Memorandum

To: CVPIA Core Team

From: Science Integration Team (SIT) and Central Valley Science Coordinator (Acting)

Date: 6 February 2019

Subject: CVPIA Science Integration Team: FY19 Decision Support Model Activities and FY20 Priorities

Background

Members of the Science Integration Team (SIT) met during a series of in-person workshops and conference calls from the latter part of 2018 to February 2019 to complete a number of tasks including: (1) identifying restoration scenarios and refining the fall-run Chinook Salmon (*Oncorhynchus tshawytscha*) Decision Support Model (DSM) as detailed in the 2017 SIT Technical Memorandum; (2) identifying and refining objectives for winter-run and spring-run Chinook Salmon; (3) collaborating with the Winter-run Chinook Salmon, Steelhead (*O. mykiss*) and Sturgeon (*Acipenser sp.*) Project Work Teams (PWTs) in developing objectives, scenarios, and priorities for the corresponding taxon; and (4) the identification of Fiscal Year 2020 (FY20) priorities. Additionally, the SIT was asked to provide priority recommendations for monitoring needs for Chinook Salmon (fall-, winter-, and spring-run), Sturgeon and Steelhead for FY20.

The purpose of the FY19 SIT activities was to: (1) improve the existing DSM and use it to identify priorities; (2) use the information to initiate the integration of priorities for all focal taxa that were identified by the Core Team in the initial Structured Decision Making (SDM) efforts (Peterson et al. 2014); and (3) to assess monitoring needs that address areas of uncertainty.

The CVPIA Science Coordinator position was temporarily filled with a staff detail from the USFWS from January 15 to present to assist the SIT with drafting this Technical Memorandum that describes the prioritization process in FY19, and to provide the SIT prioritization recommendations to the Core Team and specific PWTs described above. Notes from SIT meetings and conference calls can be found on the data portal at:

https://connect.doi.gov/fws/Portal/cvpiasitfp/FY18%20Priorization%20meeting%20materials/Forms/AllI tems.aspx

FY20 Prioritization Process Overview

The SIT attempted to implement the same process for all focal taxa detailed in the 2017 SIT Technical Memorandum. Additionally, the SIT ranked priorities that were beneficial to all Chinook runs and also included and prioritized monitoring needs for FY20. The first step in the process included the identification of key population attributes (scientific objectives) that were quantifiable (measurable) and could be used to track progress toward the fundamental objective of achieving strong, self-sustaining populations of anadromous fishes. For the three Chinook Salmon runs, the SIT ranked and prioritized previously identified fall-run Chinook Salmon objectives and identified objectives for winter- and spring-run Chinook Salmon, Steelhead and Sturgeon.

Due to a partial government shutdown that occurred from December 22, 2018 to January 25, 2019, full participation of National Marine Fisheries Service (NMFS) and U.S. Geological Survey (USGS) SIT members was constrained and only 17 respondents participated in the ranking of objectives and monitoring prioritization. Members of each PWT were likewise unable to voluntarily participate early in the SIT process; therefore, the SIT is soliciting comments and review of this draft Technical Memorandum to ensure each team has input in the process and final prioritizations.

The second step in the prioritization process was to identify restoration scenarios that could lead to achieving the fundamental objective of achieving strong, self-sustaining populations of anadromous fishes. Participating SIT members used model output from the fall-run Chinook Salmon model, summary scores and rankings, and personal knowledge/expertise, and were asked to think about the primary factors affecting or hypothesized to affect their taxa of interest and use these to identify specific actions and/or grouped synergistic actions that would lead toward achieving their fundamental objectives.

The third step in the process was to evaluate the effectiveness of each scenario to change the population attributes (objectives) using simple scoring criteria: ranking each scenario from 0 to 100 that corresponded with no effect (0) to most-positive effect (100), similar to a consequence table (Conroy and Peterson 2013). For fall-run Chinook Salmon, the SIT members relied on previous model simulation output described in the FY17 Technical Memorandum. A similar evaluation and ranking process was followed for Steelhead and Sturgeon, with volunteers from the SIT scoring each scenario based completely on expert judgment. The taxon-specific scores were summarized and provided to the SIT.

The fourth step in the process was evaluate Chinook Salmon monitoring needs for FY20 that either continue to provide data for existing modeling (fall-run Chinook Salmon) or address data gaps and uncertainty for future modelling of all taxon.

FY20 Prioritization Overview for Sturgeon Restoration Actions

The SIT implemented an expert elicitation process to develop Sturgeon priorities for FY19 within the past 10 months; therefore, they chose to keep the same Sturgeon priority scenarios for

FY20. This process is detailed in the April 18, 2018 technical memorandum titled *FY19 Sturgeon Activities and Priorities* and is briefly outlined here for clarity.

The first step in the prioritization process was to identify key population attributes (objectives) that were quantifiable (measurable) and could be used to track progress toward the fundamental objective of achieving strong, self-sustaining populations of anadromous fishes. During the FY18 prioritization process, the Sturgeon group had identified objectives and potential restoration actions (scenarios) to achieve their Sturgeon objectives. After reviewing the previous list of Sturgeon objectives, the group made modifications to the original list and proposed attributes of these objectives that represent potential ways to measure these objectives via monitoring data.

The second step in the prioritization process was to identify restoration scenarios that could lead to achieving the fundamental objective of achieving strong, self-sustaining populations of anadromous fishes. The Sturgeon group was asked to build on previous efforts to develop a set of potential restoration actions (scenarios) to help the Program make improvements with respect to the identified Sturgeon objectives. They were asked to think about Sturgeon in particular, to be creative, to give specifics (i.e., amounts, timing, and locations) on each potential action, and to not let potential conflicts with other fish species in the region limit what they proposed for Sturgeon.

The third step in the process was to evaluate the effectiveness of each scenario with respect to the identified Sturgeon objectives, based on participant's expertise. In particular, participants were asked to score each potential action on a scale of 0 to 100. A "0" indicated the worst possible score, where group members believed the potential action will not help meet any of the stated objectives for the species within a 20-year time period. A "100" indicated the best possible score, where they believed the potential action will help meet all of the stated objectives for the specific species within a 20-year time period. A "50" indicated they believed the potential action will only help meet 50% of the stated objectives for the specific species within a 20-year time period. Notably, group members were asked to leave the score blank if they did not feel knowledgeable enough to score a specific scenario for a specific species. The group was also asked to indicate which population attribute that would increase (benefit) the most from the specific scenario. Once the filled-out score sheets were submitted and the score sheets were summarized, another workshop meeting was scheduled to discuss the summary scores and identify where there seemed to be relatively high uncertainty (based on variation in the scores and identified attribute most likely to benefit).

The purpose of these discussions was to ensure uncertainty was associated with ecological uncertainty and not uncertainty in what the group was being asked to score. The group was then allowed to adjust their submitted scores, if needed. When reviewing the summary of the final score submissions, the group was asked to develop five or fewer priority recommendations for each Sturgeon species, again based on expertise and professional opinion.

FY20 Prioritization Process Overview for Chinook and Steelhead Restoration Actions

Due to contracting issues and subsequent delays, the Chinook Salmon and Steelhead DSMs could not be calibrated and integrated in time for the FY20 prioritization. Thus, the SIT attempted to implement the same process as the Sturgeon to develop priorities for Chinook Salmon and Steelhead for fairness and comparability. However, the time frame for completing the process was much shorter and the process was modified to accommodate the deadlines requested by the implementing agencies. SIT members that were furloughed due to the federal government shutdown were unable to participate in the entire process.

Similar to the Sturgeon process, the first step included the identification of key population attributes (objectives) that were quantifiable (measurable) and could be used to track progress toward the fundamental objective of establishing strong, self-sustaining populations of anadromous fishes. The SIT previously identified Chinook Salmon and steelhead objectives for the FY18 priorities. After reviewing the previous list of objectives, the group made modifications to the original list and proposed attributes of these objectives that represent potential ways to measure these objectives via monitoring data. For Chinook Salmon, these led to a more focused (reduced) set of objectives. For Steelhead, this led to a greater number of objectives.

