Ecosystem Amendment Performance Measures Independent Scientific Review

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Performance Measure 4.6: Doubling Goal for Central Valley Chinook Salmon Natural Production

General Comments

The desirability of increasing numbers of spawning adult Chinook salmon in the Central Valley is clearly documented, and this performance measure supports efforts to achieve that goal. The target of doubling production is laudable but may not be achievable in light of climate change, the strong community of non-native species in the Delta, and California's growing human population. No biological or ecological justification is given for targeting a doubling of the baseline number rather than a different level of increase. However, even if the doubling target is not reached, efforts to double production may result in a healthier Delta ecosystem and Chinook salmon population than would efforts to achieve a smaller increase, depending on the actions taken in support of this target. That is, doubling the baseline production is likely to require considerable habitat restoration, non-native species control, barrier removal, and hatchery reform, whereas strategies designed to achieve a smaller increase may focus on less systemic changes (e.g., short-term changes in Delta inflow and export restrictions). Nevertheless, the target of doubling the combined natural production from all four runs of Central Valley salmon will not necessarily result in healthy populations of each individual run; the target may be met even if some runs decrease in size or are extirpated as long as the population gain for the larger runs offsets the loss in the smaller runs. Similarly, although the performance measure will provide a simple overall assessment of the effectiveness of management efforts at salmon recovery in the Central Valley, the simplistic nature of the measure may not provide the level of specificity necessary for informing adaptive management efforts because it combines data from all 4 runs, both river basins, and all streams in the Central Valley.

It is not clear from the performance measure what is meant by "natural production," whether the baseline is appropriate, and how statistical uncertainty will be accounted for in assessment of the performance measure compared to the target. These issues should be addressed to avoid future stakeholder disagreement and possible litigation in assessments of whether the target has been reached. It is also not obvious that the available data are suitable for monitoring of the performance measure.

Charge Question #1

Question

How clear and thorough are the performance measure's metric, baseline, and target? What, if any, additional information is needed?

Response

The metric, baseline, and target should all clearly state that all runs are to be combined in a single number, and should all clearly define what is meant by "natural production." Omitting these details leaves open the possibility for stakeholder disagreement in whether the target has been reached. Otherwise, the baseline is clear and thorough in the sense of identifying a number that is dictated by the Central Valley Project Improvement Act (CVPIA). However, the basis for selection cites a report that questions the appropriateness of the baseline for comparisons to natural production and claims that the baseline represents some hatchery production as well as natural production (i.e., Dahm et al. 2019). If the report's findings are justified, then the baseline value is too high and the doubling goal is unlikely to be achievable.

The target has two components, and clearly identifies numerical goals that can be compared to the observed metric. However, the target does not define the statistical precision that is required, and thus raises the likelihood of stakeholder dispute about whether the target has been met. For example, if the 15-year average natural production estimate in 2065 is only 980,000 instead of the identified target of 990,000, has the doubling component of the target been reached? The answer to that question should depend on the precision of the 15-year average. For example, if the 95% confidence interval on the 15-year average does not include 990,000 or larger values, then it may be concluded that the target has not been reached. On the other hand, if the confidence interval includes 990,000, then it may be argued by some stakeholders that the target has been reached and by other stakeholders that the true 15-year average is actually lower than 980,000 because the confidence interval includes values lower than 980,000. Statistical methods from time series analysis will be required. Similar concerns apply to the second component of the target regarding the slope of the 15-year average natural production estimates. An observed slope that is positive but low (e.g., 0.05) may be concluded to meet the target with no more than 5% probability of error if the 95% confidence interval excludes 0 and negative values, but not if the confidence interval is wide enough to include negative values. In some cases, there may be a question of biological significance if the target is met with a positive slope that is very low yet meets a given requirement of statistical significance. Another issue that may result in disagreement or litigation is the possibility of only one of the two components of the target being reached by 2065; in that case, has the target been reached satisfactorily? Guidance is required on decision rules for concluding that the target has been reached.

Charge Question #2

Question

How clear is the basis for selection of the performance measure? How complete are the scientific rationale, the justification, and the supporting references for the selection?

Response

The basis of selection provides extensive references supporting the claim that the size of the Chinook salmon populations in the Central Valley should be increased for the benefit of the salmon populations themselves and the ecosystem as a whole. However, no justification was given for the target of doubling the natural production baseline rather than a lower or higher increase. The CVPIA provides a legal justification for targeting a doubling of the baseline, but not a biological or ecological justification.

The basis of selection defines neither “production” nor “escapement”; it also does not define what is meant by “natural” or whether it includes the hatchery-reared adults that spawn in natural environments (i.e., outside of a hatchery). Clarification is needed on these points. Justification is also needed for using production as the basis of the performance measure rather than escapement. Production includes hatchery returns and harvest as well as escapement, but the growth of the naturally-produced salmon population will depend on escapement, not harvest or hatchery returns. The suitability of using harvest counts or hatchery returns as a surrogate for escapement depends on the stability over time of the relative sizes of the hatchery-reared and naturally-produced populations and the marking rate of the hatchery population. Thus, it is not clear that simply increasing production will result in a healthier or sustainable wild population unless it is accompanied by hatchery reforms, 100% marking of hatchery fish, and possibly harvest reforms.

The basis of selection gives no justification for setting the years 1967–1991 as the baseline period, other than citing the CVPIA. It describes criticism of the average estimate of natural production for this time period as reported in Dahm et al. (2019); that is, that the natural production estimates during this time period included some hatchery production and are thus inappropriate (i.e., too high) as a baseline. The datasheet uses this criticism to justify the target component that the slope of 15-year average estimates be positive, rather than aiming solely for a doubling of natural production, which may be unjustifiably ambitious if the baseline is biased high. It seems appropriate to include a target of a positive slope to accommodate the possibility that the doubling goal is unattainable due to a positively biased baseline. However, the basis for selection does not justify retention of the doubling component of the target in the face of a positively biased baseline or suggest a lower baseline; in this sense, the justification for the baseline and target is inadequate. The basis of selection also does not provide justification for using 15-year averages or a period of 30 years for defining the slope, or for targeting 2065 rather than another year. Also not provided is justification for pooling natural escapement across all runs in the metric, baseline, and target. A doubling of total natural production does not necessarily imply a doubling of production for each

run; it is conceivable that the doubling target could be met even if the winter-run is extirpated if production of the fall-run is increased enough to offset the loss. This situation would meet the target but have lower potential for population resilience than if all four runs were doubled because of the loss of diversity in the population (portfolio effect, Schindler et al. 2010).

