Lower Putah Creek

2016 Gravelbed Scarification and Salmon Report

Prepared for:

Richard Marovich
Putah Creek Streamkeeper

Prepared By:

Ken W. Davis
Aquatic Biologist / Wildlife Photojournalist
Wildlife Survey & Photo
2443 Fair Oaks Blvd. # 209
Sacramento, CA
(916) 747-8537
ken@creekman.com
www.creekman.com

Wildlife Survey & Photo Service
2443 Fair Oaks Blvd. # 209 • Sacramento, CA 95825 • (916) 747-8537

To: Richard Marovich
Putah Creek Streamkeeper

Subject: 2016 Lower Putah Creek (LPC) Gravelbed Scarification and Chinook Salmon Report

Please see the report attached with this letter. The report covers:

1. The 2016 Lower Putah Creek salmon run
2. Observations and thoughts about the salmon run
3. Limited information about the scarification project
4. Results of the scarification after impacts from the 2017 floods
5. General information about benthic macroinvertebrate (BMI) communities
6. Suggestions to improve the streambed condition of Lower Putah Creek.

This report does contain some opinions that are contrary to impressions expressed by others. In every case, I have provided some observations, subsurface video footage, images, or background information to support my opinions. In some cases, I have provided direct quotes from papers that have been proved especially wrong or expressed opinions that have been demonstrated to be unsupported by factual or scientifically proven data. Considering the history and nature of the Lower Putah Creek salmon runs, it is my opinion that we must remember that good science must reign, not just opinions without documentation.

In most cases, my observations and supported opinions are expressed to assist the Streamkeeper in making management decisions. In addition, this report is just one in a series that is required for fulfilling the permit requirements of the **2016 Lower Putah Creek Gravelbed Scarification Construction and Monitoring Plan** approved by the California Department of Fish and Wildlife.

When this report is viewed online, it is an interactive PDF that has links to video footage. This is especially helpful when documenting some of the observations we have learned from using subsurface video of spawning salmon and other native fish.

Ken W. Davis
Aquatic Biologist / Wildlife Photojournalist

Executive Summary

On May 1, 2013, direct observation and subsurface video footage documented thousands of juvenile Chinook salmon near the Putah Diversion Dam (Juvenile Salmon Video). Their presence proved that adult salmon had been in the Lower Putah Creek system and spawned successfully. This fact is important became this video footage can be considered the genesis of the Lower Putah Creek Fish Video Project by documenting the juvenile salmon in the system. For numerous reasons, including limited surveys and muddy water, neither adult salmon or carcases were seen in the creek during the December 2012 spawning season. The date was also important for stream management because it was after the annual Spring Pulse Flow required by the Putah Creek Accord and the fact that thousands of juvenile salmon remained in the system and did not migrate downstream.

In December 2013, eight adult Chinooks (Video Link) were documented spawning in an area directly below the Pickerel W-Weir where the gravel was open (not embedded), possibly due to the action of the weir. Other observations lead to the development of five scarification test sites and a control site in 2014.

Cobble showing the lower area that was 75% embedded (The lower algae-free section was buried). The top 25% of the cobble was the only section that was usable to benthic macroinvertebrates. Note the Glossosoma (caddisfly) cases on the top of the cobble. Most Glossosoma can survive fish predation due to their protective cases. Ken W. Davis

In the December 2014 salmon spawning season, more than 200 salmon were documented within the Lower Putah Creek spawning section (Davis 2015). Salmon selected the five scarification sites first with each site supporting a maximum number of salmon. Rainbow trout also spawned at several of the test sites. That was the first documentation of rainbow trout spawning in the Lower Putah Creek.

No additional scarification work was conducted in Lower Putah Creek prior to the 2015 salmon spawning season. In December 2015, more than 800 salmon were documented in the Lower Creek (Davis 2015). Daily observations documented that each of the five 2014 scarification sites were again selected first by the migrating salmon. Spawning occurred successfully at each scarification site,

Cross section of large chuck of embedded gravel. Note the layers of small gravel (top), a layer of gravel, and a thick layer of sand and fines. Collected from a section of Lower Putah Creek in an area that is plagued by embedded and cemented gravel.

with redds that were well-developed and deep enough to support eggs and alevin. Other sites were used by the salmon, but as documented by subsurface video, the redds were shallow and in poor streambed conditions that did not support the protection of eggs and hatching alevin. Funded by the Solano County Water Agency, the 2016 Scarification Project was permitted by CDFW with 13 sites allowed in 2016 (Davis 2016). Twenty-six more sites will be allowed under the permit, thirteen in 2017 and thirteen in 2018.

The 2016 Lower Putah Creek salmon run was estimated at 1800 (plus) Chinook Salmon, many in the 30-40 pound range (Salmon Video). Toward the end of the run, additional fish arrived near the Putah Diversion Dam making the existing salmon count difficult. The actual number was certainly more than 1800. The count was based on daily observations of spawning fish in specific areas that allowed for strong estimates. Other salmon count protocols use the number of redds and carcass counts to estimate the number of spawning salmon. Those techniques were rejected due to the fact that the spawning salmon in Putah Creek primarily concentrated in distinct and spatially separated scarification areas. That situation allows for accurate observation and fish counts., The concentration allows for the observation and filming of specific fish. In the past, salmon counts have been made by one or two canoe trips which were possibly efficient during small salmon runs. In contrast, creek side and subsurface observation (video) allows for direct observation of the fish with comparison of health, the number of fish per redd, construction of the redds, quality of redds and other unusual factors such as the video in 2015 that documented Chinook spawning with rainbow trout and eighteen-inch female Chinook salmon (Jills) that spawned with normal size males. The results of the video process documented the spawning process and provides a plethora of media for use in education, public relations and official documentation of the salmon run.