The second step in the prioritization process was to identify restoration scenarios that could lead to achieving the fundamental objective of achieving strong, self-sustaining populations of anadromous fishes. Members of the SIT were asked to think about the primary factors affecting or hypothesized to affect their taxa of interest and use these to identify specific actions that would lead toward achieving their fundamental objectives. They were asked to be creative, to provide specific details (i.e., amounts, timing, and locations) on each potential action, and to not let potential conflicts with other fish species in the region limit what they proposed. These potential restoration scenarios were provided to the SIT for review. Given the limited number of responses (14 total), the SIT decided to score all of the potential restoration scenarios rather than develop a reduced set of potential restoration scenarios and scoring the reduced set.

The third step in the process was to evaluate the effectiveness of each scenario to change the population attributes (objectives). In particular, participants were asked to score each potential action on a scale of 0 to 100. A "0" indicated the worst possible score, where they believed the action will have no effect or a negative effect on the objective/metric for the species/run within a 10-year time period. A "100" indicated the best possible score, where they believed the action will have a strong positive effect on objective/metric for the specific species/run within a 10-year time period. A "50" indicated they believe the action will have a moderate positive effect on the objective/metric within a 10-year time period. For Chinook Salmon, they were instructed that the "Valley-wide Metrics" pertain to fish in the entire Central Valley, and the "Watershed-specific Metrics" pertain to fish from that specific watershed that corresponded to the scenario. For example, for the "pulse flows in the Upper Sacramento River" scenario, the juvenile biomass metric at the valley-wide scale refers to all juvenile fish in the system and the watershed scale metric only refers to the juvenile fish that were produced in the Upper Sacramento River. Notably, group members were asked to leave the score blank if they did not feel knowledgeable enough to score a specific scenario for a specific species/run. The SIT members used DSM output from the fall-run Chinook Salmon from FY18 prioritization and personal knowledge/expertise to score each scenario.

The fourth step in the process was the identification of taxon-specific priorities based on the summary of the SIT scores. Seventeen SIT members submitted score sheets. Of these, seven, 11, 10 and six respondents scored potential restoration scenarios for winter-run Chinook Salmon, fall-run Chinook Salmon, spring-run Chinook Salmon, and Steelhead, respectively. The relatively low number of responses may be related to the government shutdown, which prohibited USGS and NMFS personnel from participating. The SIT considered the fact that scores may not be comparable across participants due to different perspectives. That is, some participants may be more optimistic (i.e., tended to score scenarios higher), critical (i.e., tended to score scenarios lower), or somewhere in between. Thus, scores were scaled using a min-max normalization before combining the scores across submissions, so that each participant's scores ranged from 0 to 100. However, summaries of the raw and normalized scores indicated identical patterns (i.e., rankings based on scores were the same). As a result, the SIT chose to use the combined raw scores for the prioritization process to maintain interpretability.

During the January 23, 2019 meeting, the SIT discussed the scenarios and characterized the priorities using the following criteria: (1) the average score (across objectives and responses) associated with the scenario/ priority, with larger score or higher rank interpreted as higher priority; (2) the potential of a scenario to successfully contribute to the spatial diversity objective; and (3) the number of times a scenario/priority was in the top 10 (winter-run Chinook Salmon, spring-run Chinook Salmon, and Steelhead) or top 15 (fall-run Chinook Salmon) when examining the mean scores across responses within each of the objectives. For the third criteria, a scenario was omitted if it was in the bottom 10 (winter-run Chinook Salmon, spring-run Chinook Salmon, and Steelhead) or bottom 15 (fall-run Chinook Salmon) when examining the mean scores across responses within each of the objectives. Scenarios that were only scored by a single SIT member were also omitted from consideration. Finally, scenarios with relatively strong potential to help achieve fundamental objectives, but high uncertainty, were considered as candidates for adaptive resource management. Priorities for each taxon were discussed individually without regard to other taxa. Priorities were identified by consensus of the participants attending the meeting (in person or electronically).

FY20 Prioritization Process Overview for Monitoring Needs

The SIT was asked to provide priority recommendations for monitoring needs for Chinook Salmon (fall-, winter-, and spring-run), Steelhead and Sturgeon. The SIT developed a list of monitoring data needs for Chinook Salmon (Table 1). When developing this list, SIT members identified Chinook Salmon information needs and categorized these needs according to three criteria: (1) is the information used directly in the DSM; (2) what is the needed frequency of collecting and compiling information; and (3) is the information needed for adaptive management? The SIT considers these data essential to the DSM and adaptive management and are working under the assumption that the data will be available in the future. In addition to this list, the SIT was provided with an initial list of potential model inputs and parameters that the SIT uses to run the DSMs and developing priorities for Chinook Salmon, Steelhead and Sturgeon.

When developing the lists of potential restoration actions for Chinook Salmon and Steelhead, the SIT was asked to add to monitoring priority items to taxon-specific lists. The lists were then sent to the Science Coordinator who compiled and sent them to the SIT for scoring. The SIT was asked to score these monitoring priorities on a scale of 0 to 100. A "0" indicated the parameter is not as useful for the SIT's DSMs or does not represent a key uncertainty when developing priorities. A "100" indicated the parameter is critical for the SIT's DSMs and/or represents a key uncertainty that makes evaluations difficult when developing priorities. Again, the SIT members were asked to leave the score blank if they did not feel sufficiently knowledgeable to score monitoring priorities for specific taxa/runs.

The SIT categorized the monitoring priorities into three tiers based on the summary of the SIT scores. Fourteen, 13 and eight SIT members submitted scores for Chinook Salmon, Steelhead, and Sturgeon, respectively. The number of responses received was likely a function of the federal government shutdown, which prohibited USGS and NMFS personnel from participating. Given the normalized scores did not change the rankings for the monitoring priorities, the SIT chose to use the combined raw scores for the prioritization process to maintain interpretability. During the January 23, 2019 meeting, the SIT discussed the monitoring priorities using: (1) the average score; (2) the urgency of the information gap; and (3) the type of information (i.e., survival parameters, habitat estimates, etc.). Priorities for each taxon were discussed individually without regard to other taxa. Priorities were identified by consensus of the participants attending the meeting (in person or electronically). Note that the SIT prioritization process does not propose specific projects, to avoid the perception of a conflict of interest, in ranking scientific objectives or monitoring needs.

Table 1. SIT monitoring data needs specific to Chinook Salmon[1]

Information	Used by DSM	Update frequency	Used for DSM refinement (i.e., update model weights)	Location(s)
DSM INPUTS (CURRENT SYSTEM STATES)				
Habitat availability	Directly	Some annual	Only in conjunction with fish monitoring data	Central Valley wide
Flows and temperature	Directly	Some annual	Only in conjunction with fish monitoring data	Central Valley wide
Water diversions	Directly	Some annual	Only in conjunction with fish monitoring data	Central Valley wide
Passage obstructions	Directly	Some annual	Only in conjunction with fish monitoring data	Central Valley wide
Predator contact points or predation levels	Directly	Some annual	Only in conjunction with fish monitoring data	Central Valley wide

[1] To avoid the perception of conflict of interest, SIT attempted to avoid the identification of specific projects for priorities as instructed by the Core team during FY20 prioritization.

Information	Used by DSM	Update frequency	Used for DSM refinement (i.e., update model weights)	Location(s)
ANNUAL FISH MONITORING DATA[1]				
Screw-trap captures and efficiency trial data	Calibration of model, parameterizing model components	Annual	Yes, very critical component	Red Bluff Diversion Dam Feather River Clear Creek Battle Creek American River Stanislaus River Mokelumne River Yuba River Tuolumne River
CWT data (hatchery allocation)				Tributaries (Central Valley wide)
Trawl catch data	Calibration of model, parameterizing model components	Annual	Yes, very critical component	Chipps Island
Adult escapement estimates	Calibration of model, parameterizing model components	Annual	Yes, very critical component	Central Valley wide
PROJECT SPECIFIC MONITORING[1]				
SIT/program requested information addressing key DSM uncertainties (e.g., survival)	Yes, for targeted components	Annual until project completion	Yes, but project specific as identified by SIT	Variable
Information on the proposed and actual changes made to the system states (e.g., amount of habitat increased)	No	Infrequent	Limited	Variable

[1] To avoid the perception of conflict of interest, SIT attempted to avoid the identification of specific projects for priorities as instructed by the Core team during FY20 prioritization.

