

Evaluation of potential drought effects on brood year 2013 Sacramento River winter Chinook

March 8, 2015

Introduction

Here we examine the evidence for drought effects on brood year 2013 Sacramento River winter Chinook salmon (SRWC), which will be exposed to ocean fisheries in 2015 as age-3 fish, and will return to spawn as age-3 during the winter of 2015/2016. Mature SRWC adults that returned to the Sacramento River in the winter of 2013 spawned in the summer of 2013. Their brood year 2013 progeny reared and emigrated from the Sacramento Basin in a period between the autumn of 2013 to winter/spring of 2014.

The winter/spring of 2013 was dry in northern California. By early March 2013, the U.S. Drought Monitor (<http://droughtmonitor.unl.edu/MapsAndData/MapArchive.aspx>) classified the region as “abnormally dry”. By mid-June, the region was considered to be in a “moderate drought” and by July conditions were classified as a “severe drought”. By February 2014, the region was classified as being in an “extreme drought”, and remained at this classification through the emigration period for brood year 2013 SRWC. In the summer of 2014 drought conditions degraded to the classification of “exceptional drought”, though the effects of drought from this period would be confined to brood year 2014 SRWC, which are not considered in detail here.

The next sections evaluate whether the effects of drought could be detected from examination of brood year 2013 SRWC abundance and survival estimates from the Sacramento River and delta. In most cases, the effects of drought were inferred from examination of time series of abundance or survival estimates to determine whether estimates for brood year 2013 were anomalous. We consider spawner abundance data, as well as juvenile information from Red Bluff Diversion Dam (RBDD) downstream through the Delta.

Spawner escapement in 2013

The estimated spawner return to the Sacramento Basin in 2013 was 6,085 (5,623 adults and 462 jacks). Figure 1 displays a time series of spawner returns, estimated from carcass surveys, for years 2001 through 2014. The 2013 escapement was the largest since 2006, and was similar in magnitude to escapement in 2001-2004. Reclamation (*in press*) noted that there was little evidence for prespawn mortality for the parents of the 2013 brood.