Embeddedness:

Streambed embeddedness is a condition best understood by those who measure communities of benthic macroinvertebrates. Having to enter a waterway and dig your hands into the benthic gravel will quickly determine the amount of open, loose gravel versus a loose veneer of surface gravel and a hardened layer of cobble, and fines below. In severe cases it is impossible to dig out larger cobble with your hands or with small hand tools.

Scarification demonstration site in 2014. Image shows line of embedded cobble that was opened by a medium-reach excavator operating from the bank. Image Ken W. Davis.

Scarification process prior to the 2016 salmon spawning season. Using expert operators, riparian damage is minimal. A biologist is always on-site before and during the process to watch for wildlife. Image Ken W. Davis.

Gravelbeds can appear healthy from the bank, when in fact the gravelbed can be essentially cemented in place. As outlined below, the scientific literature is replete with descriptions of embeddedness with no appreciable suggestion(s) about how to cure or correct the condition. The quote below from Sennatt (2008) reveals the scientific confusion about embeddedness and even its measurement:

> *"Embeddedness is a seemingly simple concept regarding the degree of streambed sedimentation. Waters (1995) defines it as the percent saturation of interstitial spaces. As Sennatt et al. (2006) point out, numerous studies have correlated the concept of high embeddedness with degraded benthic habitat and a decline in macroinvertebrates. However, measurement of embeddedness in the field has always been problematic (Sylte and Fischenich, 2002). Validated standard methods are lacking and there is no common precise definition of embeddedness. While embeddedness is generally defined as the ''degree to which fine sediments surround coarse substrates on the surface of streambeds'' (Sylte and Fischenich, 2002), most measurement techniques measure embeddedness as the depth of fines surrounding larger substrate while visual techniques tend to estimate the percentage of the streambed surface covered by fines. To further complicate the matter, the weighted Burns Quantitative (BSK) Method, combines an estimate of surface coverage with a measurement of embeddedness depth."*

Cementation:

It appears that over time, the condition of "embeddedness" can turn to a condition that we call "cementation" for the purpose of this project. When the streambed becomes cemented, it is even difficult for an excavator to break through the crust, and essentially impossible for benthic invertebrates or salmonids to use.

Female Tree Swallow with a beak full of mayflies to feed her chicks. She caught the mayflies over the creek and riparian interface. Image Ken W. Davis.

Causes of Embeddedness / Cementation:
The cause of the embedded condition appears to the settling of sand, silt, fines and other material. Cementation, from our observation is a more complex condition that is certainly understudied. We are attempting to have the condition analyzed using chunks of the material and to determine how they might have been formed. We suspect a complex chemical reaction in water combined with fines and sand creates the cemented condition. This is similar to the formation of concrete using powdered cement, gravel and water.

Impact(s) of Embedded Gravels on Aquatic Benthic Macroinvertebrates (BMIs): The aquatic food web, and a significant portion of the riparian food web, are driven by the BMI community. The aquatic phase of BMI species are a primary food source for native fish, including trout and juvenile salmon. The adult phase of aquatic BMIs are a major food source for several avian species that nest along the banks of Putah Creek. Other wildlife are also affected. BMI communities are negatively impacted by cementation. Closed interstitial spaces, called embeddedness or in severe cases cementation, prevents sensitive BMI species from seeking safe harbor among the streambed cobble. Mechanical scarification opens up the interstitial spaces allowing BMIs to seek safe areas within the cobble spaces and avoid predatory fish.

Salmon, trout and steelhead alevin can only survive when they have access to protective interstitial spaces between the appropriate size of cobble. Image Ken W. Davis.

Impact(s) of Embedded Gravels on Spawning Salmon and Trout: Benthic scarification will also significantly improve salmon and trout spawning areas as documented in 2014, 2015 and in 2016. Spawning improved dramatically without additional water releases, other management actions, or at additional cost. While other factors, such as the Accord Flows and stray hatchery-born salmon are contributory to the number of salmon in the system, the spawning success is solely driven by the scarification projects. Since 2004, and prior to the scarification projects I observed sporadic attempts by a few salmon to construct redds in embedded conditions that were suboptimal. Additional water releases would have minimal or NO positive effect on the spawning salmon. The Accord Flows, while potentially important for salmon attraction did not increase the Chinook population in Lower Putah Creek between 2000 and 2013. Salmon straying from Central Valley hatcheries can only successfully spawn when gravelbed conditions allow the females to construct effective redds. That was not possible to any significant level prior to specific areas being scarified (See image on Page 13). We anticipate another increase in salmon in 2017 and are scarifying 13 more spawning