Charge Question #3

Question

How clear and complete is the scientific basis for setting the targets? How complete is the consideration of key scientific references, available data, and existing monitoring capabilities?

Response

The scientific basis for setting the targets is incomplete. Although a scientific basis for targeting some increase in salmon production during the near future is provided, no basis is provided for (a) doubling the baseline natural production rather than some other level of increase, (b) using 15-year averages rather than a longer or shorter window for the moving averages, (c) setting the completion date at 2065 rather than sooner or later, or (d) setting the slope goal at merely “positive” (i.e., >0) rather than a higher value. Additionally, no discussion of the statistical precision requirements of the target is addressed, or of how imprecision in either the 15-year estimates or the slope will be accommodated in assessing whether the target has been met. The available estimates of adult natural production and escapement are provided and discussed, as represented by the U.S. Fish and Wildlife Service (USFWS) Anadromous Fish Restoration Program (2016) in Figure 1, and criticism of those estimates is also discussed as presented by Dahm et al. (2019).

Additional biological or ecological support is needed to justify retaining the doubling goal legislated in the CVPIA, both in comparison to a different level of increase and in light of the criticism in Dahm et al. (2019) of the baseline. Production of 990,000 is within the range of estimates of historical escapement numbers according to some sources (1 million to 2 million spawners; Fisher 1994). However, the reduced amount and degraded nature of the currently available habitat (e.g., Herbold et al. 2018) and the potential for future decline of that habitat under climate change (Lindley et al. 2007) suggest that production of 990,000 is not feasible under current habitat conditions. Even if the baseline value is biased high because of some hatchery production, there may be some justification for using that baseline and targeting a doubling rather than a lower level of increase because the efforts that the community implements in pursuit of this target may result in a healthier Delta ecosystem and Chinook salmon population than would efforts to achieve a smaller increase. That is, doubling the baseline production is likely to require considerable habitat restoration, non-native species control, barrier removal, and hatchery reform, whereas strategies designed to achieve a smaller increase may focus on less systemic changes (e.g., short-term changes in Delta inflow and export restrictions). However, given the economic cost of the intense effort required

to reach the doubling goal, there is likely to be stakeholder disagreement in the appropriateness of the baseline and target in light without further justification.

Additional justification is also required for targeting only a positive slope in the 15-year average of natural production, rather than a higher slope. A very low but positive slope is unlikely to be sufficient to guarantee population persistence or recovery over the next century any better than the current population trend. This is especially true given the possibility of increased occurrence of catastrophic droughts and ocean warming events expected under climate change (Diffenbaugh et al. 2015).

The suitability of using the 15-year average as the basis of the metric should be justified using ideas from time series analysis. Salmon production estimates tend to have a cyclic component, representing influences of the 3- to 5-year generation length of Chinook salmon (Healey 1991) and climate phenomena such as the Pacific Decadal Oscillation (Mantua et al 1997). A moving average window length that is shorter than, or on the order of, a cycle length in the raw data will provide a misrepresentation of the average status of the population, and will be too variable for useful interpretation. The apparent lengths of the “boom or bust” cycles in the data provided in Figure 1 range from about 6 years to about 17 or 20 years, and average approximately 10 years. A 15-year window is at least minimally appropriate in that it satisfies the requirement of being longer than the average cycle length. The 30-year monitoring period used for the slope assessment is long enough to witness approximately 3 cycles, which will lend support to using the observed slope as a measure of population health.

Measures of statistical precision should be included in the target, and should be justified in the basis for selection. Even if the annual estimates are not reported with accompanying measures of precision (i.e., standard error, coefficient of variation, or confidence interval), the estimate of the 15-year moving average for any given time period and the 30-year estimate of the slope will have a standard error that should be used in determining whether the target has been met. It will be important to use methods appropriate to time series analysis in computing the precision estimates (e.g., standard error) for the slope of the 15-year average, because the individual 15-year averages used as the basis for the slope calculation will depend on overlapping sets of annual production estimate and so will not be independent. Alternative methods for assessing progress toward the doubling goal are presented in Newman and Hankin (2004); they recommend using a state-space model to better account for temporal dependence in natural production values between adjacent years.

Also unclear in the definition and basis of selection for the target is how to define “natural production” and how it relates to “escapement”, which is referred to in the basis of selection but not in the target. The USFWS ChinookProd estimates include hatchery returns of naturally-produced adults, but attempt to account for the proportion of total production that comes from hatchery-produced adults. Inasmuch as the ChinookProd estimates are based on the California Department of Fish and Wildlife (CDFW) GrandTab estimates of escapement, which do not account for rearing type of naturally-

spawning adults, it is not clear from the datasheet language if “natural production” used in the metric, target, and baseline refers to the source of the returning adults, the fate of the adults (i.e., spawning outside of hatcheries, spawning in hatcheries, ocean harvest, or in-river harvest), or both. If hatchery-reared adults are to be excluded, it is not clear how fishers are to identify rear-type (hatchery vs natural) in the realistic event that some hatchery-reared fish are unmarked and caught in a fishery, or if there is variable marking of hatchery-reared fish among either years or hatcheries. It is also unclear how the hatchery proportion of total production is estimated, and whether the estimates in ChinookProd account for sampling effort.

