SACRAMENTO RIVER DRAINAGE SPRING-RUN CHINOOK WORKSHOP SUMMARY

SEPTEMBER 8-10, 2020

Photo Credit: Randy Root U.S. Bureau of Reclamation

Contents

Background

The Delta Science Program (DSP) in coordination with the California Department of Water (DWR) and the California Department of Fish & Wildlife (CDFW), organized a workshop September 8 to 10, 2020, to support science-based management of Sacramento River Drainage spring-run Chinook salmon—a species vulnerable to extinction and listed as threatened under the Federal and California Endangered Species Acts.

The objective of this workshop was two-fold: to convene subject matter experts in order to take stock of the latest science regarding spring-run, and to serve as a public scoping meeting to inform management actions related to the Incidental Take Permit (ITP). The ITP, issued by CDFW to DWR for its operations of the State Water Project, calls for the development of a Juvenile Production Estimate (JPE). A JPE helps regulators determine the number of spring-run that can be "incidentally taken" by pumping operations without jeopardizing the survival of this species. This workshop was a key first step in identifying critical knowledge gaps, and in developing approaches to filling those knowledge gaps, for developing a scientifically robust JPE.

With those objectives in mind, the workshop was structured around **four themes**:

1. the state of knowledge of spring-run **distribution and life history**;
2. the extent and nature of spring-run **adult and juvenile monitoring** and gaps;
3. spring run **identification tools**, including genetic and length-at-date tools, and their tradeoffs;
4. current approaches to producing and using **juvenile production estimates** and identify knowledge gaps for producing a JPE for spring-run.

Workshop Format

The workshop was scheduled in half-day sessions, over three consecutive days, and held virtually. The full workshop agenda is available in Appendix 1. Fact sheets contextualizing the four themes above were developed by relevant experts and provided in advance of the meeting (life history, monitoring, run identification, JPE approaches). In addition, DWR provided a management brief outlining the regulatory background relevant to the workshop.

Day 1: The first day of the workshop served to provide key context on the state of science for spring-run chinook salmon. The first day was held entirely in plenary and included several presentations (inspired by the fact sheets) followed by a question and answer session. The facilitator used a live polling tool (Mentimeter) to solicit feedback from the ~151 participants on their affiliations, interests with respect to spring-run, and more.[1]

Day 2: The second day consisted of six concurrent breakout sessions, with two breakout sessions devoted to each of the following three themes: spring-run monitoring, run identification tools, and JPE approaches (the life history theme was considered in all breakout groups). Each breakout group included a facilitator and a notetaker. Breakout sessions convened for three and a half hours to respond to and discuss the following guiding questions:

1. ***What is the common understanding of information on this topic?***
2. ***What are the most critical gaps that need to be filled?***
3. ***What are the tradeoffs (i.e., pros and cons) to filling different gaps?***

Notes from each of the breakout sessions are included in the appendices of this document.

Day 3: The final day of the workshop was held in plenary and began with brief report-outs on each of the breakout sessions from the respective facilitators. A plenary discussion followed, and the workshop concluded with a synthesis presentation from DWR's Lead Scientist Ted Sommer and DSP's Deputy Executive Officer for Science Louise Conrad.

Recordings of the plenary sessions (days one and three) are available on the Delta Stewardship Council's YouTube channel. PowerPoint presentations from the workshop are available upon request from engage@deltacouncil.ca.gov.

Workshop Outcomes

Over the course of the three-day workshop, discussions among participants covered significant ground. Detailed notes on these discussions is captured in Appendices 2 and 3. While it's impossible to completely distill these conversations,

[1] The main takeaways from the poll were that most participants: were from State and Federal agencies (77 and 34 respectively), with a handful from the private sector (17), academia (11), local government (6), civil society (4) and tribes (2); and were interested in the implications of spring-run science to management and policy (76) and broader chinook salmon science questions and implications (59). The results of this poll can be provided upon request.

the following section seeks to highlight the main takeaways from the workshop, including items of general agreement among workshop participants and outstanding challenges across themes. [2] These takeaways are outlined in bullet form to enhance readability and the dissemination of this information.

General takeaways

- **Agreement—Entrainment management is the goal:** The workshop highlighted that the primary purpose of developing a JPE is for managing entrainment of spring-run in SWP diversions. However, the information generated by a JPE offers other potential applications (e.g., life cycle modeling).
- **Agreement—Multiple tools are necessary:** There was general agreement that generating a JPE for spring-run would require the application of multiple tools and the incorporation of new and historical data (e.g., monitoring, experimentation, modeling, mixed methods, etc.).
- **Agreement—Adaptive management will be essential:** There was general understanding that the first JPE to be developed will not be perfect. As more information is collected and science is advanced, the JPE will be iterated to enhance predictive capabilities for entrainment management. The spring-run JPE may also be integrated with the existing winter-run JPE approach.
- **Challenge—Balancing timeliness, data quality and cost:** Participants noted that for entrainment management to be most effective, timeliness of key information inputs is critical. However, timeliness is constrained by cost and limited resources. Timeliness may also influence the quality and resolution of data.
- **Challenge—Characterizing different life histories:** Participants remarked on the multiple tributary sources of spring run (including San Joaquin River spring-run, Feather River hatchery spring-run), the nature of spring-run behavior to not be linear, the uneven distribution of monitoring across tributaries (in terms of methods and frequency, and the need to tailor monitoring differently for yearling and young-of-year)—thereby complicating efforts to characterize the different life histories of spring-run. While a JPE doesn't need to be developed for each source of spring-run, separation for entrainment accounting is critical.
- **Challenge—Differentiating spring-run from other runs:** Available approaches for differentiating spring-run from other runs (e.g., fall run) have made significant technological strides. That said, challenges remain with

[2] In this context, general agreement does not necessarily imply consensus, but simply an area of common ground among workshop participants.

respect to genetically identifying spring-run at different life stages and from different natal tributaries. Further complicating the issue is that spring-run may not rear in their natal tributaries; for example there was acknowledgement of a "black box" of knowledge with respect to the number of spring-run juveniles that rear in the mainstem of the Sacramento River.

Monitoring takeaways

- **Agreement—A lot of monitoring is already underway:** There was general agreement that a lot of monitoring relevant to producing a JPE is already underway, though there may be a need for some alignment and standardization of this monitoring (e.g., reducing monitoring redundancy, filling monitoring gaps) to better address the needs of developing a JPE.
- **Agreement—Monitoring needs to be incorporated with other tools:** To further enhance the robustness and resilience of monitoring efforts, monitoring must leverage and incorporate different types of monitoring and tools (e.g., screw traps, snorkel surveys, juvenile sampling, genetic tools, etc.).
- **Challenge—Monitoring different life stages:** While significant monitoring is underway (particularly of adults, e.g., CDFW escapement estimates), monitoring efforts to more effectively assess spring-run across all life stages (e.g., yearlings are not effectively sampled in rotary screw traps), to better characterize productivity of spring run in tributaries and survival in the main stem of the Sacramento river are needed. However, difficult decisions must be made on where to focus limited resources: for example, should effort be increased to understand trap efficiency for juvenile monitoring, or should resources be increased for estimating egg production via carcass and redd surveys? More information on these tradeoffs is available in Cordoleani et al.'s 2020 SFEWS article.

Run ID takeaways

- **Agreement—Need better spatial resolution in run ID across all life stages:** There was general agreement that the toolbox for identifying runs is expanding to include rapid genetic ID approaches. Higher resolution to accurately identify spring-run in systems where they may be hybridization with other runs (e.g., Feather River) is needed in order to develop a robust and accurate JPE. Accurate run ID across life stages is critical as well in order to determine how different life history strategies are contributing to the population.
- **Agreement—Mustn't ignore San Joaquin River spring-run:** Sacramento River Drainage spring-run can be confused with San Joaquin River spring-run. Run identification advancements should be leveraged to differentiate spring-

run fish from each Delta basin, particularly where they may be collected together at south Delta pumping facilities.

- **Challenge—Tradeoff between rapid results and resolution:** A key challenge with respect to identifying spring-run is balancing the cost and timeliness of identification methods with the resolution needed for the purposes of the JPE and entrainment management.

JPE Approach takeaways

- **Agreement—Clear definition and scope of JPE:** Participants remarked on the need for having a clear definition of what the JPE would be—something critical to decision-making. In a similar vein, the scope of the JPE conceptual model must be defined, including Sacramento River tributaries and accounting for the Feather River and the San Joaquin River.
- **Agreement—Balancing timeliness, resolution and resource availability:** For entrainment management to be most effective, timeliness of key information is essential. That said, there may be tradeoffs between timeliness and resolution of information. Moreover, timeliness and resolution are also limited by available resources (e.g., staff, equipment, take permits, budget, etc.).
- **Agreement—Leveraging existing work:** Participants agreed that leveraging and better coordinating existing work is essential. In developing the JPE science plan for spring-run Chinook Salmon, DWR and CDFW will continue to work with partners to ensure existing work is leveraged and integrated as much as possible.

Next Steps

A number of next steps will follow after the workshop. These next steps and their estimated timing are outlined below.

- **Ongoing:** There will be a need for ongoing input, coordination and outreach for the purposes of the JPE development process, and DWR will provide more venues for interested parties to provide this input.
- **September to December 2020:** DWR will review the information gathered at the workshop to help inform the development of a draft JPE science plan, and submit this draft plan to CDFW for review and approval.
- **January 2021 to May 2024:** An inter-agency team, including scientists and managers from DWR, CDFW, NMFS, USFWS, USBR, Metropolitan Water District, and State Water Contractors, will be formed to implement the draft JPE science plan approved by CDFW and conduct research and development.

- **December 2021:** Organizers of this workshop will aim to publish a peer-reviewed manuscript that synthesizes some of the key information and outcomes from the workshop.
- **October 2024:** A JPE approach will be selected based on multiple factors (e.g. feasibility, accuracy, timeliness, management value, scientific value, cost) for approval by CDFW.
- **January 2025 and beyond:** The approved JPE approach will be implemented each year and subject to ongoing evaluation.

Acknowledgements

It takes many people to make a workshop successful and we would like to thank and acknowledge the hard work of the planning committee members, the staff at DWR, CDFW, Kearns & West and DSP as well as all of our facilitators and notetakers. And a special thank you to all the participants who took the time to come and share their knowledge and provide input.

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Appendix 1: Workshop Agenda

Workshop Objective

The objective of this public, virtual workshop is to convene subject-matter experts in order to develop the best possible approach to accurately estimating the population of Central Valley spring-run Chinook salmon (hereafter spring run)[3]. This workshop will help to more accurately inform management actions, particularly given that spring run are vulnerable to extinction in the next 50 years or less, including requirements described in California's Department of Water Resources' incidental take permit as part of State Water Project operations.

With that objective, the workshop will broadly tackle **four themes**:

1) the state of knowledge of spring-run **distribution and life history**;
2) the extent and nature of spring-run **adult and juvenile monitoring** and gaps;
3) spring run **identification tools**, including genetic and length-at-date tools, and their tradeoffs;
4) current approaches to producing and using **juvenile production estimates (JPEs)** and identify knowledge gaps for producing a JPE for spring-run.

The Delta Science Program is organizing the event, given its mission to provide unbiased, best possible science on issues critical to managing the Bay-Delta system, in coordination with California's Department of Water Resources (DWR) and the California Department of Fish and Wildlife (CDFW).

Workshop Agenda

The workshop will span three consecutive half days, from 9:00am to 12:30pm, and be held virtually via Microsoft Teams. The first day (Tuesday September 8) will be in plenary and feature informational presentations relating to the four workshop

[3] For the purposes of this scientific workshop the organizers are using the U.S. Endangered Species Act terminology, given that most of the scientific literature employs this term and recognizing that this evolutionarily significant unit includes naturally spawned spring-run Chinook salmon originating from the Sacramento River and its tributaries, and also spring-run Chinook salmon from the Feather River Hatchery Spring-run Chinook Program.

themes in order to tee up discussions and breakout sessions. The second day (Wednesday September 9) will be dedicated entirely to three concurrent breakout sessions. The breakout sessions will be facilitated and will aim to collaboratively answer key questions (see agenda below). Participants will reconvene on the third day (Thursday September 10) in plenary where breakout session facilitators will present the group's input for discussion and next steps. The full, annotated agenda is outlined below.

Workshop Materials

The workshop will be informed by five "fact sheets". Four of these fact sheets serve as background documents for each workshop theme (life history and distribution; monitoring; run identification tools; JPE approaches). These fact sheets were written exclusively for this workshop by scientists with expertise in the system and in various aspects related to spring-run Chinook ecology. The fact sheets incorporate existing scientific knowledge and offer questions as food for thought for the breakout sessions. The fifth fact sheet was prepared by DWR and CDFW and provides background information on the management context related to this workshop and the incidental take permit.

Outputs from the workshop are expected to include video recordings of the workshop presentations, and ultimately a scientific article synthesizing information gathered from the fact sheets and workshop discussions.

Day One: Tuesday September 8th, 9:00—12:30

Time	Item	Facilitator/Presenter	Background document
9:00	Welcome and workshop overview	**Julie Leimbach (facilitator)**	Workshop Agenda (this document)
9:05	Opening remarks	**Louise Conrad**, Deputy Executive Officer, Delta Stewardship Council	
9:10	Opening remarks	**Carl Wilcox**, Policy Advisor to the Director for the Delta, CDFW	
9:15	Context-setting presentation	**Ted Sommer**, Lead Scientist, DWR **Brooke Jacobs**, Environmental Program Manager, CDFW	Management context fact sheet
9:25	"Mentimeter" icebreaker	**Julie Leimbach**	
9:30	Spring-run distribution and life history, including updates on NOAA's 5-year viability assessment	**Rachel Johnson**, Research Fisheries Biologist, NOAA	Life history fact sheet
9:50	Spring-run state of monitoring and key gaps	**Flora Cordoleani**, Project Scientist, National Marine Fisheries Service	Monitoring fact sheet
10:10	Q&A and Discussion	**Julie Leimbach**	
10:25	*Break*		
10:40	Tools for spring-run identification	**Daphne Gille**, Environmental Program Manager, DWR	Run identification tools fact sheet
11:00	Spring-run lifecycle modelling	**Adam Duarte**, Research Wildlife Biologist, USDA Forest Service and OSU	
11:20	Juvenile production estimate approaches	**Peter Nelson**, Senior Environmental Scientist DWR	JPE approaches fact sheet
11:40	Q&A and Discussion	**Julie Leimbach**	
11:55	"Mentimeter" recap	**Julie Leimbach**	
12:00	Overview of day two	**Julie Leimbach**	

Day Two: Wednesday September 9th, 9:00—12:30

Time	Concurrent breakout sessions*	GROUP 1 Facilitator / Notetaker	GROUP 2 Facilitator / Notetaker	Questions to be addressed
9:00	**Monitoring and gaps**	Flora Cordoleani (NOAA) / Kassie Hickey (PSMFC)	Brooke Jacobs (CDFW) / Mike Eakin (CDFW)	1. *What is the common understanding of information on this topic?* 2. *What are the most critical gaps that need to be filled?* 3. *What are the tradeoffs (i.e., pros and cons) to filling those gaps?*
	Run identification tools	Pascale Goertler (DSC) / Chris Kwan (DSC)	Brett Harvey (DWR) / Kaylee Griffiths (DSC)	
	JPE approaches	Pete Nelson (DWR) / Jada White (PSMFC)	Towns Burgess (USBR) / Molly Williams (DSC)	
10:30	*Break*			
11:00—12:30	*Continued*: **Monitoring and gaps**	Flora Cordoleani (NOAA) / Kassie Hickey (PSMFC)	Brooke Jacobs (CDFW) / Mike Eakin (CDFW)	***Continued***: 1. *What is the common understanding of information on this topic?* 2. *What are the most critical gaps that need to be filled?* 3. *What are the tradeoffs (i.e., pros and cons) to filling those gaps?*
	Continued: **Run identification tools**	Pascale Goertler (DSC) / Chris Kwan (DSC)	Brett Harvey (DWR) / Kaylee Griffiths (DSC)	
	Continued: **JPE approaches**	Pete Nelson (DWR) / Jada White (PSMFC)	Towns Burgess (USBR) / Molly Williams (DSC)	
(13:00)	(Facilitator/Notetaker check-in)			

*the life history workshop theme is relevant to all breakout sessions and as such does not have a dedicated breakout session

Day Three: Thursday September 10th, 9:00—12:30

Time	Item	Facilitator/Presenter
9:00	Resume Plenary and Overview of Day Two	**Julie Leimbach**
9:05	Presentations of breakout session discussions (x6)	Breakout session facilitators (x6)
9:35	Plenary discussion	**Julie Leimbach**
11:35	Synthesis of breakout sessions	**Ted Sommer**, Lead Scientist, DWR **Louise Conrad**, Deputy Executive Officer, DSC
12:00	Closing	**Julie Leimbach**

Appendix 2: Breakout Session Notes

Monitoring & Gaps Breakout Group #1 – Notes

Question 1. What is the common understanding of information on this topic?

