Ecosystem Amendment Performance Measures Independent Scientific Review

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

Description: Achieve the state and federal doubling goal for Central Valley Chinook salmon natural production against the baseline for the period of 1967-1991.

Question 1.
How clear and thorough are the performance measure's metric, baseline, and target? What, if any, additional information is needed?

Metric

"Fifteen-year rolling annual average natural production of all Central Valley Chinook salmon runs (fall, late fall, spring, and winter)… measured annually"

Generally the wording of the metric is clear, although it requires an unambiguous definition of what is meant by "natural production" (e.g. via a footnote). According to a U.S. Fish and Wildlife Service (USFWS) working paper "*Title 34 defines natural production as: '... fish produced to adulthood without direct human intervention in the spawning, rearing, or migration processes' (Section 3403[h]),"* (U.S. Fish and Wildlife Service, 1995).

Straight away, this brings up a critical issue with the 'doubling goal'. Technically, hatchery fish are not meant to be included in natural production estimates (either the baseline or subsequent estimates), but they likely represent a large fraction of the escapement estimates still used to calculate natural production in the USFWS dataset "Chinookprod". In most years, the extent of hatchery "contamination" is unknown, and because of low/inconsistent marking rates of hatchery fish, they cannot be retrospectively removed with any real confidence. But in recent years (well beyond the years included in the baseline) 100% marking or constant fractional marking (CFM; typically 25%) of hatchery produced salmon means that "natural production" could be estimated with relative confidence. Thus for escapement years 2010 onwards accurate natural production estimates could be used, but (presumably because they would then be incompatible with earlier estimates?) they are not. More on this later.

In terms of the language used in the metric, a short explanation for why 15 years was used for the window would be helpful: e.g. "*A rolling average was used to dampen short-term stochasticity, with 15 years chosen to represent c.5 generations of salmon (as today, most Central Valley salmon return to freshwater as 3 year olds)".* See below for further discussion of the 'why 15 years' question? Finally, to ensure that the metric is readily quantifiable it would be worth clearly defining the window used (e.g. 2035 represented by 2020-2035) given that rolling averages can also be centered around the year of interest (e.g. 2035 represented by 2028-2042).

Baseline

"*1967-1991 Chinook salmon natural production annual average of 497,054 for all Central Valley runs."*

Again, this requires a clear definition of "natural production" (e.g. a footnote) and a short explanation for why this particular 24-year period was used (rather than a 15-year period as will be used in subsequent comparisons). I presume that the baseline is immutable given that it was used in Section 3406(b)(1) of the Central Valley Project Improvement Act (CVPIA), but if CVPIA itself provided any kind of justification for using that time period it would be helpful to mention this in the Performance Measure (PM) for context.

Targets

Target 1 ("*15-year rolling annual average of natural production for all Central Valley Chinook salmon runs is 990,000 by 2065, nearly doubling the baseline of 497,054.*"). First, Target 1 should more clearly define exactly what would constitute success. Does production need to exceed 990,000 specifically in 2065, in multiple years before it, etc? What if the rolling average is >990,000 in 2050-64 then drops to 890,000 in 2065 - would that be deemed failure? Based on the wording in the USFWS 1995 working paper it seems like 'recovery' would need to show natural production remaining above 990,000 for at least 5 generations (e.g. 2050-2065 or 2065-2080).

More of a concern to me is how to deal with hatchery "contamination" in Chinookprod, which was also a major concern of Dahm et al. (2019). Because so few salmon were marked in earlier years, the fraction of the escapement comprised of hatchery fish was poorly resolved until ~2010 onwards. I personally have not looked at the coded wire tag (CWT) release/recovery data for 1967-1991, but while marking rates were low, I do wonder if it might be possible to at least bookend the likely range of hatchery contamination. In any case, it would appear to be impossible to reconstruct true natural production during this period with high certainty, and it is highly likely that the baseline value of 497,054 "natural-origin" adults is overestimated. Unfortunately, subsequent natural production estimates continue to use the same flawed methods to estimate hatchery contributions (detailed below), but hatchery releases have changed through time (more fish produced, transported further downstream prior to release (Huber & Carlson, 2015; Sturrock, Satterthwaite, et al., 2019) – see also Bay Delta Live Hatchery Releases. Collectively, this has likely resulted in even higher hatchery contamination