It is further unclear if some groups of fish will be excluded from the natural production total on the basis of their or their parents’ migration method. The CVPIA restricts “natural production” to those fish that reach “adulthood without direct human intervention in the spawning, rearing, or migration processes” (Section 3403 of Public Law 102-575). The Anadromous Fish Restoration Program (AFRP) Working Paper draft Volume 2 parses the USFWS interpretation of this definition, and claims that fish would be included in the natural production total (1) even if they were salvaged at the Central Valley Project (CVP) or State Water Project (SWP) and trucked as juveniles or (2) if the “direct human intervention” occurred only after reaching adulthood, but (3) not if their parents reached their spawning grounds through direct human interpretation (AFRP 1995, p. 2-IX-9). Thus, if fish passage solutions at rim dams take the form of trap-and-haul operations to move fish to and from historical spawning habitat upstream of those dams, then apparently only the first generation of adults subject to the trap-and-haul operation would be included in the natural production estimate; all future progeny would necessarily be excluded because (1) their parents reached the spawning grounds through direct human intervention, and (2) they themselves migrated as juveniles from the spawning grounds to the ocean through direct human intervention. Such an exclusion limits the potential for achieving the target of doubling the baseline natural production level. It is possible that the actual interpretation of “natural” that is being invoked is not as restrictive as that described in AFRP (1995); further clarification is required for the definition of “natural production.”

Charge Question #4

Question

How achievable are the targets relative to the state time scales?

Response

No discussion of the achievability of the target is provided. The target of doubling production is laudable but may not be achievable in light of climate change, the strong community of non-native species in the Delta, and California’s growing human population. The possibility that the baseline may be higher than the actual average natural production during the baseline period (Dahm et al. 2019) raises the probability that the target is not achievable. Production of 990,000 is within the range of estimates of historical escapement numbers according to some sources (1 million to 2 million

spawners; Fisher 1994), but is likely to require systemic changes to Delta and upstream habitat, hatchery practices, and possibly harvest policy (e.g., Herbold et al. 2018). The fact that the 15-year average natural production has declined since the baseline (as shown in Figure 1 of the datasheet) raises grave doubts about the ability to achieve either component of the target unless drastic changes are implemented soon. The longer the community takes to design and implement systemic changes to habitat and resource use in the Delta, the less likely it is that the target can be achieved at all, and especially within the stated time frame.

A simple simulation model that represents natural production as a cyclic process shows that even with 10% production increase between successive generations, the 15-year average is unlikely to reach the target of 990,000 by 2065 (Figure 1). The simulated production data in this model start from the 2014–2016 natural production estimates from ChinookProd (total for Central Valley, all runs combined), and use a cycle equal to a generation length of 3 years:

$$N_y = N_{y-3} \times 1.10 + \varepsilon,$$

where

$$\varepsilon \sim N(0, 10000) \text{ for year } y = 2017, 2018, \ldots, 2065.$$

The annual production values in the simulated data pass the 990,000 target for the peaks of the 3-year cycles starting in 2053 (Figure 1(a)), but the 15-year moving average is simulated to reach only 870,764 by 2065 (Figure 1(b)). This model includes only autocorrelation effects of generation dependency (i.e., successive generations have similar size), random additive error on an annual basis, and population growth between generations. It omits a realistic spawner-recruit relationship, longer-term cyclic patterns, non-cyclic oceanic and climate patterns, climate change, effects of management or ecosystem change, and effects of catastrophic events. A more sophisticated model is required to adequately assess the feasibility of meeting the doubling goal target. However, this simple model shows that even very ambitious growth of 10% between generations may be insufficient to reach the doubling goal target. Meeting the secondary target of a positive slope of the 15-year moving average over 30 years is more attainable because it requires only a generally increasing population size. However, the trend in recent years has been a decline rather than growth, so even this target may be unattainable unless action is taken quickly.