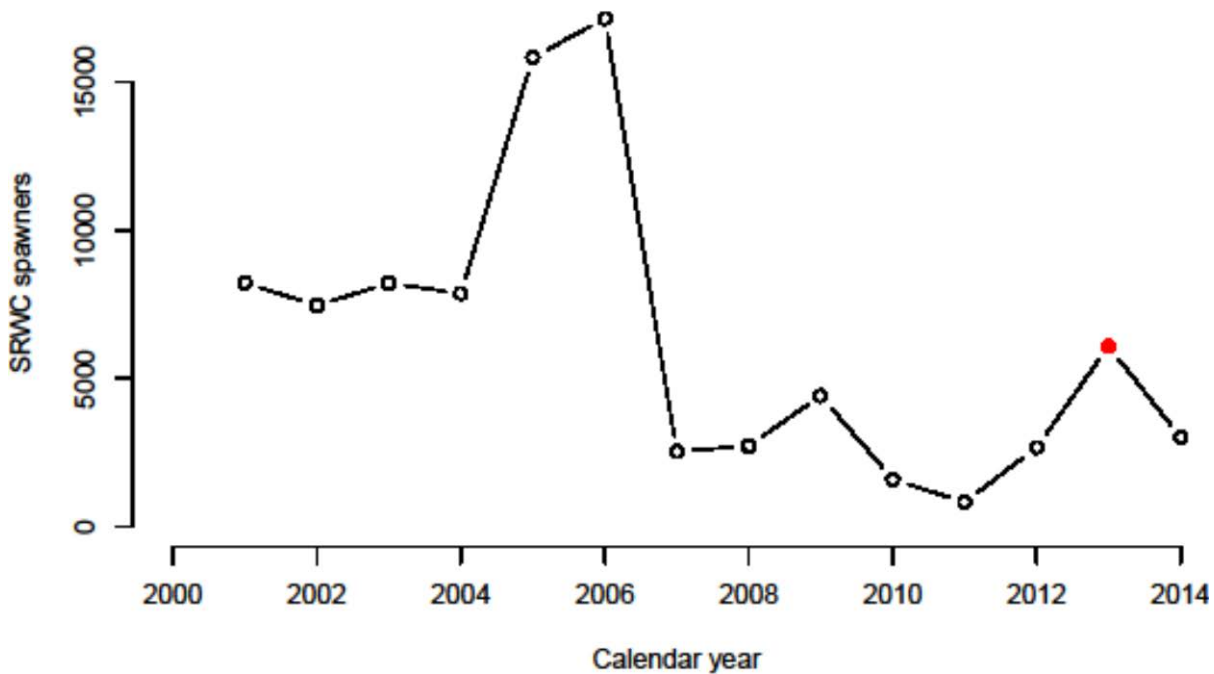


Figure 1. Estimates of Sacramento River winter Chinook spawner escapement. The red dot indicates the parental spawning escapement for brood year 2013. Data obtained from the PFMC Review of 2014 Ocean Salmon Fisheries Report.

Juvenile production and survival based on Red Bluff Diversion Dam data

USFWS has estimated a rotary screw trap data-derived juvenile production index (JPI) in most years since 1995; details regarding the sampling and estimation procedures can be found in Poytress and Carrillo (2012). The JPI is an estimate of the brood year-specific, natural-origin winter Chinook passage at RBDD, in terms of fry equivalents. It is a direct measure of juvenile production from natural spawning areas. Egg to fry survival rates are derived from winter Chinook carcass survey female escapement estimates, estimates of the number of eggs per female, and the JPI.

The brood year 2013 JPI was not abnormally low relative to estimates from the past several years (Figure 2). This occurred despite a relatively low egg to fry survival rate, though the brood year 2013 survival rate was similar in magnitude to several broods in the mid-2000s (Figure 3). The preliminary brood year 2014 egg to fry survival rate is substantially lower than all previous years.