(via increased straying rates and survival rates), and even more overestimation of "natural" production in the 1990s-2010s. While the reasons behind the doubling goal are commendable and I wholeheartedly support any efforts to increase natural production of anadromous fishes, in terms of tracking progress towards this particular target, there do not seem to be any perfect options on the table. It seems to be that the current plan is to continue using flawed methods to estimate and exclude hatchery fish to make resulting natural production estimates more comparable to the baseline. However, given changes in hatchery practices through time (see above), I'm not convinced this is the best way to go. Given that the CFM program now provides far more accurate hatchery estimates it seems bizarre not to use these data for years they are available (escapement year 2010 onwards). But I recognize that switching methods/datasets in 2010 would create new discrepancies with the baseline. I wonder if it would be possible to improve the baseline (e.g. if we could use any marking data available and/or better model predicted hatchery contributions and straying rates based on annual release distances and release numbers [available in Sturrock, Satterthwaite, et al. 2019])? Or whether we could create a new baseline, using the earliest year(s) with reliable hatchery data (i.e. escapement year 2010)?

Regarding Constant Fractional Marking (CFM), since at least brood year 2006, all Central Valley hatchery fish or a constant fraction of them have been marked prior to release (adclipped plus CWT): 100% of winter, spring and late-fall run Chinook salmon and typically 25% of the numerically-dominant fall run. Exceptions to the latter include some experimental releases and Mokelumne River Hatchery in-river releases, which tend to be marked at 100%. For escapement years 2010-2014 (n=5 so far) CFM reports have revealed the true proportion of hatchery fish on natural spawning grounds and in the ocean fishery (Kormos, Palmer-Zwahlen, & Low, 2012; Palmer-Zwahlen, Gusman, & Kormos, 2018, 2019; Palmer-Zwahlen & Kormos, 2013, 2015). With the exception of Battle Creek (where Chinookprod quite accurately assumes that hatchery fish represent 90% of in-river spawners each year), Chinookprod consistently underestimates hatchery contributions. For example, on the Feather River, Chinookprod assumes that 40% of fall run in-river spawners are hatchery-origin every year, yet CFM reports indicate that 78-90% of in-river spawners were hatchery origin in 2010-2014 and otolith reconstructions indicate that 55-89% of in-river spawners were hatchery origin in 2002-2010 (Willmes et al., 2018). Chinookprod also assumes a static contribution of 40% hatchery-origin fish on the Mokelumne and American River natural spawning grounds when CFM and otolith analyses (e.g. Johnson et al., 2012) have revealed much higher proportions. Chinookprod also assumes a static proportion of 10% hatchery fish on the Merced River spawning grounds, when CFM suggests that hatchery fish have actually represented 44-89% of in-river spawners in 2010-2014. Finally, on rivers with no fall run hatcheries on them (e.g. Yuba, Stanislaus, Tuolumne, Sacramento River, Clear Creek), Chinookprod assumes no hatchery fish in the in-river escapement, when in fact, CFM reports and otolith analyses (Sturrock, Carlson, et al., 2019) indicate that hatchery fish often dominate the escapement.

Target 2: "*The slope of the 15-year rolling annual average of natural production for all Central Valley Chinook salmon runs is greater than zero (i.e., positive) for the period of 2035-2065*."

This makes way more sense to me than Target 1 given uncertainties in the baseline and also whether the current/future Central Valley can even support double natural production after losing ~80% of historic Chinook habitat (Yoshiyama, Gerstung, Fisher, & Moyle, 2001). That said, I don't understand why the period used to generate this slope doesn't start earlier? Why not include the full baseline period as well (a start year of 1981 would incorporate the first rolling average period of 1967-1981), or at least the tail end of it (a start year of 1991 would include the last 15 years of it – 1977-1991)?

While this Target is somewhat softer than Target 1, it still also suffers from the same issues in terms of underestimating contributions of hatchery fish. Unfortunately it takes a good deal of time for all the CWT recoveries to be collated, QAQC'd and entered into the Regional Mark Information System (RMIS), and for the data to be analyzed and released as CFM reports (the last report was for escapement 2014, so currently five years out). But management needs to be able to act on the best available science and to be able to act quickly. Thus, I could envisage two future scenarios. First - to continue using Chinookprod as it stands, perhaps with some effort to improve past and future hatchery contributions using mean values from existing CFM reports. Second – perhaps making a Target 2B, which is basically the same analysis as Target 2, only starting in escapement year 2010 (following onset of CFM) and using observed annual hatchery contributions for all salmon rivers in the Central Valley from CFM reports to generate accurate natural production estimates by population and year. Again, the intent would be to test for a positive slope in this time series to identify whether Central Valley salmon are on a road to recovery or not.