Clarifying: Which necessary information is available or currently missing to apply each JPE approach?

- We still don't have 100% genetic run type ID across all of the monitoring programs. We need to get to a point where we have a complete understanding where genetic spring-run patterns are accurate. Yes, for certain programs that get SR (for example Yolo Bypass) genetically id-ing all salmon since 2013 and has been successful in implementation aside from 2017 when they implemented subsampling system. Acknowledge there will be situations where you need to adapt and get all programs to 100% ID to have a consistent sampling method/protocol, where if there are too many fish to genetically sample, we have a subsample protocol to refer to. Implementing swab sampling could be an option, though fin clip workflow tends to work best.
- Agree that's a good idea, but in some cases, there are issues about cost or ability to capture fish. Difficulties at Clear/Battle Creek are the abilities to trap juvenile fish and puts the trapping season during the fall when it is difficult to trap. We need a more effective way to capture fish and develop a trap efficiency which is where they are limited. There are different monitoring methods across the valley, and all are unique to each watershed. We need consistency amongst projects and ability of what can/can't be done. We need to ask questions like what would help improve? What are the various monitoring objectives? Is it juvenile passage estimate development? Other programs may just be looking at presence or timing of outmigration. Production estimates may just be based on assumptions. Objectives need to be streamlined to a common goal and you could reorganize funding and staffing to fit that goal. Clear/Battle addresses monitoring the effectiveness of restoration activities and how they have benefited the fish. We need to determine why the data is collected and what the other objectives may be.
- What about when you can't run RST on waterways, conditions are not ideal?
- RBDD uses a flow-based model to determine trap efficiency and compares mark/recapture rate during different flow events. It is challenging on Clear Creek looking at how fish emigrate during certain flow events and those were

not equal. The proportions were not the same depending on the increase in flow. The fish seemed to be waiting to move out on the downside of the flow increase and if your model is decreasing efficiency related to flow then it may inflate your passage estimate. You can attempt to monitor traps on an hourly basis, but if you are building a model that is applicable then you need to be able to account for all factors of juvenile emigration. Could this model be applied? At the basic level that could work but there needs to be additional investigation into other parameters of the model. Work with the data and better understand how restoration effects population. Clear Creek can look at survival rate instream and how they may have trouble with water temperature management, what are the fecundity of fish, averages of that and then calculate based on number of redds and then apply to RSTs. Using this data you could say this is the expected number of capture at the RST and then compare trap efficiency, storm events etc. and combining all elements to result in a passage estimate. Battle/Clear Creek already determine spring-run passage estimates.

- We need to know what the size classes are, what are they as early fry and over summer smolts? It is difficult to collect those fish as they tend to avoid traps. There may be something we can do to try and decipher what would be holding over summer rather than the early fry emigration. Snorkel surveys could be utilized to determine juvenile usage of the watershed during the summer. We can develop habitat restoration activities towards increasing potential for over summering and develop something more robust. How does that help JPE? Looking at one-year, juvenile production would be based on emigration of fry though there are other fish in the system that come down later that may not be accounted for in the JPE.
- So how would we implement that, extend RST season and add snorkel surveys?
- Definitely add more snorkel surveys to the monitoring efforts to determine what fish are holding and not migrating. These are important life history strategies that need to be accounted for.
- You could also utilize electrofishing to determine number of fish holding over summer
- It depends on permitting but yes, e-fishing is an efficient tool.
- I'm mainly familiar with the lower watershed but could eDNA be helpful? I acknowledge that we lose the quantification aspect if you use this technique, but you can detect presence of fish during particularly challenging sampling times. Or you could use this data to inform where you target efforts for quantifying fish. We are currently using genetic techniques to detect

predation and then looking at diets of predators. Determining if there is an incidence of predation, not quantification of presence but overall sampling. Say 60% was positive for a certain species. Could we get funding for eDNA or is this something that could be incorporated into the JPE?

- How do you put this into use for JPE?
- The group agreed that we need to ask, "What are the data needs for JPE??"
- Another gap is that once the fish leave the streams, we are unable to track them. We have a difficult time capturing them efficiently if the JPE needs to be extended past each tributary. This monitoring would be different than just RSTs in the rivers.
- JPE in the Delta is where it would be estimated
- Agree that you can capture SR in the tributaries, but it is difficult to estimate how many SR are moving through the system
- We need more monitoring in the mainstem Sac near Sacramento aside from only Knights Landing RST.
- An option would be to use acoustic telemetry so you can better estimate trap efficiency, specific to smolts. You can place receivers near RSTs, effectively get capture efficiency/survival rate and compare catch rates in the RSTs to how many fish were actually detected at the arrays. Difficult with SR because too few are tagged so we would need a larger sample size. You could potentially use surrogates (fall-run) and may be similar to SR in movement and then use an acoustic array and a larger sample size.
- So, we could survey further in the watershed. Is there another area in the Delta? FWS Sacramento trawl, Sherwood harbor?
- They are currently using LAD criteria on the trawls and need to take genetic samples.
- Russ Perry may be the one to contact. Trawl efficiency methods for Chipps island and believe Sherwood is a part of that effort. Should be able to get estimates of abundance entering/exiting Delta using the trawl data. Unsure of genetic sampling protocols of SR and efficiency and believe this is currently more focused on winter-run estimates.
- What do you think of using other fish for trap efficiencies?
- Using surrogates are just like using a different fish. Using late-fall instead of SR they behave differently. Compared hatchery to m/r studies (fry) upon release there was observations of major differences. Hatchery fish may get acclimated as they move down stream and change survival techniques and may eventually perform like a wild chinook but not a lot of confidence in that.
- What about fall-run?

- Issues with using fall-run. We are already putting in late-fall surrogates for NMFS BiOp. Implement for JPE and coordinate with NMFS and ensure there are consistency within the surrogates that we collectively agree on. DWR funds USFWS to release 1 million late-fall Coleman Hatchery fish as surrogates for natural SR and their detection at salvage is meant to be presence of SR. Salmon monitoring team (DOS) may have more input.
- You could potentially release late-fall after the first fall freshets. Could have a separate group tag in surrogates (acoustic tags). Need to tag Mill and Deer creek to compare with surrogate movement. Pitched proposed study to BOR. Could compare movement between the two groups.
- San Joaquin River Restoration Program (SJRRP) released tagged SR hatchery juveniles into system and used tagged SR hatchery juveniles for RST efficiencies. Only in San Joaquin for river restoration monitoring.
- What have you learned? Could we use this in other tribs?
- Worked fairly well for RST efficiencies. Challenges still in knowing if production estimates based on RSTs are effective and if they are capturing all of the fish. We are trying to determine if we should be monitoring other areas in the river. We are trying to extend RST season by a month to potentially capture yearlings, but we have challenges with contractors and it is difficult to get full scale facility constructed and space limitations.
- Where are these hatchery fish from? Thinking about using surrogates, maybe Feather River Hatchery could grow out SR for use in these efficiency trials.
- Raised SR in SCARF facility and they were from feather river (fry sized).
- The benefits of using Coleman fish is that they are far up in the watershed. If you are taking FR fish and putting them higher in the watersheds they may potentially imprint in other tributaries. What is your goal lower in the watershed?
- We've talked a lot about Juveniles and monitoring gaps but what about monitoring gaps for adults
- There are video monitoring stations in the watershed. Yuba VAKI station is okay but are the fish holding downstream of Daguerre and moving up with the Feather River fish. The snorkel survey on Butte Creek and the escapement surveys go well together for adult monitoring.
- Agree that escapement surveys are good on northern tributaries but need to get pre-spawn mortality. Could implement index reaches. Likely couldn't snorkel weekly but could take a few sections of Deer Creek and snorkel biweekly to get an estimate. Electronic device counters mounter what fish are entering creek but unsure what happens to them over summer. Life history aspect and determine if they are spending time in the warm water.

- Snorkel surveys are good, but you also have to consider there are other pre-spawn mortality aspects such as predators on adults (i.e. bears). Could also conduct a pre-spawn survey and look at the number of eggs on the pre-spawn mortality on Butte to refine fecundity number.
- Consensus that we need to determine egg production and sex/length ratio
- On Clear Creek, Feather River fish were planted in the early 90s and followed cohort-cohort and used fecundity value that Feather River adults at the hatchery had. This estimate is based on fork length. It is difficult to recover pre-spawn mortalities, because either you are not coming across the fish or the fish is in a condition where egg sacks are unreliable for an efficient egg count.
- How is it estimated?
- San Joaquin (SJRRP) has its difficulties. They have tried to determine egg to fry survival using emergence traps placed on redds and then determine the number that emerged and compared that to fecundity estimate. They though they may be able to excavate redd and see how many remained but that is not the best approach, so they are currently using FRFH fecundity.
- Butte Creek? With the extensive surveys can you get a good size/sex ratio estimation?

Question 2. What are the most critical gaps that need to be filled?

Clarifying: What are key uncertainties in spring-run life history that are relevant to JPE development, and what tools are appropriate to address these uncertainties?

- Various life history modeling could be helpful. Such variation in all tributaries and differing environmental conditions. Various habitat and environment for all of these runs throughout the upper watershed. Clear Creek SR survive based on cold water pool. Determine how the various watersheds are able to support each of the runs. One creek may have a gap, though it could not be as necessary as another creek having the same gap. For example, Clear Creek wouldn't see many over wintering/summering in river. Instead they saw a significant number of the population would move out during the fall/winter so you need to try and determine where they are rearing. Not in RBDD or further downstream. Where are they holding in the Sacramento river? These different responses to varying watersheds are not addressed on a consistent model but could develop models for each watershed. All different fish coming out of each watershed at different times with different life histories but getting there is the challenge to acquire the data to create a model. If what we are trying to get at collectively and if we want to know

more about populations and where to benefit the watersheds, then there needs to be a change in the monitoring strategies. Do you increase more pre-spawn surveys, or look at more smolt capture by running RSTs in summertime to get rid of data gaps by changing monitoring efforts? Juvenile snorkel surveys would be good but may be difficult due to water clarity, accessibility.

- *Facilitator: What are the critical gaps?*
- Need efficiency estimates for all gears in different areas. Have a trend and not how it changes in responses to flow changes or other environmental variables.
- Agree, otherwise you are just making assumptions and just relying on adult counts and then you are making assumptions on f/m sex ratios. If you aren't doing redd surveys it may bias your overall count. Are redd surveys the most critical? If you see one fish per redd then you could assess how many eggs were produced. Need one or the other to determine production.
- So we have a handle on how many wild fish are spawning with the hatchery fish?
- On Butte there are no influences from hatchery. On Yuba there may be hatchery influence from Feather River but trying to make a change with HGMP. You could implement tagging of SR adults, releasing at different sites and then JSAT monitoring. Based on VAKI river watcher looking at the adipose clipped fish. When there was a wild fish crash, hatchery fish increased. Low numbers of ad-clipped fish on Yuba. Critical gaps – finding out with JSATs looking for areas where there is low survivability and monitoring that area to determine what the reasons are. Particularly in high water years, non-natal rearing occurs in small tributaries along the emigration and then they could dry up and juveniles are unable to successfully emigrate and the JSAT survey looks at where some of these sites are.
- Determine where and why juvenile survival is low.
- What adds to low survival? Currently considering tagging predators (striper) to see if they coincide with low juvenile survival. Upstream of Butte City is likely attributed to striper, tag them and then see if the low survival of juveniles coincides with striper movement. Water diversions and junctions in the late-spring when water deliveries are occurring could be attributing to low survival. Glen Colusa water district, and it is possible that juveniles are going in to the diversions.
  In Butte Creek, Butte Slough can route fish from the creek into the Sacramento river. More fish need to be tagged and increase coverage in the

watershed. Seen fish routed into Sac and those fish had low survival compared to smolts that remained in Butte Creek.

- What about PIT? E-fishing?
- Difficult to set up arrays in system and high flows washing out arrays. PIT are small, JSAT are more state of the art but need to be larger fish.
- E-fish and beach seine to get a general sense of where fish are, could PIT tag them but then difficult to implement array. Could get a better sense of how they are utilizing the water system.
- There's already an array in Mill Creek and could put an array in Deer Creek, to better understand emigration. Difficulties with high flows and detection rates.
- What are the methods used for the winter-run JPE team, could we implement those monitoring efforts to help out and solve the spring-run JPE issues? Do they use RBDD estimate? If we have RST and estimates for all tribs are egg-fry/fry-smolt estimates necessary?
- Winter-run JPE used for the salvage estimates. Need a certain amount of estimates coming from egg-fry survival, fry-smolt survival to get a JPE. Use RBDD smolt survival and redd data to get number of eggs produced.
- Do we have more gaps in the juvenile or adult monitoring?
- San Joaquin, except for redd surveys, trying to determine adult escapements. Issues with having a high enough sample size to do a mark/recap carcass estimate. Juveniles are more plentiful and can focus more on that aspect than adults.
- Is genetic identification a critical data gap?
- Is it important for us to know how many fish from each tributary are making it to the Delta?
- Do we need to genetically identify?
- Use SNP panel that differentiates the tributaries and obtain resolution by genetic ID. Downstream sampling is possibly the more useful to prioritize getting 100% genetic ID.
- Deer/Mill populations are definitely important. LAD charts do not work. Unable to get suitable number of adult samples but could get a large number of juvenile samples using RSTs. Explore efficacy of genetic sampling rather than trapping for JPE. Estimate number of fish using genetics rather than other approaches, seems like less handling and trapping through high water events. Looking for collecting small sample of fish and then extrapolate based on genetics. Genetics are going to have to be a part of JPE, no trapping locations on Mill/Deer that are above the influence of fall-run.