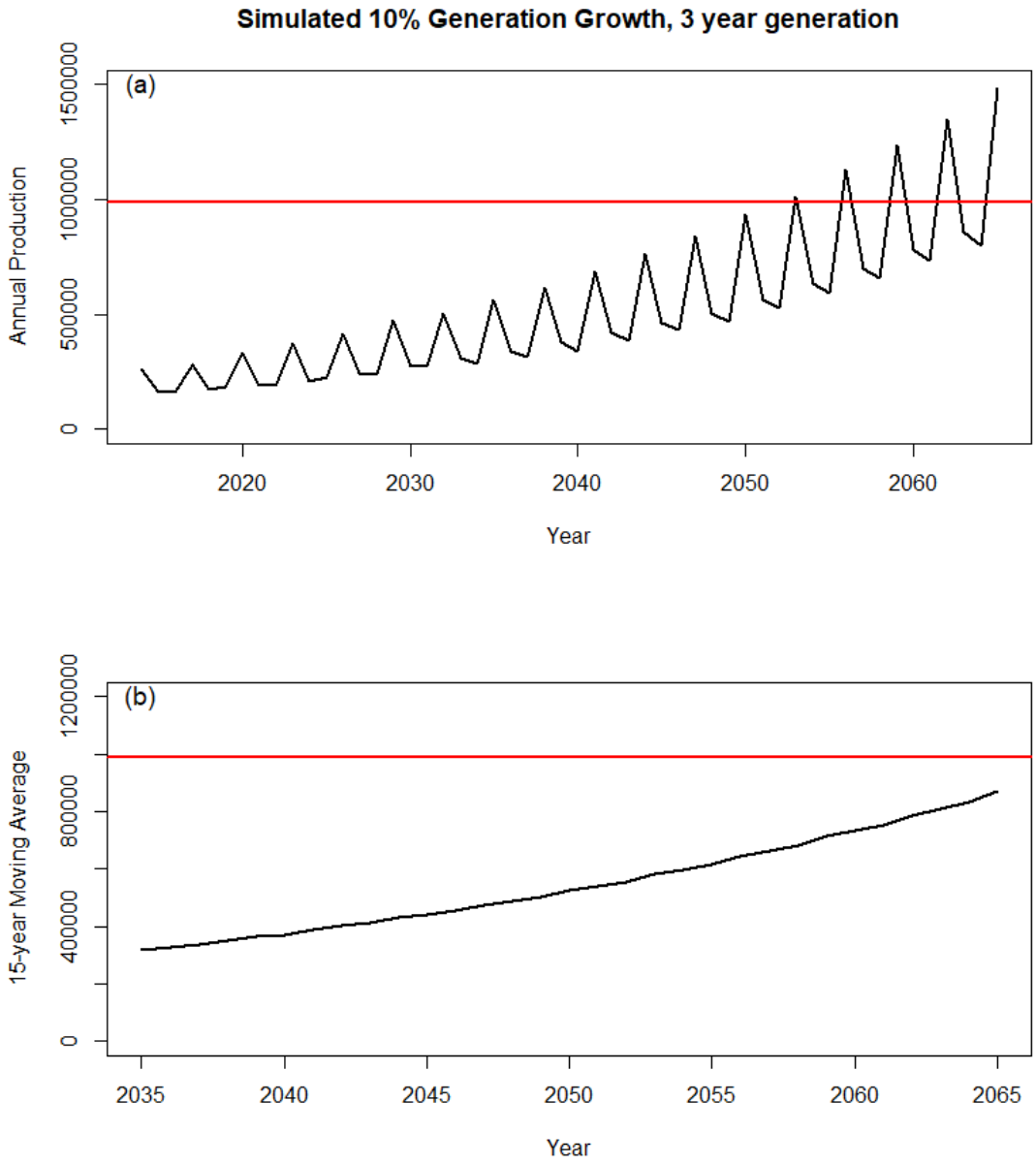

Figure 1. Top figure (a) shows simulated time series of natural production values from 2014 through 2065 compared to the target of 990,000 (red horizontal line). Bottom figure (b) shows simulated time series of the 15-year moving average from 2035 to 2065 compared to the target of 990,000 (red horizontal line). Both figures simulate natural production starting from the reported 2014-2016 total natural production estimates reported by ChinookProd for the Central Valley (all runs combined), assume a generation length of 3 years, include 10% production growth between successive generations, and include additive random error.

Charge Question #5

Question

How well were scientific uncertainties (both outside and within management control) incorporated in the development of the targets and in the assessment of progress towards the targets?

Response

The scientific uncertainty surrounding the appropriateness of the baseline was represented by including the target of a positive slope over 30 years of the 15-year average production estimates. It is appropriate to include some such target, but justification for requiring only a positive slope and not a higher minimum slope was not provided.

Some factors that affect natural production and are also under management control were addressed (e.g., water operations, fishing regulations, habitat restoration), as well as factors that are outside management control (ocean food-web productivity, climate change). The uncertainty raised by these issues in the ability to meet the target was addressed briefly, but no quantitative assessment of the uncertainty was provided. Such an assessment would be difficult and likely be imprecise. Nevertheless, it is useful to consider the extent to which ocean conditions may limit the ability to achieve the target. Climate change is resulting in ocean warming, acidification, and a change in prey availability; it is possible that the changes that can be implemented in the freshwater and estuarine habitats (e.g., habitat restoration, barrier removal, non-native species control, hatchery reform, harvest rates) may be insufficient to achieve either the doubling goal or the goal of increasing production (positive slope) in light of degrading ocean conditions. The ocean life stage has been shown to account for the majority of life cycle mortality in Chinook salmon from the Columbia River Basin (e.g., Buchanan et al. 2010), and has been suggested as a major source of mortality for Central Valley salmonids as well (Lindley et al. 2009).

No method is given for accounting for statistical precision in assessing the target. Also, no method is given for assessing intermediate progress toward the target before the target end date of 2065. Also not addressed is the reliability of the community commitment to the doubling goal or positive slope over the next 30 years, especially as climate change and human population growth put added stress on water and land resources in the Central Valley.

Charge Question #6

Question

Are the identified data sources complete and appropriate to support robust assessment of the performance measure?

Response

Both the USFWS ChinookProd database and the CDFW GrandTab database are listed as primary data sources. The ChinookProd database provides annual estimates of

production by run and total. Inasmuch as it is currently the tool used to assess progress toward the CVPIA doubling goal and the extent to which it estimates the natural production value that is referred to in the metric, baseline, and target, it is an appropriate data source for this performance measure. The datasheet's description of the ChinookProd database, however, points out that hatchery returns are included in the ChinookProd estimates and that current monitoring efforts do not adequately characterize the rear type (hatchery or wild) of sampled fish. This makes not only the ChinookProd data but also any existing or expected monitoring data inadequate for tracking this performance measure. If the hatchery proportion of the natural production estimates changes over time, either because of changes in hatchery practices or the health of the wild population or because of improved monitoring, then the time series of available and expected future natural production estimates will reflect an unknown contribution of hatchery returns, and will not be a good gauge of the status of the natural population (however that is defined). It is not clear from the datasheet (or the ChinookProd database itself) whether the estimates in the ChinookProd database are adjusted for sampling effort, as they should be, or how reliable the estimates are.

The GrandTab database provides annual estimates of natural escapement for each run, including all naturally-spawning adults, whether hatchery-reared or naturally produced. The GrandTab estimates are included in the ChinookProd estimates and the GrandTab estimates are of escapement rather than production, so it is not clear why GrandTab is included as a primary data source in addition to ChinookProd. It seems more reasonable to list it as an alternative data source in the event that the ChinookProd database becomes unavailable. The listed alternative data source is the USFWS Comprehensive Assessment and Monitoring Program (CAMP) Annual Report, which appears to contain the same data as ChinookProd. It is unclear if the CAMP Annual Report will include estimates of natural production if the ChinookProd database is not maintained or is otherwise unavailable.

Charge Question #7

Question

How well are adaptive management and alternative actions considered in performance assessments and reporting?

Response

No possibility of adaptive management is included as it refers to setting or modifying the targets based on intermediate progress toward meeting the targets, changes in ecosystem or population status, or changes in management priorities. The inclusion of the target requiring a positive slope over 30 years accommodates uncertainty in the baseline, but is not amenable to reflecting updated information or management needs. The progress made toward meeting the targets, as reflected by the annual reporting of the metric, may support adaptive management decisions. However, there is a possibility that the data provided for the metric will not be specific enough to be of real management use. The data will give a simple snapshot of effectiveness of the region's

salmonid management efforts as a whole and will thus indicate whether more needs to be done, but because the metric combines all runs, both river basins, and all streams within the Central Valley, it will not indicate where changes in management are required. For example, in the event that efforts to meet the doubling goal are successful for fall-run Chinook salmon, it may not be apparent that they are failing winter-run or spring-run Chinook salmon. In this sense, there is limited use of this performance measure to either support or reflect adaptive management.