Question 2.
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?

Generally, the sections of the PM covering its basis for selection are clearly written and cite key literature about the ecological importance of salmon and how their performance can reflect overall ecosystem health.

Importantly, the Delta Reform Act directs the inclusion of measures in the Delta Plan (for which these Performance Measures have been created) that promote a healthy Delta ecosystem (Water Code Section 85302(c)) and "*conditions conducive to meeting or exceeding the goals in existing species recovery plans and state and federal goals with respect to doubling salmon populations*". So while there may be obvious flaws to the underlying datasets and methodologies making it more difficult to measure/demonstrate progress towards the goal, its inclusion as a Performance Measure seems defensible.

Something I would like to see a greater focus on are metrics that track salmon resilience and stability through time rather than only focusing on total abundance. Particularly in a changing climate, management actions that promote phenotypic and genetic diversity are likely to be far more important for salmon persistence that just average population size. Central Valley fall run Chinook salmon are genetically homogeneous (Williamson & May, 2005) and exhibit a weakened portfolio effect (Carlson & Satterthwaite, 2011). Goals that, say, promote diversity in age structure and outmigration timing, and/or those that help to strengthen weaker runs and populations (e.g. winter & spring run, San Joaquin tributaries) could create a far more resilient stock complex in a changing climate, and help to stabilize ecosystem services such as nutrient flux and fishery returns (Herbold et al., 2018).

Question 3.
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?

There is nothing in this PM really going into the scientific basis for setting Target 1 – it seems to suggest that the PM has been formulated purely to help meet the CVPIA doubling goal. A 1995 USFWS working paper suggests that the intent is to achieve this goal by either doubling the productivity of existing freshwater habitats or by doubling the area of available freshwater habitats (U.S. Fish and Wildlife Service, 1995). Given this focus on actions that impact freshwater conditions, it seems generally flawed to focus purely on adult returns and harvest. Aside from the difficulties associated with separating natural- and hatchery-origin fish, the fact is that ocean conditions (over which we have no control) can have a huge effect – both good and bad – on salmon abundance. I feel that a more tangible and relevant metric would be to track in-river juvenile production using spawner-recruit curves, modeled as a function of flow conditions (e.g. the abundance of adult spawners [proxy for potential juvenile production] vs. the abundance of juvenile outmigrants gleaned from rotary screw traps). Restoration actions in a river that result in positive deviations from the average curve for that water year type suggest positive impacts on production. I did analyses like this on the Stanislaus River, which does not have a hatchery so we didn't have to worry about unmarked hatchery releases "contaminating" the rotary screw trap data (Sturrock, Carlson, et al., 2019), but so long as you know marking rates you should be able to remove hatchery fish as required. Obviously if they marked 100% of fall run hatchery fish it would be a lot easier to track and exclude them from these datasets, but it's looking like this is unlikely to happen anytime soon.

The scientific basis for Target 2 seems logical (basically, if we think the baseline is overestimated because of hatchery fish, then why aim to double that number? Instead, let's focus on a softer goal of generally increasing productivity through time). However, for the reasons outlined above, I'm not convinced that recent natural production estimates in Chinookprod aren't ***more*** overestimated than the baseline, and thus even if natural production remained exactly the same through time we might see an upward

trend in Chinookprod estimates purely as a result of changes in hatchery practices. In any case, I think a target focused on the slope of a rolling average (not sure I would have gone with 15 years but some interannual smoothing function) makes a lot of sense.

Along those lines, some clear reasoning behind using a **15**-year rolling average would be helpful, particularly as the window used in the initial baseline (1967-1991) is different (24 years). Why not just use 24 years? Or a shorter period (e.g. 3, 5, 10 years)? I wonder if 15 years relates to language in the same working paper mentioned above that suggested "long term" constitutes at least 5 generations of salmon. However, note that their discussion of this was in the context of the doubling goal and considerably more ambitious than the target for this PM. There, rather than suggesting averaging production across 5 generations, they were suggesting that natural production would need to exceed twice the baseline every year (i.e. **across all water year types**) for at least five generations to constitute success. (Direct quote here: "*Long term, in this context, must encompass at least several generations of fish (not less than five) over a variety of hydrologic conditions (to allow for natural variation in production) and will continue indefinitely"* (U.S. Fish and Wildlife Service, 1995)).