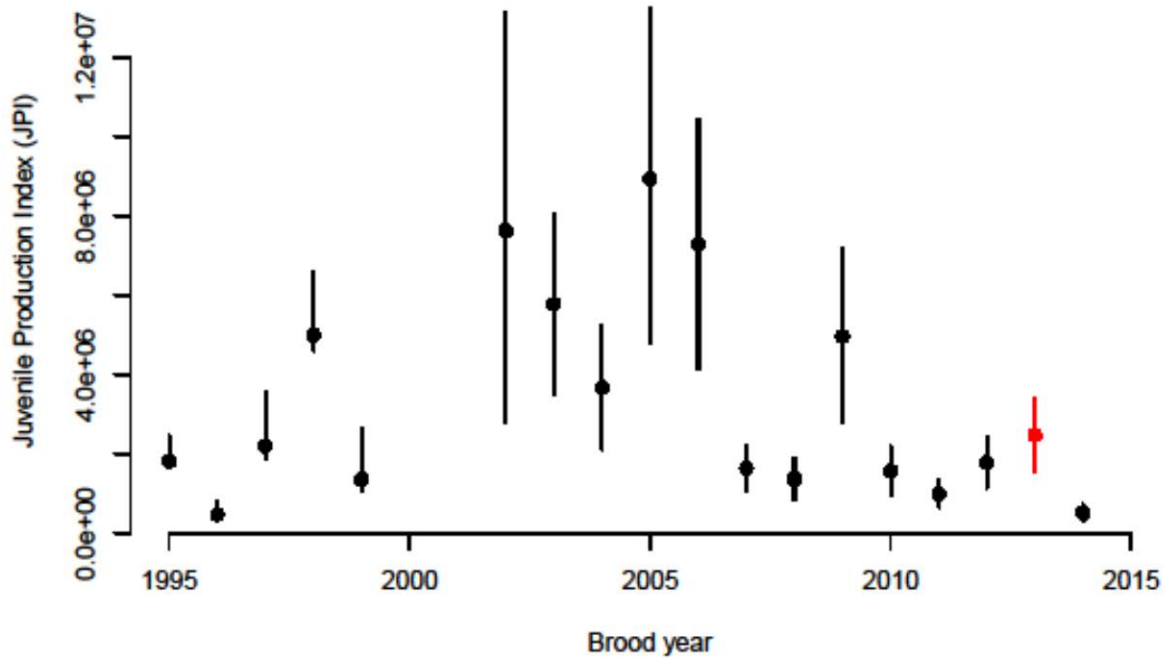


Figure 2. Juvenile Production Index (JPI) estimates with 90% confidence intervals. Brood year 2013 is depicted in red. Data obtained from Poytress and Carrillo (2012), B. Poytress (personal communication), and J. Smith (personal communication).

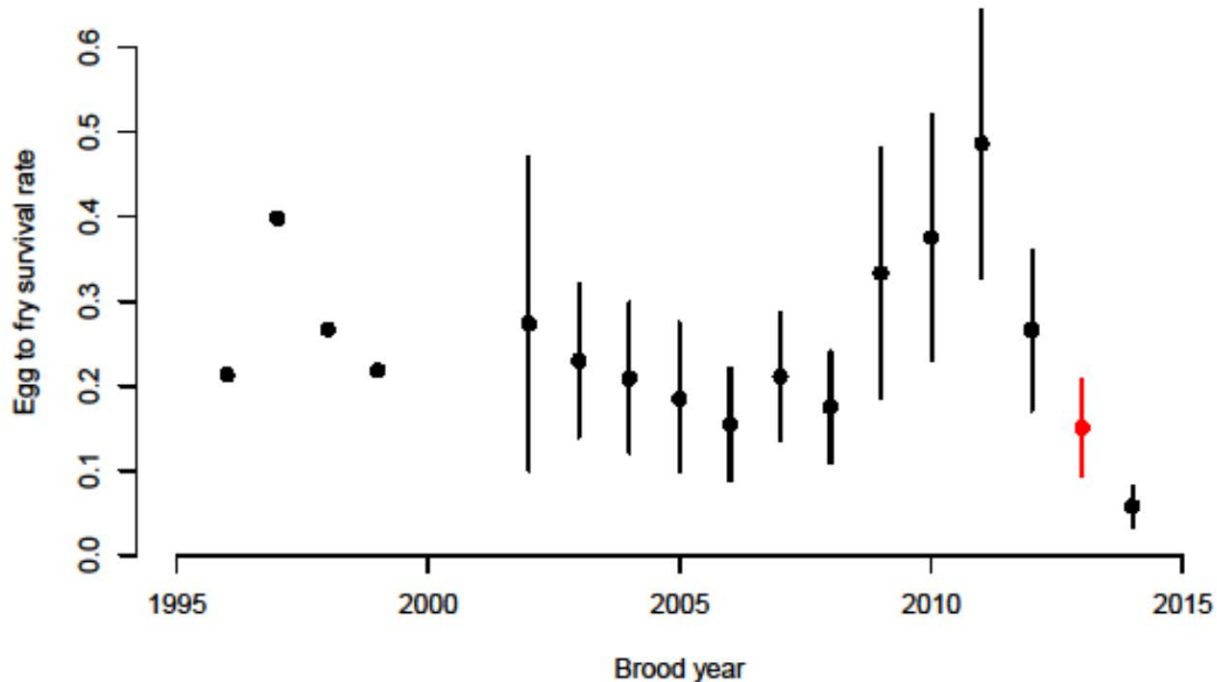


Figure 3. Egg to fry survival rates with 90% confidence intervals. Brood year 2013 is depicted in red. Data obtained from Poytress and Carrillo (2012), B. Poytress (personal communication), and J. Smith (personal communication).

In summary, despite the low egg to fry survival rate for brood year 2013, a modest JPI resulted due to the relatively large (for the recent past) parental spawner escapement.

