October 4, 2017

Response to 2017 Peer Review Comments on the Scientific Basis Report in Support of New and Modified Requirements in Support of the Phase II Update of the Bay-Delta Plan

This document provides responses to peer review comments received on the State Water Resources Control Board's (State Water Board), April 2017 report titled *Scientific Basis Report in Support of New and Modified Requirements for Inflows from the Sacramento River and its Tributaries and Eastside Tributaries to the Delta, Delta Outflows, Cold Water Habitat, and Interior Delta Flows* (Science Report or Report). In accordance with requirements of the California Health and Safety Code, the State Water Board submitted the Report for independent external scientific peer review and the peer reviewers determined that the Report is based on sound science. As such, no changes are needed to the Report and no further action is necessary related to the Science Report. While not required, State Water Board staff has developed responses to minor comments and questions raised by the peer reviewers.

Background

The Science Report discusses the scientific basis for developing new and revised water quality objectives for the Phase II update of the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan). California Health and Safety Code section 57004 requires that all California Environmental Protection Agency organizations submit for external peer review the scientific basis and scientific portion of all proposed policies, plans, and regulations. The State Water Board currently maintains a contract with the University of California to provide for independent peer reviews by outside scientific experts to meet these requirements. The University of California selected five experts (Table 1) with substantial experience in hydrology, flow and non-flow needs of freshwater and estuarine fish, and establishment of environmental flows to review the Science Report. State Water Board staff appreciates the time and effort the reviewers dedicated to developing insightful comments.

Table 1: Independent scientific peer reviewer names, affiliations and fields of expertise

Name	Affiliation	Field of Expertise
Dr. Murdoch McAllister	Associate Professor, Quantitative Modeling Group Canada Research Chair in Fisheries Assessment UBC Institute for Oceans and Fisheries University of British Columbia	Applied statistical modeling; fisheries management
Dr. Thomas Meixner	Professor & Associate Department Head Hydrology and Atmospheric Sciences University of Arizona	Hydrology and water resource management
Dr. Thomas Miller	Professor and Director Chesapeake Biological Laboratory University of Maryland Center for Environmental Science	Fisheries ecology; population dynamics and stock assessment; quantitative methods in ecology
Dr. N. LeRoy Poff	Professor Department of Biology Colorado State University	Establishing environmental flows to support freshwater biodiversity and sustainability; response of riverine ecosystems to environmental alterations
Dr. Elowyn Yager	Associate Professor, Center for Ecohydraulic Research Department of Civil Engineering University of Idaho	River morphology; river restoration; channel erosion

The California Health and Safety Code requires that the peer reviewers evaluate whether the scientific portions of the proposed rule are based upon sound scientific knowledge, methods, and practices. If the peer reviewers find that any scientific portion of a proposed regulation is not based upon sound science then the reviewers are required to state those findings and the reasons for their conclusions. In this circumstance, the agency promulgating the regulation may either revise the scientific portion of the proposed rule or, if it disagrees with the finding, explain why the proposed rule is indeed based on sound scientific knowledge, methods, and practices.

For the peer review, State Water Board staff submitted the Report and its references, and a statement of scientific assumptions, findings, and conclusions (Table 2) on which the proposed changes to the Bay-Delta Plan are based. In addition, State Water Board staff requested that the peer reviewers identify whether, when taken as a whole, the scientific portion of the proposed regulation is based upon sound scientific knowledge, methods, and practices and also requested input on whether any additional scientific issues should have been included in the assessment.

Table 2 Summary of conclusions submitted for peer review

	Conclusion
1	Significant changes have occurred in the hydrology and hydrodynamics of the Sacramento River and its tributaries, Delta eastside tributaries and the Delta.
2	Changes to the flow regime of the Sacramento River and its tributaries and the eastside tributaries to the Delta, Delta outflows, cold water habitat, and interior Delta flow conditions have contributed to the impairment of the ecosystem and native fish and wildlife beneficial uses and could contribute to future impairments without additional regulations.
3	To expeditiously address the impairment to native fish and wildlife beneficial uses in a very large, highly complex and heavily modified system such as the Bay-Delta, an approach based on the holistic method to the development of environmental flows that provides for flows of a more natural pattern that can then be further managed to maximize flow-related functions for the benefit of fish and wildlife beneficial uses is feasible and scientifically justified.
4	Inflows that more closely mimic the natural flow and water quality conditions to which native migratory fish are adapted are needed in the Sacramento River Basin and Delta eastside tributaries to provide spawning and rearing habitat and connectivity with the Delta.
5	Delta outflows that more closely mimic the natural flow and water quality conditions to which native migratory fish are adapted are needed year round to support the migration, spawning and rearing of native estuarine and anadromous species.
6	Cold water habitat is needed below reservoirs to compensate for natural cold water salmonid habitat lost by reservoir construction above dams.
7	Interior Delta flow requirements help protect resident and migratory species from entrainment and related effects in the southern Delta associated with Central Valley Project (CVP) and State Water Project (SWP) diversion activities.
8	Other aquatic ecosystem stressors have negative effects on fish and wildlife beneficial uses and non-flow actions are needed for ecosystem recovery