Some important groups of benthic macroinvertebrates can only survive when the spaces between cobble particles are open and allow them to forage and seek harbor from predators such as trout and other predatory fish. Ken W. Davis

Open interstitial spaces between cobble is crucial to the protection and survival of salmonid eggs and alevin. Ken W. Davis

sections to prepare for additional salmon. Several studies of the gravel resources and viability for salmon spawning in Lower Putah Creek were grossly misleading with citations such as:

> *"Gravel is a limiting resource in Putah Creek for salmon; it occurs in only small patches and is often only a thin veneer over the underlying clay (Small 2004).*

Unfortunately another report (Yates 2003), which possible affected management decisions, surveyed the gravel resources, by digging down only 6 inches and testing the suitability for salmon spawning by

> *"...a hydrographer firmly swishing his hand (fingers pointed down) back and forth close to the gravel surface, mimicking the hydraulic effect of a fish tail."*

Fortunately, more recent and complete surveys have shown that Lower Putah Creek has copious deposits of gravel that are ideal for Chinook salmon. In some areas, gravel is 5-6 feet deep.

Impacts on Salmon eggs and Alevin

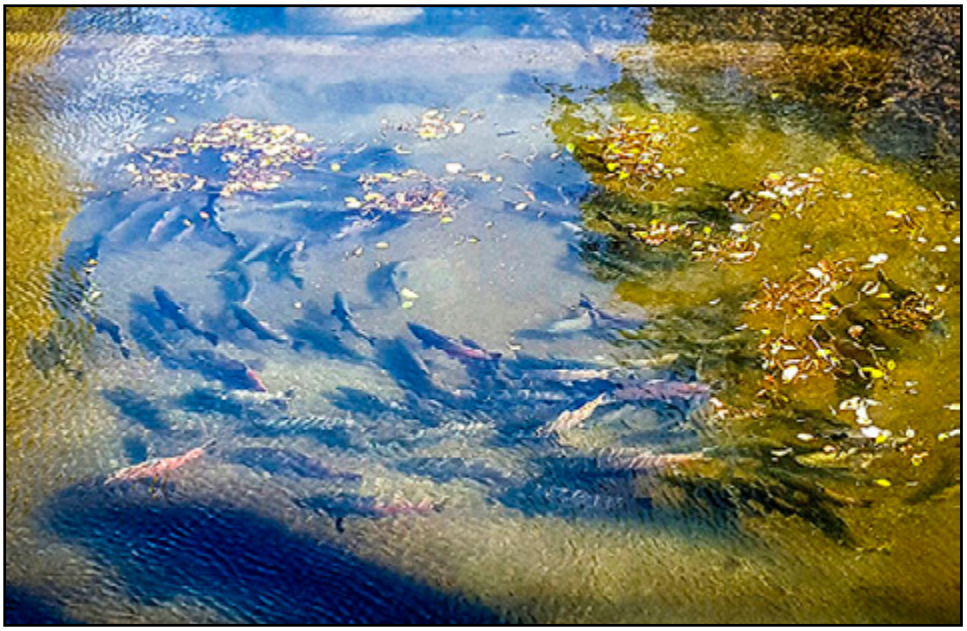
Open interstitial spaces between cobble particles allows water to flow through salmonid redds keeping eggs oxygenated. It also creates safe harbor for alevin (sac fry) until they emerge from the rocky nests. Alevin remain within a healthy redd for up to two months, or after utilizing the food resources within the egg sac. The embedded condition closes those spaces and prevents the survival of salmonid eggs and alevin. Of course, when the gravel is embedded, survival of alevin is a mute point because the adults can not successfully spawn.

Scarification Site Selection - Discussion:

Site selection is based on areas with significant gravel deposits, ease of access, landowner cooperation, riparian conditions, width of channel, flow regime, former studies, known salmon spawning areas, canoe survey data, and visual streamside examination. CDFW Agreement No. 1600-2016-0058-R3 (Weightman 2016) allowed for 13 sites to be scarified in 2016. We selected 16 sites, of which only 13 were scarified. Three backup sites were chosen in the event that unknown circumstances would exclude one or more of the original sites from the project.

Control Sites:

Several control sites were selected, the most interesting one was an original scarification site (2014 Harris C-2) that has been used by Chinook salmon for spawning in 2014, 2015, and 2016. They have effectively kept the gravelbed in a condition that would probably not require scarification. The salmon have also enlarged the site significantly every year. They have essentially tripled the size of the spawning area in three years (after the original scarification) by digging away at the edges. Once the embedded crust is opened with an excavator, it appears that salmon in the system annually can maintain the open gravel condition and enlarge the spawning area. It remains to be proven that the nonembedded condition maintained by the salmon will increase the diversity and density of certain benthic macro-



November 29, 2016 Putah Diversion Dam (PDD) Forebay: Shows small group of Chinook salmon in the PDD Forebay. Many remained for several days then moved downstream. Some even attempted to spawn in area of forebay that has very large boulders. Image Ken W. Davis.

invertebrates which require much of the same conditions as salmon. The redds from the 2016 salmon spawning seasons are still visible. The site has mild inundation by the sands moved during the 2017 floods. That site will remain untouched as a control site for at least five years.