The JPI has somewhat limited explanatory power for adult spawner escapement in brood year + 3 (Figure 4). The data in this figure have been confined to escapement estimates made from carcass surveys (brood year 1998 onward), and omits estimates based on RBDD counts and expansions. The number of natural-origin spawners in brood year + 3 is not confined exclusively to progeny from a particular brood year as there are likely to be a small number of 4 year old SRWC included in the adult escapement estimate. Nevertheless, there is a noisy but positive relationship between the JPI for a particular brood and the returning, natural-origin adults in brood year + 3.

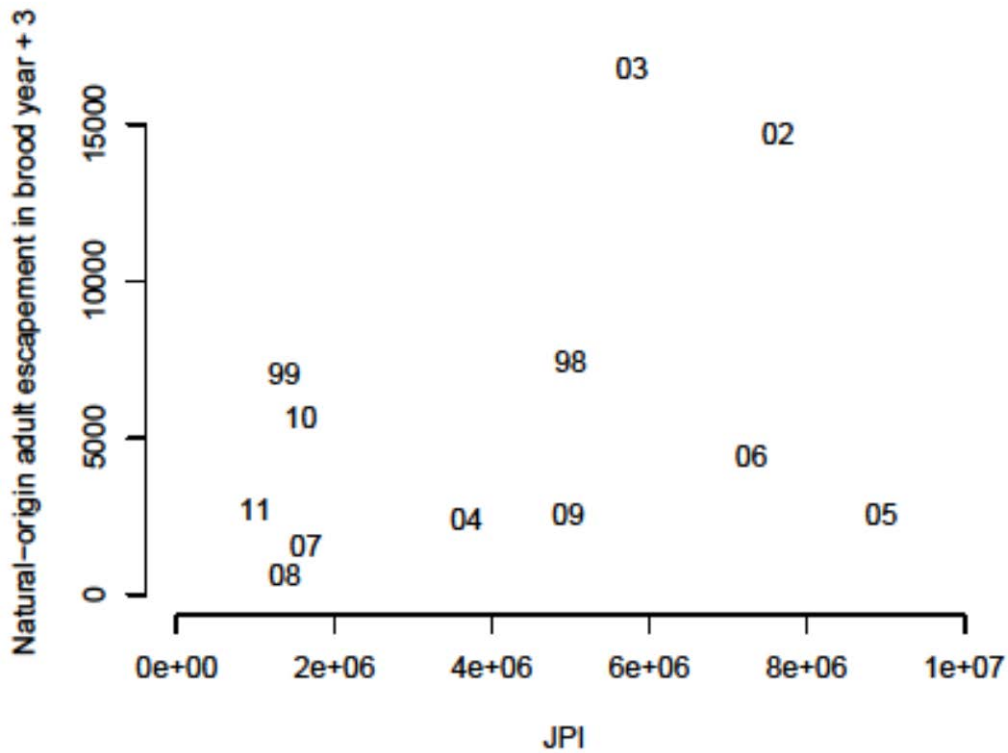


Figure 4. Relationship between the Juvenile Production Index (JPI) and the number of natural-origin adult spawners three years later. Numbers denote brood years.

Reclamation (*in press*) evaluated the potential for bias in the brood year 2013 JPI owing to a variety of factors, including the cessation of trap operation during federal government shutdown, which coincided with a historically heavy period of winter run passage at RBDD. They made no definitive conclusions regarding the magnitude of potential biases in the JPI, except to mention that: “The Team believes the estimated JPI, which is outside the range of deviation from expected JPI values [as compared to the NMFS JPE], and its overall low value may reflect effects of other environmental and management drivers on juvenile production above Red Bluff Diversion Dam and not just sample effort alone” (Reclamation *in press*).

Catch-per-unit-effort at Chipps Island

Chipps Island is located in the Sacramento-San Joaquin Delta, downstream of the confluence of the Sacramento and San Joaquin rivers. Midwater trawl sampling has been conducted at Chipps Island year-round since 1994, primarily to gain relative abundance information on juvenile salmon as they leave the Delta.