Performance Measure 4.13: Barriers to Migratory Fish Passage

General Comments

Justification for barrier removal in general is provided; additional justification is required for screening diversions, and for the barriers and diversions specifically targeted. The definition of the key action in the performance measure, “resolve”, is imprecise. While the definition leaves open room for flexibility in completing the action for different barriers and diversions, it also requires interpretation and may lead to disagreement over what constitutes “resolution” for any given barrier or diversion. This is of particular concern regarding fish passage at high head rim dams, where fish passage programs are likely to be both technically challenging and costly. It is unclear if the performance measure allows for initial resolution of a barrier or diversion that is followed by subsequent degradation of the structure to the point where fish passage or screening is no longer effective or deemed acceptable.

Also unclear is how newly constructed barriers and diversions, or newly identified barriers and diversions, will be represented in the metric and assessment in future years. Inasmuch as the performance measure refers only to the 2018 baseline conditions, it has limited potential for adaptive management of the Delta as it changes over the next 30 years.

The target includes an objective for 2030 and an objective for 2050; these two objectives represent different components of the baseline. No guidance is provided on intermediate waypoints to be used to assess progress toward the 2030 and 2050 targets.

The target for rim dams and unscreened diversions implies that there is no prioritization among the rim dams or among the unscreened diversions, an assumption that overlooks variability in the feasibility of resolution at different structures (dams or diversions), the amount of habitat opened up by fish passage at different dams, and the size and ecological and/or regulatory importance of the population affected by different structures. No assessment of the quality or amount of habitat currently blocked by rim dams is provided, and no justification for targeting 50% fish passage.

Charge Question #1

Question

How clear and thorough are the performance measure’s metric, baseline, and target? What, if any, additional information is needed?

Response

The metric definition requires more specificity and a clearer evaluation method. As it is written, the metric is an unspecified collection of barriers and diversions, including some large dams. A metric should be numeric rather than a list or collection. Whether the metric is meant to be a list, a list length, or the percent change in the list length from the baseline, it appears that it actually has three components: priority barriers, rim dams,

and unscreened diversions. It is not clear from the metric definition that these three components are to be evaluated separately. Furthermore, interpretation of the description of the metric requires referral to the baseline, but the metric does not itself refer to the baseline. This leaves open the possibility that the metric will be assessed using barriers, dams, and unscreened diversions that are not included in the baseline; it is not made clear in the datasheet if this is the intention or not. The metric does not itself define “priority fish migration barriers”, “select large dams”, or “anadromous fish migration corridors in the Delta and Suisun Marsh.” Even if the metric initially refers only to the baseline, may it eventually reflect newly constructed or newly identified barriers and diversions? This ambiguity raises the potential for argument over interpretation, how the metric is evaluated over the years, and whether the region is meeting the target. The metric includes annual evaluation but does not define “evaluation,” how it will be performed, or who will perform it. If newly added barriers and diversions are to be considered in evaluation, then the list length is not a sufficiently informative measure. A complementary measure might be the weighted average of the item age on the list, weighted by priority. This complementary measure would reflect whether many high priority structures (barriers or diversions) are still unresolved, or if the list is primarily newer, lower priority structures. If newly constructed or identified barriers and diversions are not allowed in evaluation (i.e., only items on the baseline lists are considered), then the performance measure has less potential to reflect the suitability of the Delta and watershed for native fish over time, in that it refers only to the current status, whereas native fish populations will be responding to both old and new barriers and diversions. By restricting the performance measure to refer only to the baseline list of barriers and diversions, it also has limited use in adaptive management. In a related issue, once barriers or diversions are removed from the list(s) referred to by the metric, it is unclear if they may be subsequently returned to the list if the efficacy of the fish passage structure or screen degrades over time. A one-time resolution may be insufficient for all components of the baseline.

The baseline is defined as a number that is the length of four lists of passage barriers, rim dams, and unscreened diversions as identified in four reference documents named in the baseline. However, the “Data Collection and Assessment” process indicates that the baseline is actually the length of three lists: priority passage barriers, rim dams, and unscreened diversions considered as three separate lists. The baseline appears to be precisely defined for the priority barriers named in the CDFW and California Department of Water Resources (CDWR) documents. However, it appears that there are some structures on the CDFW 2018 list of priority barriers that are in the Sacramento-San Joaquin River watershed but are not included in Tables 1 and 2 under Baseline Methods (e.g., Deer Creek Stanford Vina Dam Fish Ladders); it is not clear if this is an oversight or an intentional omission, or what prioritization rules were used to further refine the CDFW 2018 list of priority barriers.

The baseline language refers only to unspecified rim dams in the watershed, although a precise list is provided under Baseline Methods. I am unaware of a list of all rim dams

affecting Central Valley salmonids, so I cannot confirm that the list of rim dams is thorough; however, the potential effectiveness of fish passage at the listed dams depends on fish passage at downstream dams.

The baseline is not clearly defined for unscreened diversions. It refers to the "[u]nscreened diversions along Delta native, anadromous migration corridors listed in CalFish Passage Assessment Database (PAD)," but that database does not appear to differentiate between unscreened diversions that are along Delta native anadromous migration corridors and other unscreened diversions. There may be differences of opinion on what is a Delta native anadromous migration corridor; the baseline requires more precision in this component. It is also unclear how the diversions shown in Figure 1 were selected out of the larger group of unscreened diversions in the Delta and Suisun Marsh. A minor point is that the first sentence under "Baseline Methods" is confusing; it implies that the priority barriers identified by CDFW and CDWR are the 10 rim dams and 1,400 unscreened diversions.

