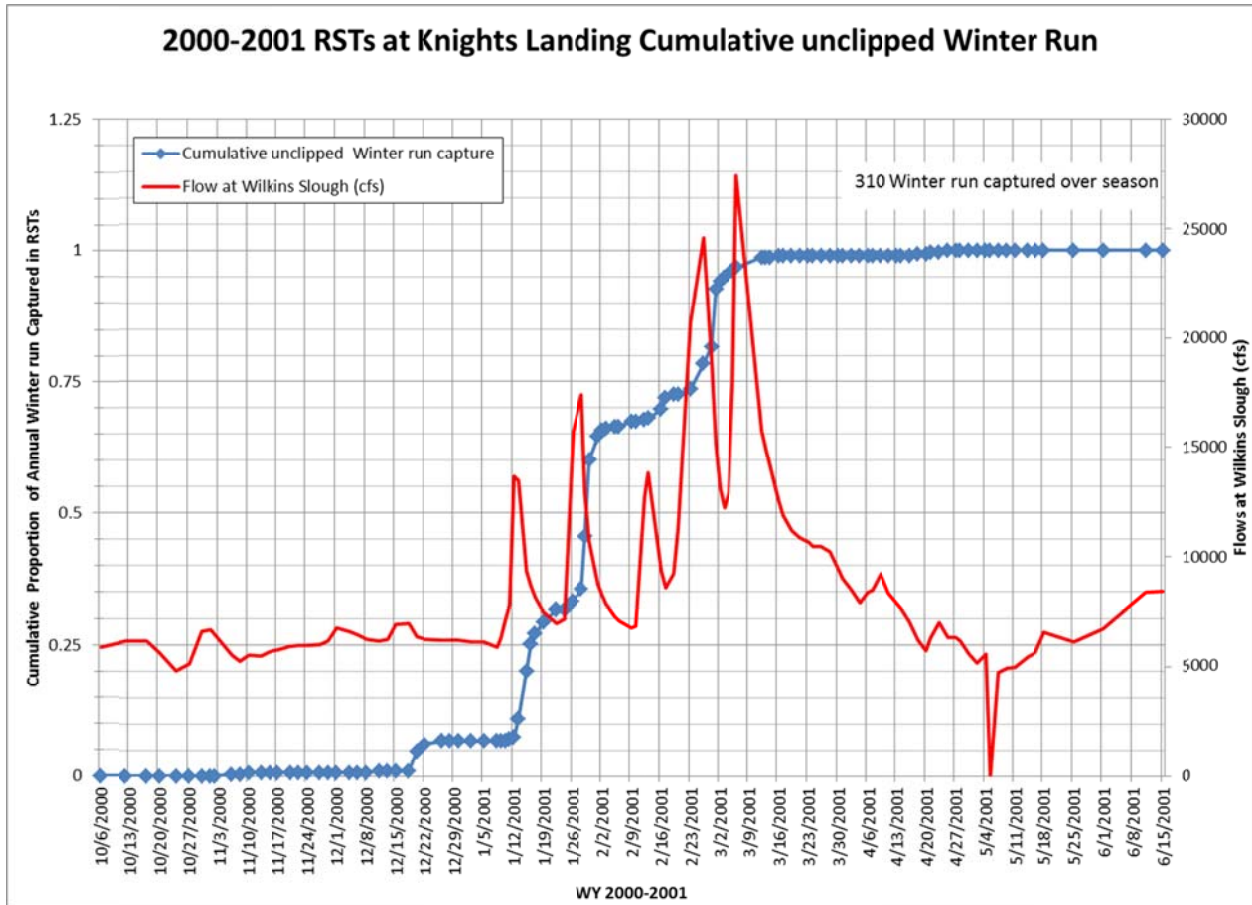


Figure 1. Knights Landing rotary screw trap cumulative captures of winter-run Chinook salmon for water year 2001, a dry year.

The first and second triggers indicate that a significant emigration event is occurring (see Figures 1 and 2). When the indices of 3 or 5 fish per trap day are exceeded, the cumulative number of fish increases rapidly and as previously described occurs with a co-occurring pulse in flow as measured at Wilkins Slough. We expect that in 2014, a smaller flow pulse as measured at Wilkins Slough will stimulate migratory behavior and a resultant increase in winter run captures will occur. The trigger thresholds of 3 and 5 fish per trap day will allow operators to have notice that a pulse of fish are moving down through the system and the protective actions of closing the DCC gates can be implemented.