Estimates of SRWC catch-per-unit-effort (CPUE) from Chipps Island trawls are depicted in Figure 5. The CPUE results suggest that the relative abundance of brood year 2013 SRWC was of approximately equal magnitude for the previous several years. These CPUE indices do not suggest anomalously low abundance of brood year 2013 SRWC emigrating from the Delta in 2014. Estimates for brood year 2014 were unavailable at the time this analysis was completed.

Winter Chinook are distinguished from other Chinook runs in the Chipps Island data by length-at-date criteria. However, there is considerable overlap between SRWC length and the length of other Chinook runs in similar date ranges which could contribute to stock assignment errors. See Pyper et al. (2013) for a comparison of length-at-date and genetic assignment differences for Chinook salmon sampled at Chipps Island.

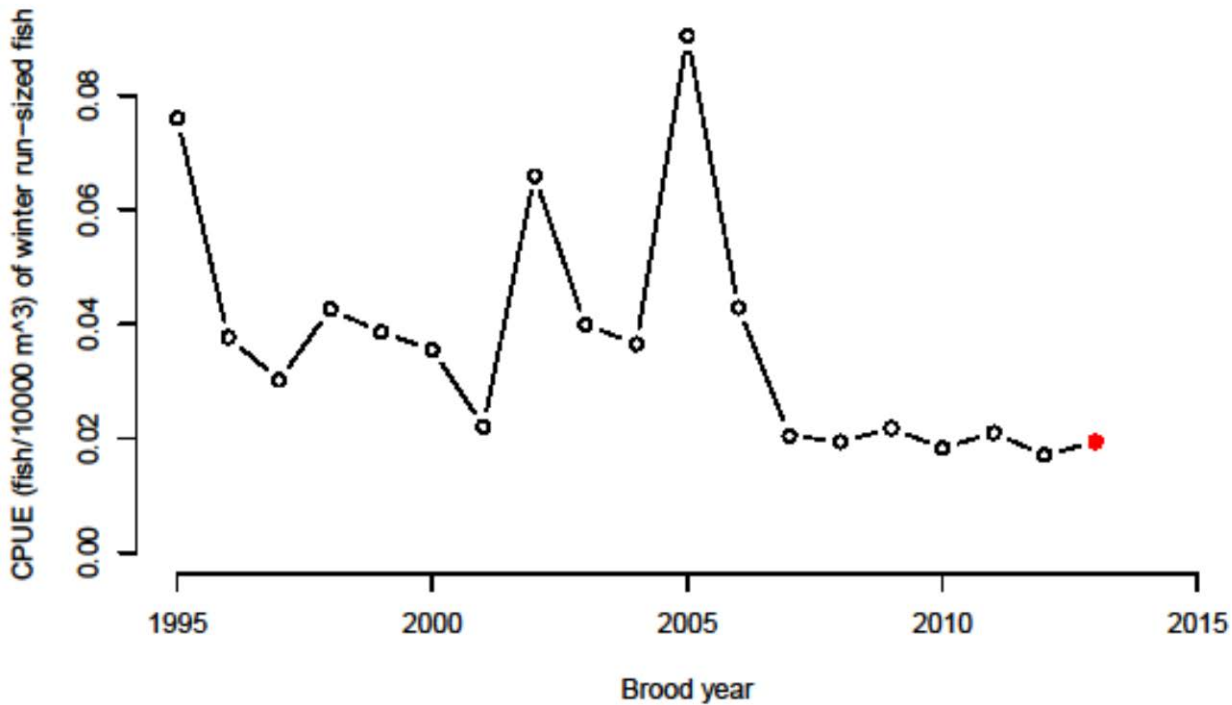


Figure 5. Estimates of catch-per-unit-effort (CPUE) for winter Chinook-sized fish plotted by brood year. Brood year 2013 is denoted by the red dot. Data provided by P. Brandes and M. Dekar (personal communication).