The significant floods of 2017 totally buried our original 2014 Control Site under 3-5 feet of sand. Other sites impacted on various levels depending on their location and possibly their proximity to the flood plain.

Scarification Technique:
Scarification methodology used in Lower Putah Creek. (Quote from Agreement 1600-2016-0058-R3):

> *"Operating from the top of the bank, a small excavator fitted with a bucket rake attachment will mechanically scarify or rake the creek bottom to a depth approximately 12-18 inches to loosen cemented gravels. Over the term of the Agreement, scarification will occur at approximately 40 locations along 13 miles impacting approximately 1.5 miles (5 acres) of Putah Creek. If a pre-existing road is not available, then an excavator will remove vegetation to create an access road. The excavator will not grade or cut the access road and no trees larger than 4-inches in diameter will be removed. Riparian areas disturbed by the excavator will be restored with native grasses, trees and shrubs.*

On-site Monitoring for Wildlife
Before and during all scarification operations, an experienced biologist is on site. The area scheduled for scarification is checked for all signs of wildlife. The wildlife check includes all aquatic, riparian and aerial wildlife. If species are encountered that are not mobile, such as native mussels, the area will be abandoned and scarification will not occur. The existing permit allows for thirteen sites per year to be scarified. To ensure we capitalize on using the optimum number, sixteen sites are selected per year to have backup sites that qualify for the scarification project.

2016 Scarification Sites Update: See Page 15

2016 Salmon Run - Information and Update
The Lower Putah Creek Salmon run potentially begins with the removal of the boards at the Los Rios Dam which allows the Chinook salmon to enter the system. The boards were removed on 11/14/2016. The Fall Pulse flow of 50 cfs started at the Putah Diversion Dam on 11/18/2016. The required five-day pulse flow was terminated on 11/23/2016. Typically, the salmon can reach the Putah Diversion Dam within 24 hours if they are in the system and there are no obstructions preventing their upstream movement. By November 18th we could not find any salmon


One of initial wave of 30-40 pound Chinook that arrived at Putah Diversion Dam

at spawning sites where I can reasonably predict they will initially appear. Being that salmon had been observed near the Los Rios Dam soon after the boards were removed, we assumed that an obstacle (such as a large beaver dam) was possibly preventing the salmon from moving upstream. Indeed, a large beaver dam was located in an area where the fish could not navigate around or over the structure because it was built in an area where it had levee walls at both ends. Many large salmon were seen attempting to pass the dam. After legally notching the dam, the large Chinooks immediately raced through and continued upstream. It should be noted that the salmon almost knocked over the SCWA employee who temporarily opened a slot for the salmon to continue upstream. On the morning of November 19th, we had many salmon working areas within the scarification sites downstream from the Putah Diversion Dam. On November 20th, an estimated 100 salmon had reached the Putah Diversion Dam and were milling around in the forebay.

Initial Wave of Salmon:

Several waves of very large (30-40 pounds) were the first to arrive at the spawning grounds. Important to note that the first wave captured on subsurface video (approximately 50 fish) had their adipose fin. (Note: Approximately 25% of the Central Valley Chinook hatchery-raised salmon have their adipose fin clipped.) This is important because until 2016, the estimates of hatchery-raised salmon was by observation from the bank. In 2016, the Solano County Water Agency contracted with University of California, Davis to study the genetics of adult salmon and juvenile salmon in Lower Putah Creek. The results of otolith collections to determine natal origin of the adult salmon and other studies are pending.


Salmon over a redd developed in a Scarification Test Site. Note the smaller cobble in the middle of the "pot" and the larger cobble used to armor the redd. Image Ken W. Davis.

Counting Salmon on Daily Basis:

Every day possible, the main spawning sites were visited and the salmon counted. This included holidays such a Thanksgiving to maintain the integrity of the counts. Because the majority of the scarification sites are separated spatially, the counts can be more accurate by redd mapping and counting the salmon on specific redds. Control sections and other identified spawning areas were also mapped and salmon counted. Fish seen moving between spawning areas were not counted.

Flow Regime vs. Substrate Selected:

It appears that in some cases, the female salmon selected sites for spawning that featured ideal flows (depth and water speed) versus benthic conditions. At some sites, the females proceeded to attempt redd construction despite almost impossible conditions for egg and alevin survival. See recommendation for suggestions to possibly remedy this situation.

Post-flood section on 5/4/2017 at the Pickerel crossing and weir. Note the copious amount of sand on the opposite side of the crossing. Image Ken W. Davis.

Post 2017 flood. Sand dune developed along Lower Putah Creek near the Morales property. 4/5/2017 Image Ken W. Davis.

Size of Gravel Recommended for Spawning:

After significant observations of salmon spawning sites on the West Coast, Canada and Alaska, and direct observations and video surveillance of redds in several California waterways, I believe that the size of spawning gravels suggested for Lower Putah Creek (LPC) is too small. Direct observation in LPC and elsewhere has documented that when larger cobble are available, the female moves them to the outside of the redd and effectively creates an armored condition that protects the inside of the pot against high-water or flash-flood events. After reviewing articles relative to the suggested spawning gravel size, I suspect that the gravel measured (and suggested size) was collected from the redd in the bottom of the "pot." A sample of all the cobble from the outside of the redd to the inside was not collected or measured. In other words, the cobbles used to armor the redd on the outside were not considered.