- Sherwood Harbor trawling but we need to remember that during certain periods there is another route through Yolo Bypass. Account for Yolo Bypass route when there is connectivity and how do we monitor that. Compare efficiency between the two? No efficiency studies on RSTs in Yolo Bypass due to varying channel width and water volume. No resources or ability to explore efficiency estimates. During certain periods there are also tidal influences and all of these issues results in difficulties trapping and performing trap efficiencies.
- Migration survival to the Delta may be the key and how do you get that and how do you maintain accuracy in context of JPE. May be impossible when Yolo Bypass is flooding. Variation in life history is also a challenge, ensuring which population is being sampled in any pre-delta monitoring.

Question 3. What are the tradeoffs (i.e., pros and cons) to filling different gaps?

Clarifying: Is a JPE more critical for some populations/locations more than others?

- Delta production estimate will predict what is going on with ITP. What is the validity of upstream monitoring?
- Is that what the ITP will be focused on, in the Delta? Different subject than what is leaving the tributaries. Money is the biggest trade-off than putting efforts into the tributaries.
- Important to get an accurate assessment of what is leaving the tributaries in order to determine migration survival to the Delta, using genetic sampling.
- Important what's going on in tributaries and then contributes to some sort of loss based on water operations. Try no to add too much sampling so we need to optimize monitoring efforts and avoid over handling.
- better modeling techniques to expand data into an abundance estimate along with genetic confirmation at the Delta.
- It may be difficult to rely on genetic samples in the Delta because of the time it takes to process them and may not be beneficial for developing JPE. Current protocols are to collect throughout the year and then send to genetic archives in the Fall. Timing of genetic results will be crucial for developing JPE and it is not quick enough.
- maybe over time use what we know in the upper tributaries and what we get in the delta and then we could develop a model to determine what we would get in the Delta. Genetically sampling tributaries and predict JPE based on survival.
- developing more accurate LAD model is critical. Currently working on that and it continues to get updated as we collect more genetic information.
- Continue to genetically ID in Delta and the development of a LAD model is better but Noble is giving up on Yolo Bypass fish. SHERLOCK, 10-30 minutes

can give real time genetic IDs. This is currently under development and need to check where Chinook run differentiation tests are at. There will be tools for all four runs but unsure if they will be tributary specific.

- genetic ID is not 100% and we need to incorporate the uncertainty
- What are the specific goals of JPE? Talking about monitoring fish entering from the North, if JPE is concerned about determining take can it be differentiated between North and South fish (in reference to San Joaquin).
- Adult populations in dependent populations will still be monitored, can we use historic RST data to determine when juveniles would be out migrating? Specifically, in Big Chico Creek.
- Not a lot of money/time in Big Chico Creek.
- Are there independent populations that need to be focused on?
- Do you care more about yearlings that may be mistaken for winter-run?
- interested in all life stages, maximize all life histories and wouldn't want to only focus on specific strategies or life stages.
- Good question. Will bring it up to water branch. Also, adults are important, but we need to understand more about the juveniles. Still need to go through outmigration process. You can put them above the dams with reintroduction, but they still have a difficult outmigration.
- using otolith analysis to better understand, according to each tributary, how juveniles use a different outmigration strategy. Expanding to other systems would be beneficial.
- hard to determine in Butte creek and flood plain because of different movement of water. Important to have an age estimate of adults that has been sampled. We assume they are 3 years but if we had the actual age of adults then we could pinpoint when they out migrated as juveniles. Cannot estimate time of incubation. We would learn more if we could age the adults. Currently only get length and sex of fish, no scale samples.
- need to integrate, is there any other information necessary with the otoliths?
- could use SR as surrogates but could not distinguish age. Can't determine actual date of outmigration.
- If you had unlimited funding, how would you go about determining a JPE? Is it possible?
- Ideally you strive for a small confidence interval with your downstream juvenile abundance. So do more monitoring efforts in tributaries to decrease overall confidence interval. Implement e-fishing, PIT tagging, photonic tags to increase trap efficiencies in order to estimate tributary abundance well. Perhaps trawl above Freemont weir rather, though that would result in increased handling.

- Sherwood trawl location in place because it captures potential delta smelt
- Assess historic sample sites and ease of location and possibly determine a better place to sample. Maybe move Tisdale/Knights or add another sampling site and spend the resources and create access to other sites that need to be sampled. Area between Chico to Tisdale is unknown because of lack of monitoring. It's difficult to sample at Tisdale during high flows, which is typically on one side or the other of outmigration. Design something that can put you out there during those events. Expand a sampling program, create efficiencies that are indicative of the conditions and determine how to collect data during these difficult sampling periods. Use acoustic detections to determine where we are losing these fish. Maybe put a site at Hamilton Branch? Would it help to sample more?
- new acoustic tags are being developed to be able to tag smaller fish (>50mm) and potentially have a larger sample size. Implement real-time arrays. If all Central Valley tributaries were interested, then they would be developed since they are only a prototype. No sutures needed and quick, less invasive surgery (ELAM). They don't affect growth rates.
- Could you use smaller tags in bigger fish?
- Battery life is a tradeoff, doesn't last as long.
- Look into floating PIT arrays in the mainstem river and strategically spaced those out.
- Mokelumne implemented floating PIT tag arrays and tagged hatchery salmon and paired that data with the RST data which was effective.
- Battle/Clear Creek taking scale and otoliths from all carcasses

Main Take Homes:

- Focus on juvenile side of monitoring, currently doing a good job on adults. Genetic sampling of juveniles to determine if they are spring-run. Monitor different life history strategies and determine what sizes they are when they out-migrate. Potentially use Feather River Fish Hatchery Spring-run as surrogates for fry-smolt survival. Determine sex ratios.
- Use winter-run JPE information and determine what can be used for spring-run JPE. Continue to work on migration survival to the Delta and have a better understanding which will be key for JPE development.
- Develop a better, more accurate LAD model and use new genetic tools.

Monitoring & Gaps Breakout Group #2 – Notes

Questions 1. What is the common understanding of information on the topic?

- Common understanding – CDFW has a lot of data regarding juvenile screw trapping since 1994, we know a bit about life history strategy, timing, outmigration history, floodplain rearing (Sutter Bypass). However, Butte creek is difficult to monitor because of how "flashy" the system is. Debris loading and safety issues at high flows make it difficult to deploy traditional sampling programs to estimate abundance (such as mark recapture studies) that are much easier to do in watersheds with regulated flows. There are some tagging efforts underway or have been done in the past (acoustic, CWT, etc.). Acoustic is difficult to do from samples at the screw trap because fish are too small (fry stage). Thus, estimates of survival through reaches of creeks such as Butte become difficult to produce due to some of these data/sampling limitations.
- There is a lot of newer data which is not included in the fact sheets provided in the pre workshop package, such as much of the work that CDFW is conducting. Group is encouraged to look at the long-term data sets that are already available for creeks such as Mill, Deer, and Butte to understand how to leverage them for creating a Spring-run JPE prior to adding new monitoring.
- Length at date is an unknown regarding the overlap of Fall-run and Spring-run in larger watersheds, as hatching can be only weeks apart between the two. Thus, it becomes confounding and potentially difficult to capture without some sort of validation process (likely genetics). This overlap is most problematic when fish are entering into the Delta and length at date is not as reliable.
- Survival Is a challenge regarding the yolo bypass. There are some studies which provide some insight but have not fully addressed the survival uncertainty within the bypass. This would likely require some sort of acoustic tagging study to better understand.
    - Yolo has similar limitations to Butte Creek with monitoring, such as small size fish (tagging) and uncertainty of flooding events makes it difficult to monitor these fish when they enter the bypass.
- Gap on "Fact Sheet": Difficult to get egg count on Butte Creek because of pre-spawn mortality, as fish are not mature and therefore do not have fully developed eggs and thus is problematic for fecundity studies. Hatchery

Spring-run are bigger than wild fish in Butte Creek. There is also a gap in survival as they emerge from the substrate. Additionally, overall spawning success is unknown/uncertain. Egg structure and adult size may be related to some sort of estimate of fecundity, but more information is needed to better understand that question.

- Feather River data Gap: Total escapement number. Tag broodstock at hatchery in May and June but don't know how many adults do not return to the hatchery. Additionally, current carcass survey ID methods are unable to determine Spring-run from Fall-run, thus traditional methods for escapement estimates aren't as viable due to this overlap. likely a similar problem in carcass surveys in other watersheds where overlap occurs. Likely need a way to leverage genetics to provide better detail in the carcass survey data for this problem.
- Age structure also unknown. Current assumption is a 3-year cohort; however, we know there are 4-year old fish too based on CWT and scale data, and that these 4-year old fish can represent a large portion of the returning adults. There are some 2-year olds (also referred to as Jacks/Jills) but they represent less than 10% of the returning adults.
- Another comment on the Survival by reach; Disease and predation, are they playing a role? If so, how big/impactful is it on the population? We know the Feather river has a "huge" problem with *C. shasta* with, and that fish experience nearly a 90-100% mortality rate in some years from it.
- Survival through the Delta is largely unknown. Timing of migration through the Delta. Generally assumed to move rapidly through the Delta. Smolt sized fish can be tagged and tracked through existing acoustic arrays through the Delta. Smaller sized fish are difficult to tag and remain a knowledge gap.
- Based on the discussion from the previous day, the JPE is intended to be an estimate of survival and production upstream of the Delta. If this also includes fish entering Yolo, then estimates of the Spring-run population which uses the Yolo bypass is uncertain and worth understanding. Benefits can be better understood when understanding how many fish are accessing the floodplain. The new Fremont weir modifications coming in the future are unknown on how effectively it will entrain juvenile fish onto the bypass.
- Another data gap is fish stranding on flood plains. We simply do not have a good idea how many fish are being stranded behind weirs and flood plains as the hydrograph rescinds. Both for juveniles and adults (both are stranded on the weir). Sometimes there are significant stranding events within the bypass. Limited data available despite substantial rescue efforts over the years.

- Wants to include climate change as an uncertainty/gap. How will this impact conditions such as water Temperatures and what the effect on every lifestage is unknown.
- Survival through "Key" reaches, emphasis on juvenile survival. Also understanding egg survival, and viability. There are uncertainties regarding the viability of eggs within females that are exposed to warmer summer temperatures, as well as eggs within redds similarly exposed to warmer water temperatures. Habitat superimposition is also another uncertainty and Is unknown whether that is having an impact on egg survival.

- Over summer habitat opportunities are poorly understood.
- Existing monitoring and data: Beegum (not discussed in fact sheet), Big Chico, Cottonwood and Antelope Creeks, Clear Creek, Battle Creek, and Yuba on other smaller tributaries. Challenges with inadequate or inconsistent funding and ability to integrate with other surveys. Also different survey methodologies used (video, snorkel, other).
- Existing monitoring and data: Prior effort by Alice Low (CDFW) to fund adult escapement estimates for spring-run in late 90's. Big Chico Creek, Beegum, Cottonwood have some level of video monitoring that is done but not standardized or fully (?) funded. Incudes effort to identify prior efforts and think through how to augment and integrate them.
- (Does this overlap with data presented in Grandtab?)

Question 2. What are the most critical gaps that need to be filled?

- Alice Low (CDFW) did a huge effort in the late 90's to do some escapement estimates. She attempted to get funding to provide estimates where spring run occur across the watershed. This may be a good resource for us to help identify where and how surveys can and were trying to be done. There are smaller tributaries that are on the (eastern?) side that are likely underrepresented. The feather river also really hinges on a separation weir being implemented otherwise the confounding issue of overlap will continue forward. Suggested that smaller studies focusing on the egg viability and survival through key reaches are likely where to prioritize first while DWR await implementation of the segregation weir. By the time the weir will be constructed, we should theoretically have the estimates ready to apply to escapement and production estimates. There is some monitoring which currently occurs but is variable (snorkel, video, others) that's not particularly standardized and comparable between watersheds.

- What is the level of predation and disease on juveniles migrating through the system, and how does this impact survival through key reaches?
- Potential impacts of superimposition. Critical for spring-run in particular that hold over the summer and are exposed to higher water temperatures potentially affecting egg viability before spawning and after spawning in redds. Does superimposition impact egg survival in areas with limited habitat availability?
- Estimates of escapement seems likely an important area, particularly where overlap between fall run can confound traditional sampling techniques (carcass surveys). This seems to be important when discussing ways to develop a JPE, as it would be very difficult to do without some sort of metric of adult spawning stock that is representative of Spring-run and not a mix with Fall-run.
- higher priorities appear to be focused on upstream monitoring thus far, while lower priority would be something like through Delta survival.
- We have talked about a lot of different kinds of monitoring, but there exists a challenge to integrate multiple data sources into a large scale modeling effort. For example, how to best integrate genetics, in river surveys, and tag data? How does all this information work together for the analytical component of this effort? This includes assumptions and sources of errors associated with [JPE] estimates that would be produced from newer monitoring, for example.
- Critical gap to fill would be data science. We need the ability to have data in a timely fashion, ability to integrate, account for the strengths and weaknesses of each monitoring program, improving access to data science experts. Example of this is SacPAS, which integrates many different data sets but could be fleshed out with additional data sources as they become available. Tool to help visualize data and "see" the population based on LAD identification of juveniles.
- Discussion on having the data available in a more real-time manner is important (emphasis on something more frequent than annual estimates)
- JPE is needed before fish hit the Delta. High priorities he should probably be focused on adult returns and juveniles as other lifestages would occur outside of the scope of this effort. It's noted that those areas are still important for science, but would emphasize that for this purpose, the discussion should focus on adults and juveniles. Some existing acoustic studies examining survival through the Delta - not as big of an information gap as others identified previously.
- Where should we prioritize the monitoring we discussed earlier?

- The priority on Core 1 is important, but also thinks that looking at comparisons between Butte and Mill and Deer creeks regarding why Butte is so much more productive is also important. We are waiting for the Feather river hatchery to begin implementing spatial and temporal separation of spring-run and fall-run. Notes that DWR's segregation weir is important to this process but is pending due to the FERC license.
- Do we have sufficient juvenile sampling downstream of the confluences to capture juvenile fish in the mainstem Sacramento? And do we believe it is important to have?
    - Fish move a lot through the bypasses in addition to the mainstem Sacramento. Simply sampling the mainstem may not be enough as fish have multiple avenues to use for emigration. Maybe more upstream monitoring to help better understand. The rotary screw trap at Knights Landing does not capture juvenile entrainment onto the yolo flood plain, and would require some sampling near the exit of the bypasses, where an RTS such as the one at Tisdale could contribute to the data gap. DWR does some sampling within the toe drain of yolo bypass, a fyke trap that is used. However, these are problematic areas for methods such as a RTS. Additionally, flows on the mainstem can easily limit many monitoring approaches, would need to develop ways to monitor these fish which are not impacted by high flows.

Break: Facilitator provides a review of notes from the discussion prior to the Break.