In terms of "*How complete is the consideration of key scientific references, available data, and existing monitoring capabilities?",* as I already went to in detail above, I would consider using hatchery proportions from Constant Fractional Marking reports to improve natural production estimates in both Target 1 and 2. References provided at the end.

Question 4.
How achievable are the targets relative to the stated time scales?

Based on the trends in "natural" production across the entire time series thus far (1952-2015, see Fig. 1) it seems unlikely that Target 1 will be achieved in the stated time scale. Having lost ~80% of historic Chinook habitat behind dams (Yoshiyama et al., 2001) and with climate change, harvest, and multiple other anthropogenic stressors acting on Central Valley salmon simultaneously, it is unclear if and how it could ever be achieved without some extreme habitat and/or harvest changes. However, opening up new habitat and providing much needed thermal refugia by removing fish barriers and providing access to historic habitats (Performance Measure 4.13) could have significant benefits and help to achieve the doubling goal (so long as the definition of natural production was relaxed to include fish moved across barriers via trap-and-haul). Furthermore, increasing fish access to (and/or food exports from) managed and natural floodplains and agricultural fields could provide novel ways to increase growth and survival of salmon during their seaward migration (Jeffres, Opperman, & Moyle, 2008; Katz et al., 2017; T. Sommer et al., 2001; Sommer, Nobriga, Harrell, Batham, & Kimmerer, 2001). Target 2 (positive slope) does seem to be achievable in the stated time scale, but it largely depends on climate conditions over the next 50 years and how they impact salmon survival during freshwater and ocean residence.

Question 5.
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?

Scientific uncertainties did not seem to be formally incorporated into either target, nor their assessment criteria. Climate change effects (beyond our control) and poor resolution of hatchery fish "contamination" (potentially within our control – see above) were mentioned, but did not seem to be formally incorporated into target development.

Question 6.
Are the identified data sources complete and appropriate to support robust assessment of the performance measure?

I strongly suggest using CFM data to provide more accurate estimates of hatchery contributions (detailed above). It would also be great if this PM included cohort reconstructions in order to link adult returns to their juvenile freshwater experience (e.g. cohort reconstructions in Supporting Information of Sturrock, Carlson, et al., 2019), however, very few natural populations in the Central Valley have age reconstructions performed (e.g. via scale reads). Longer term I would consider alternative methods and metrics to track salmon performance and identify factors influencing salmon survival across habitats, years and life stages. Some examples include Smolt-to-Adult return ratios (SARS) (Michel, 2018), otolith-based reconstructions of juvenile rearing behaviors, growth and survival rates (Phillis, Sturrock, Johnson, & Weber, 2018; Sturrock, Carlson, et al., 2019; Sturrock et al., 2015; Woodson et al., 2013), spawner-recruit curves (Dahm et al., 2019; Sturrock, Carlson, et al., 2019), life cycle models (Hendrix et al., 2015; Hendrix et al., 2017) and individual-based models (Dudley, 2018).

Question 7.
How well are adaptive management and alternative actions considered in performance assessments and reporting?

Adaptive management was mentioned only at the end of the PM, in the context of using the status of this performance measure (primarily whether the slope of the rolling average of natural production was positive or not) to "*inform the Five-year review recommendations, Council's adaptive management and other relevant decision makings*". However, it the PM did not explain anything specific about how the data would be used or provide additional information about the Council's adaptive management plan.

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Performance Measure 4.13: Barriers to Migratory Fish Passage

Description: Resolve fish passage at priority barriers and select large dams in the Sacramento-San Joaquin Watershed, and screen diversions along native, anadromous fish migration corridors within the Delta.

Question 1.
How clear and thorough are the performance measure's metric, baseline, and target? What, if any, additional information is needed?

Metric

"*Priority fish migration barriers and select large dams in the Sacramento-San Joaquin River watershed, and unscreened diversions along native, anadromous fish migration corridors in the Delta and Suisun Marsh. This metric will be evaluated annually*."