The target is thorough in the sense that it addresses all components of the baseline. The target for the CDFW and Central Valley Flood Protection Program (CVFPP; CDWR) priority barrier lists is clear. The target for the rim dams is unclear as written because there are multiple ways to interpret "resolve 50 percent of fish passage at rim dams." Does it mean: 100% fish passage of both juveniles and adults at 5 of the 10 rim dams listed; 100% fish passage of either juveniles or adults at all 10 dams listed; passing only 50% of all fish who try to pass, but at all 10 dams listed; some combination of all of the above? The target for unscreened diversions is unclear because of the imprecise definition of the unscreened diversions list in the baseline. Also, the target implies equal priority among all unscreened diversions. It seems likely that there is actually varying priority among the rim dams and among the unscreened diversions, either because of the numbers of native fish affected by different unscreened diversions or because of the geographic location and quality of habitat upstream of different rim dams. As the metric, baseline, and target are written, that priority is overlooked, and the target will be met even if only lower priority rim dams and unscreened diversions are resolved. Furthermore, the target implies that it is acceptable to leave 50% of fish passage unresolved at rim dams and 50% of diversions unscreened, that no new migration barriers or diversions will be constructed, and that no existing barriers or diversions will become problematic in the future.

Charge Question #2

Question

How clear is the basis for selection of the performance measure? How complete are the scientific rationale, the justification, and the supporting references for the selection?

Response

There is acceptable scientific rationale justification for resolving fish passage at barriers and rim dams as a class. There is less justification provided for the focus on unscreened diversions. Although there is potential for unscreened diversions to reduce

salmon survival through entrainment that removes fish from the migrating or rearing population, there is little documentation of the actual effect of unscreened agricultural diversions on salmon populations (Moyle and Israel 2005). Additionally, it is likely that the benefit of screening diversions will vary among the diversions, regions, and operations considered (Moyle and Israel 2005, Zeug and Cavallo 2014). There may be alternatives to installing fish screens, such as modifying the diversion structures themselves (Mussen et al 2015). More justification is needed for the selection of the 1,400 unscreened diversions included in the performance measure.

The priority fish migration barriers that are included in the baseline are clearly identified based on the baseline reference documents (CDFW, CDWR, although some barriers may be missing). The prioritization used by those documents is summarized and seems reasonable from a scientific viewpoint, although I have not reviewed the source documents in detail. It is unclear if the CDWR prioritization considered feasibility or the ability to assess effectiveness. It is also unclear if there are other possible lists that are not being used, and if so, why they are omitted. It appears that a lack of water, such as impaired flows in regions of the San Joaquin River after Friant Dam was completed, is not considered to be a priority barrier. However, lack of water is as much a hindrance to fish movement between habitats as a manmade structure that blocks fish passage. It is possible that lack of water or river flow was considered in the process of defining the priority barrier lists and was not determined to meet the standards, or that the impaired San Joaquin River flows have been resolved already. As the datasheet text points out, some barriers can be helpful if they prevent fish from entering poor migration routes or habitat; some examples are the Delta Cross Channel gates, the non-physical barrier at Georgiana Slough, and screens on water diversions. Additionally, the priority given to barriers and unscreened diversions may depend on the status of other items on the baseline lists. As items are resolved, the priority of the remaining barriers and unscreened diversions may change, or barrier and diversions that were initially excluded from the lists may become more important because access to those areas has improved. For example, if barriers are installed to limit the access of Sacramento basin salmonids to the South Delta, then the importance of screening water diversions in the southwest Delta will be less than if no such barriers had been installed, at least for consideration of Sacramento basin salmonids (Perry et al. 2013). The importance of resolving the unscreened diversions in the Old and Middle river corridors north of the CVP and SWP will then depend, to some extent, on whether San Joaquin basin salmonids are effectively prevented from entering those facilities; if they are likely to enter those facilities, then there will be relatively few migrating salmonids using the Old and Middle river corridors north of the facilities (Buchanan et al. 2018). Unscreened diversions in that region will remain a risk factor for resident native Delta fishes, but the priority given to resolving those diversions may change based on resolving barriers and diversions in other regions.

Although there is justification given for resolving fish passage at rim dams (e.g., Herbold et al. 2018), there is inadequate justification for assigning all rim dams equal priority for

fish passage. Implementing fish passage at high head dams, such as most of those dams listed in Table 3 of Baseline Methods, is a difficult and costly process, and the likelihood of success and the size of the impact on the native fish populations will depend on a host of factors and will vary from dam to dam. It is unclear if the list of rim dams in Table 3 includes all rim dams, or if a prioritization process has already been implemented to produce this list. Questions that have been asked regarding fish passage decisions at dams include: Is historic habitat blocked? Is blocked habitat potentially viable? Is fish passage technically feasible and practical with respect to land ownership? What is the cost of fish passage? Will restored access to habitat appreciably contribute to resource management goals for watershed or fishery? (NOAA 2019: California Fish Passage: Frequently Asked Questions. Accessed 12/9/2019). These issues are not sufficiently addressed in the performance measure. Additionally, the definition of the target pertaining to rim dams is unclear: "resolve 50 percent of fish passage at rim dams" could mean: 100% fish passage of both juveniles and adults at 5 of the 10 rim dams listed; 100% fish passage of either juveniles or adults at all 10 dams listed; passing only 50% of all fish who try to pass, but at all 10 dams listed; some combination of all of the above. None of these interpretations is ideal. It is unlikely that equally effective fish passage systems will be installed at all 10 dams, so guidance is required for prioritizing among the dams. Passage of only one life stage is unsuitable for anadromous species that need to pass the dam both as juveniles and as adults. A 50% passage rate of fish that attempt to pass is remarkably low compared to requirements in other systems (e.g., 98% juvenile dam passage success required at Columbia River mainstem dams). Justification is needed for setting the target at resolution of 50%, rather than a higher or lower target. Given the difficulties and uncertainty in implementing effective fish passage at high head dams, it is reasonable that the target is less than 100%, but it is not clear whether 50% will be sufficient for recovery and persistence of anadromous species under climate change.

The performance measure for unscreened diversions also implicitly assumes equal priority given to all of the 1,400 unscreened diversions in the baseline. As mentioned above, the importance of screening diversions in some regions of the Delta may depend on the effectiveness of barrier use or barrier resolution, and thus priority within the list of unscreened diversions may change over time. Similarly, it is not addressed whether it is more desirable to screen all or the majority of diversions in one set of channels at the expense of less effort spent screening diversions in other channels or regions, or whether effort should be spread more evenly across the various channels and waterways.