- Static and dynamic data/metrics. Some areas of interest, such as survival through key reaches, will likely produce a static metric through a short focused study, which would be applied to a more dynamic dataset (annually) to ultimately derive an annual JPE. Which of these is more important prioritize, the static or the dynamic data? Do we have data that currently exists for all areas where spring-run occur, and do we feel that we have adequate representation of all populations in these data? Essentially, do we need to prioritize carcass surveys where they do not currently exist, or are there bigger issues, such as reach specific survival, which would need to be figured out prior to establishing new monitoring?
- Group notes that the Fact sheet covers some of the data gaps that were mentioned – such as which creeks have carcass survey, and which do not –

however, it's not complete (ex. Beegum Creek sampling is not incorporated). But does show what is mostly known. Also mentioned that funding consideration is important and that the of the fact sheet emphasizes this as well.

- Group notes that the Fact sheet is a great start but it's possible to develop it further as there are some studies occurring within the department (CDFW) that could be important but are not listed.

Question 3. What are the Tradeoffs (i.e. pros and cons) to filling the gaps?

- Adult escapement – resources depending on level of effort can vary widely. Pre-spawn mortality is underrepresented in our escapement counts but is being conducted only on butte creek. Some surveys such as snorkeling, or redd counts can provide good information, but do not really provide an estimate of escapement. This creates tradeoffs regarding levels of effort with respect to how we gather the correct information. There is always a hesitation to do mark recapture efforts on the unregulated tributaries because it is very costly and potentially not informative due to the flashiness of the system. Efficiency trials would be very labor intensive, therefore current efforts appear to focus more on relative abundance estimates (snorkels or modified screw traps). These relative numbers can help compare population variability through time, however, are not estimates of population size. More cost effective to use the relative abundance methods than to implement larger scale estimates of abundance.
    - Citizen scientists can become snorkel surveyors when provided wetsuits and masks. organizing costs return stream reach data.
    - The sample size of fish at knights landing is small compared to samples on Butte Creek. Sub samples and samples by weight are often implemented to help mitigate impacts to fish health, thus not ideal for mark recapture studies. But still important information.
- Other tradeoffs of trying implement more intensive efforts include: staff safety, trap efficiency, and other variables that are problematic for both fish health and human safety.
- What about PIT tags? Is there any consideration for this approach or does this not effectively work in this situation?
    - Some are unsure how it would it work, but have been interested in exploring PIT tag approaches in the more unregulated

watersheds but there is little to go on regarding how well they will work (detection probabilities, etc.).
    - The Columbia river and the PIT tag effort occurring there. Researchers use a combination of hand readers and in stream PIT tag arrays to capture data from tagged fish. There was success with this approach and this tagging technology is much more cost effective.
    - The other interest in exploring this option is that young fish in current sampling programs are generally too small for acoustic tagging practices, but could be viable for PIT tags.
    - Acoustic tags are increasingly getting smaller in size, not quite to a level of size that they are usable on a small fry. PIT tags were used in Putah creek, and there were detection problems with that approach in that study. However the group wanted to note that this is the only experience known of in the moment of the discussion, and may not represent the potential of the method.

Facilitator: What are the pros and cons to the filling egg viability gap?

- This can be difficult to do in stream due to conditions and redd capping efforts on unregulated systems. Flow is simply too much of a determent.
- San Joaquin River experience some conditional problems with redd capping efforts during storms events (<550 cfs). So there is some conditions that interfere with this effort even on a regulated system. Biologist on the San Joaquin River are currently trying to study red capping efficiency due to the low use of this method over the recent history.
- Egg viability may be really suited for lab situations. Mention that much of the discussion today focused on how conditions impact processes related to spawning, but in order to compare to a baseline, we would need some ability to control conditions, which is difficult to do in an unregulated system.
    - There is some research regarding this at the salmon conservation research facility. However, these egg viability related studies are done with san Joaquin fish and initially started as an effort for fall-run but may be applicable in implementation for spring-run.

- CESA/ESA “take” may be problematic when considering approaches, and uses Delta smelt take as an example. In addition to spring-run, projects may likely require take of other ESA/CESA species in the watersheds, such as winter-run, green sturgeon, and central valley steelhead. Take authorization is definitely a limiting factor.
- Another tradeoff need is regarding resources for these programs and new efforts.
- Group wanted to discuss genetics and noted we haven’t really covered the topic. Mentions SHERLOCK from yesterdays presentations, as well as the use of EDNA and other methods and wanted to discuss the tradeoffs associated with application of these approaches. How would this be integrated into a JPE? It comes with a level of understanding and comfort level that maybe not be as easy to interpret by people without training in that field, where as a snorkel survey is more straight forward.
    - Likely worth pursing genetic ID as a part of monitoring efforts given the magnitude of challenges associated with current LAD ID. For example, this could provide an earlier opportunity to address overlap problems on Feather River not yet addressed by implementing segregation weir and other projects.
    - Current understanding of genetics as a tool, likely cannot get us estimates of production or abundance for Spring-run at the moment, though eDNA is getting closer to being able to potentially do this, but still not there yet. However, the benefit of genetics is that we will be able to identify runs with more confidence in areas where overlap with fall-run is problematic.
    - Long term consideration for investing resources into developing new tools to use genetics (ex. eDNA) to provide high quality abundance estimates.
- What does the group think about accessibility and its effect on the ability to collect data on some of these issues?
    - yes, this is a limitation.
- We should really understand the data sets we have out there. For example: What DWR is doing on the Feather river, what CDFW is doing in the San Joaquin, etc. We have done strategies where we have combined Mill, Deer, and Butte Creek to look at some metrics of juvenile production. There is also a lot of data from the Yuba management team, however they don’t share until they issue a final report. Emphasizes that a great starting point is to create some sort of data library where all the known datasets are in one place and more can be learned about limitations, efficacy, etc.

- Group discusses some of the prior points related approaches which produce relative abundance metrics and how they might be more cost effective and easier to implement across the broader landscape, will also be standardized, and hypothetically easier to integrate into larger modeling efforts. In contrast to more intensive approaches that would be better suited for fine scale estimates of abundance for each watershed.
- CDFW has compared data between their snorkel surveys and carcass surveys on Butte Creek and know they are generally under estimating abundance by ~ 50% by snorkel survey, however with this linkage, they can theoretically implement a much more cost effective snorkel survey and achieve a good relative estimate of abundance through the relationship to the escapement estimate. This idea could be applied across all tributaries. It is much more cost effective to do a snorkel survey than a carcass survey.

Run Identification Breakout Group #1 – Notes

Question 1. What is the common understanding of information on this topic?

Clarification: At what life stages and geographic locations would identification be necessary? What existing identification tools, or set of tools could be used?

- USBR and DWR pilot studies at Red Bluff and Knights Landing samples to correct JPE calculations to see juvenile abundance and pop; need to confirm spawning is actually occurring for Spring-run Chinook (SR) in tribs and see when juveniles are coming out; need to move toward CV programs to distinguish Sac and SJ since both Feather River hatchery
- Wallace Weir genetics markers say Fall-Run Chinook (FR) but SR since from same Feather River hatchery. Need unique migration haplotype.
- Need location that funnels all the tribs for JPE
- Need several 1000 SNPs to be more accurate
- Even with isolated pop like WR estimate doubled from what was actually there
- Wild fish makes it a problem; Mariah paper with enough marker SJ fall run and Sac fall run; need to know what is absolute necessary
- SR hatchery all have CWT but natural origin makes it tough
- What are the main problems for estimating SR and is the purpose so they can help with take at the Pumps? Need to know SR passage. As downstream as possible for sampling info is needed. Need many methods to distinguish

FR and SR. RTS, length of date, weir, CWT all combined to complement each of these methods.

- Minimalist approach to see what is absolute necessary and add to that if possible; but even minimum is huge undertaking; confluence can be sample location but many juveniles may be lost by then; genetics can do largely on it own; can first distinguish SR on behavior phenotype then okay with genetics; probabilistic length of date as precursor to increase genetics efficiency as in if 100% percent fall then don't need genetics because of resources cost but 50% SR can use genetics
- Out-migrating SR Chinook travel distance from RB to pumps is known; April to June; use timing of natural-origin to help predict; how quickly do we need this info?
- CWT for WR for take, 3 SR surrogates for yearling; dependent on flow, can be as fast as 9 days to pumps to up to 40 days if missed storm pulse, 120 days from battle creek; average is 15 days. Exports 4-5 days later also factor to travel time.
- Couple of days, weeks may not need real-time
- Upstream of Wawona, before Delta entry; efficiency will not get info they need; Tisdale capture rate higher but still not enough; mainstem not good returns, like WR need acoustic tagging at Knights Landing, Mill, Deer, Butte, RBDD; incorporate Yuba, Feather river part of ESA need more interagency collaboration
- Is this driven by take purposes and what is salvage mechanisms?
- Development of JPE take limit can be set for salvage, never had protection of young of year because can't ID; understanding JPE can also help show habitat needs, bottlenecks such predation hot spots, identify issues with SR and how to fix
- Skinner louver fish facility (diff from screens) creates ripples that guide fish for collection, based on behavior, 75-85% efficient for salmon, designed partly for salmon; 25% subsample examined all fish for tags, length, CWT, genetic sample; for real-time operations use mainly length of date; if near trigger levels, use genetic sample for a couple days; trucked salvaged fish out to Central Delta and released and get a mitigation credit for every fish released
- Sommer doing sampling at tribs says cost prohibitive and impossible to sample at tribs, not just genetics
- Mill and Deer Creek snow dominant so may only need to do one or the other, not both
- Do you still need RTS on mainstem?

- WR has JPI at Red Bluff and JPE at Chipps
- RTS cost prohibitive need staff, but other metrics such as redd surveys, snorkel among tribs
- Other rough estimates if can't use RTS but can't follow WR exactly; a lot of sampling like steelhead need genetics sampling; should develop length of date specific for each trib and use genetics to correct; many programs not involved but should know what needs to be supplemented; steelhead not funded in full because costly but has good monitoring at Feather River
- Enhance efficiency studies and coordination studies

Question 2. What are the most critical gaps that need to be filled?

Clarification: How can run identification tools better integrate multiple aspects of life history diversity or be more inclusive of a broad range of juvenile life history variants (Figure 2 in LH factsheet)? Can several identification tools be used in combination to address uncertainties when describing juvenile life history diversity?

- How to distinguish migration behaviors?
- Genetics within tribs SR dictated by suitable habitat; will move to better habitat so need dates to identify downstream; tributary specific use multiple agencies to help pay for expenses
- Different trib, different efforts, Mill and Deer over summer come back to spawn in drought; Lower American RTS show WR rearing; Strontium work great info but need accidental mortality, scales for samples; should hone in future restoration efforts to improve habitat; carcass surveys, genetics, otoliths/scales to see rearing locations; every possible method needed to address pros/cons of each
- SJ and Sac turnaround time for modeling JPE? Can isotopes be used but not in real-time
- Need JPE and refine it every year with BAS; landscape habitat, pop returns, may not be useful in first and second years but is needed info for future life cycling modeling; WR life cycle huge with many sub-models and many data sets missing and can't go back in time to collect it; need to know what info is needed to refine SR JPE; should have trib specific efforts and go from there
- Challenging to just focus on JPE since SR use diverse habitats

Question 3. What are the tradeoffs (i.e., pros and cons) to filling different gaps?

Clarification: What are the challenges to identification? What new tools would and could be developed to meet those challenges?

- What they want to know? Degree of resolution? Distinguish runs by SHERLOCK in 30 min with FR/LF and SR/WR; can't use SHERLOCK for what trib or parents, need different genetic tool;
- SHERLOCK - used for only few loci and has diagnostic loci to distinguish runs; many loci needed to distinguish locations; field ready and don't need genetics expert, no invasive sampling, just use mucus swab, SHERLOCK at 37 degrees C or in palm of hand; florescent machine portable or lateral flow strips as alternatives (like pregnancy strips) but more expensive and less sensitive; single base pair differences detected; takes time to make assays
- Feather river one of hardest to distinguish from others: all other loci it will look like FR and only one loci SR
- Utility craft worker at facilities work 24 days may not be able to do since not biologist
- Work on protocol to make facility worker comfortable to conduct
- Feather river RTS time for processing is high because ten of thousands of fish sorted; would be difficult to add SHERLOCK
- Mucus swabs may be cumbersome and mixed up with fish, especially with screw trap
- Gametes everywhere with striper and slimy carps in other studies cause east contamination
- Looked into contamination especially with RTS: all fish together so potential mucus sharing but tested and not a problem; handling with person can be a problem so need to wash hands between fish; just dip your hands in water
- Mucus swabber does not hold fish so minimize contamination and easier to do
- Only one person sampling and other is doing debris
- SJR (San Joaquin River) not included to JPE since experimentation so need to distinguish but SHERLOCK can't do that
- SJR issue touched on all three questions
- What stage is released from hatchery?
- Subparr 70-100 mm range, not fry
- All coded wire tagged, is natural spawning in SJR considered for take?
- Should use post season correction with Strontium analysis, any natural spawners and hatchery in SJ are experimental, not part JPE
- CWT requires take of fish making external markers important
- MB: use PBT to distinguish SJR and Feather River
- Carlos Garza's lab look at parentage SCARF (Salmon Conservation and Research Facility); SR not many to brought down to SJR

- If use same parents for SJ and Feather, impossible to change but not sure, need to ask genetics managers
- Spawn and extra eggs given to SJR; new hatchery for SJ in the works so have in-basin hatchery; Carlos Garza lab parentage starting at year 3 of program
- Cross with Feather and SCARF first cousins and grandparents messy to distinguish
- How does this impact salvage? Need to distinguish SJ
- Changes over time since during first BiOps, SJR was dry but better now, it will be harder to distinguish, only one was true SR in Miller creek; relationship in SWP,CVP reversed compared to Sac River salvage; if not through genetics, use surrogates or feed supplement, chemical analysis to distinguish; length of date for SJ vs Sac; will absolutely affect salvage as SJR improves
- How make SJ more identifiable?
- If smolts, pelvic clip or freeze branding but natural spawning makes it difficult; real solution may involve costly genetics
- DS VIE calcien for individual identifier more time consuming since for every single individual; aren't splitting parents between SJR and Feather river SR;
- Subsets of parents but not sure; 80,000 eggs from Feather to SJR; need to see if approved to use for dyes, chemicals but could be consumed by humans; tetracycline can go in, but external clip may be needed since easily identifiable but may be a lot of work
- Calceine USDA restricted; should just stop splitting egg lots but want to maximize genetic diversity with splitting lots
- What is most important for now? Should we consider SJR?
- Focus more on Sac basin for next two years, SJR will become more problematic over time so start early with SCARF program with wild pop used as surrogates
- SJR need to care about salvage, not JPE
- Is SJR numbers so small that it is unlikely to trigger take?
- Now it is so small, correct, unlikely to trigger take, but found 10-30 surrogate in battle creek and 300 in SJR; near future focus on Sac River; use hatchery releases to mimic natural population; verify natural origin SR
- 50% trigger level will use genetics, daily trigger will be issue and cumulative total trigger will help with variation
- Butte or Mill/Deer more subtle differences so SHERLOCK so not possible
- Need to fill gaps with coordination

Menti ID Questions

Details on improved length by date models and future of using new advanced genetic tools
How the genetic run determinations can be used with length at date to improve real-time management decisions?

- Future tool implements SHERLOCK for larval salvage and JPE but not all that is needed since SHERLOCK is lower resolution, not good for parentage and tributary

How we can move to a broader implementation of genetic identification in the field.