Focal Taxon Objectives

Sturgeon

The Sturgeon group identified five objectives that corresponded with viable Sturgeon population metrics: population growth >1 over multiple generations (Green and White Sturgeon), annual spawner abundance (Green and White Sturgeon), multiple cohorts in a population (Green and White Sturgeon), number of rivers where spawning occurs (Green and White Sturgeon), number of spawning aggregations (Green and White Sturgeon), and recruitment (abundances ages 0-1 for White Sturgeon and larva to juvenile [full development] for Green Sturgeon.

Chinook Salmon

The SIT identified three valley-wide and two watershed-specific objectives that corresponded with viable Salmon population metrics: total number of viable spawning populations per diversity group (valley-wide metric only), total number of spawning natural origin adults (valley-wide and watershed specific metrics), and juvenile biomass that reaches Chipps Island (valley-wide and watershed specific metrics). Notably, the SIT opted to use the metric "juvenile biomass", rather than "juvenile abundance", acknowledging a large number of small fish outmigrants may not be as valuable as a moderate number of medium/large fish outmigrants.

Steelhead

The Steelhead group identified nine objectives that corresponded with viable anadromous Steelhead population metrics: frequency of anadromous life history, number of spawning anadromous adults, fitness/genetic diversity, natural productivity of anadromous life history, spatial diversity of spawning anadromous life history, population growth rate ≥1, recruitment of age 0–2 fish, iteroparous spawners of anadromous life history, and smolt passage.

Scenarios Identified for FY20

Sturgeon

The Sturgeon group was asked to build on previous efforts to develop a set of potential management actions (scenarios) to help the Program make improvements with respect to the identified Sturgeon objectives. They were asked to think about Sturgeon in particular, to be creative, to give specifics (i.e., amounts, timing, and locations) on each potential action, and to not let potential conflicts with other fish species in the region limit what they proposed for Sturgeon. To improve the current conditions for Sturgeon in California's Central Valley, the group proposed the scenarios listed in Table 2.

Table 2. Proposed Sturgeon Scenarios

Scenario	Specific details (amounts, timing, locations)
Attraction flow pulse in Bear River	5000 cfs (but proportional to Sac), Jan-Mar
Attraction flow pulse in Feather River	5000 cfs (but proportional to Sac), Jan-Mar
Attraction flow pulse in Yuba River	5000 cfs (but proportional to Sac), Jan-Mar
Create passage at Daguerre Point Dam passage on Yuba	Create passage at Daguerre Point Dam passage on Yuba
Grade the stranding areas below Fremont Weir (in works)	Grade the stranding areas below Fremont (in works)
High in channel flows in Sacramento River for attraction	18000 cfs, Jan-Mar, Woodson Bridge
High in channel flows in San Joaquin River for spawning	Base flows of 1500 cfs and intermittent pulse flows reaching 3000-5000 cfs, Mar and Apr
Improve passage at Fremont (in works)	To reduce illegal harvest and reduce stranding
Improve passage at Sacramento Weir	To reduce illegal harvest and increase passage
Improve passage at Sunset Pumps on Feather	Improve passage at Sunset Pumps on Feather River
Improve passage at Tisdale	To reduce illegal harvest and reduce stranding
Improve road crossings Yolo Bypass (in the works)	Improve road crossings Yolo bypass (in the works)

Scenario	Specific details (amounts, timing, locations)
Improve spawning and rearing habitat in Feather	Increasing the availability of cobble substrate
Improve spawning and rearing habitat in San Joaquin	Increasing the availability of cobble substrate
Manage contaminants in San Joaquin (multiple sources)	Reduce concentration of metals (i.e., As, Ba, Cd, Cu, Cr, Pb, Hg, Ni, Se, and Zn), organic contaminants (i.e., DDE, PCBs, PBDEs, and galaxolide), selenium, and mercury.
Manipulate ag return flows Knights Landing and Wallace Weir	Reduce ag return flows Knights Landing and Wallace Weir
Manipulate selenium in the San Joaquin	Manage sediment in the watershed
Manipulate temperatures in spawning and rearing areas of Feather River through changes in flow	Spawning (White 14-16°C, but <18 °C); Green 12-15 °C, but<17 °C) and rearing (White < 19 °C; Green <19 °C)
Manipulate temperatures in spawning and rearing areas of the San Joaquin	Spawning (White 14-16°C, but <18 °C); Green 12-15 °C, but<17 °C) and rearing (White < 19 °C; Green <19 °C)
Reduce entrainment in unscreened diversions in Feather River	Screen diversions to prevent entrainment of age 0-1
Reduce entrainment in unscreened diversions in Sacramento River	Screen diversions to prevent entrainment of age 0-1
Reduce entrainment in unscreened diversions in the San Joaquin	Screen diversions to prevent entrainment of age 0-1
Reduce entrainment in unscreened diversions in the Delta	Screen diversions to prevent entrainment of age 0-1
Reduce entrainment in unscreened diversions in Yuba River	Screen diversions to prevent entrainment of age 0-1
Reduce harvest of adults	Reduce illegal and legal harvest through greater enforcement
Spawning flow pulse in Bear River	>3000 cfs, Mar -Apr (White) or Mar-Jun (Green)
Spawning flow pulse in Feather River	>5000 cfs, Mar -Apr (White) or Mar-Jun (Green)
Spawning flow pulse in Yuba River	>5000 cfs, Mar -Apr (White) or Mar-Jun (Green)

Chinook Salmon

The SIT identified 21, 45, and 38 scenarios to be evaluated for winter-, spring- and fall-run Chinook Salmon (Tables 3, 4 and 5). These lists included restoration actions such as decreasing the impacts from hatchery fish; eliminating or reducing artificial lighting along migratory routes; improving fish passage; manipulating flows; increasing riverine productivity; increasing juvenile habitat (perennially inundated and seasonally inundated); increasing spawning habitat; reducing and screening diversions; and routing fish. For each scenario, the SIT was asked to identify a specific location and timing (when applicable). Discussions occurred regarding how reduced water diversions and increased base flows could be considered similar scenarios in meeting the objective, despite being ranked separately and receiving different scores.

Comments from the Chinook PWT group indicated that while the Technical Memorandum was helpful for understanding how the SIT is looking at the issues, without descriptions of the various scenarios it is hard to understand the intent (e.g., for the scenario Pulse Flows in Battle Creek).

Table 3. Winter-run Chinook scenarios with average scores (across responses and objectives)

Scenario	Mean
Improve fish passage, Battle Creek	70.1
Increase spawning habitat, Upper Sacramento River	52.2
Increase accessibility to rearing North Delta habitat, Yolo Bypass	52.0
Reduce water diversions, Battle Creek	50.5
Increase perennially inundated juvenile habitat, Upper Sacramento River	49.1
Increase accessibility to rearing North Delta habitat, Sutter/Steamboat Slough	49.0
Increase perennially inundated juvenile habitat, Upper-mid Sacramento River	47.2
Increase base flows, Battle Creek	42.8
Pulse Flows, Upper Sacramento River	41.8
Install non-physical barriers Georgiana Slough/DCC, Lower Sacramento River	41.5
Improve fish passage, Upper-mid Sacramento River	40.1
Improve fish passage, Upper Sacramento River	39.8
Eliminate or reduce to <1 lux lighting on structures along the Sacramento River and tributaries used for non-natal rearing., Upper Sacramento River	38.4
Increase riverine productivity by releasing water from rice fields and refuges, Upper-mid Sacramento River	35.8
Increase seasonally inundated juvenile habitat at 2 yr freq., Upper-mid Sacramento River	34.9
Increase riverine productivity by releasing water from rice fields and refuges, Lower Sacramento River	33.7
Screen diversions, Battle Creek	33.3
Increase in rearing habitat in the Central Delta, Delta	33.3
Increase seasonally inundated juvenile habitat at 2 yr freq., Upper Sacramento River	33.2
Decrease impacts from hatchery fish	30.3
Pulse Flows, Battle Creek	24.9