Number of Observed Spawning Areas:

Although we had thirteen scarification sites, salmon spawning was observed at more than fifty sites between the Putah Diversion Dam and one-half mile down stream from the I-505 Bridge. The non-scarification sites ranged from marginally optimum sites such as the edges of the creek in Winters Putah Creek Parkway, to areas near existing weirs that were constructed prior to 2010, and suboptimal sites on the vehicle crossings.

Redd Superimposition:

Although, I'm certain that some redd superimposition occurred during the 2016 salmon spawning run in LPC, it was not significant. There appeared to be more redd coalescence where there was minor overlap and actual enlargement of the scarification sites to effectively increase the amount of prime spawning areas. The salmon at one site, that was scarified in 2014, have tripled the size of the original scarification site. They accomplished that feat by digging at the edges of the scarification area.

Other Possibilities for Increased Number of Salmon in Lower Putah Creek:

Stray Fish: Without a doubt, there has been a significant number of stray salmon that have entered Lower Putah Creek. According to CDFW, 25% of the salmon raised in Central Valley Hatcheries have their adipose fin clipped. Because many of the juvenile salmon are released in the Delta, they have no sense of their natal origin and will stray into other waterways.

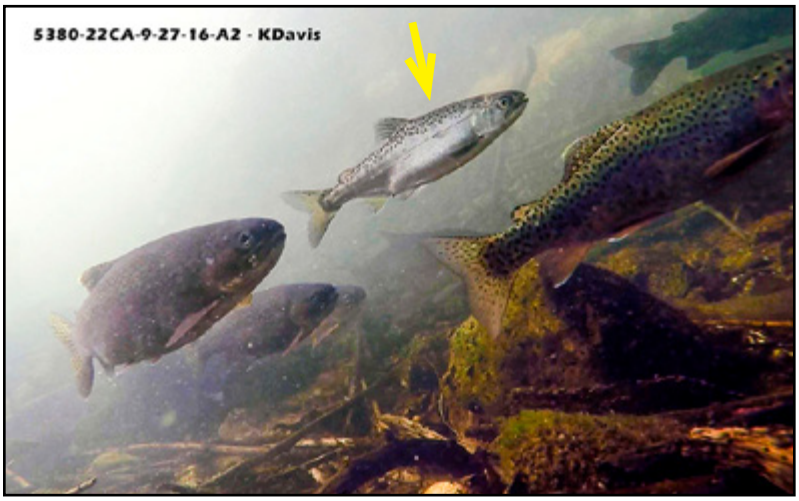


Image taken on 9-27-2017 shows a young salmon that was one of several that remained near the Putah Diversion Dam until late October 2016.

A large male Chinook carcass being held by U.C. Davis researcher.

The Drought: The extended drought has also been cited as a reason for the salmon to select Lower Putah Creek rather than seeking their natal waterway. In theory, Putah Creek, due to numerous beaver pond breaches and the Accord Pulse Flow, might have a superior "signature" or attraction flow when compared to other waterways.

Fingerings not exiting the system:
Juvenile salmon have a history of remaining in the system well past the Spring Pulse Flows that are designed to mimic spring storms and to signal the juveniles to migrate downstream. The fact that thousands of juveniles remained in the system at least until late May 2013 is not only curious and also important to managing the creek. It has been well documented that a few salmon even remain near the Putah Diversion Dam due primarily to conditions that include cool water, some safe harbor, and sufficient food conditions. The image on the upper left shows a small Chinook that remained near the Putah Diversion Dam until late October 2016.

Recommendations

1. **Scarification:** That the scarification project continue as planned within the "Lower Putah Creek Gravelbed Construction and Monitoring Plan." We are allowed to scarify twenty-six more sites via the CDFW permit. I suggest that if the number of salmon increases as it has during the last three years that we propose additional scarification sites if we can identify appropriate sites.

2. **Gravel Injection(s):**
There are numerous areas of the creek that have copious amounts of ideal spawning gravel on the banks. I submit that those sites be flagged and the gravel be cleaned, and relocated pending the necessary permits.

3. **Site Enhancement:**
Several sites that were used by spawning salmon were certainly suboptimal, but had some essential aspects such as good overhead cover, acceptable flow regime but lacked optimum benthic conditions. Several such sites are within the Winters Putah Creek Park and are possibly covered by existing permits. Those sites will be listed in the 2017 Scarification Site Schedule.

4. **Juvenile Refugia:**
One essential condition for successful juvenile down migration is having effective cover or refugia for them to seek safe harbor. In the past, we discussed using sedges to form refugia, unfortunately the plan was abandoned with the floods created by the Glory Hole flows. I will discuss this with the Streamkeeper again at the earliest opportunity.

5. Genetic Studies and Results:

I must congratulate the Solano County Water Agency for pursuing genetic studies that will help in determining the origin of the adult salmon spawning in Lower Putah Creek and incorporating the use of a screw trap to help determine the number of juveniles that migrate downstream. Distribution of the otolith results will be appreciated and will certainly help settle the ongoing controversy about the possibility of Chinook salmon returning to their natal stream. Based on observations for more than fifteen years in Lower Putah Creek I certainly have voiced my opinion that at least a few of the salmon are returning to Putah Creek as the stream of their natal origin.