- Different areas have different rates of growth
- Genetics more stable during fieldwork with constant temp so don't need experts, can bring back to lab
- Make it more user friendly and faster
- SHERLOCK samples should be sent to actual lab for confirmations
- For DCC, beach seines, handy to have SHERLOCK
- Proper controls always important

What do we need to implement and use the rapid identification for management?

- Natural origin spring run have tools for trial and error
- JPE end of seasons calculations will be used by CDFW and DWR will evaluate take
- Winter-run take made before JPE finished in Jan and salvage in Nov/Dec; use minimum backstop until JPE ready; SR protect year class anticipate JPE to set take to account for months before JPE is ready

What do we need to implement and use the rapid identification for management?

- Executive support, understand needs, if people want it, proper time to develop run type, teach people how to do assays and preparing assays needs time, get staff training in house as Lenny Grimaldo plans to first have
- Rapid ID at salvage in past years, triggers give 48 hours to do salvage; DCC operations with trawl get 24 hours so rapid ID not as useful; rapid ID would be more useful in Knights Landing because 3-4 days before fish reach DCC; DWR, USBR use rapid for sampling program until new techniques are available

Facilitator Take Home Notes

Question 1. *What is the common understanding?*

- There is a tradeoff between genetic resolution and rapid results.

    - The scope and objectives are important when choosing the best ID methods.
    - Tributary specific ID is important for broader conservation goals, but run-level ID may be adequate for JPE (especially if Feather River hatchery/San Joaquin reintroduction fish can be distinguished from the independent Sacramento River populations– which is an area for further research).
- Any proposed ID method:
    - Must consider how much time/effort the ID method adds to processing fish (especially juveniles that can be caught in large numbers).
    - Must have broad support to fully implement, understand needs and coordinate across locations (sampling or water operations).
    - Must have time to properly develop and scale up (e.g. include training, improve protocols – user friendly and adapted to the specific objectives)
    - The probabilistic LAD tool can be used to determine if a fish requires further genetic analysis (and cut down on fish processing).

Question 2. *What are the most critical gaps?*

- We need to sample before Delta entry.
    - A minimalist approach may focus on lower river mainstem sites, but we have learned from places like Knight's Landing that those sampling locations are very challenging.
    - Broad tributary/landscape scale sampling may be cost prohibitive and will require coordination to modify/strengthen current sampled to focus on a spring-run JPE.
    - Suggested locations: Mill, Deer, Butte, base of bypasses, RBDD (to understand Sacramento contribution), and Feather/Yuba.
- Life history diversity is important to consider in the context of the JPE and related to habitat availability which varies across tributaries - another benefit to sampling ID before Delta entry.
    - There are other diversity-related data gaps with spring-run that will need to be resolved in order to model year-to-year variation in population size:
        - Non-natal juvenile rearing
        - Straying/spawning outside of the primary four watersheds from the ESU
    - IDing tributary specific life history diversity may also help to better understand migration behavior of juvenile spring run for quantifying passage.
    - Tributary ID monitoring will require adaptation through space and time

Question 3. *What are the tradeoffs?*

- The ID of San Joaquin reintroduction fish is an issue that is unlikely to be resolved with genetics at this point in time. Once they begin natural spawning we can no longer rely on CWTs.
    - There is a tradeoff focusing too much on the San Joaquin fish when Sacramento basin is the target (time and money).
    - There is a tradeoff between splitting lots of eggs (to use PBT to distinguish Feather River from San Joaquin) and maximizing genetic diversity at the hatchery.
    - Could make San Joaquin specific LAD with surrogates to better understand in season migration behavior or branding (tag or clip or calcein or VIE or tetracycline).
    - Workshop some San Joaquin triggers that could help salvage anticipate those fish.

Run Identification Breakout Group #2 – Notes

Facilitator Take home Notes

ID Requirements

Some form of identification of spring run will be necessary at most JPE monitoring stages when spring run are enumerated, regardless of the eventual approach applied, including during adult spawning migration, redd counts, during outmigration at all age classes, at the point of survival tagging, and potentially survival monitoring downstream. Among these, ID of adults may have the most effective currently available tools that can be refined as part of a JPE approach, especially video monitoring potentially coupled with morphometrics for sex and fecundity estimates.

Genetic Approaches

Rapid return, CRISPR-based methods like SHERLOCK are cost effective, resource efficient, customizable, and scalable to whatever level we may require. In particular, genetic approaches may be particularly useful in conjunction with probabilistic Length at Date. Should probably apply same run ID method across all Sac tribs, and mainstem Sac. Multi-SNP panels or serial tests may be required for differentiation of spring run sub-populations and would definitely be required for Parental Based Tagging.

Probabilistic Length at Date

A separate PLAD may be established for each tributary using tributary-specific variables. By pinpointing genetic testing on ambiguously sized salmon, the PLAD would help reduce the number of necessary genetic tests, while genetic tests could be used in near real-time to update PLAD probability estimates.

Alternative ID Approaches

Genetics may not always be necessary. Adults displaying spring run phenotype are temporally segregated when during the summer and can be ID'd during counts. In streams with only spring run production, juveniles can be assumed to be spring run, and can be PIT or otherwise marked during out-migrant trapping for survival tracking.

SJR vs Sac Spring Run ID

Parental Based Tagging is most likely approach to disentangle SJR from Feather River spring run, requiring segregation of brood-stock supply each population. Some kind of isotopic test of non-lethal tissue samples may also be explored. However, at this point SJR juveniles are mostly hatchery origin (100% CWT), and currently comprise a very small proportion of take at south Delta facilities. Until natural production and survival of SJR juveniles improves, SJR proportion of take at facilities may be estimated from survival estimates without need for identification. Note: there is a technical group that has been working on this issue, which should be consulted.

Non-natal Tributary Rearing

From a monitoring and ID perspective, it may be enough to conduct several studies to establish whether rearing in non-natal tributaries is significant enough to warrant inclusion in JPE approach.

Permits for Monitoring

Both lethal and non-lethal take currently limits or curtails sampling effort for existing monitoring programs and will probably need to be adjusted to account for expanded monitoring efforts. DNA sampling and tagging for survival estimates will likely cause additional take, with the following an expert-elicited continuum of take severity: DNA-swab < DNA finclip < CWT < PIT < Acoustic Tag. However, the majority of take will likely be caused by the "operational" sampling methods used to capture fish (prior to DNA sampling and tagging). Measures taken to reduce operational lethal take will require additional effort of field staff.

Opportunities for Efficiencies

Pooling of genetic samples could be used in shoulders of migration seasons to reduce effort when spring run are not expected, or when spring run relative abundance in mixed population is expected to be small. Sample splits could be used for sampling of individuals when pooled samples indicate spring run presence.

Upper Sac monitoring of winter run may soon require genetic testing to differentiate them from Battle Creek spring run, and genetic testing would serve both winter run and spring run monitoring programs.

What about the Heterozygotes

A JPE will need to determine how to account for salmon genetically identified as heterozygous for markers associated with run-timing.

Tributary vs Mainstem Monitoring

Both will likely be required, tributaries for population estimates, and mainstem for survival rate and model calibration/validation. However, tributary effort could be focused on locations producing the bulk of the juvenile population.

Redundant JPE Estimates

Two or more parallel and independent JPE approaches would provide alternative JPEs for cross-verification. JPE based on monitoring of earlier season life-stages (spawner and egg abundance) with error rates could be used for initial operations planning and regulation, while later life stages could provide more accurate and precise JPEs for final take allowance.

Notetaker Notes Summary

Rapid CRISPR-based genetic testing has a lot of utility, especially in combination with existing monitoring tools because of its cost effectiveness and minimal resource requirements and will likely be integral in multiple components of JPE monitoring.

1. Rapid Genetic Testing is useful for identification
    a. SHERLOCK is very exciting, wide utility that is fast, easy to use and affordable. Probably a few $ a sample
    b. No logistical problem with using at-scale, don't need specialists
        i. Swab-tube and dipping into tube will not introduce a lot of user-to-user variability.
    c. Can save money via less tagging equipment and efforts
    d. While it is easy, more personnel will likely be needed to deploy tool on large amounts of fish alongside existing types of data collection.
    e. Pooling to save time/resources
        i. Sub-divide samples into groups and run a test on a pooled sample of that group. Then test samples individually if you get a detection of SR fish
    f. Uncertain if a single sample could be split for performing multiple types of genetic tests (e.g. SHERLOCK and multi-SNPs panel)
    g. The SHERLOCK tool can be customizable to a variety of alleles. Could help with differentiating tributary populations

    h. Can be used to differentiate Feather River SR/FR and SR-FR heterozygotes
    i. Combined with CDT branding, really useful to learn about life histories
    j. Starr and Day: Rapid can be of assistance in RST mark -recapture trials when using natural origin fish
    k. However, real-time genetics is not always necessary, e.g. for tagging can be applied to dataset later
    l. SHERLOCK can't ID individual fish, multi-SNPs panel necessary for this.
2. Tagging
    a. Multiple types of tags, dual tagging is could be useful tracking and ID tool
        i. Requires training for personnel to look for tags in unconventional locations e.g. anal fin coded wire tag
        ii. Can tag/release before you know the genetic information
    b. Coded wire tags are really helpful for tracking hatchery fish, but is lethal and most valuable for adult fish at harvest or entrainment at the pumps, not for interim monitoring
    c. Other types of tags: PIT tags (more affordable), color tags, cold branding
    d. JSAT tags: expensive but informative
        i. ELAT (eel lamprey acoustic tag)- can be used down to 60mm. Hoping to use on the Feather River. Unsure if applicable to SR fish because they are small. Seems like considerable effort to deploy at-scale.
        ii. These tags are good for monitoring survival but unsure of applicability for JPE.
        iii. These tags are relatively expensive. Would need to calculate how many tags would be needed to provide useful information.
3. Visual Surveys
    a. Videography: Great for also taking morphometrics. Relatively cost-effective.
        i. Good bc of temporal segregation
        ii. Each location has site specific issues
        iii. Best for adults coming upriver
        iv. Video surveys are great for winter run adults passing Red Bluff Diversion Dam but may be more difficult for SR that are being produced in multiple areas
    b. Snorkel: Reliable. Can deploy when FR are not present.
        i. Count phenotypic SR as SR

4. Probabilistic Length-By-Date
    a. Important to determine if we need to do additional genetic testing
5. Trapping
    a. Trap efficiencies are highly variable, and depend on location. Range from <1-25%, high error
        i. Additional funding for modeling efficiency needed- trawl efficiency, trap efficiency at Knights and Tisdale from Coleman Hatchery
    b. Emergence traps (redd capping)
        i. can estimate sample of SR fish to calculate initial pop estimate and then use screw traps to estimate into the modeling
        ii. redd camping has problems, fish can swim sub-gravel adding a lot of error, location differences

Life history's role in Identification

Variable life histories complicate identification mainly on the physical sampling side of things. Monitoring and run identification of adults will likely be the simplest life stage to implement due to temporal segregation of spring run phenotypes

1. Adults are more certain to identify and are a critical and reliable component of the JPE.
2. Diversity in migration timing presents Run identification challenges
3. Juveniles and yearlings are different cohorts but may enter the Delta at the same time, presenting identification challenges
4. Identifying SR is a limiting factor and needs to be done in each tributary
5. Need to identify/ count both spawning adults and juveniles
    a. Need to know how much your counts represent as a result of the spawn. Need spawners and fish exiting tributary to estimate original population
6. Non-natal rearers may be identified with isotopes, but this is lethal

Variability among tributaries

The optimal JPE monitoring approach may differ among tributaries, or between tributaries and the mainstem river, and the need to optimize approach will have to be considered against the importance of consistency across sampling locations.

1. Consistent data collection among tributaries is important
    a. Need to take tributary data and survival data for those that make it to the Delta.
2. Mainstem Sacramento

    a. Difficult to monitor due to size of the river. Some adult SR fish enter the mainstem Sac/are counted at Keswick Dam but we don't know where they go- they aren't detected in the tributaries.
    b. The Sacramento carcass surveys have a break of a few weeks, and we may be missing data here.
    c. the mainstem Sacramento, once they get there, figuring out what that survival for the group is feasible. It is more challenging to determine survival from the creeks because of sample size concerns.
    d. On the Sac, the efficiencies are often less than 1%. Challenge in lower Sacramento to get passage estimates
3. Feather River
    a. Spring Run vs Fall Run (SR vs FR)
        i. Differentiating SR and FR is difficult here because they only are a mm or two different in size. Rapid genetic testing would help with this.
        ii. There is spatio-temporal mixing of SR and Fall-Run (FR) fish here, producing heterozygotes. These are identifiable with the SHERLOCK tool.
    b. Hatchery fish vs natural production
        i. Hatchery fish are code wire tagged and ad-clipped.
        ii. From a genetics standpoint, we could sample the spawning adult broodstock to develop the baseline for SR fish in the Feather River.
    c. Additional trapping of small juveniles would help estimate abundance of these heterozygotes and proportions of SR and FR are in the Feather River.
        i. Doable in the Feather most water years except high flow years
        ii. Detecting larger individuals is difficult
4. Battle Creek
    a. Some SR and FR mixing because of temporal and spatial overlap.
    b. At Battle and Clear Creek we try to segregate fish with dams and weirs but they are imperfect
5. Mill Creek
    a. In Mill Creek you could probably sample and get a really good composition of genetics because there are early Spring Run arrivals, very easy to sample carcasses
6. Butte Creek
    a. Not seeing a lot of heterozygotes.
7. Yuba River

    a. Yuba also has temporal and spatial overlap.
    b. Additional testing underway on pop genetics here
8. San Joaquin Experimental population
    a. There are 'Feather River' genetics in the experimental SR population in the San Joaquin River (SJR). Natural production from this population may genetically look like Sac River SR and thus apply to take at the pumps.
        i. This number of natural producers in the SJR should be relatively small.
        ii. Parental-based identification (PBT) is possible but would require a lot of genetic sampling effort. Eggs used in SJR are from the Feather River, but eggs from parental pairs are unique to each river.
        iii. Some potential for isotopic analysis to identify naturally produced SJR "Sac River" fish vs 'true' Sac River fish
        iv. Isotopic analysis may not be able to differentiate hatchery SJR 'Sac River' fish vs true Sac River fish because the eggs are provided from the Feather River Hatchery. These hatchery fish should be tagged
        v. Isotopic analysis is lethal and would require widespread testing

JPE Approaches

Multiple data collection methods and sources could be beneficial by providing multiple, separate, independent JPE estimates for each population.

1. Multiple independent JPE estimates from different data sources:
    a. Fecundity, pre-spawning mortality, Egg-Fry Survival, screw traps
    b. Multiple methods can shrink error, but it also can compound it
2. Lower watershed sampling
    a. May come on-line too late to inform a -pre-Delta JPE in realtime, but apply to a timeseries dataset
    b. Can compare tributary-based JPE estimates to empirical mainstem monitoring

Permitting Issues

1. Permit issues: take while collecting data
    a. Difficult to maintain less than 1-2% mortality during certain times, so may need to reduce sampling frequency to minimize take (both lethal and nonlethal)

b. Seems like the new JPE monitoring system will require additional monitoring and thus additional take
c. Lethal take for operating sampling devices (e.g. RSTR, seine) is a larger issue than lethal take due to ID approaches (e.g. swab vs clip vs PIT)
    i. Also requires more personnel
d. Continuum of ID approach caused take: Swab < Clip < CWT < PIT <AT

Data Collection and Data Sharing

1. Coordination across entities

    a. There is a need to quickly share various data across entities to inform timely adaptive management

    b. Our group does reporting and analysis on CV Salmonids. It is nearly impossible to do real-time adaptive management without timely data access. We need to be able to integrate real ID (e.g. SHERLOCK) data with the other data so managers can coordinate on management across water bodies in a timely basis.