Table 4. Spring-run Chinook scenarios with average scores (across responses and objectives)

Scenario	Mean
Reduce water diversions, Mill Creek	61.2
Reduce water diversions, Deer Creek	60.3
Increase seasonally inundated juvenile habitat at 2 yr freq., Yolo Bypass	58.0
Increase base flows, Deer Creek	57.5
Increase base flows, Mill Creek	56.9
Increase seasonally inundated juvenile habitat at 2 yr freq., Upper-mid Sacramento River	56.8
Increase accessibility to rearing North Delta habitat, Yolo Bypass	55.2
Increase accessibility to rearing North Delta habitat, Sutter/Steamboat Slough	54.4
Increase perennially inundated juvenile habitat, Upper Sacramento River	53.9
Pulse flows, Yuba River	53.9
Pulse flows, Upper Sacramento River	53.0
Increase spawning habitat, Stanislaus River	52.4
Increase base flows, Antelope Creek	51.8
Reduce water diversions, Antelope Creek	51.8
Increase seasonally inundated juvenile habitat at 2 yr freq., Upper Sacramento River	51.3

Scenario	Mean
Increase in rearing habitat in the Central Delta, Delta	49.4
Pulse flows, Deer Creek	46.2
Pulse flows, Mill Creek	46.2
Increase seasonally inundated juvenile habitat at 2 yr freq., Sutter Bypass	46.2
Pulse flows, Clear Creek	45.3
Increase spawning habitat, Feather River	45.1
Increase riverine productivity by releasing water from rice fields and refuges, Upper-mid Sacramento River	44.2
Increase base flows, Deer Creek	43.7
Increase base flows, Mill Creek	43.5
Improve fish passage, Deer Creek	43.4
Improve fish passage, Mill Creek	43.4
Improve fish passage, Antelope Creek	40.9
Increase seasonally inundated juvenile habitat at 2 yr freq., Feather River	37.3
Pulse flows, Antelope Creek	35.3
Pulse flows, Upper Sacramento River	33.8
Increase seasonally inundated juvenile habitat at 2 yr freq., Yuba River	32.6
Pulse flows, American River	32.2
Increase perennially inundated juvenile habitat, Deer Creek	31.1
Increase perennially inundated juvenile habitat, Mill Creek	30.8
Increase perennially inundated juvenile habitat, Tisdale Bypass	27.8
Increase perennially inundated juvenile habitat, Sutter Bypass	26.5
Increase base flows, American River	25.7
Decrease impacts from hatchery fish	23.5

Table 5. Fall run chinook scenarios with average scores (across responses and objectives)

Scenario	Mean
Increase seasonally inundated juvenile habitat at 2 yr freq., Lower-mid Sacramento River	54.3
Increase accessibility to rearing North Delta habitat, Yolo Bypass	52.3
Increase seasonally inundated juvenile habitat at 2 yr freq., Upper-mid Sacramento River	52.1
Increase perennially inundated juvenile habitat, Lower-mid Sacramento River	52.0
Increase seasonally inundated juvenile habitat at 2 yr freq., Sutter Bypass	52.0
Increase seasonally inundated juvenile habitat at 2 yr freq., Yolo Bypass	51.9
Increase accessibility to rearing North Delta habitat, Sutter/Steamboat Slough	50.2
Increase perennially inundated juvenile habitat, Upper Sacramento River	49.1
Increase seasonally inundated juvenile habitat at 2 yr freq., Upper Sacramento River	48.9
Increase in rearing habitat in the Central Delta, Delta	48.9
Reduce water diversions, Delta	48.1
Increase spawning habitat, Feather River	47.2
Reduce water diversions, Lower-mid Sacramento River	45.1
Increase perennially inundated juvenile habitat, Upper-mid Sacramento River	45.0
Increase seasonally inundated juvenile habitat at 2 yr freq., American River	43.8
Increase seasonally inundated juvenile habitat at 2 yr freq., Feather River	43.1
Reduce water diversions, Lower Sacramento River	42.8

Scenario	Mean
Pulse flows, Upper Sacramento River	42.5
Increase spawning habitat, Yuba River	41.9
Increase perennially inundated juvenile habitat, Lower San Joaquin	41.7
Pulse flows, American River	41.6
Increase perennially inundated juvenile habitat, American River	40.9
Improve fish passage, Yolo Bypass	40.1
Pulse flows, Mokelumne River	39.5
Increase riverine productivity by releasing water from rice fields and refuges, Lower Sacramento River	39.3
Increase perennially inundated juvenile habitat, Yuba River	39.1
Increase base flows, Upper Sacramento River	38.9
Increase spawning habitat, American River	38.8
Increase perennially inundated juvenile habitat, Stanislaus River	38.8
Increase riverine productivity by releasing water from rice fields and refuges, Upper-mid Sacramento River	38.4
Increase seasonally inundated juvenile habitat at 2 yr freq., Lower San Joaquin	37.8
Increase seasonally inundated juvenile habitat at 2 yr freq., Stanislaus River	37.7
Increase perennially inundated juvenile habitat , Tuolumne River	37.1
Increase base flows, American River	36.9
Increase perennially inundated juvenile habitat , Mokelumne River	36.4
Increase seasonally inundated juvenile habitat at 2 yr freq., Mokelumne River	35.9
Reduce water diversions, Upper-mid Sacramento River	35.8
Pulse flows, Yuba River	35.3
Install non-physical barriers Georgiana Slough/DCC. , Lower Sacramento River	34.5
Increase seasonally inundated juvenile habitat at 2 yr freq., Tuolumne River	33.3
Increase seasonally inundated juvenile habitat at 2 yr freq., Yuba River	33.2
Reduce water diversions, Mokelumne River	32.8
Reduce water diversions, Upper Sacramento River	28.6
Decrease impacts from hatchery fish	27.0
Conservation hatchery supplementation	21.3

Steelhead

The SIT identified 21 scenarios to be evaluated for anadromous steelhead (Table 6). The list included restoration actions such as decreasing the impacts from hatchery fish; improving fish passage; manipulating flows and temperatures; increasing summer and spawning habitats; and outplanting adults above rim dams. For each scenario, the SIT was asked to identify a specific location and timing (when applicable).

Table 6. Steelhead scenarios with average scores (across responses and objectives)

Scenario	Mean
Increase spawning habitat, Battle Creek	57.2
Increase base flows, Battle Creek	55.6
Manipulate water temperatures to encourage anadromy, Upper-mid Sacramento River	42.2
Pulse flows, Upper Sacramento River	42.0
Manipulate water temperatures to encourage anadromy, Clear Creek	41.1

Scenario	Mean
Manipulate water temperatures to encourage anadromy, Upper Sacramento River	41.1
Improve fish passage, Battle Creek	40.9
Increase spawning habitat, Upper Sacramento River	40.6
Decrease impacts from hatchery fish	38.1
Manipulate water temperatures to encourage anadromy, Stanislaus River	36.2
Increase summer rearing habitat, Tuolumne River	34.5
Increase spawning habitat, Upper-mid Sacramento River	28.9
Improve fish passage, Upper Sacramento River	28.5
Manipulate water temperatures to encourage anadromy, Feather River	22.7
Increase summer rearing habitat, Mokelumne River	18.8
Manipulate water temperatures to encourage anadromy, Tuolumne River	17.0
Outplanting adults above rim dams, Upper San Joaquin River	16.3
Pulse flows, Mokelumne River	14.7
Manipulate water temperatures to encourage anadromy, Mokelumne River	12.5
Manipulate water temperatures to encourage anadromy, American River	7.8
Outplanting adults above rim dams, Yuba River	7.2

FY20 Restoration Actions and Prioritization and Results

The sections below briefly describe the general tenor of the SIT discussions regarding the priorities that were identified during the process described above. Discussions regarding other scenarios and proposed priorities are omitted for brevity. However, notes from all meetings can be accessed through the data portal link provided above (see Background section).