A pair of Chinook Salmon that eventually spawned in a section that has marginal benthic conditions for effective salmonid spawning. Most of the boulders were moved by the female. Image Ken W. Davis.

Juvenile Chinook on 5/19/2016. Image Ken W. Davis

6. Importance of crossings and weirs and protecting salmon that are spawning on the crossings:

Possibly due to the flow regime and the plunge pool below the crossing / weirs, salmon and lamprey eels have both chosen to spawning in angular gravel and sub-gravel conditions. We have discussed options for improving this situation and closing the vehicle crossings during the spawning period and several months after the spawning period to protect salmon eggs and alevin that might survive in the crossing. The inconvenience seems minor with the state of salmon in California and protecting the developing salmon run in Lower Putah Creek.

7. Restoration in Upper Reaches for the main stem and tributaries within five miles of restoration sites:

Scientific literature is replete with studies that document effective restoration projects must be within five miles of benthic macroinvertebrate (BMI) taxa pools. I think the restoration projects in the InterDam Reach, Miller Creek and Pleasant Creek are certainly contributory to increasing BMI diversity and density within the Lower Creek. The ongoing scarification project is also crucial for the increase in BMI diversity and density as the open-gravel condition provides safe areas for many species of BMIs. Some species are also essential as prey for juvenile salmon.

8. Importance of Benthic Macroinvertebrates for juvenile salmon:

Several studies have shown opposing views about the importance of certain BMI species for foraging juvenile Chinook salmon (Albertson 2010). Ongoing surveys in Lower Putah Creek (Davis) have demonstrated that the preferred taxa for juvenile salmon are well represented. Captured and videotaped juveniles certainly show physical conditions that represent healthy conditions. See photo above.

9. Development of Salmon Observation from Winters Car Bridge:

The development of a salmon viewing on and below the Winters Car Bridge is important for several reasons including keeping the public off private property, educating large numbers of visitors to Winters, and helping to keep the public away from research areas essential to understanding the effectiveness of scarification, salmon using the scarification sites, and documenting BMI communities.

10. Are Salmon Returning to Putah Creek or Simply Lost:

Although this discussion might be academic, I believe the subject is too important to be pushed aside as simply, "These are lost hatchery salmon!" This is especially important when we consider the immense amount of work, dedication, project funding, and interest from the public. I believe that a certain percent (to be determined) are fish that have a natal origin in Lower Putah Creek (Davis 2017). Numerous questions remain that will hopefully be determined by studies funded by the Solano County Water Agency. My contention is based on years of observation of the limited salmon runs in Lower Putah Creek and certain events and situations that cannot be explained by proclaiming the salmon are all strays. The image below was taken in 2010 and happens to be the exact site (GPS documented) where salmon have spawned prior to 2010, in 2010, 2014, 2015, and 2016. While I certainly understand that salmon might select ideal conditions for spawning, it seems a stretch to assume that a series of stray hatchery fish will pick the exact same site in consecutive years. Contrary to the stray fish theory, I will place my confidence in salmon returning to their natal stream and selecting sites specific to the site of their origin.

I suggest that it is important to numerous individuals working on the restoration of Putah Creek, volunteers, local citizens, and the salmon who seek to return home that we remember the salmon are more than mere numbers or someone's legacy. Treating these amazing animals as "all strays," diminishes the work, dedication and millions spent for restoration. I recommend that we treat each of the returning salmon as the reward for many years of permit acquisition, planning, funding, difficult work, patience and belief in Putah Creek.

Chinook redd taken on 12/13/2010. Note the large overall size and shallow nature of the redd. No adult salmon were seen in 2010. Image Ken W. Davis

Submitted via e-mail on 9/25/2017:

Ken W. Davis
Aquatic biologist / Wildlife Photojournalist
2443 Fair Oaks Blvd. No. 209
Sacramento, CA 95825
(916) 747-8537
ken@creekman.com
www.creekman.com

References:

Albertson L.K., B.J. Cardinale, S.C. Zeug, L.E. Harrison, H.S. Lenihan, M.A. Wydza. 2010. *Impacts of Channel Reconstruction on Invertebrate Assemblages in A Restored River. Society for Ecological Restoration International*. 19: 627-638.

Davis, K. W. 2015. *Report 4963: 2014 Putah Creek Salmon Run*. Report to the Putah Creek Streamkeeper, the Lower Putah Creek Coordinating Committee and Solano County Water Agency. PDF 6pp.

Davis, K. W. 2015. *Interim Report: 2015 Salmon Survey (Winters Putah Creek Park).* Report to the Putah Creek Streamkeeper and the Lower Putah Creek Coordinating Committee. PDF: 6 pp.

Davis, K. W. 2016. *Construction and Monitoring Plan: Lower Putah Creek 2016 Streambed Gravel Scarification*. Prepared for the Streamkeeper and the Lower Putah Creek Coordinating Committee. 12 pp.

Davis, K. W. 2017. *Putah Creek Salmon: Lost or Coming Home?* Winters Express. Volume 134, Number 20. June 15, 2017.