JPE Approaches Breakout Group #1 – Notes

Question 1. What is the common understanding on this topic/goal?

- Need as specific goals as possible, to construct JPE. Geographic considerations: 11 tributaries, do we include them all?
- Goal is to improve the science, in general.
- Follow-up: Focus on major contributors to production (independent) or also include minor (dependent populations). Natural origin versus hatchery-derived.
- *Facilitator: Understanding that JPE is supposed to focus on natural origin fish*
- Priorities, from NMFS perspective, require YOY spring-run CHN Delta performance. Yearlings more difficult to sample. Need to specify focus. From hatchery perspective, can it be dismissed for now, given 100% CWT tag (way to account) in place currently.
- FRFH CHNSR included in ITP. Interim trigger, until JPE completed. Interest is operational effects on spring-run. Focus on more robust contributors to population, to generalize results.
- Need to focus on tributaries that will be best predictors
- Focal populations important question. Historically, RBDD offered good counts of migrating adult spawners. Mainstem Sacramento River juvenile production great uncertainty that must be resolved.

- Follow-up: There are tributaries that contain CHNSR above RBDD. RBDD may not be originate from the mainstem. Data that are available – yearling data are sparse. Hatchery CHNSR 100% tagged since 2014. Expanded loss for Hatchery CHNSR very low (36 individuals) – need to be estimated?

Facilitator: JPE not an indicator of the health of ESUs; rather a tool for management.

- Mainstem is an area of uncertainty. We need to gain clarity on our focus. Mainstem likely mixed population ("sprall"); which is likely of less regulatory interest.
- Old rules of introgression no longer applied. Modern genetic tools will allow determining whether / extent to which introgression is occurring. IFF CHNSR, must account for them if they are numerically abundant.

Facilitator: Segway to second question… what are the data gaps? Minimum to ideal data collection? What do we need to know in order to deal with mainstem, hatchery, etc. issues?

- Which tributaries do we focus on? What is the interest? If it is not how many enter the Delta? We could calculate each tributary and compensate for losses based on distance? Or we could use metric closer to the Delta, instead, that integrates across basins?

Question 2. What are the most critical gaps that need to be filled?

Clarifying: Are data available sufficient for a basic JPE model? If not, what else is minimally necessary & what would be ideal?

- Follow-up to calculating each tributary suggestion: Challenge is that we need it (data) in Dec/Jan (winter-run) but spring-run individuals haven't arrived (until March / April)
- Process question: Where (geographically) do we need to focus? Can we look at the map?
- If goal is to forecast, that requires a lot of upstream data. Can we calibrate our model (based on observations at the Delta)? It may be a more direct measure, if your goal is how many juveniles reach the Delta.
- What is time frame? Short-term or long-term? Old JPEs are based on adult escapement and could develop forecasts quickly. May not advance science in the way we intend. Actual passage into the Delta will likely require advance monitoring / additional data to improve estimates.

- Timeframe for prediction is important to define. For example, Barb pointed out we could collect number of CHNSR in trawl. Or, are we moving forward in real-time monitoring (using genetic data)? Independent populations on map based on historical data (2004)
- Take a step back: JPE will be used for take limits for ITP. Laying a framework for a better estimate for appropriate take limits to protect the species. Let's think outside the box. May not need single number at Delta like we use for the winter-run. Possibility of determining estimate(s) that incorporate diversity, e.g., include each tributary, to insure one dominant population cannot swamp others. Develop loss triggers that would help preserve most limited population. We can do this simply and be more robust. ITP, when proposed, will develop better science. What addition monitoring / technology (e.g., genetics) can create more robust plan?
- A lot of the required monitoring/ data are available but may not be submitted quickly enough to allow forecasting. Many populations were separated into diversity / life history strata across the landscape – may be useful approach. Minimally, coverage / data collection in each ecoregion. Determine relationship between habitat and juvenile production across these different regions.
- Monitoring must be standardized to validate JPE. Precision of estimate is related to efficiencies (can vary widely – especially for yearlings). First step, is to know the goal. If it is fry production, develop monitoring for that. If all life stages, will need trap (or seine or trawl, etc.) efficiencies across environmental conditions (flow, turbidity, temp).
- Goals: Up until now, two goals: 1) advancing science and 2) informing take limit. If goal is preseason take limit, what level of take is protective of the population? If we do not want to take more than X of a population, may need to work backwards. If there isn't much entrainment loss… what data do we need to inform JPE
- Focus on best way to protect species. Do we know parameters for CHNSR life table? Key factors that affect mortality at various life stages? Flow? Migration mortality? If it is the take at the export pumps, it may need to be factor. Develop time (age) or life stage population life table. Some tribs have RSTs and Knight's Landing is good indicator of Sacramento River mainstem to Delta. Gap in data between confluence of each trib and Knight's Landing. Hatchery CHNSR entrained at pumps – how representative are they? Will inform whether hatchery surrogates are appropriate for natural origin CHNSR.

- Reiterate – start with endpoint and move backwards. If number at salvage facility is vital, how well can we differentiate CHNSR and CHNFR genetically? Are FRFH CHNSR good surrogates for natural origin? Develop tools to determine what percentage will be protective of the population.
- Started using new markers this year (with Cramer Fish Sciences). Of the fall / Spring-run fish, only 1 had the haplotype (so very low).
- Hatchery fish provide possible estimate of percentage. Very low (<1% or just over 1%). Acoustic telemetry also mostly based on FRFH CHNSR.
- Confirm that spring-run take very low (genetically). CHNSR and CHNFR overlap and most were actually fall-run (genetically).
- Goal is to monitor / estimate for each tributary. First step may be to examine literature and existing data to develop JPE within 5 years (with additional monitoring incorporated). Wanted to clarify, CDFW does not issue take limits. CDFW manages take triggers – percentage is for management.
- Data gaps for new science related to CHNSR:
    - CHNSR temps tend to be warmer earlier, relative to later – does the thermal tolerance vary for CHNSR?
    - Thermal profile of tributaries. Some site-specific information available but may need more data to model temperatures outside of hobo sensors. Illuminate possible mortality events.
    - Additional acoustic telemetry and CWT not really new science / monitoring… can we use the existing baseline data from Lower Feather River? Other releases of CWT? Synthesize information = new science using old data.
- To add to comment about hatchery spring-run fish released from the Feather River Hatchery. I am also curious as to how representative these effects are considering these fish are typically released late March/early April and at least since 2009, export operations are generally limited during the time these fish are emigrating through the Delta. Those measures built into the previous biological opinion no longer exist in the 2019 biological opinion
- I have a really basic question: As someone that has not yet been involved in producing a JPE-- how do you determine if the data available is sufficient for a basic JPE model? And if it is not, how to you determine if your sampling/monitoring design will produce useful data to use in a JPE? Assuming the JPE goal is for informing regulatory take.
- Estimates of JPE can vary from basic = JPI x s (survival through system). We can start with something crude but need to determine level of confidence –

and we have time – so we can improve model as additional data streams come online. To determine adequacy, we need some estimate of the error / variability estimates. Can incorporate into the model / refine / improve as possible.

- CHNSR on the San Joaquin now. When released in prior years, higher exposure to facilities. Is the same approach valid for Sacramento River and San Joaquin CHNSR? Will same JPE be used to manage exports? Will restoration fish be factored in or out? Work on San Joaquin JPE also?
- If entrainment loss is primary focus, it must account for San Joaquin CHNSR. If not, Sacramento River CHNSR may be primary focus.
- San Joaquin CHNSR must be addressed ultimately. This JPE is focused on Sacramento River…. CDFW must determine legal requirements for inclusion. Ideally, incorporate from the beginning.
- Identify data gaps, ranging from critical (must have) to ideal (would be nice).
- San Joaquin CHNSR? Hatchery CHNSR? Minor tributaries?
- Reiterate: San Joaquin CHNSR will be included in JPE / take
- All tributaries, if adults included.
- Estimate of Delta entry of CHNSR juveniles. Survival of CHNSR juveniles from tributaries to Delta.
- *Facilitator: Understanding is natural origin CHNSR is focus*
- Expect FRFH CHNSR will be component of JPE (similar to how Livingstone is part of CHNWR JPE). Mitigation fish.
- If include adults to construct number that should arrive at Delta (i.e., winter-run JPE), and we only include some adult populations, our estimate will be off.
- Parentage genetics could allow differentiation of take in the Delta to particular drainages / tributaries, if that is our focus. Need to identify question/ focus.

Facilitator: Fry-to-smolt survival (for each population/ tributary). Incorporating hatchery and San Joaquin fish

- San Joaquin may be more important because they are more likely to arrive at salvage facilities (relative to Sacramento River) fish. It doesn't take many adults in San Joaquin to produce juveniles at salvage facilities.
- Commented that SJ fish important and may be considered as separate JPE per SJR settlement rules
- Quantifying absolute abundance at monitoring locations

- If abundance estimates are needed from tribs – which ones? Will summarize ITP requirements; may be good start but may not fill all needs. What about life history variation?
- Yearling life history strategy complicates model. Whatever cue might be controlling which strategy is implemented (Genetics, Environment, or GxE), capturing that may be really important.

Facilitator: Run ID / monitoring workshops hopefully solving some of these issues.

- Lots of overlap (among workshops) – possible to discuss run ID and monitoring also – to insure included.

Facilitator: Table until tomorrow

- Yearling salvage data? More rare than young-of-year (YOY)? Value of yearling may be higher than YOY (because 1 year older). Only Mill, Deer, and Butte Creek populations have been monitored well. Yearlings play important role in Mill/Deer during droughts, but not in Butte Creek.
- Juvenile equivalence important concept. Yearlings may be incorporated down the line. Other data gap, what is prevalence of yearlings in salvage facilities? What historical data are available? How can it be incorporated?
- Follow-up on Steve's comment, if discussing life history, must also discuss difference in maturation, timing, hatching, growth, etc. among tributaries. That (geographic) diversity is important to keep in mind as we approach this modelling problem.
- Otolith microchemistry indicates a lot of variation if life history strategies exist – what is best predictor remains to be determined.
- To answer yearling question – only 2 yearlings identified in salvage facilities in 2014(?) – but may be limitation of LAD (length at date) mis-IDs. Current ITP does not include fall-time but may be amended if that is when yearlings are encountered (October and November).

Question 3. What are the tradeoffs (i.e., pros and cons) to filling different gaps?

- Yearlings
  - *Pros:* Important life history strategy *Cons:* Very few at salvage facilities; Data limited in general
  - How to incorporate life history strategy (portfolio)?

- Survival estimates (fry-to-smolt) Each tributary(?) Size distributions of emigrating juveniles – most are too small for acoustic tags

Pros: Essential to JPE, ELAT tags may allow smaller fish (65 mm)
Cons: Highly variable among tributaries May not be real-time / available for annual forecast Size of fish monitored Cost of telemetry

- Historically, have a lot of prior CWT releases Forward, if focus is Sacramento River
  Pros: Addresses ITP *Cons:* Ignores San Joaquin (management) requirements
- Which tributaries most important? Mill, Deer, and Butte Creek Focus?
  Cons: Diversity strata may fit needs?

Remaining Data Gaps

Geographic framework particular issue

- Inclusion in JPE of:
- Sacramento Mainstem?
- San Joaquin?
- Which tributaries?
  - All?
  - Main? (Mill, Deer, Butte)
  - Every eco-region?

Resolution

- Hatchery-derived (FRFH)?
- Minimum requirements likely insufficient. San Joaquin may be best as separate JPE?
- Ability to meet ideal requirements depends upon: Run ID solutions? / Monitoring solutions?

Temporal framework particular issue

- Inclusion of stage-specific estimates to capture life history variation:
- YOY (young-of-year) vs. Yearlings
- Survival rates for natal tributary-to-Delta

Resolution

- Ability to meet ideal requirements depends upon:
- Run ID solutions? / Monitoring solutions

JPE Approaches Breakout Group #2 – Notes

Question 1: What is the common understanding of information on this topic?

- Helpful to break this down; impression so far is that there may be ways to categorize the general JPE approaches, based on geography etc. Three areas:

1. Generate a JPE where we put most of the emphasis on getting the adult numbers right in locations; then use survival information to translate that into numbers of fish (furthest upstream emphasis)
2. Lots of emphasis in tributary juvenile sampling; but still need survival data
3. Take it right down to the Delta; places like Nights Landing have been useful for Winter Run; need efficiency and accuracy
    - For management in the Delta, we need more of a warning early on in the season. Need to manage entrainment using another tool (coded wire tags as a surrogate?)
- Structure by life stage or geography? Focus on adults? What do we need to know for the JPE if we're going to focus on the juvenile life stage?

- Can't see how to separate fish coming in from the San Joaquin side from those coming in from the north. Whole purpose of spring-run JPE is not clear because of that
    - Yes, this is a huge challenge
    - Relying on entrainment data is way too late to protect any fish
    - there are labor-intensive ways on the genetics end to account for fish coming from the San Joaquin when we're looking at the pumps
        - Can manage entrainment based on hatchery surrogates
    - this makes some sense; but is this still not too late for protecting them that year?
    - can use genetics to classify as spring-run, then more detailed analysis to find out which ones are originating from the San Joaquin
- Not really sure what question the JPE is trying to answer; its design depends on that.
    - JPE overestimates survival for the Delta - how can we get a more accurate picture?
- In terms of general approach, it makes sense to keep things as simple as possible to get a model going (which will only be as good as the data going into it)
    - Life stage breakdown: areas where improvements can be made, can focus on each of those
    - Take monitoring at the pumps has error associated with it
    - Numbers should add up as fish are moving through the system; should validate the model

- I suggest starting by breaking it out by basin. Feather and Yuba Rivers, Sacramento Basin and San Joaquin. Next think about data needs from upstream of Delta and separately Delta entry and in Delta needs."
- Easy to come up with lots of hurdles we'll have to navigate, but important to break it down into individual pieces and parts
    - Starting place: identify data needs on the adult and juvenile side for each basin
    - Can then fill in what's needed for that basin either in terms of estimates for adults , get more data points online, transition into juvenile production estimate based on passage estimates at different points
    - Components: tributaries, Delta entry, in-Delta
- Re comment about JPE estimates and survival in the Delta: Want to have your solution crafted around what the question is.
    - ITP main question: what is the proportional entrainment at the pumps? Having a tool to answer this is paramount
    - When ITP negotiations were started, idea was to set a threshold connected to historical data (separated from population) - all agreed this was not helpful because of the uncertainty at the pumps, not tied to population etc.
        - Releases are the current proxy that allows accounting of fish at the pumps
        - Ultimately, CDFW director liked the way it was going for winter run where you have a real estimate of the number of fish coming in
            - Related - have an estimate at the pumps.
    - Recognizes that entrainment is a myopic way to look at things. Goal is to have a tool that serves the primary need but is also useful for other purposes (evaluate effectiveness of restoration projects, understand long-term status of stocks)
    - Fundamental question: can we develop a population estimate that we can use for entrainment management?
- "Very challenging to create and early signal of presence into the Delta that is representative of the different life history expressions across the different strategies. This seems like a fundamental challenge to address."
- "I agree with what Ted is saying about having a model based on the existing monitoring to not only estimate spring-run take at the pumps, but also identify other areas/sources of mortality so that the JPE can have multiple uses."

