Estimates of Chinook salmon embryo production within the Lower American River, California, 2013-14 spawning year and ramifications for flow management decisions

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Executive Summary

- Two methods were used to estimate (bookend) potential number of Chinook salmon embryos exposed to dewatering during the January flow reduction in the Lower American River.
- Using the estimated adult Chinook salmon escapement to the LAR, an approximated 146,796,462 eggs were available for natural incubation in the LAR for the 2013-14 season.
- If we assume that each redd has the same number of embryos then 16,167,411 potential embryos were in the estimated dewatered areas using this method.
- Using the estimated 2840 redds from aerial photo surveys and the assumption that each redd has the same number of embryos, we estimate 17,042,840 embryos in the river from natural production.
- If we assume each redd has the same number of embryos and 11% of redds were dewatered, then 1,874,712 potential embryos are in the estimated dewatered areas.
- It is important to note that genetics, predation and other environmental conditions would reduce these estimated numbers even within the flow-related issues.

Background

To estimate the effects of the January 2014 flow reduction on LAR Chinook salmon production, it is important to approximate reproductive success, and in turn, potential embryos and fry that could be affected by the initial flow change and subsequent management actions.

Because exact enumeration of reproduction is difficult, population appraisals are often made via sub-sampling and extrapolation. We have two potential methods to estimate production within the LAR: approximations of (1) adult escapement to the LAR and (2) approximations of redds produced from escaping adults. In both cases, the goal will be to estimate the number of Chinook salmon eggs/embryos that were produced in the 2013/14 season and then approximate those exposed during the flow reduction.

***Adult escapement.*—** A variety of methods are used to estimate CV adult escapement including hatchery returns and direct counts at fish ladders and weir facilities (Williams 2006). However, the most consistently used method to generate escapement estimates involves mark-recapture techniques applied to carcasses (Williams 2001). Since 1976, the California Department of Fish and Wildlife (DFW) has used a modified Schaefer method but recently has reported estimates based on the Jolly-Seber method (e.g., Snider and Reavis 1996), and the agency is currently developing procedures for calculating adult escapement estimates using a superpopulation modification to the Cormack-Jolly-Seber model. This effort has been expanded and significant work has been performed to compare and contrast various escapement estimates on specific systems including video, infrared imaging, DIDSON, carcass, and hatchery escapement estimates (Merz and Merz 2004; 2004b; Holmes et al. 2005). Estimates of female escapement multiplied by fecundity provide an estimate of potential eggs and embryos available to the reproduction year.

Spawning. —Redd counts are commonly used to index adult escapement and assess population trends (Beland 1996; Rieman and Myers 1997; Isaac et al. 2003). As the product only of reproductive females, redd counts provide an index of effective population size (Meffe 1986). The use of redd counts for population monitoring may be complicated by superimposition or if females produce false, "test" redds (Crisp and Carling 1989; Gallagher and Gallagher 2005). Redd enumeration errors must be identified and reduced before this method can be useful for long-term monitoring (Maxell 1999; Dunham et al. 2001).

Chinook salmon redds are typically monitored by two methods: direct count by wading and boat on smaller streams (Merz and Setka 2004) and aerial photographs on larger streams where water quality is clear enough to identify where female salmon have disturbed the gravel substrate (Williams 2001). Egg retention, identified in post-spawn females collected during carcass surveys, is often used as an indicator of spawning success and has been correlated with stream temperature and predation in other systems (Quinn et al. 2007).

Because not all females escaping to the Lower American River (LAR) are successful in redd production we will use (1) female escapement as an upper end. Because redds are consistently under-estimated by aerial photo surveys, we will use (2) redd estimate as a bottom-end estimate of reproduction[1].

(1) The female escapement method for estimating the number of potential embryos affected by redd dewatering is calculated by the following equation:

    Potentially Impacted Embryos = total number of females escaping to LAR * estimated fecundity of LAR females * the proportion of carcasses that did not retain eggs * the proportion of redds dewatered during the draw down.

(2) The redd method for estimating the number of potential embryos affected by redd dewatering is calculated by the following equation:

[1] If the group decides it is warranted, we can calibrate aerial photos with ground surveys to make a stronger estimate of actual redds at a future date.

Potentially Impacted Embryos = total estimated number of LAR redds * estimated fecundity of LAR females * proportion of redds dewatered during draw down.

Another important parameter is the success of incubating embryos to emergence. This is related to numerous parameters including, genetics, water quality, predation, substrate quality, and flow. Some of these parameters, such a genetics, we do not have good information on. However, for some, such as water quality, we will not be able to make a final estimate on until samples are completed. Therefore, the numbers provided below are an estimate of the total embryo potential for the 2013-14 period. The number that would survive to emergence would be less than this even if low flows were not an issue.

Method 1

We used the preliminary estimates from the carcass surveys provided by BOR, CDFW and PSMFS (Special thanks to John Hannon and Jeanine Phillips).

- The final in-river escapement estimate for 2013 is 54,259.
- The male/female (including grilse) proportions are 48%/52%, respectively
- An estimated 13.3% unspawned (Therefore 86.7% successful)
- 54,259 * 0.52 * 0.867 = 24,462 successful females

Estimated female fecundity comes from data collected by CDFW at the Nimbus Hatchery from 2008 – 2011.

- Average 6001 eggs per female (range 5480-6259)
- An estimated 146,796,462 eggs available for natural incubation in the LAR for 2013-14 season

The proportion of redds dewatered is from the draft report provided by CFS.

- Estimated redd dewatering/stranding for the entire LAR for each cumulative flow step (i.e, 1100-800, 1100-700, 1100-600, 1100-500 cfs) was <1%, 1%, 3% and at completion of the 600 cfs flow reduction was 11%, respectively.

If we assume that each redd has the same number of embryos then 11% of 146,796,462 is 16,167,411 potential embryos in the estimated dewatered areas.

Method 2

The total estimated number of LAR redds was provided by Aerial photo surveys (John Hannon):

- 2,840 identifiable redds

Estimated female fecundity comes from data collected by CDFW at the Nimbus Hatchery from 2008 – 2011.

- Average 6001 eggs per female (range 5480-6259)
- An estimated 17,042,840 eggs available for natural incubation in the LAR for 2013-14 season using redd counts

The proportion of redds dewatered is from the draft report provided by CFS.

- Estimated redd dewatering/stranding for the entire LAR for each cumulative flow step (i.e, 1100-800, 1100-700, 1100-600, 1100-500 cfs) was <1%, 1%, 3% and at completion of the 600 cfs flow reduction was 11%, respectively.

If we assume that each redd has the same number of embryos then 11% of 17,042,840 is 1,874,712 potential embryos in the estimated dewatered areas.

Discussion

Calculations provided in this draft report are bookend estimates meant to afford information for discussion on potential management actions. Neither takes into account natural variability in female health, genetics, predation or other parameters that may have made spawning Chinook salmon more or less successful in depositing young into the gravel. Even so, these data provide a good range of potential loss or benefits from environmental conditions and management actions.

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