As stated above, the SIT discussed the scenarios and characterized the priorities using the following criteria for Chinook Salmon and Steelhead: (1) the average score (across objectives and responses) associated with the scenario/ priority, with larger score or higher rank interpreted as higher priority; (2) the potential of a scenarios ability to contribute to spatial diversity; and (3) the number of times a scenario/priority was in the top 10 (winter-run Chinook Salmon, spring-run Chinook Salmon, and Steelhead) or top 15 (fall-run Chinook Salmon) when examining the mean scores across responses within each of the objectives. For the third criteria, a scenario/objective was omitted if it was in the bottom 10 (winter-run Chinook Salmon, spring-run Chinook Salmon, and Steelhead) or bottom 15 (fall-run Chinook Salmon) when examining the mean scores across responses within each of the objectives. Scenarios that were only scored once were also omitted. Finally, scenarios with relatively strong potential to help achieve fundamental objectives, but high uncertainty were considered as candidates for adaptive resource management. The information for criteria 1 and 3 are in Tables 7, 8, 9 and 10.

Table 7. The number of times a scenario/priority was in the top 10 when examining the mean scores across responses within each of the objective for winter-run Chinook Salmon. Note that a scenario was omitted if it was in the bottom 10 when examining the mean scores across responses within each of the objectives. Scenarios that were only scored once were also omitted

Scenario	Number objectives in top
Improve fish passage, Battle Creek	5
Increase spawning habitat, Upper Sacramento River	5
Reduce water diversions, Battle Creek	5
Increase perennially inundated juvenile habitat, Upper-mid Sacramento River	5
Increase base flows, Battle Creek	5
Increase accessibility to rearing North Delta habitat, Yolo Bypass	4
Increase perennially inundated juvenile habitat, Upper Sacramento River	4
Increase accessibility to rearing North Delta habitat, Sutter/Steamboat Slough	4

Table 8. The number of times a scenario/priority was in the top 10 when examining the mean scores across responses within each of the objective for spring-run Chinook Salmon. Note that a scenario was omitted if it was in the bottom 10 when examining the mean scores across responses within each of the objectives. Scenarios that were only scored once were also omitted

Scenario	Number objectives in top
Increase seasonally inundated juvenile habitat at 2 yr freq., Yolo Bypass	4
Increase base flows, Deer Creek	3
Increase base flows, Mill Creek	3
Reduce water diversions, Deer Creek	3
Reduce water diversions, Mill Creek	3
Increase accessibility to rearing North Delta habitat, Sutter/Steamboat Slough	2
Increase accessibility to rearing North Delta habitat, Yolo Bypass	2
Increase base flows, American River	2
Increase base flows, Antelope Creek	2
Increase perennially inundated juvenile habitat, Upper Sacramento River	2
Increase seasonally inundated juvenile habitat at 2 yr freq., Upper-mid Sacramento River	2
Pulse flows, Yuba River	2
Increase in rearing habitat in the Central Delta, Delta	1
Increase seasonally inundated juvenile habitat at 2 yr freq., Upper Sacramento River	1
Increase spawning habitat, Stanislaus River	1
Pulse flows, Upper Sacramento River	1
Reduce water diversions, Antelope Creek	1

Table 9. The number of times a scenario/priority was in the top 15 when examining the mean scores across responses within each of the objective for fall run Chinook. Note that a scenario was omitted if it was in the bottom 15 when examining the mean scores across responses within each of the objectives. Scenarios that were only scored once were also omitted

Scenario	Number objectives in top
Increase seasonally inundated juvenile habitat at 2 yr freq., Lower-mid Sacramento River	5
Increase seasonally inundated juvenile habitat at 2 yr freq., Sutter Bypass	5
Increase accessibility to rearing North Delta habitat, Yolo Bypass	4
Increase seasonally inundated juvenile habitat at 2 yr freq., Upper-mid Sacramento River	4
Increase perennially inundated juvenile habitat, Lower-mid Sacramento River	4
Increase seasonally inundated juvenile habitat at 2 yr freq., Yolo Bypass	4
Increase accessibility to rearing North Delta habitat, Sutter/Steamboat Slough	3
Increase seasonally inundated juvenile habitat at 2 yr freq., Upper Sacramento River	2
Increase perennially inundated juvenile habitat, Upper Sacramento River	2
Reduce water diversions, Delta	2
Increase in rearing habitat in the Central Delta, Delta	2
Increase spawning habitat, Feather River	1
Increase perennially inundated juvenile habitat, Upper-mid Sacramento River	1

Table 10. The number of times a scenario/priority was in the top 10 when examining the mean scores across responses within each of the objective for Steelhead. Note that a scenario was omitted if it was in the bottom 10 when examining the mean scores across responses within each of the objectives. Scenarios that were only scored once were also omitted

Scenario	Number objectives in top
Increase base flows, Battle Creek	9
Increase spawning habitat, Battle Creek	9
Manipulate water temperatures to encourage anadromy, Clear Creek	7
Manipulate water temperatures to encourage anadromy, Upper Sacramento River	7
Manipulate water temperatures to encourage anadromy, Upper-mid Sacramento River	7
Pulse flows, Upper Sacramento River	7

Chinook Salmon (all runs)

Seven, 11 and 10 members of the SIT scored potential restoration scenarios for winter-run Chinook Salmon, fall-run Chinook Salmon, and spring-run Chinook Salmon, respectively. The relatively low number of responses may be related to the government shutdown, which prohibited USGS and NMFS personnel from participating. Summaries of the scoring suggested that there was a subset of scenarios that consistently scored high across all three Chinook Salmon runs. As a result, the SIT opted to develop a set of general Chinook Salmon priorities and then a couple run-specific priorities for Chinook Salmon (Table 11). For example, creating juvenile rearing habitat in the Sacramento River was scored high for all runs and the general sense was that creating juvenile rearing habitat in this area would benefit all Chinook runs. However, debates centered on whether the SIT had sufficient information to justify giving a higher priority to creating rearing habitat in specific sections of Sacramento River (e.g., upper, upper-mid, mid-lower, lower defined in Table 12 and Figure 1). Further discussions also centered on whether the belief that juvenile Chinook Salmon survival increases in response to habitat creation/improvement is supported by data or just a shared hypothesis among the SIT members.

The SIT believed that reducing this uncertainty (i.e., the effect of habitat restoration on juvenile survival) was critical to future prioritization efforts and the effectiveness of restoration actions in the Central Valley. They also believed that this uncertainty could be resolved through an adaptive management process. The SIT requested that process include: 1) a well thought out design including explicit quantifiable hypotheses regarding the relationship between habitat features and the survival of wild juvenile Chinook Salmon; 2) implementing the management actions, such as the creation of juvenile floodplain habitat, under conditions that can be transferable to other areas of the Central Valley; and 3) implementing a monitoring design (the SIT identified a before-after, control-impact or BACI design) that can clearly demonstrate the effect of the management actions on wild juvenile Chinook Salmon survival. The SIT was clear that this was not to be an experiment but should be the implementation of actual management actions intended to improve juvenile rearing habitat in different locations in the Sacramento River; therefore, this adaptive management scenario was adopted by consensus.

The poor conditions for fish in the central Delta was also a point of discussion. In particular, the SIT discussed that the long-term goal should be to make the central Delta more hospitable for Chinook Salmon, but in the short-term a beneficial action would be to keep juveniles out of the central Delta using multiple alternative routes from the Sacramento River into the north Delta, such as the Yolo Bypass and Sutter and Steamboat Sloughs. This scenario was also adopted by consensus. Increasing seasonally inundated juvenile rearing habitat in Yolo Bypass was also ranked high across Chinook Salmon runs. The SIT discussed how there is actually sufficient habitat in the Yolo Bypass but the fish do not have access to it. It was also discussed that increasing access to juvenile rearing habitat that already exists in both the Sutter and Yolo Bypasses would benefit all Chinook Salmon runs. Thus, this general Chinook Salmon priority was adopted by the SIT by consensus.