The peer reviewers completed their assessment of the science supporting the update to the Bay-Delta Plan and determined that all eight conclusions are based upon sound scientific knowledge, methods, and practices. At least two, and in most cases three, reviewers evaluated the scientific merit of each conclusion. None of the reviewers identified any major additional scientific issues meriting assessment or a general lack of support for the overall science upon which the update to the Bay-Delta Plan is based. Therefore, State Water Board staff concludes that no revisions to the Science Report are required. The peer reviewers did include a number of minor suggestions and questions; and while not legally required, staff provides the following responses organized around the eight conclusions submitted for peer review.

Response to Comments

Conclusion 1: Significant changes have occurred in the hydrology and hydrodynamics of the Sacramento River and its tributaries, Delta eastside tributaries, and the Delta.

The reviewers found Conclusion 1 to be based on sound scientific knowledge. Dr. Meixner concluded that *"[t]he scale of work involved in putting together this report as a whole and in the Chapter 2 on hydrologic changes is truly impressive. The diverse systems represented and the author's careful explication of the hydrologic variety of the system is very well done.*" (Meixner, p. 1.) Dr. Yager concluded that *"[b]ased on the detailed reading of the Science Report, I conclude that the modeled/measured data presented support Conclusion One. The hydrologic data presented outlined here are also used for the basis of many of the following conclusions (2-8), which is scientifically sound."* (Yager, p. 2.) Dr. McAllister found the scientific portion of the regulatory actions following from Conclusion 1 to be "*based on sound scientific knowledge and flow dynamics modeling methods that have been peer reviewed in workshops, meeting, reports and journal articles."* (McAllister, p. 5.)

Dr. McAllister pointed out two minor concerns, one related to calibration of the Sacramento Water Allocation Model (SacWAM) discussed below, and the other on the issue of using unimpaired flow rather than natural flow. Unimpaired flows are used in the Report to help characterize how human uses of water have altered the magnitude, timing, and duration of flows in the watershed under the current physical configuration of the watershed over time. Unimpaired hydrology or "*unimpaired flow*" represents an index of the total water available to be stored or put to any beneficial use within a watershed under current physical conditions and land uses, whereas "*natural flow*" is a theoretical estimate of what would have occurred absent human development of land and water supply. Dr. McAllister indicated that he would have liked to have seen some representation of how natural flow results were sensitive to different assumptions about the configuration of pre-development vegetation, river geomorphology, and riparian habitat structure. He also indicated that he would have liked a comparison of model predicted flow patterns from a pre-development flow regime as native fishes have life history attributes at least partly shaped by and adapted to the pre-development flow regime and not the recent historic unimpaired flow regime.

Use of unimpaired flows is an appropriate tool for analyzing alterations to flows from human activities as well as a basis for new flow requirements in the Bay-Delta watershed. Understanding precisely what the natural flow regime was under pre-development conditions is not necessary for these purposes. Dr. Meixner underscored this point, stating that "*knowing what natural flows in this system would be without human influence is a difficult if not unknowable system attribute. The authors thus rightly, in my opinion, focus on unimpaired flows to investigate the impact of human water resources management on the hydrology of the Delta and its tributary rivers.*" (Meixner, pp. 1-2.)