Charge Question #3

Question

How clear and complete is the scientific basis for setting the targets? How complete is the consideration of key scientific references, available data, and existing monitoring capabilities?

Response

For the priority barriers identified in the CDFW and CDWR lists, the target is 100%. There is no justification given for needing to deal with all of the barriers on these lists rather than only some of them, but to some extent that question was addressed in the prioritization process used in CDFW (2018) and CDWR (2016). The target itself does not identify the priority barriers, but instead refers to the baseline. The “scientific basis” for the target for the priority barriers is primarily references to the CDWF (2018) and CDWR (2016) reports and describing their prioritization basis. Additional references other than those documents could be cited to shore up the basis for this target, but I am not aware of particular additional references.

No scientific basis is provided for the 50% target for fish passage at rim dams; the target for rim dams appears arbitrary. As described in response to Charge Question #2, the target implies (without justification) that there is no difference in priority among the existing rim dams for fish passage, or that continuing to block 50% of fish is acceptable. It is unclear the extent to which opening up upstream habitat to 50% of currently blocked fish will promote population recovery or resilience. Likewise, no scientific basis is given for the 50% target for unscreened diversions, and no indication of priority among the 1,400 unscreened diversions referred to in the baseline. For both rim dams and diversions, there is some justification provided for addressing these structures, but not for the actual target. In each case, a target of 50% appears to have been selected because it is infeasible to resolve all 100% of the rim dams and unscreened diversions. I agree that 100% resolution is unlikely, but additional justification is required for selecting a target of 50%.

More information is required on the availability and quality of existing monitoring capabilities of the priority barriers, rim dams, and unscreened diversions in the baseline.

Charge Question #4

Question

How achievable are the targets relative to the state time scales?

Response

The achievability of resolving the barriers and diversions identified in the baseline is unclear, and will depend on weather patterns, political will, funding, technology development, etc. The priority list from CDFW takes feasibility into consideration, although it is based on the feasibility outlook at the time when the list was constructed (2018); feasibility may change over time. Although feasibility and assessment are addressed in the CDWR source document for the CDWR priority list (CDWR 2016), neither feasibility nor assessment appears to be a factor in identifying the priority barriers in that list. Fish passage has already begun to be developed at some of the priority barriers (e.g., adult passage at Fremont Weir). Meeting the target in the next 10 years will require consistent funding and political and management attention.

For diversions, it is probably feasible to physically put a screen on a small agricultural pump, depending on landowner participation and available funding, but it will require maintenance and monitoring on a regular basis. Failing to maintain the screens may result in loss of the screens, especially under climate change where there may be increased demand for water from the Delta. The success of meeting the target of screening 50% of the currently unscreened diversions by 2050 will depend largely on funding and political and landowner goodwill; early meeting of the target will not guarantee that the objective continues to be met in 2050.

The feasibility of achieving resolution of fish passage at the rim dams is probably the lowest of all three components of the performance measure (priority barriers, rim dams, and unscreened diversions); the fact that the target is only 50% improves the probability of meeting the target. It is reasonable to assume that fish passage through trap-and-haul operations could be successfully designed and implemented at some dams by 2050 (i.e, 30 years from now). Nevertheless, the possibility of achieving fish passage at the rim dams will vary from dam to dam, and implementation of passive fish passage systems may be impossible at some dams. Installing fish passage at high head dams such as most of the dams identified in Table 3 is challenging and involves many technical issues. The annual variability in water levels and reservoir size also complicates fish passage. What works at one dam or in one year may not work at another. Simply providing for fish passage may not be sufficient, if that passage is stressful to the fish, available only seasonally and not timed to fish migration, passes only a subset of the migrating population, favors one life history over others, or doesn't also promote a healthy habitat either upstream or downstream of the dam. It is not sufficient to install passage structures and conclude that fish passage has been resolved at the dam; it is necessary to monitor fish passage using tagging studies. Managers of dams in the Columbia Basin have installed PIT-tag readers and viewing windows, and they monitor fish passage annually; they also perform regular tagging studies to document fish passage survival using either PIT tags or acoustic tags. (The Columbia River dams are mostly lower than the rim dams). At dams where fish passage is provided by trap-and-haul operations, it is advisable to monitor collection efficiency and passage survival for both juveniles and adults on an annual basis. A dedicated funding source is necessary for this monitoring.

Charge Question #5

Question

How well were scientific uncertainties (both outside and within management control) incorporated in the development of the targets and in the assessment of progress towards the targets?

Response

The question of scientific uncertainty, both outside and within management control, is addressed very briefly. To some extent, uncertainty is allowed for by using a target that is <100% for the rim dams and unscreened diversions. However, no justification is given

for using a target of 50% rather than another target < 100% (e.g., 30% or 70%). Uncertainty is also incorporated by using several sources of the baseline priority targets; although the target of 100% resolution omits the possibility of uncertainty in the prioritization process that created the lists, the fact that more than one list is included raises the possibility of achieving useful progress in improving migration potential and habitat quality through barrier removal in the event that the target of 100% resolution is unmet.

The targets are set for 2030 and 2050, with no intervening goals on progress between now and then. Although assessment happens on a regular basis for barriers and diversions and ideally on a regular basis for rim dams, the targets are not defined on that basis. In the absence of intervening milestones, it will not be clear whether a failure to meet the 2050 target by 2040 should raise concerns about the ability to meet it by 2050, or if the progress made by 2040 is on track for 2050. Finally, there is no quantitative or qualitative assessment of the probability of success; such an assessment would incorporate feasibility, risk, and uncertainty.

More consideration should be given to assessment of fish passage at individual barriers and dams. How often will resolution of fish passage be assessed, and what are the requirements for resolution to be established? For example, is fish passage at a dam concluded if dam passage survival is only 50% (this is one interpretation of the target), or is a higher level required (e.g., 98% with a standard error ≤ 2%, as in the Columbia River)? Who is the entity who concludes that fish passage has been resolved, and how long does that certification last? It is not necessary for the datasheet to decide on these issues, but it is necessary to identify a well-defined process for these decisions. It is not clear if such an assessment will allow for the possibility of a previously resolved dam or barrier to subsequently become unresolved (e.g., failure of fish passage or discontinuation of the passage system), or if it requires regular monitoring of fish passage at each of the supposedly resolved structures. It is also not clear if both adult and juvenile passage are required. The wording implies that only one-way passage is sufficient, but that is not useful for anadromous species that need to pass the dam on both the juvenile seaward migration and the adult spawning migration.