This is – as it stands – not a quantifiable metric. I would modify to something like:

*"**The percentage of unresolved*** priority fish migration barriers and select large dams in the Sacramento-San Joaquin River watershed, and unscreened diversions along native, anadromous fish migration corridors in the Delta and Suisun Marsh, evaluated annually."*

I would then make sure that the footnote (*) clearly states how this performance measure (hereon, "PM") will define "resolved" in the context of all three components of the PM (1-"priority fish migration barriers", 2-"select large dams" and 3-"unscreened diversions"). The current definition does not seem to include rim dams: "*Resolve in this context means to construct, modify, or remove a barrier to allow migratory fish to travel past the barrier or former barrier. For unscreened diversions, resolve means to screen the diversion so that juvenile or adult fish are physically protected from entrainment"*. I may be wrong, but I would remove the word "construct", because it suggests that one option on the table would be to *construct a barrier to allow fish to pass an existing barrier*, which I don't think is the intent. Modifying or removing an existing barrier to improve fish passage makes sense. As does providing alternative means for fish to move above or below dams where the dams cannot be removed or altered (e.g. trap-and-haul), but if this is one of the intended ways to "resolve" a dam or barrier it should be described clearly in the footnote. Furthermore, based on the current definition, my assumption is that for a modified barrier to be counted as "resolved" it needs to allow free passage in both directions under **all** flow conditions (i.e. comparable to if it had been removed altogether). If this not the case (e.g. there is potential for allowances under extreme flows), this should be fully disclosed.

Baseline

"*Number of fish passage barriers, rim dams, and unscreened diversions listed in*:

1. California Department of Fish and Wildlife (CDFW) Priority Barriers (2018).
2. Central Valley Flood Protection Program (CVFPP) Conservation Strategy (Appendix K, 2016).

3. Rim dams in the Sacramento–San Joaquin River watershed.
4. Unscreened diversions along Delta native, anadromous migration corridors listed in the Passage Assessment Database (PAD), March 2018 version (CalFish 2019)."

The baseline should include numbers of each of the three "components" (1-"priority fish migration barriers", 2-"select large dams" and 3-"unscreened diversions") to provide transparency, clarity, and allow easier comparisons with the baseline. The specific barriers and rim dams included in the baseline are revealed later in the document in 'Baseline Methods' but they should really be defined or at least enumerated here.

Many of the data sources will be updated through time – in particular the unscreened diversions - which could make it difficult to reconstruct the specific inventory included in this baseline. As such, it would be helpful if a full list of the 1,449 structures and diversions were added to the PM as an appendix.

The third "source" ("3. Rim dams in the Sacramento–San Joaquin River watershed") is clearly not a source or a list. The language, as it stands here, makes it sound like *all* Central Valley rim dams are included, but later on in Table 3 it is revealed to be a selection of 10 of them. The source and/or logic behind the selection of these ten dams should be explained or at least alluded to in the main "Baseline" section.

I would rephrase the wording of "Baseline" to something like the following and provide a clear explanation for the rationale to include the 10 rim dams in the Baseline Methods:

"Total number of unresolved high priority fish passage barriers[1,2] (n=39), select rim dams[3] (n=10) and unscreened diversions along Delta native, anadromous migration corridors (n=1,400)[4] identified during the establishment of this baseline in 2019. The criteria used to select the fish barriers and rim dams in the baseline are described in Baseline Methods. Given that many of the underlying data sources are updated through time, we provide a full inventory of the 1,449 structures and diversions that are included the baseline in Appendix A.*

Data sources:

[1] *California Department of Fish and Wildlife (CDFW) Priority Barriers (2018)*
[2] *Central Valley Flood Protection Program (CVFPP) Conservation Strategy (Appendix K, 2016)*

[3] *Selection of rim dams identified manually for this Performance Measure based on recommendations in <insert citation> (and/or by <insert expert name>)*

[4] *Passage Assessment Database (PAD), March 2018 version (CalFish 2019)."*

Target

1. *"By 2030, resolve all (100 percent) of the priority fish migration barriers (listed in CDFW 2018 Priority Barriers (2018) and CVFPP 2016 Conservation Strategy).*
2. *By 2050, resolve 50 percent of fish passage at rim dams in the Sacramento-San Joaquin River watershed, and screen 50 percent of unscreened diversions along native, anadromous fish migration corridors in the Delta."*

Target 1 seems sufficiently clear.