The proposed Bay-Delta Plan amendments are not intended to restore the ecosystem to a pre-development condition. Massive landscape alterations like mining, agriculture, and urbanization started in the mid-1800s irrevocably transforming the Bay-Delta watershed and its flow regime in ways that will likely never fully be understood. The Report recognizes that it will not be

possible to restore the ecosystem to a pre-development condition (Report, p. 4-2). Unimpaired flows are used in the Report to understand and help balance between human uses of water and environmental uses of water in recognition that water supplies for all purposes are limited. While used as an approximation of more natural flow conditions protective of native aquatic species, the proposed regulatory requirements based on unimpaired flows acknowledge that the physical environment has been modified and that adaptive management is needed to allow for sculpting and shaping of those flows to address the realities of that altered landscape that native species now inhabit and the fact that this landscape will change over time with climate change, habitat restoration, and other factors.

For these reasons, use of the post-development hydrology in the Report is adequate and appropriate. State Water Board staff appreciates the reviewers comments on this topic and notes that additional information is available in DWR 2016(a). Additional study of pre-development flow regimes and landscape attributes has, and will continue to be useful in designing and implementing restoration strategies and related purposes. (See e.g. http://www.sfei.org/sites/default/files/biblio_files/DeltaRenewed_v1pt3_111516_highres.pdf.)

Dr. Yager noted that the Report would have benefitted from additional detail regarding SacWAM (Yager, p. 2). Both Drs. Yeager and McAllister were interested in additional information regarding the calibration of SacWAM and the updates made in response to the Delta Science Program organized peer review of SacWAM. Staff agrees that the Report could have provided a better roadmap to the available information on SacWAM. Appendix A of the Report describes the use of SacWAM to produce estimates of unimpaired flows in the watershed. The SacWAM documentation, referenced in the Report as State Water Board 2017 and available at www.waterboards.ca.gov/SacWAM, was provided to the reviewers in the library of reference material. The SacWAM documentation contains graphical, statistical, and narrative accounts of the calibration and validation of the model's representation of the valley floor (Appendix B) and updates made to SacWAM in response to the peer review and consultation with local experts (SacWAM documentation Appendix C). In response to Dr. McAllister's comment on real-time monitoring of flow, SacWAM contains a large number of historical flow records, allowing the user of the model to compare simulated and historical flows. Appendix B of the SacWAM documentation includes comparisons of simulated flows to recent historical streamflow records throughout the watershed as part of the model validation. A detailed response to the SacWAM peer review has also been prepared and is posted on the State Water Board's website.

Conclusion 2: Changes to the flow regime of the Sacramento River and its tributaries and the eastside tributaries to the Delta, Delta outflows, cold water habitat, and interior Delta flow conditions have contributed to the impairment of the ecosystem and native fish and wildlife beneficial uses and could contribute to future impairments without additional regulations.

The reviewers found Conclusion 2 to be based on sound scientific knowledge. Dr. Poff found that the Report presented ample evidence of the strong association between biological impairment and flow alteration, that these empirical associations show that downward trends in

populations of key freshwater and estuarine species will continue under present levels of flow impairment, and that reducing the flow impairment would likely contribute to some degree of biological restoration (Poff, p. 2). Dr. McAllister found Conclusion 2 to be based on sound scientific knowledge, methods and practices, but detailed minor concerns, some of which are addressed in more detail below. (McAllister, p. 12). Dr. Miller (pp. 5-6) found clear evidence of the decline of most species analyzed in the Report, including high confidence for the Report's conclusions for Chinook salmon (*Oncorhynchus tshawytscha*, all runs), Central Valley steelhead (*O. mykiss*), longfin smelt (*Spirinchus thaleichthys*), and delta smelt (*Hypomesus transpacificus*). Dr. Miller cited additional research papers to support the Report's conclusions, including Maunder et al. (2015), Maunder and Deriso (2011) and Latour (2016). (Miller, p. 6.)

Dr. Miller specifically agreed with the Report's conclusions that abundances of white and green sturgeon and Sacramento splittail (*Pogonichthys macrolepidotus*) have been negatively affected by changes in the Bay-Delta flow regime with moderate confidence but found there was low confidence in the flow/abundance relationships for starry flounder (*Platichthys stellatus*), California bay shrimp (*Crangon franciscorum*), and two species of zooplankton. To raise the confidence level of the Report's conclusions for starry flounder, Dr. Miller recommended the use of a multi-stage model that includes gravitational circulation on the selective tidal stream transport of young starry flounder into the Bay-Delta. To raise the confidence level for California bay shrimp, Dr. Miller recommended use of an integrated statistical model that accounts for commercial harvest and survey uncertainty. (Miller, pp. 6-7.)