Charge Question #6

Question

Are the identified data sources complete and appropriate to support robust assessment of the performance measure?

Response

The primary data source for assessment of the performance measure is the California Passage Assessment Database (PAD) (CalFish 2019). The California PAD is designed to be a comprehensive list of barriers to anadromous fish, and so it presumably includes all barriers on the CDFW and CDWR priority lists, the 10 rim dams listed, and the unscreened diversions indicated. It is updated multiple times annually to reflect changes to fish passage status at listed structures. To the extent that the performance measure's

definition of “resolution” agrees with the definition used by the PAD, this database provides sufficient data for calculating the metric for the performance measure. However, it is unclear if the definition of “resolution” used in the performance measure agrees with that used by the PAD. The lack of an unambiguous definition of “resolution” for passage barriers and diversions is of concern for all components of the baseline (priority barriers, rim dams, and unscreened diversions). Even using the barrier or diversion status as reported in the PAD database, there may be disagreement among stakeholders in what constitutes adequate resolution.

The quality of the PAD data for all the barriers on the baseline lists is unclear; there may be inadequate data on some barriers or unscreened diversions. In particular, the Passage Assessment Database reports on existing data, rather than undertaking monitoring and collection of that data itself. The amount and quality of passage data may vary among barriers and diversions, including fish passage at large dams where monitoring is difficult and costly.

The secondary data sources consist of annual updates to the CDFW priority barriers list, and 5-year updates to the CDWR’s Central Valley Flood Protection Plan (CVFPP) Conservation Strategy priority barriers list. Depending on updates to the CVFPP will lower the performance measure reporting frequency to at most every 5 years for the barriers that are on the CVFPP list but are not on the CDFW list. For both lists, the fact that a barrier disappears from the list means that it is no longer considered high priority by the list owner, but it is unclear if that will necessarily satisfy the definition of “resolution” as used in the performance measure. Inasmuch as the priority and definition of “fish passage resolution” assigned to passage barriers by CDFW and CDWR agrees with the definitions used in the performance measure, these priority lists and the California PAD will be sufficient for assessment of the performance measure.

No alternative sources of data are provided for assessing the status of unscreened diversions or fish passage at rim dams. The adequacy of the PAD as the data source for these components depends on the continuation of the PAD, its reporting on unscreened diversions and fish passage at dams, and the quality of monitoring of both components. It is not clear if the performance measure includes ongoing assessment of previously resolved fish barriers and unscreened diversions; it is recommended that it does include ongoing assessment because passage solutions and screens may degrade or lose efficacy over time or lose funding for maintenance and operation (e.g., trap-and-haul operations at dams). It is also unclear whether resolution of fish passage at rim dams requires only construction of the passage structure or system, or whether it requires that fish are successfully passing the dam. For example, a fish collection system used in a trap-and-haul operation that is poorly placed may appear to allow fish passage but does not actually result in effective passage. Under the expectation that resolution requires actual fish passage with some minimum level of success (is that the 50%? – if so, it is low), it will then be necessary to monitor fish passage on a regular basis through any newly constructed passage structures or systems in order to confirm

that fish passage has been adequately resolved. Monitoring of fish passage success at the dam will require carefully designed and implemented tagging studies. It is unclear if use of habitat upstream of the dam by anadromous fish is required by the performance measure; if so, then stream or redd surveys, smolt traps or rotary screw traps, or possibly environmental DNA sampling will be necessary to monitor habitat use. The level of data required depends on the precise definition of “resolution” as it applies to dam passage. This information is missing from the datasheet. Also, monitoring will need to occur on an ongoing basis to document that fish passage remains “resolved”, unless the rim dam is completely removed. Similar considerations apply to the priority barriers.

The equation used in the calculation of the metric is appropriate as long as there is an agreed upon definition of “resolution” for all passage barriers and diversions, and as long as only the structures identified in the baseline are considered. However, the assessment methods do not address the situation where the new dataset total has increased because new barriers or diversions have been added to the PAD beyond the original baseline list. Presumably those new barriers and diversions will not be considered in assessment. That approach lowers the possibility of confusion and aids in interpretation, because the performance measure will always relate to the baseline. However, it also makes the performance measure less useful for adaptive management and as a representation of the availability of habitat for native fish. Partial progress toward barrier or diversion resolution is not reflected in the planned assessment methods.

Charge Question #7

Question

How well are adaptive management and alternative actions considered in performance assessments and reporting?

Response

The potential for adaptive management and alternative actions is only loosely addressed in plans for performance assessments and reporting. The potential for adaptive management is included by updating the performance measure metric on a regular basis (annually for the priority barriers, every 5 years for the unscreened diversions). The datasheet does not address how often fish passage at rim dams will be monitored; as such, it is not only inadequate to conclude ongoing fish passage resolution at these dams, it also does not provide information necessary for adaptive management. No well-defined plans are given for how this performance measure will be used in adaptive management other than to report it to the Council and to use it in the 5-year reviews of the Delta Plan. Also not discussed is how the performance measure may evolve over time. For example, it is likely that as the barriers on the baseline lists are resolved, there will be a desire to resolve new barriers, barriers whose priority has increased over time, or lower priority barriers. It is not clear whether the performance measure value will reflect newly constructed barriers or newly identified barriers. In this

sense, the performance barrier does not support adaptive management. No alternative actions are considered in performance assessments and reporting.

Adaptive management is not considered in the planned performance assessments. The reporting described is designed to use the performance measure to support adaptive management, but adaptive management is not allowed to introduce changes in the performance assessments or reporting; that is, the possibility of new information needs will be not addressed by the planned assessment and reporting structure. Thus, if management needs evolve, a new performance measure will be required.

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