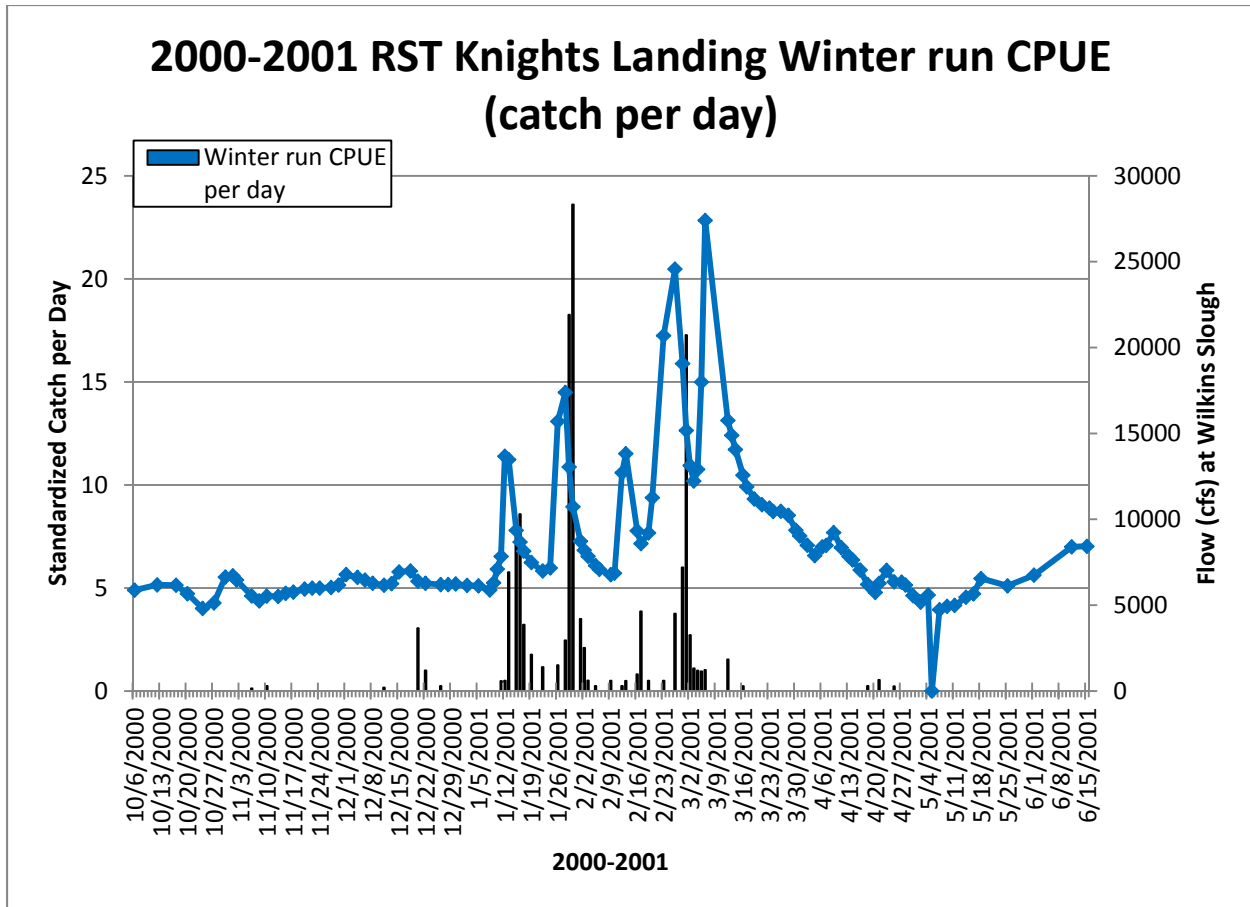


Figure 2. Catch of winter-run Chinook salmon at Knights Landing measured as catch per unit effort for water year 2001.

As juvenile Chinook salmon move downstream, they are more likely to move at night rather than during the day. Several studies have indicated such behavior (Martin *et al.* 2001, Chapman *et al.* 2013). Results from the 2012 Georgiana Slough non-physical barrier study illustrate that behavior when looking at fish. Entrainment into Georgiana Slough was highest during the night as compared to the day time hours. Fish tended to hold during the day and were less vulnerable to entrainment into Georgiana Slough.

References:

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