Hatchery-origin winter Chinook survival rates

Survival and movement of hatchery-origin SRWC through the Sacramento Basin into San Francisco Bay using acoustic telemetry has been conducted since 2013 (representing the rearing and emigration period for brood year 2012). Brood year 2013 outmigrants experienced higher survival (12.5%) relative to brood year 2012 outmigrants (5%) in the region from the upper Sacramento River to Benicia, which is 52 river kilometers from the

Golden Gate Bridge (A. Ammann, personal communication). Movement data indicated that for both the 2012 and 2013 broods, juveniles held in similar locations in the Sacramento River, but the holding period was substantially shorter for brood year 2013 relative to 2012. This result suggests that increased survival is associated with shorter holding periods in the Sacramento River.

While these results are informative, the short time series does not allow for placing these survival rates into a historical context. Furthermore, the survival rates are estimated from hatchery-origin fish and may not be representative of survival rates for natural-origin juveniles.

Ancillary information

Reclamation (*in press*) describes various aspects of rearing duration and characteristics of emigration for brood year 2013 SRWC. While these descriptions do not allow for quantitative inference regarding survival through the Sacramento River and delta, we note the patterns described in the report.

In their analysis of brood year 2013 SRWC, Reclamation (*in press*) noted that: (1) SRWC exhibited unusually extended rearing above RBDD that ended abruptly with a quick, high density emigration toward the end of the rearing period; (2) the time between the median cumulative catch at RBDD and Knights landing, a measure of residency time in the Sacramento River, was above average, but well within the range of previous years; (3) and fish arrived in the Delta later than normal, reared for a shorter period of time than normal, and emigrated out of the Delta quickly.

Summary

Available information for brood year 2013 SRWC indicates that juveniles exhibited extended rearing in the upper Sacramento River above RBDD, which likely contributed to the relatively low egg to fry survival rate. However, owing to the relatively large spawner return, the JPI for brood year 2013 was not abnormally low and was in fact larger than many recent years.

Below RBDD, the results of Reclamation (*in press*) suggest that residence time in the Sacramento River and Delta for brood year 2013 were either in the range of past years (Sacramento River) or relatively short (Delta), with unknown survival consequences. Acoustic telemetry data suggest relatively large differences in holding times and survival rates in the Sacramento River between the 2012 and 2013 broods, with brood year 2013 characterized by a shorter residency time and higher survival rate.

It has been hypothesized that extended residency in the Sacramento River is associated with higher mortality. This hypothesis appears to be consistent with the low egg to fry survival rate above RBDD coinciding with extended rearing in the upper river and with the acoustic telemetry results when compared across brood years 2012 and 2013. Following this hypothesis, the residency periods in the Sacramento River and Delta noted in Reclamation (*in press*) do not suggest that abnormally high mortality rates would be expected for brood year 2013. We however make this statement with caution because these inferences are based on an assumed association between residency time and mortality rates. Estimates of winter Chinook-sized fish catch-per-unit-

effort estimated from Chipps Island trawls do not suggest anomalously low winter run density when compared to the previous six years.

References

Reclamation. *In press*. Winter-run Chinook Salmon Drought Operations and Monitoring Assessment. Prepared by: J.A. Israel, B. Harvey, K. Kundargi, D. Kratville, B. Poytress, K. Reece, and J. Stuart.

Poytress, W. R. and F. D. Carrillo. 2012. Brood-year 2010 Winter Chinook Juvenile Production Indices with Comparisons to Juvenile Production Estimates Derived from Adult Escapement. Report of U.S. Fish and Wildlife Service to California Department of Fish and Game and US Bureau of Reclamation.

Pyper, B., Garrison, T., Cramer, S. Brandes, P.L., Jacobson, D.P, and M.A. Banks. 2013. Absolute abundance estimates of juvenile spring-run and winter-run Chinook salmon at Chipps Island. A report funded by Delta Science of the Delta Stewardship Council (previously CALFED Bay-Delta Program), Grant Agreement Number 1049.