Target 2 is unclear and disjointed. I would separate rim dams and unscreened diversions into separate targets. They are quite different objectives - one is to reconnect fish with their historic habitats and the other is to reduce entrainment.

Once separated, the target to resolve 50 percent of unscreened diversions seems ambitious (700 diversions in 30 years), but it at least makes sense based on the current definition of "resolve" in the footnote.

The other part of Target 2 (fish passage at rim dams) needs some work. As mentioned, the definition of "resolve" in the footnote needs to be updated to include rim dams. As it stands, the language suggests that the intent is to modify or remove the 10 select rim dams to enable fish passage. Given water security issues, removal of these rim dams is unlikely, but even if modifications to promote passage were a potential course of action, this would not actually allow upstream passage of anadromous fishes because the 10 selected dams are not the ones currently blocking upstream migrating fishes. Rather, the ten selected dams are higher in the watershed, often with multiple other large dams below them. While not explicitly explained, presumably, the intended actions to support this target would primarily involve 'trap-and-haul' to move salmonids above these dams so that they can access historic habitat in the upper watershed (e.g. Lusardi and Moyle 2017). I personally think this could be an excellent strategy to help salmonids persist in an increasingly volatile climate, but in the context of this PM it needs to be more clearly defined and described. In addition to updating the definition of "resolve" in the footnote, the target needs to be described in a way that makes it readily quantifiable. It is not clear what exactly is meant by "resolve 50 percent of fish passage at rim dams". Even if the technology is not yet fully developed, the desired outcome can still be clearly stated. For example – to me it sounds like the target would be to move 50% of individuals past each of these 10 structures in order to meet this target (but if that's the case are they talking about all populations or particular ESUs, and would it have to be in every year?) However, based on the wording in the "Data Collection and Assessment" section (copied below) I believe the target is - in fact - for at least 50% (i.e. 5) of these select rim dams to have their fish passage status in the PAD database changed to "resolved"? It's all quite confusing. If this PM is fully relying on PAD to determine whether "fish passage" has been "resolved" at these rim dams, it should still state here how PAD assesses achievement of this. For example, does a certain number or proportion of the population need to be moved above/below the dam? In every year?

Based on language in “Data Collection and Assessment” (“*For the rim dams, identify those dams where fish passage was resolved, including either upstream passage for adult fish or downstream passage for juvenile salmon. Calculate the percent change between rim dams’ baseline and the most recent PAD dataset at the time of analysis*”) it sounds like the intent would be to enable passage in either or both directions. If so, my assumption would be that if one were to go to the trouble of collecting outmigrating fry and smolts at the 10 select dams, surely they would then take said fish **past the lower-most barrier** in that river to avoid mortality past subsequent dam(s)? For example, salmon passage into and out of the upper Merced River would presumably require actions that enable passage past New Exchequer Dam for spawning adults and passage past Crocker Diversion Dam [not listed in document] for outmigrating fry and smolts? And on the Stanislaus River I would assume the goal would be to move outmigrating fish safely past Goodwin Dam [also not listed in document]? If so, for the watersheds included in the ‘rim dam selection’ (Sacramento, American, Feather, Yuba, Stanislaus, Tuolumne, Merced & San Joaquin Rivers) I believe the target should include language in the following vein: “*if reintroductions above the select dams in Table 3 are successful, the target for that watershed would then change to include resolving passage of X% of outmigrating juvenile salmon past the downstream-most barriers in each watershed (Table 3)*”. And to add a new column to Table 3 showing the lower-most dams in question. Alternatively, if downstream passage is not explicitly part of the PM it should acknowledge this clearly. As it stands, the rim dam baseline, metric and target are really quite confusing.

Question 2.
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?

The overarching scientific rationale, justification and supporting references for the selection of the PM are generally well-described, with multiple lines of evidence showing that habitat heterogeneity promotes phenotypic and genetic diversity, increased connectivity increases habitat carrying capacity and fish productivity, and reduced entrainment increases survival. Furthermore the PM discusses the many linkages to the Delta Reform Act and the Coequal Goals.