Table 11. Chinook Salmon model inputs/parameters with average scores across responses

Model Input/parameter	Mean score
Through Delta survival juvenile	78.5
Juvenile tributary survival	78.2
Juvenile mainstem survival	76.4
Juvenile Delta survival	70.7
Ocean entry survival	70.0
Water temperature statistics	68.5
Egg to fry survival	68.2
Hatchery origin influence reproduction	60.4
Juvenile river growth	58.9
Proportion water diverted	56.5
Juvenile Delta growth	53.8

Model Input/parameter	Mean score
Hatchery origin adult returning	50.0
Behavioral dynamics in Delta	49.6
Predator prevalence	48.8
Pathology	39.2

Table 12. Defined sections of the Sacramento River and Delta.

Reach	Extent
Upper Sacramento River	Keswick to Red Bluff
Upper-mid Sacramento River	Red Bluff to Wilkins Slough
Lower-mid Sacramento River	Wilkins Slough to American River
Lower Sacramento River	American River to Freeport
North Delta	Area west of and including the Sacramento River below Freeport to Chipps Island
South Delta	Area east of the Sacramento River below Freeport to Chipps Island and the San Joaquin River below Vernalis

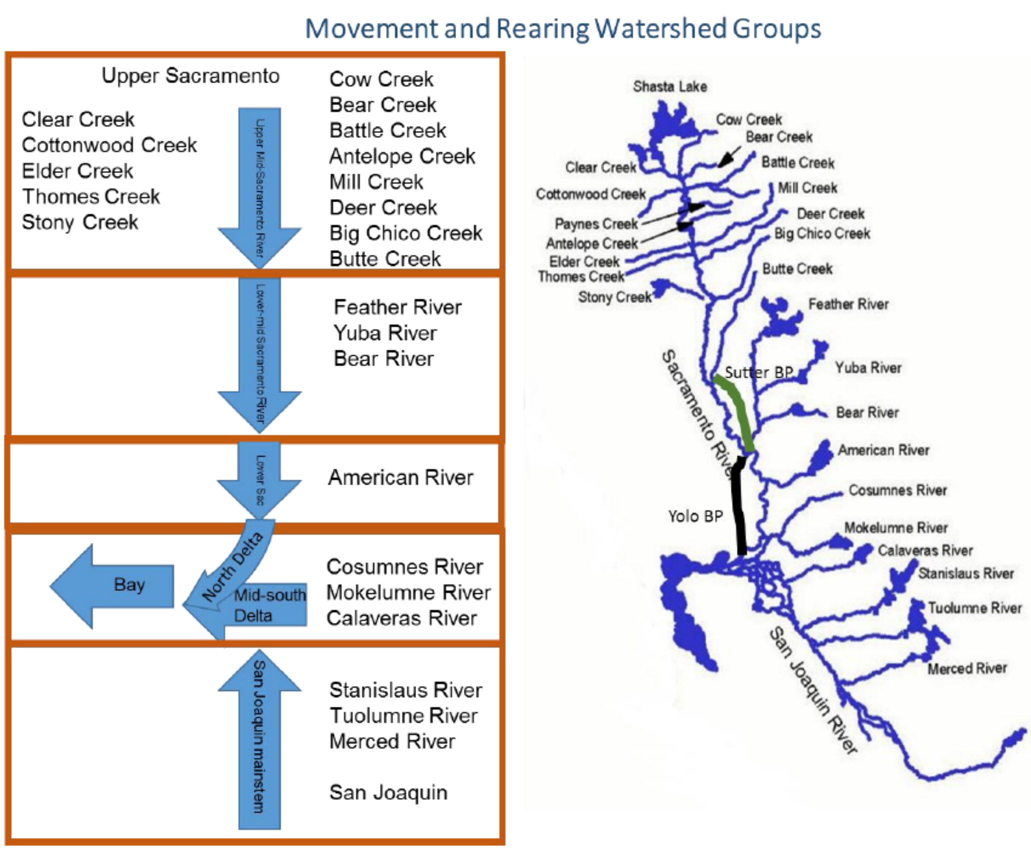

Figure 1. The relative location of the 26 CVPIA watersheds and routing that were included in the coarse resolution prioritization. The watershed groups (in boxes) are listed from top to bottom as: upper Sacramento, lower Sacramento, Delta, and San Joaquin.

Fall-run Chinook Salmon

Many of the highly scored scenarios were included in the priorities that pertain to all Chinook runs. However, the SIT discussed the need to ensure that actions were taken in different regions of the Central Valley to improve conditions for fall-run in order to achieve the total number of viable spawning populations per diversity group objective. Acknowledging that most of the 11 SIT members focused on Sacramento River populations, the SIT decided to also include the highest scored scenarios for San Joaquin populations as well. Also, as part of their discussion centered on the importance of improving conditions in the central Delta over the long-term (see above) the SIT decided to prioritize creating rearing habitat in the Lower San Joaquin and Stanislaus Rivers for fall-run Chinook Salmon. In addition, instituting pulse flows in the Mokelumne River during late April to early May was also identified as a fall run priority because it was the highest scoring action.

Winter-run Chinook Salmon

Based on the summary of the submitted scores, there was high agreement on what actions would most benefit winter-run Chinook Salmon. For example, eight scenarios were in the top 10 across objectives using the selection process described above. Not surprisingly, working in Battle Creek and the upper Sacramento River were the most consistently highlighted areas to work in for winter-run Chinook Salmon due to the large-scale habitat restoration efforts and thermal refugium benefits of the Battle Creek watershed. The SIT discussed the need to ensure that there was sufficient water to support winter-run Chinook Salmon in Battle Creek through reducing water diversions or increasing base flows. It was discussed that these actions are related to each other; that is, to increase base flows on Battle Creek the water diversions need to be reduced. This scenario was adopted by consensus.

The SIT also discussed, at length, increasing access to non-natal tributaries to open up habitat in the upper and upper-mid Sacramento from October to March. In particular, these are tributaries that provide additional juvenile rearing habitat to winter-run Chinook Salmon. One potential issue with this scenario is that these fish have a high potential to be stranded, which requires California Department of Fish and Wildlife (CDFW) to perform rescue operations. Non-natal tributaries provide important rearing opportunities for juvenile winter-run Chinook Salmon and other Salmon runs. These tributaries are often dry at the mouths and thus unavailable for juvenile winter-run Chinook Salmon during their rearing period in the upper river (late July into autumn months) until it rains, or water diversions at irrigation dams on these tributaries are stopped for the off season (typically in Oct). For winter-run Chinook Salmon, having flows to the mouth of tributaries in summer and autumn months (where possible) will increase non-natal rearing opportunities and provide benefit to winter-run Chinook Salmon survival.

For winter-run Chinook Salmon, stranding in tributaries is not a big issue as most have left the area by March and most tributaries are still flowing in March. Stranding in seasonal tributaries is more of an issue for other runs and Steelhead) whose juveniles have not out-migrated before tributary flows dry up or are diverted.

It was also discussed that this scenario may be redundant with juvenile rearing habitat creation scenarios that apply to all Chinook Salmon runs. After some discussion, the SIT decided to include this as a priority scenario for winter-run Chinook Salmon, particularly to highlight the potential benefits of these non-natal tributaries.

Spring-run Chinook Salmon

There was also much agreement among the SIT members on the priority location for spring-run Chinook Salmon. In particular, the importance of Mill, Deer, and Antelope Creeks for spring-run Chinook Salmon was discussed at length by the SIT, particularly the need to increase base flows. There was much discussion on the timing of the increased base flows and how different parts of the year would benefit different life stages. The SIT discussed that the benefit of increasing base flows in Antelope Creek may not contribute to the spatial diversity objectives or the valley wide objectives because Antelope Creek may not support a large independent spawning population. However, others argued that while Antelope Creek is smaller and warmer than Mill and Deer, there were decent runs of spring-run Chinook Salmon before the 2013-2016 drought. Water diversions and increasing summer air and river temperatures are likely factors reducing Antelope Creek's possibility as a major spring-run Chinook Salmon stream. However, the SIT discussed Antelope Creek's importance as a back-up tributary in case of natural disasters (forest fire, etc.) in Mill and Deer Creeks in a given year. And as a non-natal tributary for other Chinook Salmon runs, Antelope Creek could provide rearing if it had year-round flows below diversions to the mouth. Comments from the spring-run Chinook Salmon PWT stated that dependent spring-run Chinook Salmon populations are important to the Evolutionarily Significant Unit (ESU) in general.