Mertz, J.E. and C.K. Chan 2005. *Effects of Gravel Augmentation on Macroinvertebrate Assemblages in a Regulated California River.* River Res. Applic. 21:61-74. Wiley & Sons.

Sennatt, Kelly M., N. L. Salant, C.E. Renshaw, and F.J. Magilligan. 2008. *Assessment of Methods for Measuring Embeddedness: Application to Sedimentation in Flow Regulated Streams.* Journal of the American Water Resources Association. 42:6., 1671-1682.

Small, K.M., P.K. Crain, and P.B. Moyle. 2004. *Chinook Salmon in Putah Creek, Spring 2004*. 2004. Report to the Lower Putah Creek Coordinating Committee. 10pp

Yates, Gus. 2003. *Gravel and Temperature Surveys in Lower Putah Creek*. Prepared for the Lower Putah Creek Coordinating Committee. Berkeley CA. 34pp.

Weightman, G.J. 2016. Final Lake or Streambed Alteration Agreement. Notification No. 1600-2016-0058-R3. Lower Putah Creek Salmon Spawning Habitat Enhancement Project. 14 pp

2016 Scarification Site Update			
Note:			
Site No.	Site Name	Spawning Success	Current Post-Flood Conditions
C-1	2014 Control # 1	Few salmon attempted to spawn in Control Section that was embedded and hampered by copious willow roots. Success appeared to be marginal.	Section is currently covered by 3-5 feet of sand.
C-2	2014 Harris Scarification Site.	Salmon have spawned in this scarification site for three consecutive years, 2014, 2015, and 2016. It was selected for scarification in 2014 due to the fact that I found one redd at this site in 2010 and one redd in 2012. The redds were large in circumference and very shallow. No salmon were seen here during the years prior to scarification.	This scarification site has been kept as a control site in 2015 after approximately 30 salmon were observed using the site in 2014. As additional salmon reached the site, they enlarged the original scarification site by digging at the edges. After three consecutive years of salmon spawning on this site, they have effectively enlarged the site by 3.5 times. The site will remain as a control area through the life of the scarification project. Currently, the site has some sand between the interstitial spaces. Some of the 2016 redds remain visible.
C-3	2016 Morales Control Site	No spawning in 2014 or 2015. Several salmon dug into the edges of this site in 2016.	Marginally covered with sand.
1	PDD North	Site had marginal gravel resources mixed with sand. Several pair of salmon were observed digging redds.	The site was impacted by the 2017 floods. Although sand is copious at the site, there is also a large supply of spawning gravels nearby on the banks. Due to the proximity to the Putah Diversion Dam, nearby gravel and excellent tree cover, I will be recommending that this site be considered for minor retouch.
2	Pickerel Run	Site was scarified in 2016. On certain days, this site had 50-75 salmon	The site was greatly impacted by the 2017 floods and the removal of numerous fallen trees. The upper section of this site supported several pairs of spawning Lamprey eels. Unfortunately, this site has minor impacts from landowner activities such as rafting, swimming and trimming riparian Alder trees.

3	Pickerel N. Side	Side Channel had 8-10 groups (more than one female and one male) spawning in the narrow channel. Additional salmon showed up toward the end of the main spawning period.	The channel was essentially destroyed by the flood with copious amounts of sand, flood refuse and large logs. The site has been cleaned to remove flood debris. It will remain a significant spawning area in 2017.
4	Morales Riffles	The section had at least 12 redds with as many as 35 salmon using the site. The site was characterized by excellent spawning gravel and ideal flows.	Site was impacted by the 2017 Floods. Sand and logs impaired. Minor adjustments will be necessary to return the site to ideal spawning conditions.
5	Morales Curve	Site was characterized by excellent riffles, some overhead cover and a deep pool that separated the spawning areas. Twenty to twenty-five salmon spawned in this section. Additional fish showed up at the end of the regular spawn and attempted to enlarge the scarification site into the control (embedded) area.	Site was impacted by the 2017 Floods. Sand and logs impaired. Minor adjustments will be necessary to return the site to ideal spawning conditions.
6	Morales Run	Numerous pairs of salmon spawning in this section. Some is covered by streamside vegetation which complicates counting.	Site was impacted by the 2017 Floods. Sand and logs impaired. Site is currently being examined for work that might be needed.
7	Morales Pool	Deeper section of the reach. Great gravel on site. Numerous pairs of salmon spawned in this area. The depth and overhead cover made counting difficult. We estimated that 6-7 pair of salmon spawned during the regular spawning period.	Currently being studied for flood impact and future improvements to be recommended.
8	Dry Creek Confluence	This section was used by 30-40 salmon and several pairs of trout. It has ideal cover and gravel resources recruiting from Dry Creek.	Currently being studied for flood impact and future improvements to be recommended.
9	Bertinoia 1	Site used by 8-10 pair of salmon. It had ideal overhead cover, and excellent gravel resources.	Currently being studied for flood impact and future improvements to be recommended.