One peculiar thing is that one of the rationales for this PM is that achieving the targets will contribute “to the Doubling Goal for Central Valley Chinook Salmon Natural Production (PM 4.6)” yet if – resolving fish passage at rim dams will rely on trap-and-haul – it is not clear whether juveniles moved downstream would even be counted as “natural production.” U.S. Fish and Wildlife Service (1995) includes the following statement: “*Title 34 defines natural production as: "... fish produced to adulthood without direct human intervention in the spawning, rearing, or migration processes" (Section 3403[h]).”*)

Question 3.
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?

- The high-level linkages between fish passage, entrainment and survival, productivity and/or resilience are generally well-described and the PM cites an array of peer-reviewed literature.
- Given that there is very little information about the methods or actions that will be used to remove/modify barriers, screen unscreened diversions, and/or to move fish above/below rim dams it is hard to fully judge the scientific basis for the targets. Brevity is not a bad thing, but some additional information about how exactly the targets will be achieved would be useful, particularly references that include case studies and or discuss the advantages or disadvantages of alternate courses of action. The Lusardi & Moyle 2017 paper mentioned above reviews trap and haul options (e.g. barging vs. trucking) and lessons learned from other systems.
- The reasoning behind the intended timelines (2030 or 2050) and target numbers (100% or 50%) are not explained anywhere (e.g. will screening 50% of unscreened diversions improve survival rates above some threshold amount?).
- There is no information about which 50% of unscreened diversions will be targeted first. It would seem logical to target any that are known (or predicted) to result in higher entrainment rates, such as those with larger intake volumes or those located along busier migration routes.
- The rim dam target is – as mentioned above – currently tucked into Target 2, and is as it stands, very vague and unclear, and the scientific basis for how the 10 dams were selected is not explained at all.
- The section “Prioritization of Barriers” clearly lays out CDFW’s and California Department of Water Resources’ (DWR) prioritization methods for selecting the 39 instream barriers included in Target 1. These seem sensible and provide a good basis for Target 1.
- I assumed that the subsequent section “Rim dams and climate change” (p.6) would explain the basis for how the 10 rim dams in Table 3 were selected. While it provides well-written, conceptual information about the importance of habitat heterogeneity in a changing climate - and therefore why enabling fish passage above rim dams could promote resilience - it does not provide any specific information on why/how these particular dams were selected. The caption for Table 3 describes these 10 dams as “*Rim Dams to Provide Fish Passage Identified in Recent Recovery Plan Biological Opinion for Salmonids” (“Source: NMFS 2014 and 2009”*). In each of the eight rivers in Table 3, allowing fish passage above the 10 selected dams would provide salmonids, including listed

species such as winter run and spring run Chinook salmon and steelhead, to access vast swathes of historical habitat, which could be extremely beneficial, particularly in drought years. However, I could not find a clear list in either source specifying these particular dams. In a previous version of this PM the list was described as “manually identified.” It would be valuable if the basis for selection were more clearly described in this PM.

- None of the targets or background literature provide quantitative estimates of fish responses. It would be great if the PM included even some approximate predictions (e.g. X% fewer fish entrained, X% increase in recruits per spawner, X km^2 more habitat available), even if these are not formally monitored as part of the PM. Are there no studies that have modeled the number of fish lost at unscreened diversions that could be used to estimate the survival benefit provided by screening these diversions? Similarly, providing fish access to additional habitat via barrier removal/modification or trap-and-haul would presumably result in a larger total habitat carrying capacity (i.e. more fish). It would be great if this PM (or subsequent studies) could more directly link the changes in habitat area/quality achieved by reconnecting historic habitats (e.g. we predict X km^2 more rearing habitat will be created by removing X barrier, predicted to result in X% more recruits per spawner [averaged across X number of water years]). My hope would be that existing monitoring efforts (e.g. escapement surveys; rotary screw trap sampling; Delta Juvenile Fish Monitoring Program and novel field, experimental and modeling efforts will monitor changes in Central Valley fish survival, distribution and abundance as this PM progresses. By measuring fish responses to this PM it will inform future management actions, allow managers decide between alternative actions (e.g. via cost benefit analyses), and provide a quantitative basis for adaptive management.
- That said, apart from the areas I feel really need increased clarity and transparency (see above), I still think that this is an important PM that will result in significant benefits to anadromous fishes. The importance of improving fish passage in the Central Valley is urgent enough to warrant moving forward even if quantifying fish responses are not formally part of it. Here, it’s worth stepping back and learning from some of the salmon literature in Alaska. There, multiple threads of evidence have shown that habitat complexity and life history diversity promote salmon resilience and stability in the fishery (e.g. Schindler et al. 2010, Brennan et al. 2019). Reconnecting habitats and providing thermal refugia will be particularly important in California given its variable Mediterranean climate and projections for more frequent and intense droughts (Cloern et al. 2011). Depending on interactions between physical, chemical and biological factors, in-river and off-channel habitats change dynamically through space and time (e.g. in temperature, area, depth, primary production, food web structure, water velocity etc.) and this can drastically alter their capacity to support spawning or rearing fishes. For example, Beverley Lake in the Bristol Bay sockeye salmon