The SIT also focused a discussion on the benefits of pulse flows in the upper Sacramento River. The SIT agreed that this would benefit spring-run Chinook Salmon, but it was noted that the timing of the pulse flow would depend on the water year type. That is, in dry to below normal water years with would be beneficial to have pulse flows extend until May, but in normal water years there would be little benefit to adding pulse flows on top of the normal hydrograph after December. Comments from the spring-run Chinook Salmon PWT stated pulse flow volumes should be maintained through mid-lower Sacramento River regions to help offset low water and high temperature impacts for spring-run Chinook juveniles in these regions.

Steelhead

Six members of the SIT scored potential restoration scenarios for Steelhead. Discussions among the SIT members emphasized the lack of information and high degree of uncertainty about how to enhance or encourage anadromous life history in Steelhead. This uncertainty was represented in the score summaries as well. For example, of the 21 scenarios only six were consistently scored high among objectives. Of these, pulse flows in the upper Sacramento River and increasing base flows in Battle Creek were already identified as priorities for Chinook Salmon. The SIT agreed that creating spawning habitat in Battle Creek and improving access through removal of manmade and natural barriers would benefit Steelhead populations and this scenario was adopted by consensus. Finally, three of these scenarios focused on manipulating habitat conditions to encourage anadromy. The SIT discussed the substantial uncertainty and the importance of understanding the factors that affect the expression of the anadromous Steelhead life history and the management actions that can be taken to increase the frequency of anadromy; therefore, the SIT believed that this uncertainty can be resolved through an adaptive management. The SIT requested that process include: (1) a well thought out design including explicit quantifiable hypotheses; (2) implementing management actions under conditions that can be transferable to other areas of the Central Valley; and (3) monitoring design (the SIT identified BACI design) that can clearly demonstrate whether the actions were successful or not. The SIT was clear that this was not to be an experiment but should be the implementation of actual management actions intended to increase the frequency of anadromy; therefore, this adaptive management scenario was adopted by consensus.

Table 13. Steelhead model inputs/parameters with average scores across responses

Model Input/parameter	Mean score
Factors related to anadromy	91.9
Frequency of anadromy	81.9
Through Delta survival juvenile	76.3
Adult population estimate	75.0
Juvenile tributary survival	74.2
Juvenile mainstem survival	72.7
Juvenile outmigrant abundance estimate	70.4
Ocean entry survival	70.0
Water temperature statistics	69.2
Juvenile Delta survival	68.8
Juvenile in channel rearing habitat	67.5
Egg to fry survival	66.2
Juvenile floodplain rearing habitat	63.8
Hatchery origin influence reproduction	63.5
Spawning habitat	63.5
Juvenile Delta rearing habitat	58.8
Behavioral dynamics in watershed	56.5
Adult en route survival	54.2
Adult prespawn survival	49.6
Contact point data	48.3
Proportion water diverted	48.1

Sturgeon

Using the process described above, the group identified five priority recommendations. Understanding that the score sheet was meant to help guide discussions and not meant to limit priority recommendations, the group added "Maintain flows for spawning/rearing in Sacramento River for recruitment" (White Sturgeon → from Hwy 32 (Hamilton City) to Knights Landing (Verona, including Yolo Bypass); Green Sturgeon → from ACID (Anderson-Cottonwood Irrigation District) to GCID (Glenn-Colusa Irrigation District)) after thoughtful discussions related to needs for sturgeon conservation. Furthermore, the group identified if the relationship between the Sturgeon objectives and potential management actions were data limited or well supported hypotheses.

A lack of Sturgeon data was a common topic in discussions for scenarios and priorities. In particular, much of the uncertainty when scoring the scenarios was related to whether Sturgeon use specific locations for spawning or not. Thus, not having explicit information on Sturgeon spawning locations across the Central Valley limited the group's ability to score many of the scenarios with certainty (Table 14). Monitoring data limitations can also be gleaned from the Sturgeon objectives identified above. For example, fundamental objective attributes must be monitored (and explicitly tied to management actions) to inform the future quantitative Sturgeon DSM (to be developed during the current cycle) and for adaptive management to take place. No such valley-wide monitoring program for Sturgeon exists.

Table 14. Sturgeon model inputs/parameters with average scores across responses

Model Input/parameter	Mean score
Juvenile mainstem survival	91.3
Juvenile tributary survival	79.2
Egg to fry survival	78.1
Juvenile Delta survival	77.9
Adult spawner abundance estimate	77.5
Juvenile Delta rearing habitat	75.0
Spawning habitat	74.4
Juvenile in channel rearing habitat	74.3
Ocean entry survival	69.3
Streamflow statistics	68.6
Adult en route survival	63.8
Entrainment of larval stage in diversions	63.8
Adult prespawn survival	59.4
Juvenile routing rules	56.0
Juvenile river growth	55.0
Juvenile floodplain rearing habitat	51.4
Proportion water diverted	50.0
Behavioral dynamics in Delta	46.0
Juvenile movement rate vs. flow model	44.3
Juvenile abundance estimates	25.0

Sturgeon priorities are listed in Table 20. A data limited scenario is a scenario that has relatively high support by the group based on their experience and anecdotal information, but monitoring data to quantify these relationships are lacking. The group discussed how explicitly linking Sturgeon recruitment parameters to scenarios aimed at increasing spawning/rearing habitat and flow manipulation, perhaps using a BACI design, was a needed for Sturgeon adaptive management.

FY20 Monitoring Prioritization and Results

In addition to the monitoring data needs previously identified for Chinook Salmon in Table 1, the SIT categorized other monitoring priorities into three tiers based on the summary of the SIT scores. Fourteen, 13, and eight SIT members submitted scores for Chinook Salmon, Steelhead and Sturgeon, respectively. Similar to the other responses, the number of responses received were likely a function of the federal government shutdown, which prohibited USGS and NMFS personnel from participating. The SIT discussed that all of the model inputs/parameters were critical to the program to assist them when making science based decisions, which is why they were listed in the first place.

To prioritize them, the SIT opted to use a tier system, which tier 1 being the highest priority and tier 3 being the lowest priority. For Chinook Salmon, there was strong agreement among SIT members based on the scores that juvenile survival metrics were the highest priority. The tiers for Chinook Salmon were based on natural breaks in the scores. The SIT discussed, at length, the uncertainty associated with Steelhead and Sturgeon and how population parameters, particularly for juveniles, were needed at the very least to parameterize the DSMs. This pattern was generally supported by the mean scores. The SIT also discussed the importance of metrics to track changes in adult and juvenile abundances to calibrate the DSMs. Therefore, the SIT prioritized model inputs/parameters for these species based on the type of information.

Table 15. Monitoring priorities for Chinook Salmon[1]

Model Input/parameter	Tier
Egg to fry survival	1
Juvenile Delta survival	1
Juvenile population estimates	1
Adult population estimates	1
Juvenile mainstem survival	1
Juvenile tributary survival	1
Ocean entry survival	1
Through Delta survival juvenile	1
Water temperature statistics	1
Hatchery origin influence reproduction	2
Juvenile Delta growth	2
Juvenile river growth	2
Proportion water diverted	2
Behavioral dynamics in Delta	3
Hatchery origin adult returning	3
Pathology	3
Predator prevalence	3

[1] To avoid the perception of conflict of interest, SIT attempted to avoid the identification of specific projects for priorities as instructed by the Core team during FY20 prioritization.

Table 16. Monitoring priorities for Steelhead[1]

Model Input/parameter	Tier
Adult population estimate	1
Egg to fry survival	1
Factors related to anadromy	1
Frequency of anadromy	1
Juvenile Delta survival	1
Juvenile mainstem survival	1
Juvenile outmigrant abundance estimate	1
Juvenile tributary survival	1
Ocean entry survival	1
Through Delta survival juvenile	1
Water temperature statistics	1
Hatchery origin influence reproduction	2
Juvenile Delta rearing habitat	2
Juvenile floodplain rearing habitat	2
Juvenile in channel rearing habitat	2
Spawning habitat	2
Adult en route survival	3
Adult prespawn survival	3
Behavioral dynamics in watershed	3
Contact point data	3
Proportion water diverted	3

[1] To avoid the perception of conflict of interest, SIT attempted to avoid the identification of specific projects for priorities as instructed by the Core team during FY20 prioritization.