Staff agrees that well-developed biological models could be useful in evaluating the relative importance of flows and other stressors on the population abundance of various species; however, these models are only beginning to be developed for native fish in the Bay-Delta Estuary and are not yet fully developed and validated for general use. The Science Report does include results of models developed by Latour (2016),[1] Maunder et al. (2015), and Maunder and Deriso (2011). Latour's (2016) findings on the importance of turbidity on the abundance and decline of several native pelagic species, including delta smelt and longfin smelt, are described on page 3-9 of the Report; Maunder et al.'s (2015) findings on the relative effect of Delta outflow and interior Delta flow on longfin smelt are described on pages 3-55 and 3-57 respectively; and Maunder and Deriso's (2011) findings on the effects of predators, SWP and CVP exports, food availability, and summer water temperature are described in the Report on pages 3-73.

Dr. Miller had several comments on statistical analyses referenced in the Report (Miller, pp. 2-4 [review findings 2-4]). He noted that there was little evidence to standardize the species survey data or to adjust for surveys in which no target species were caught; there was limited exploration of the potential for lagged effects of flow when evaluating flow abundance relationships, and there was limited clarity over which flow year was used in the lagged analyses.

[1] Except where noted otherwise, full citations to references are provided in the bibliography in Chapter 6 of the Science Report.

The California Department of Fish and Wildlife Service's (CDFW) methods for calculating species survey indices are well documented and the resulting indices, including the use of surveys in which no target species were caught, have been widely used and accepted in the peer-reviewed literature. (Miller et al. 2012; Nobriga and Rosenfield 2016.) The temporal lags used in the Science Report are consistent with other peer reviewed publications (Jassby et al. 1995; Kimmerer 2002a, b) and were described in the Science Report. Flow conditions that occurred in the season immediately prior to the production of the cohort of interest were considered. For example, the flow term used in Figure 3.5-3 referenced by Dr. Miller used spring flows to predict production of juveniles during the following fall, taking into consideration parental stock that had been produced two years prior. This approach is consistent with recent analyses examining similar responses. (Nobriga and Rosenfield 2016.)

Dr. McAllister further commented that the Report lacked references for the finding that naturally variable flows help to maintain native fish species. (McAllister, p. 6.) The importance of naturally variable flows was discussed in the section on riverine flows (Section 3.2.1). Support for naturally variable flows is provided by multiple references including Brown and Bauer 2009; Kiernan et al. 2012; Pringle et al. 2000; Freeman et al. 2001; Bunn and Arthington 2002; Moyle and Mount 2007; Sparks 1995; and Lytle and Poff 2004.

Dr. McAllister and Dr. Miller also addressed other aquatic ecosystem stressors that contribute to the decline of species. Dr. McAllister found that "*…where possible some additional covariates and factors were appropriately introduced to enable more precise and accurate definition of the relationship between population abundance or rate of population change and flow volume.*" (McAllister, p. 8.) Dr. Miller found that the analyses' focus on habitat suitability as measured by flow, temperature and dissolved oxygen (DO) provides "*limited consideration of the broader ecosystem context of the Bay-Delta ecosystem.*" (Miller, pp. 2-3.) Dr. Miller's characterization that the analyses ignore ecological mechanisms that may constrain the expression of flow, temperature and DO relationships with abundance does not take into account the detailed description of flow and ecosystems in the first half of Chapter 3, the entirety of Chapter 4, and many other components of the Report. The Report specifically concludes that other stressors have negative effects on fish and wildlife beneficial uses and non-flow actions are also needed for ecosystem recovery. The Bay-Delta Plan update focuses largely on flow-related issues in keeping with the State Water Board's authority and responsibility to protect the quality of the waters of the state and the beneficial uses of those waters; however, the Report acknowledges the importance of habitat restoration and reducing other stressors in combination with providing more flow. As discussed under Conclusion 8 and in Chapter 4 of the Report, the precise effect of other non-flow stressors on the abundance and distribution of native species is difficult to determine because stressors interact and may act in conjunction with flow. The Report acknowledges the importance of continuing work to better understand these stressors and how they interact with flows to inform adaptive management decisions for flow and non-flow actions.

Conclusion 3: To expeditiously address the impairment to native fish and wildlife beneficial uses in a very large, highly complex and heavily modified system such as the Bay-Delta, an approach based on the holistic method to the development of environmental flows that provides for flows of a more natural pattern that can then be further managed to maximize flow-related functions for the benefit of fish and wildlife beneficial uses is feasible and scientifically justified.