stock complex “switched on” in 2018 (for reasons not yet fully clear to scientists), and this small watershed (which represents **<0.01% of global sockeye habitat**) produced 387 million pounds of sockeye harvest, representing **13% of global sockeye catch** (D. Schindler 2019, pers. comm.). This example demonstrates the importance of maintaining a connected habitat mosaic, and that even small areas of habitat can be amazingly productive. Otolith reconstructions have also shown how important non-natal rearing habitats can be in order to obtain sufficient growth prior to entering the ocean, with juvenile Sacramento River winter run Chinook salmon often ‘wandering’ into other streams during their seaward migration (Phillis et al. 2018). Thus, improving fish passage, and reconnecting fish to an array of alternative habitats could provide large benefits to migratory fishes by – for example – providing new options for food production and thermal/predator refugia. The benefits might not be immediate or obvious, but from a bet-hedging stand point it is important to try and keep options on the table (or create new ones) wherever possible. This is particularly critical in the Central Valley given that salmonids are at the southern edge of their native range and facing an increasingly variable climate (Cloern et al. 2011).

Question 4.
How achievable are the targets relative to the stated time scales?

The targets do seem ambitious (10 years to remove/modify all 39 high priority barriers, 30 years to screen 700 diversions, and 30 years to “resolve 50% of fish passage” above and below 10 major rim dams [exact meaning TBC]). However, this is not my area of expertise so I do not feel I can answer this question with any certainty, and there is no information provided indicating time scales for previous efforts or comparable efforts in other systems.

Question 5.
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?

- The section dedicated to uncertainty “Process Risks and Uncertainties” was entirely qualitative and did not show how uncertainty was incorporated into the targets. Nor did the section “Target Methods.” With the exception of the rim dam component, the targets and assessment protocols seem clear with little room for uncertainty (*of the original list of 39 barriers and 1400 unscreened diversions, what proportion were removed/modified to allow fish passage or screened to prevent entrainment, respectively?)*
- If expected fish benefits were also incorporated into the PM, then scientific uncertainty (e.g. in the relationship between habitat area and fish production) would obviously need to be built into it.
- In “Target Methods” (“*Setting the target of resolving 50 percent of fish passage at the rim dams, and screening 50 percent of unscreened diversions, considers the*

feasibility of developing technological solutions to fish passages at large dams that also provide water supply and flood control benefits and the large number of mostly agricultural water diversions within the Delta") it was not clear to me what they mean.

- Depending on their definition for how PAD and/or this PM defines "resolving fish passage" for the rim dams (e.g. do a certain number of fish or proportion of the population need to pass the dam?) then scientific uncertainty in the methods used to assess that metric should be described in this PM.

Question 6.
Are the identified data sources complete and appropriate to support robust assessment of the performance measure?

I am not very familiar with the CA Fish Passage Assessment Database (PAD) but it seems thorough and frequently updated. My only concern with this would be that updates - particularly to the unscreened diversions - would be that a future query of it could include new diversions that were not in the original baseline. My understanding is that the intent of this PM is to query the 1400 diversions in the baseline annually to assess the percent change in the proportion screened. Thus, so long as any of these future queries are filtered against the baseline inventory before calculating the percent change there shouldn't be a problem.

Question 7.
How well are adaptive management and alternative actions considered in performance assessments and reporting?

Adaptive management or alternative actions are not really discussed in this PM performance assessment. However, the intent is to track its progress on an annual basis, and for the Delta Plan five-year review process to evaluate these data to "inform Council adaptive management and decision-making processes." Exactly what that might entail or lead to is not detailed in the PM.

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