- Develop early warning of entrainment risk for fish entering the Delta
    - Multiple expressions of life histories and emigration
    - End goal from a species protection perspective is to have representation in a JPE for all the listed populations
    - How do we break this down into parts that gives effective representation of populations and life history strategies
- Reiterating point about knowing what question JPE is trying to answer
    - Knowing what's going on at the pumps will require a totally different approach
    - Having more information isn't necessarily helpful
- I agree. This is why we are getting input from all of you"
- Assuming that one of the things needs to be developed - how many fish are available in the Delta to be entrained?
    - Need to not settle on one type of data (juvenile vs adult) - combine statistically to provide a best estimate that can be refined over the season or post-hoc (not easy, but feasible)
    - In fisheries management, it's easier to measure take
        - Relate to export activities and entrainment
    - "That is a great point. By suggesting three general geographic areas/life stages, I didn't mean to imply that we could use combinations of all."
- Early warning winter-run movement toward the Delta, time to take action as the fish are approaching the Delta
    - Knight's landing would serve same type of purpose
- Steve had a great point - we should have an approach with refinements over the course of the year.
    - Likely to have some sort of approach that can include early warnings and be able to evolve the approach over time as we learn more and develop new tools
- "Approach within season and over time. Think of how the use of the JPI and JPE have evolved over time"
- Refined more recently the JPE with the use of acoustic tags to track fish,
    - Be open to including multiple data points
    - Will need to be changes over time as our understanding evolves and more data becomes available
    - Because of where they're positioned, monitoring locations can allow us to calculate passage estimates into the Sutter Bypass etc.
- There are long-term datasets of spring run escapes, but we have almost zero understanding of juvenile production coming out of the tributaries

    - Embrace the idea of the evolving approach
    - Worth starting with context of looking at adult escapement and what we know about survival
    - Can we model out juvenile production based on adult escapement?
    - Would probably take a long time to get the monitoring program permitted and running.
- "Great point Howard. The additional problem with estimating trib survival is that it would be hard to justify using our typical tool, tagged hatchery surrogates. Instead, we would have to tag wild fish, which has take issues."
- Are we developing an estimate that we can exclude yearlings from? Are we doing a JPE for just juveniles?
    - We need to account for life stages; this is where the suggestion from Steve (including improving information over the course of the year) comes in - we have basic information about juvenile survival. Could be the initial basis of the estimate, but would probably evolve as we collected fish and got a better idea of the life stages and timing
    - "Ted, yes the take of wild fish could be very high (capture, handling, tagging). Also layer on top their declining status and the monitoring/take effects could be a serious concern"
    - Should we incorporate a YOY estimate/yearling strategy? Would that be a simpler approach in terms of monitoring cost?
    - Yearlings don't get entrained at the pumps. If we're building a tool to help us understand when fish are entrained, then we should focus on outgoing juveniles. Need to explicitly say we're not including yearlings
    - "Sorry Bruce, I don't see how we can ignore yearlings, even though it would be an easier problem without them."
        - "Then maybe we need two different tools"
        - "I do think we need to consider two tools. Yearling and young of year?"
- Circle back around to thinking of this like an equation and plugging in the variables. There's an important life history component for spring-run that maybe hasn't been included before
    - Think about tributary vs mainstem monitoring and look at it across time
    - We have been screw-trapping on Butte creek for years, difficult to develop passage estimates because of water velocities
    - Recognize that trap avoidance behavior is high and turbidity is low
        - Might not detect them in the tributary; acoustic tagging and tracking would be useful

    - Lots more confidence in our adult estimates for spring-run
    - Trap efficiency understanding to help with model
    - Reiteration of breaking up into individual parts.
- "I feel like we need a solid inventory on where juvenile spring-run emigration monitoring is occurring, and where it is not occurring. I was under the impression that all the major spring-run tribs had screw trap monitoring in place. Definitely, the "best" numbers we have to start with is escapement. We need then the best fecundity estimates available. Most accurate number of eggs laid would be a length-fecundity relationship that would then be interfaced with length-frequency distributions of females from individual escapement surveys. This would be more accurate than using average fecundity and would help account for annual variation in female size distributions. If not already developed, could develop a length-fecundity relationship (will have lots of variation) at Feather River Hatchery. Sorry for the long comment. I don't necessarily need to speak on this. "
- Agree, want to get a reliable estimate of yearling fraction, probably need to use other techniques other than screw traps (PIT tags, electrofishing, radiotags)
- Recognize the importance of protecting major life stages
- We entrain a lot of yearling spring run
    - "question should be what % of yearlings are entrained"
    - Not just a matter of entrainment in the pumps, but in the interior Delta. Interior Delta is known to have overall poor conditions in the fall
- JPE is not intended to be the only tool used for entrainment management
    - Other sampling programs - need predictive instead of reactive tools

Question 2. What are the most critical gaps that need to be filled?

- One of the best sources of information we have is the adults.
- Rob brought up different ways we could sample for juveniles in the creeks - why not snorkel surveys?
    - Nets or screw traps don't seem as likely to work in the fall
- Difficult to separate adults in spring and winter run in feather/Yuba river basin
    - Another data gap - currently no juvenile monitoring going on either; have a mixed spring/fall run escapement survey but no juvenile monitoring
    - Good point about adult data gaps in this area, for the rest of the Sacramento basin its pretty comprehensive for adults

    - "Colin, assuming that we could at least do genetics are carcasses following spawning?"
    - "Can the spring-run component on the Yuba be split out with Vaki counts, or has that not been successful/discontinued?"
    - Increasing monitoring on the Butte in November
- Juvenile monitoring is ongoing on Battle creek; antelope/deer is unclear right now
    - Also, juvenile monitoring on the Feather thanks to DWR
        - Carcass surveys
        - Vaki river watcher system on the Yuba tracks passage of salmon upstream of the Gare? Dam. Not all of the spring run decide to move past the Gare, hang out below before moving up to spawn later in the season
    - We need the JPE from the Sac basin, but fish coming out of the San-Joaquin have a lot of feather river characteristics, need a way to account for them somehow
    - Distinguish between the reintroduced fish vs spring run in the Stanislaus and Tuolumne pre-dating the restoration programs
        - Picking up numbers of individual fish that are migrating outside the window
        - Should be distinguishing between the populations
        - Perennial tagging/testing to see parentage
- In order to improve data, we need to do additional monitoring in the core streams; additional tribs would be an add-on
    - If we're not including dependent populations in the JPE calculation, how will that affect error?
    - Increase monitoring in a tiered fashion
    - "Status on juvenile emigration monitoring on Mill and Deer from Matt Johnson, CDFW: Currently we are just using the RST's on deer and Mill for capturing and tagging steelhead smolt. Traps run Oct-Dec and March-June. Some overlap with juvenile spring-run emigration but very incomplete."
        - Programs could be augmented to fill in gaps
    - If we focus on the main stems and are underestimating input from tribs, would that reduce the take estimate? Take would be less than the real production?
- Getting back to the idea of **dependent streams** (incl San Joaquin tribs) - what about aerial drone surveys for redds? Fairly inexpensive; would they work?

    - Should have triggers for monitoring in place; know how many adults and juveniles there are
    - Dependent tribs (e.g. Chico creek) can have physical barriers that separate spring run from fall run
        - What is the threshold for deciding to increase monitoring effort?
        - Drones are cool, but some of the systems are wild/remote
    - Like the idea of redundancies and multiple approaches
    - "Ground surveys also good for data collection on fish; e.g., female size distributions for estimates of # eggs laid. No verbal needed."
- Working with US F&W to evaluate disease in fish in both the Sac and Feather river; quite an issue with C. shasta on the feather river - something there that needs to be evaluated
    - Might be able to account for losses with an estimate
    - Lots of factors that influence survival, there's already enough data out there we could work with to begin building a simple model (how many fry you're starting with based on escapement and numbers at various checkpoints) - assemble basic information to get a feel for how well the data we have now will work to achieve the desired goal
    - What factors are limiting survival through certain reaches?
    - Use some data to build out the model and some for verification
        - In addition to thinking about temperature-dependent mortality, also be thinking about flow impact on survival
        - I agree about hatchery fish as a method to measure trap efficiency, but what do we do in streams without a hatchery? Perhaps limited work with wild fish?"
            - Trap efficiency is a huge data gap; but no one wants to throw hatchery fish in those streams. Need to figure out a way to use wild fish for these assessments
            - Yes, I was thinking about that, too. You really want to have large numbers of fish for gear efficiency trials to get high resolution, but that is typically difficult on small tribs, even the larger ones at times. My old-school fish and game self says to make some exceptions and use hatchery fish in non-natal waters. Tough sell, though."
            - Tributary vs mainstem monitoring has a completely different capture efficiency. Sampling a smaller volume of water/spawning grounds results in a higher proportion of the population being captured

    - In one of the locations on the feather river, DWR saw 30-40% passing the trap
    - A portion could be captured and released upstream to give you a trap capture efficiency calculation
    - Looks like we're capturing way more spring-run at Night's landing than we actually are; maybe do an after-the-fact analysis
    - Post-hoc analysis can correct estimates
    - Acoustic tag based survival estimate in the future? Nuance for near-term genetic analysis in season and creating a passage estimate (should be timely based on hatchery releases)
    - Genetics is a fast-moving area; DWR goal is to develop a field-based method so you don't have to send samples back (CRISPR!).

Question 3: What are some of the tradeoffs to filling different gaps?

- Tools to evaluate tradeoffs (7 identified)
- Inherent tradeoff in allocations across the system
    - Identify whether we want to move towards key data gaps within a system or spread effort out across tributary (share knowledge gaps across them)
- Look at current data being collected and how they're being used for monitoring, then what we would do in the short term (focusing on specific locations or expanding), but first step is to know what we have currently
- We have to have some sort of starting point; one of our best data sources is adult population estimates, so first priority would be to make sure we are accurately estimating adult survival and tiering juvenile sampling beyond that.
    - Need to have an understanding of what's happening in the Central Delta in addition to the estimates from the screens (not that informative on its own)
- Additional monitoring in the basins would be beneficial for many reasons
    - Having more data relevant to spring-run alone is beneficial, but seeing status and trends and inferences into population conditions for steelhead and fall-run are important as well
    - Seeing changes in ratios across years would be powerful

        - "how variable that is will drive some of how important it is to get in on all sites in all years, or not?"
- "Do we have much data on sex ratios for adults?"
    - should be ratio information from the escapement surveys and from the Feather river hatchery as well (typically a routine part of data collection)
    - sex ratio and pre-spawn mortality are easily monitored through carcass surveys
- What would it take for the tributary surveys to be useful for modeling?
    - Put together a comprehensive monitoring plan
        - With central valley chinook escapement monitoring is standard for making estimates; open-population type model has shown an evolution to get the most accurate estimates
    - Worth it to understand methods for each survey to determine if they're useful
- Simplistic vs detailed approach; time vs permitability, $ vs accuracy etc.
    - In the workplan we're putting together we'll have a menu of different options. All could be used potentially at different levels/times
        - Be able to break down strengths and weaknesses for each of the general approaches
- Are we keeping YOY and yearling separated? Could be different inputs to the same model
    - Makes more sense to have a strategy for both estimates; they're linked and dependent on each other
- Estimates get convoluted; there may be utility in accounting for overall effects for a given year class, but also would be good to have them integrated
    - Pay attention to different budgets

Appendix 3: Day 3 Plenary Session Notes

I. *Monitoring Breakout Group: Flora Cordoleani*
   a. There are enough adult spawners overall
   b. Should be more focus for juvenile monitoring
   c. Focus on upper part of system – how many fish are leaving the upper tributaries
   d. What are other sampling locations important for spring run
      i. Capture juvenile spring run using trawling
   e. Overall what size and time do juvenile move to Delta? Where do they rear?
      i. More monitoring to focus on life history types
         1. Using otoliths
         2. Using modeling
   f. Using modeling tools is important
      i. Juvenile trapping + juvenile abundance estimates
      ii. Look at historical data – predict JPE using current numbers
   g. Want better estimate of juvenile survival from tributaries to Delta
      i. Where do they experience high mortality?
      ii. New technology we can use/try: tagging (smaller, better tags)
      iii. Pit tagging + other types of tags
   h. Include SJR into JPE and have idea of abundance of juveniles
   i. Feather River hatchery is the only one that produces spring run
      i. Use spring run fish them to do studies and get data (i.e. egg productivity data)

II. *Monitoring Breakout Group: Brooke Jacobs*
   a. Current monitoring data that needs to be included/accounted for
      i. Use the existing knowledge from CDFW in the monitoring plan process and learn from what we've already done
      ii. Adult escapement estimates
      iii. Monitoring been done in Yuba and Feather rivers – need more access to this data
      iv. Small natal streams have monitoring but the data is not accessible
   b. Gaps
      i. Juvenile monitoring
         1. Hard to monitor where hydrology is flashy
         2. High cost – staff and equipment

3. Fremont weir modifications
4. Predation
5. Floodplain stranding (juvenile and adults)

ii. Escapement and early life stage survival
1. Egg viability
2. SJR restoration successes and challenges
3. Egg to fry survival estimates
4. Document age of returning adults
5. Better adult escapement
    a. Resource needs are different based on techniques
6. Combine different survey methods

iii. Better identification of runs
1. Fall and spring run differentiation
2. Spring run yearlings
    a. Could use better genetic tools

iv. Overall monitoring needs
1. Integrate different monitoring and methods when planning & implementing JPE
2. Access to data scientists
3. Benefits of combining data sources
4. Staff safety and fish health
5. Take authorization

III. Run Identification Breakout Group: Pascale Goertler

a. Tools
    i. Tradeoffs between genetics ID and rapid results
    ii. Run level ID is okay for JPE
b. Must haves
    i. Time or effort for processing fish (especially juvenile processing)
    ii. Broad support
    iii. Time to develop and scale up methods
        1. Use probabilistic date at length tool + genetics
c. Critical gaps
    i. Sample before Delta entry
    ii. main stem sites difficult to sample
    iii. life history diversity important
        1. for JPE
        2. for habitat availability
    iv. spring run non-natal rearing
    v. adult spawning in less typical streams

1. need to do more modeling

vi. tributary ID monitoring needs adaptations (space +time considerations)

vii. Split egg lots – can use genetic tool, but it's not ideal

viii. SJR fish specific length at date or use different branding + tagging methods

IV. Run Identification Breakout Group: Brett Harvey

a. Non-genetic methods
   i. Video ID of spring run – effective, but can be refined
      1. Can be used to learn sex and fecundity
b. Genetic methods
   i. Crisper based
      1. Rapid return
      2. Customizable
      3. Rapidly scalable
      4. Cost effective
      5. Useful with probabilistic length at date
c. Alternative ID methods
   i. Opportunities for efficiencies
      1. Pool samples and look for spring run allele, once found, then look for individual spring run fish
      2. Winter run and spring run mix more, thus need efficiencies in genetic testing to track both runs
      3. In SJR, currently fish are hatchery fish, and account for a small proportion of the take at salvage facility
   ii. Permits
      1. ID fish and take genetic samples, or use tagging which will increase level of take
         a. Group said tagging does not increase the amount of take
         b. Most take is caused by capturing a fish period
      2. Heterozygotes – cross of spring and fall run
   iii. Would help to have redundant JPE methods
      1. Adult fecundity initially
      2. Monitor different life stages