10	Neil Weir	The section between the Neir Crossing and the Neil Weir was used by 20-25 salmon over the period of the spawn. Deeper water at the head of the crossing made counting difficult.	Site is covered with copious amounts of sand, except along the edges. This site remains of the most ideal spawning sites in Lower Putah Creek due to the underlying cobble, flow regime and the sedge cover along the banks.
11	Winters Car Bridge	Site was designed with the intention for it to be ideal for public viewing. As it developed, several pair of salmon used the area directly under the Winters Car Bridge and 10-15 salmon used the section (nonscarified) immediately upstream from the bridge.	The site need to be refined, banks cleaned up and the section upstream should be scarified. This area is ideal for public viewing and should be developed with that intent.
12	WPCP Phase 2 (Outflow)	This site was severely embedded and difficult to scarify. The results were impressive with ideal spawning cobble underneath the embedded crust. 20-25 salmon were documented using this site.	Currently being studied for flood impact and future improvements to be recommended.
13	Kilkenny	Several sites were attempted in this area. Most were low in cobble and mostly deep mud. Despite the issues, each site had some cobble and each was used by spawning salmon.	Currently being studied for flood impact and future improvements to be recommended. The areas upstream and downstream of the weirs are ideal for salmon spawning.
Other Chinook Spawning Sites Noted in 2016			
Note: Many spawning sites were noted, mapped and observed. Some were marginal, some sub-marginal and a few were extremely marginal spawning areas. In several cases, it appeared that the females chose areas based on water flow rather than streambed conditions. Even with GPS data, many of the areas were decimated by the 2017 floods and currently unavailable for study. Several are being recommended for scarification, minor adjustments or gravel injection if permitted.			

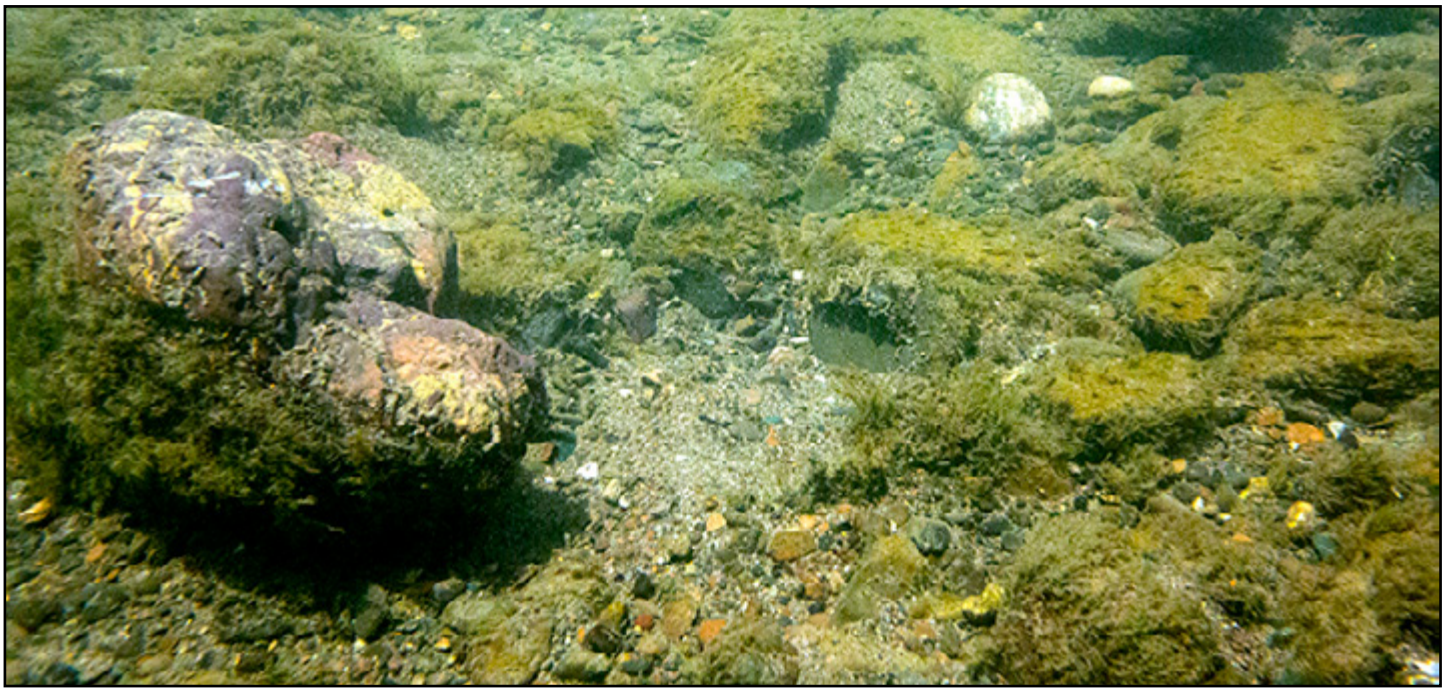


Image shows a cemented group of cobble that was flipped over, in the creekbed, leaving a "footprint" in a hard base of embedded gravel and sand. Only a limited number of BMI taxa can survive in this benthic condition. Planned Morales Scarification Site, 2017. Image Ken W. Davis.

Salmon viewers watching fish that were spawning below the Winters Car Bridge in December 2016. Difficult to debate the positive response of the local citizens and visitors to Winters. This is the new "Fanny Bridge." Image Ken W. Davis

END