Table 17. Monitoring priorities for Sturgeon[1]

Model Input/parameter	Tier
Adult spawner abundance estimate	1
Juvenile abundance estimates	1
Juvenile Delta rearing habitat	1
Juvenile Delta survival	1
Juvenile in channel rearing habitat	1
Juvenile mainstem survival	1
Juvenile tributary survival	1
Spawning habitat	1
Adult en route survival	2
Adult prespawn survival	2
Egg to fry survival	2
Entrainment of larval stage in diversions	2
Ocean entry survival	2
Behavioral dynamics in Delta	3
Juvenile floodplain rearing habitat	3
juvenile movement rate vs. flow model	3

Model Input/parameter	Tier
Juvenile river growth	3
Juvenile routing rules	3
Proportion water diverted	3
Streamflow statistics	3

[1] To avoid the perception of conflict of interest, SIT attempted to avoid the identification of specific projects for priorities as instructed by the Core team during FY20 prioritization.

FY20 Recommendations to the Core Team

The final FY20 recommendations to the Core team are detailed in Tables 18, 19, and 20. Again, note that the SIT does not propose specific projects to avoid the perception of a conflict of interest in ranking priorities for FY20.

Table 18. Chinook Salmon SIT Priorities for FY20

All Chinook Runs
Increase perennially inundated juvenile habitat, Sacramento River above the American River confluence
Increase seasonally inundated juvenile habitat at 2 yr freq., Sacramento River above American River confluence
Increase spawning habitat, Upper Sacramento River
Keep juveniles out of central Delta
Adaptively manage juvenile habitat restoration to allow the evaluation of the effect of habitat restoration on wild juvenile Chinook Salmon survival in the Sacramento River
Increase access to juvenile rearing habitat in Sutter and Yolo Bypasses
Maintain spawning habitat in the CVP streams
Winter-run Chinook Salmon
Improve adult and juvenile passage on Battle Creek
Increase flows through increasing base flows and/or reducing water diversions on Battle Creek
Increase access to non-natal tributaries to open up habitat in Upper and Upper Mid Sacramento Aug-March
Spring-run Chinook Salmon
Increase base flows year round to target benefits to multiple life stages, Deer Creek
Increase base flows year round to target benefits to multiple life stages, Mill Creek
Pulse flows, Upper Sacramento River Oct-Dec (till May in all years except Wet)
Increase spawning habitat, Stanislaus River
Fall-run Chinook Salmon
Increase in rearing habitat in the Central Delta , Delta
Increase spawning habitat, Feather River
Increase perennially inundated juvenile habitat , Lower San Joaquin
Increase perennially inundated juvenile habitat , Stanislaus River
Pulse flows, Mokelumne River Late April early May

Table 19. Steelhead SIT Priorities for FY20

Steelhead
Increase access to spawning habitat, Battle Creek
Adaptively manage tributary flows, habitat, and/or temperatures to increase the frequency of anadromy

Table 20. Sturgeon SIT Priorities for FY20

Species	Scenario	Data limited?	Notes
Green Sturgeon			
	Pulse flows for attraction and spawning in Feather River	Yes	
	Improve passage at Tisdale, Fremont Weir, and Sunset pumps		
	Reduce fishing mortality (poaching and bycatch) of adults		
	High in-channel flows in Sacramento River for attraction	Yes	Important, but not as hard to get under current conditions. Might just look at in-hand data before "spending" resources for this scenario
	Maintain flows for spawning/rearing in Sacramento River for recruitment	Yes	Uncertainty with how to currently quantify recruitment across watersheds because there is not a monitoring program in place for Sturgeon (outside spawner abundance)
White Sturgeon			
	Reduce harvest (legal and illegal) of adults		
	Improve spawning and rearing habitat in San Joaquin River		
	High in-channel flows (spawning) and manipulate temperatures in spawning and rearing areas of San Joaquin River	Yes	Uncertainty with how to currently quantify recruitment across watersheds because there is not a monitoring program in place for Sturgeon (outside spawner abundance)
	Improve passage at Tisdale and Fremont Weir		
	Maintain flows for spawning/rearing in Sacramento River for recruitment	Yes	Data are available, but analyses are limited

Literature Cited

Brett, JR. 1952. Temperature tolerance in young Pacific salmon, genus Oncorhynchus. J Fish Res Bd Can 9(6):265-323.

Cavallo, B., J. Merz, and J. Setka. 2012. Effects of predator and flow manipulation on Chinook Salmon (Oncorhynchus tshawytscha) survival in an imperiled estuary. Environmental Biology of Fishes 96:393–403.

Connor, W. P., Smith, S. G., Andersen, T., Bradbury, S. M., Burum, D. C., Hockersmith, E. E., Schuck, M. L., Mendel, G. W. and Burgert, R. M. 2004. Post release performance of hatchery yearling and subyearling fall Chinook Salmon released into the Snake River. North American Journal of Fisheries Management 24: 545–560.

Conroy, M.J. and J.T. Peterson. 2013. Decision making in Natural Resource Management: a structured, adaptive approach. Wiley-Blackwell. New York.

Grant, J.W.A. and D.L. Kramer. 1990. Territory size as a predictor of the upper limit to population density of juvenile salmonids in streams. Canadian Journal of Fisheries and Aquatic Sciences. 47: 1724- 1737.

Healey, M. C. 1991. Life history of Chinook Salmon (Oncorhynchus tshawytscha), pages 311-393 in Pacific Salmon Life Histories. Groot, C. and Margolis, L. (editors), UBC Press, Vancouver B.C.

Marine, K.R. and J.J. Cech, Jr. 2004. Effects of high water temperature on the growth, smoltification, and predator avoidance in juvenile Sacramento River Chinook Salmon. North American Journal of Fisheries Management 24: 198 -210.

Moyle, P. B. 2002. Inland Fishes of California. University of California Press, Berkeley CA.

Newman, K. B. 2003. Modelling paired release–recovery data in the presence of survival and capture heterogeneity with application to marked juvenile Salmon. Statistical Modelling 3:157–177.

Newman, K.B. and P.L. Brandes 2010. Hierarchical Modeling of Juvenile Chinook Salmon Survival as a Function of Sacramento–San Joaquin Delta Water Exports North American Journal of Fisheries Management 30:157–169.

Perry, R. 2010. Survival and Migration Dynamics of Juvenile Chinook Salmon in the Sacramento-San Joaquin River Delta. Doctoral dissertation. University of Washington.

Peterson, J.T., K. McDonnell, M.C. Colvin. 2014. Coarse Resolution Planning Tools for Prioritizing Central Valley Project Improvement Act Fisheries Activities. Progress Report to Central Valley Project Improvement Act Fisheries Program, Sacramento CA.

Satterthwaite, W.H. S.M. Carlson, S. D. Allen-Moran, S. Vincenzi, S.J. Bograd, and B.K. Wells. 2014. Mach- mismatch dynamics and the relationship between ocean-entry timing and relative ocean recoveries of Central Valley fall run Chinook Salmon. Marine Ecology Progress Series 511: 237-248.

Schreck, C.B., J.C. Snelling, R.E Ewing, C.S. Bradford, L.E. Davis, C.H. Slater. 1994. Migratory behavior of adult spring Chinook Salmon in the Willamette River and its tributaries. Oregon Cooperative Fishery Research Unit, Oregon State University, Corvallis, Oregon. Project Number 88-160-3, Prepared for Bonneville Power Administration, Portland, OR.

Sekhon, J.S., and W. R. Mebane, Jr. 1998. Genetic Optimization Using Derivatives: Theory and Application to Nonlinear Models Political Analysis, 7, 189-213.

Sommer, T. M. Nobriga, W. Harrell, W. Batham, and W. Kimmer. 2001. Floodplain rearing of juvenile Chinook Salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58:325–333

Zambrano-Bigiarini, M. and R.Rojas. 2014. hydroPSO: Particle Swarm Optimization, with focus on Environmental Models. R package version 0.3-4