V. JPE Approach Breakout Group: Pete Nelson

a. It's important to identify specific goals and objectives, especially that help limit efforts, define efforts geographically, etc.
   i. Clear framework should list which tributaries are included

ii. Must come up with appropriate management objectives

b. What goes into a model and what doesn't?
    i. Necessity to evaluate tributaries and main stem Sacramento River production is important
    ii. Account feather river hatchery and SJR fish
    iii. Life history variability in spring run and how we account for yearlings
        1. Is ecologically and evolutionarily important life history for yearlings
    iv. Value in historical data sets
    v. Incorporate historical data + downstream monitoring data that compliments upstream monitoring
    vi. Array of errors and variability – test models (error estimates)
c. Miscellaneous
    i. Need clarity on logistics of timing – when must annual JPE be available for management?
    ii. Adult monitoring, there is a robust data set, should be factored in
    iii. Alternative approaches have merit
        1. Approximate and ultimate objectives
            a. Maximize resources
    iv. Account for sprawl run – fall and spring mixed fish
        1. Use new genetic tools
    v. Independent and dependent populations based on historical data – things probably change so needs considerations
    vi. Loss triggers for systems
    vii. Use of tools (habitat production models, monitoring eco-regions, integrate temperature profiles from different tributaries)
    viii. Develop chinook spring run life table – key factors that affect mortality at different life stages - optimize monitoring strategy
d. Multiple management and scientific objectives

VI. JPE Approach Breakout Group: Oliver Burgess Towns

a. Understood the focus is Sacramento basin spring run, SJR spring run not included
b. As we use JPE for managing entrainment or export control in Delta
    i. San Joaquin basin fish in the Delta = challenge
c. JPE needs to provide early warning system for managers for Delta exports

        i. When planning monitoring for JPE, think carefully for where locations are
    d. Not required to pick one method, multiple can be used and combined statistically or in a model for robust juvenile production estimate
    e. Monitoring = evolve within season and over years
        i. JPE for winter run does this
        ii. Be flexible in approach
    f. Gaps
        i. Genetics = can be critical gap
            1. Risk associated with relying too heavily on length to date model
    g. Differences in timing and behavior between young of year (YOY) vs yearling
        i. Yearling and YOY handled separately for production estimate and timing data
    h. Annual escapement from tributaries = good data set exists but room for expansion
        i. General understanding of survival exists
        ii. We need to know what the actual production is
    i. Existing monitoring need modification to be useful for JPE
        i. Ex: Feather and Yuba escapement is mixed between fall and spring run = use vaki river watcher to separate the two runs
    j. Utility of including dependent streams in JPE – there's value in this
        i. Some years larger population, other years, adults entering = low
        ii. Monitoring that includes trigger so we know when to increase monitoring in these streams
    k. Redundant monitoring
        i. Helpful in case we use one specific method and it doesn't work well
    l. Overall trade offs
        i. Inherent trade off of simple vs complex approach and cost vs accuracy
            1. Consider phasing in new components as needed
        ii. New long-term monitoring = long time to fund, design, permit
            1. Phase in new data overtime
            2. Start with robust datasets

VII. *Monitoring Plenary discussion about group report outs:*

    a. Barb Byrne (NMFS): current and future funding options for all of this

        i. Brook Jacobs: good monitoring right now – year to year funding availability; resource needs = key limiting factors in monitoring program – balance data quality with funding needs.
    b. Brad Cavallo (Cramer Fish services): juvenile monitoring – lot that goes into getting reliable JPE, especially at different life stages, more than just doing trap efficiency test, it's a challenging process – rigorous sampling design, sample at different times, in all conditions, at all life stages – this isn't a trivial matter
        i. Brad Cavallo: has written bunch of things that can help synthesize this info
    c. Mark Gard (CDFW): vaki river watcher is a good idea, but for Yuba needs to be supplemented with genetics of carcasses; back in the day we found some redds of spring run timing; most spring run found upstream; CLARIFES: not sure if Yuba collects carcass surveys genetics

VIII. Run ID plenary discussion

a. Steve Zeug: run ID, for regulation in Delta, if identified as spring run, it's going to count as take regardless of origin so needs to be accounted for. Feather and Yuba counted the same in take; regulation vs ecological scientific exploration. More Details: if you know the goal of the JPE, then you can determine expected take. What level of resolution for spring run do you need? Basin specific? – need more complex methods – so defining goals =important to lead to what info you have
b. Brett Harvey (DWR): initially the JPE goal is going to deal with water manager perspective – regulate pumping around juvenile; long-term goals and objectives in interim take permit – develop life cycle model and ultimately work towards recovery; but with this short timeline, there's a narrower focus
c. Pascale Goertler (DSP): goals are different depending on the model: extinction risk vs JPE or conservation vs resilience. Diversity = important; climate is variable so need to figure out which life histories work better in which years and move forward with that
d. Tracy McReynolds (CDFW): trap efficiencies: overarching factor is how take fits in; level of effort to do JPE, includes lot of take – what are tradeoffs of take per species – how is take appropriated for projects, especially for methods that require heavy take or that take two/multiple species like green sturgeon – take jumps out as a problem for me.

i. Brett Harvey: sampling needs to be curtailed at certain time of year. As JPE develops, lots of conversations with NOAA fisheries; trying to protect species but not hold back important research – got to find good balance
ii. Barb Byrne: need to consider take, tools we use is "stopping rules" which can create gaps in records, so it's challenging, but NMFS needs to balance
iii. Pascale Goertler: coordination; spring run exist across large landscape; swabbing and other options, so take can be less invasive than finclip
iv. Melinda Baerwald: even if less invasive, it's considered take
v. Josh Israel: JPE doesn't have to be monitoring in perpetuity. Using models to improve the monitoring. Struggle a lot with research monitoring that goes on in perpetuity – how to work with other agencies to balance that with take. Use specialized targeted studies
vi. Tracy McReynolds: hope we get more outside the box ideas from these discussions like what Josh Israel said; targeted research to build a model and figure out monitoring that way
vii. Cathy Marcinkevage: challenge to find balance between take for research and take. Take limits are made with context of population. We don't want to stand in way of beneficial research, but take limits exist for important reason – to sustain population.
viii. Flora Cordoleani: use approach to look at trap efficiencies in tributaries can lead to less take, look at some tributaries where trap efficiency works well and then extrapolate – learn from what we know then use math tools for more info.

IX. Plenary JPE approach

a. Ted Sommer
i. Short high-level integration, but ideas will evolve overtime and as discussion continues
ii. Must evaluate each idea based on cost feasibility etc.
iii. Key locations for estimates
iv. In state permit, focus is entrainment management – need to know number of fish coming into Delta, and quantify of fish lost at diversions
1. Need focus, but that data has broader application and interest

2. We want the data to be useful for other information

v. Timely information. For entrainment management need info as soon as possible
vi. General challenges
    1. Life history diversity – unique aspect of spring run
    2. Multiple tributary sources, varied monitoring across tributaries
    3. Non-natal rearing
    4. Timely information of data
    5. Race id – huge issue we want to tackle
vii. What's in our toolbox?
    1. Acknowledge that this is a hard problem
        a. Harder than winter run
    2. Multi-tool approach – monitoring, experimentation, modeling, redundancy & mixed methods
        a. What works best and for what conditions (redundancy)
    3. Compromise necessary
        a. Don't have unlimited resources
        b. A lot of issues (i.e. take) to consider + rationalize for workable approach
    4. Need to be able to account for SJR and Feather River hybrids (sprawl run) fish (diff sources of fish)
        a. Don't need JPE for each source, but need way to account for them in entrainment measures
    5. Separate approaches for yearling and YOY?
        a. Spring run = unique life history
        b. May need different JPE for yearling and YOY
        c. In entrainment year, two separate year classes to deal with – yearlings from older year class, and YOY from current year class
    6. Effort to vary by location
        a. More effort in core locations (independent sources), but we can try to account for dependent locations
    7. Approach likely to evolve
        a. Seasonally
            i. Initial estimate and progress as we get more info about life stages

        b. Annually (i.e. triggered plans)
            i. Varying effort by location
            ii. If adult spawning detected in peripheral tributaries, we can focus monitoring there
        c. Into the future
            i. Going to do research that hopefully gives predictive capabilities and not monitor like this forever
    8. Modeling and analysis
        a. Existing winter run JPE approach
            i. Integrate with existing winter run JPE approach
            ii. Approach should be useful for life cycle models
        b. Life cycle models
    9. Special challenges
        a. Run ID
        b. Error estimates
        c. Data availability
    10. JPE concepts
        a. Have guiding conceptual model – have a starter for now
            i. Adults make eggs, some survive as juveniles in tributaries, some survive as juveniles into Delta
        b. Early season estimates
        c. Management in Delta for entrainment: place where we need to get things right
            i. Managing juveniles in tributaries = heavy lift and need more effort
        d. Juveniles entering Delta is bottom of list because of timing despite being overall goal
        e. Model should show where we put effort differently along life stages
        f. In Delta what portion coming in as juveniles
b. Louise Conrad
    i. Monitoring to support a JPE
        1. Align monitoring with JPE goals

        a. Tradeoffs: increase efforts for juveniles or spawning adults/eggs?
        b. Tributaries (also a black box of mainstream of Sac River)
            i. Get handle of productivity in these tributaries
        c. Survival estimates
        d. Where do we enhance and put in more resources?
        e. Trap efficiency is hard
    2. Target yearling and YOY life histories
        a. Yearlings not well seen in existing monitoring right now
            i. Need more focus here
    3. Methods
        a. Explore the full toolbox
            i. Multiple tools – snorkeling, genetics etc. = build resilience
        b. Incorporate genetic tools
ii. More resolution needed for Run ID
    1. All life stages
        a. Explore full toolbox for run ID
        b. Key tradeoffs: time/money; genetic resolution vs rapid results
    2. Geography, especially upper watershed
    3. Life history diversity: more run ID could help
    4. Sacramento vs SJR spring run in south Delta
        a. Can't ignore SJR for south Delta issues
iii. JPE development; connecting the dots
    1. Management relevance
        a. Entrainment: early warning system
        b. Fast turnaround?
    2. Scope
        a. Needs a framework (see concept model)
            i. Critical to have this as starting point
            ii. Life table for spring run salmon – useful tool for homing in on key uncertainties
        b. Sacramento tributaries, SJR, Feather River
    3. Resources
        a. Staff, equipment, safety!

b. Permits/takes
    i. Take is a resource – resource that's limited
c. Money
    i. Got to make careful decisions

4. Coordination
    a. Lots of interest, and groups and programs – how to leverage all that towards JPE?

iv. Initial expectations
1. Multiple tools necessary
2. Efforts should sustainably advance salmon science and management
3. Lots of research & development needed over next several years
    a. Iterative process
        i. Reminded of adaptive management wheel
4. JPE won't be perfect
5. Further refinement essential even after JPE implementations

c. Ted Sommers
i. Next steps
1. Manuscript – mid 2021
2. Draft JPE science plan to CDFW for approval December 2020
3. JPE research & development (Jan. 2021 to May 2024)
4. Approved JPE approach implemented each year with ongoing evaluation (Jan. 2025 -)
5. Need for ongoing input, coordination and outreach; need for ongoing evaluation and refinement; will have more venues for input from folks
    a. We've talked about framework, but need adaptability
    b. Put together that has good starting point and process to have good JPE process

X. Questions for Ted and Louise

a. Bruce Herbold: enjoyed and learned more than expected to. Encouraged. Brought in skepticism about keeping San Joaquin spring run out of the issue; we can't do that because they'll affect the take numbers; if we embrace SJR spring run as they represent timing, survival and response to climate conditions = easier to sample. Can

sample them coming out of tributary streams because there're less tributaries down there, but if we can use them to correlate what we expect from spring coming out of sac.
    i. Ted: yes we can learn from SJR spring run; Flora noted idea of statistical understanding of trap efficiency to extrapolate across places less sampled; limited resources = can learn from the tributaries, but not put our efforts there, use info from resources already existing there

b. Barb Byrne (NMFS): if DWR and CDFW are thinking 5 years out and JPE is used for entrainment loss threshold; current loss threshold based on combined CVP and SWP; SJR fish show up more often in CVP, Sacramento fish show up more in SWP; so for the 5 year target, think about if there is a facility-specific element to loss threshold or measures. Both basin fish show up at both facilities but at different levels.
    i. Ted: yes, that's true, we collect salvage at both facilities, but with good race ID we can account for losses individually
    ii. Brook Jacobs: slate is clean right now for how we'd approach take of spring run – suggestions welcome. Talk about potential of early warning minimization measure, salvage = reactive; just another potential idea.
    iii. Ted: Brook said that JPE isn't only tool for entrainment management; we'll use all data sources

c. Brad Cavallo (Cramer Fish Sciences): focus = entrainment management; gap = have existing info of spring run entrainment, so use it to find standards for entrainment management; also genetic spring run loss at export facilities can be found in archived info
    i. Ted: we'll definitely learn a lot from historical information at export facilities

d. Brad Cavallo: who can we sent materials to now? Who's the point person for us to funnel stuff to?
    i. Send to Eva Bush

e. Rachel Johnson: wire-tag data could look at different entrainment at the export facilities

f. Jada White (PSMFC): impressed with otolith geochemistry; can we collect otoliths that already exist to look at different life history strategies and use to inform methods moving forward?
    i. Flora Cordoleani: we don't have funding to look at more otoliths than what we've presented right now. It would be exciting to

look at more spring run otoliths. Not sure where funding would come from for this.

ii. Rachel Johnson: interested in survey cruises that collect otoliths; some surveys have historically archived them, can use that to reveal life history strategies; keen on Battle Creek, collecting spring run for restoration program; keen to learn if other ppl initiate collection of otoliths

iii. Corey Phillis (MWD): focus so far has been reconstruction of what adults have done as juveniles. Not great representation for what while cohort did as juveniles. We don't have best monitoring to capture life history strategies of a cohort

1. Flora Cordoleani: agree with Corey, look at life history at two times: when they are juveniles and then when they come back as adults; getting info when they are at the juvenile stage is important

iv. Chris Van Holmes (SacPAS): make adjustments based on public ally available genetics, would love to get any archived genetics stored at facilities.

g. Mariah Meek (Michigan State Uni): Anna Sturrock and I have project happening that is looking at genetics and otoliths in Yuba River juveniles; will run genetics on samples and work on otoliths in next month

XI. Louise Conrad closes Workshop

a. Hope you learned something about spring run salmon, population, run, science, management needs, challenges
b. Good change of pace to connect with others you wouldn't get to on the daily
c. We have some sense for the path forward
d. Big thanks to organizers and steering committee from diverse organizations
e. Thanks Henry DeBey – leading steering committee, Eva Bush for facilitation and keeping people on track. All facilitators and note-takers for breakout sessions, Brandon and Brittany Young and external affairs team
f. Appreciate everyone's time and engagement.