Dr. Poff's review of Conclusion 3 found that the "holistic" method for developing environmental flows "*is well-reasoned scientifically in accordance with well-accepted principles of environmental flow science and management.*" (Poff, p. 2.) Dr. McAllister found that "*the scientific portion of the regulatory actions following from Review Conclusion 3 to be based on sound scientific knowledge, methods, and practice.*" (McAllister, p. 17.) Dr. McAllister also noted that the pronounced declines in native fish populations and analyses showing higher survival rates of fish with seasonal flows that are closer to the unimpaired seasonal flow levels strongly support the principle that more natural flows that more closely mimic the shape of the unimpaired hydrograph, including the general seasonality, magnitude, and duration of flows, provide essential ecosystem functions. (McAllister, p. 13.) He found it credible that managing water use for flow patterns that follow an unimpaired flow regime but are subject to known habitat requirements for key species would likely meet flow and habitat requirements of a full set of native species. (Id., p. 14.)

Dr. McAllister indicated that information in Chapter 5 on how tributary-specific plans are to be developed is appropriate and sufficiently rigorous, but did point out that more details are needed on minimum monthly flow rates for salmon-bearing tributaries to ensure appropriate conditions are provided for salmonid migration, rearing and spawning. (McAllister, pp. 14-15.) Staff appreciates Dr. McAllister's comments on minimum flows and tributary plans. Additional details on the content of tributary plans are still being developed and refined, and it is expected that these plans may include minimum flows, especially during dry conditions, to ensure the protection of fish and wildlife.

Dr. McAllister observed that a large body of literature exists that supports the idea of a holistic approach to environmental flows; however, he also noted that "*there does not appear to be yet an accumulation of supportive evidence from existing holistic flow regime implementation, i.e., that changing from strongly altered flow regimes back to a flow pattern that mimics an unimpaired or natural flow regime has systematically restored river ecosystem structure and function and helped to facilitate the recovery of depleted native fish populations.*" (McAllister, p. 16.) There are a number of reasons for the lack of anecdotal evidence of success with changing the flow regime in a watershed at this large a scale. Implementation of instream flows is difficult and requires the participation and cooperation of stakeholders. There are many ongoing efforts to develop the required flows that are still in process (including the Bay-Delta Plan). Even when flows are agreed upon or mandated, it may take many years to register overall population improvements.

However, there is local evidence cited in the Report and summarized below that implementation of environmental flows will be successful. Kiernan et al. (2012) reported that a return to a more

natural flow pattern resulted in the reestablishment of native fish and reductions in the abundance and distribution of non-natives in Putah Creek, a tributary to the Sacramento River. Ahearn et al. (2006) has also shown that pulses of floodwater that inundate the Cosumnes River flood plain in winter stimulate blooms of both phytoplankton and zooplankton. Juvenile Chinook salmon feed on the zooplankton blooms and have higher growth rates than fish rearing below the floodplain in the Cosumnes River channel. (Jeffres et al. 2008.) Sommer et al. (2001) also found higher juvenile salmonid growth rates for individuals rearing on the flooded Yolo Bypass than in the river. Faster growth has been shown to be associated with higher marine survival in other west coast Chinook salmon populations (Beckman et al. 1999.) Finally, recent observations in the Bay-Delta Estuary are also consistent with the need for higher tributary and Delta outflows. Population abundances of longfin smelt, delta smelt, Sacramento splittail and other aquatic species increased following wet conditions in 2011. The next four years were very dry and the abundance of each species declined to near all-time low values. These results are consistent with Kiernan et al. (2012) and demonstrate that the aquatic ecosystem in the Bay-Delta estuary will respond positively to the higher flow levels to which native fish evolved.

Conclusion 4: Inflows that more closely mimic the natural flow and water quality conditions to which native migratory fish are adapted are needed in the Sacramento River Basin and Delta eastside tributaries to provide spawning and rearing habitat and connectivity with the Delta.

Dr. Miller found Conclusion 4 to be supported with a high degree of confidence. (Miller, p. 7.) Dr. McAllister also agreed that the flow and habitat requirements detailed in Chapter 3 "*showed that positive rates of population increase and higher population abundances were associated with higher flows. Fish survival, growth, and successful migration and spawning were found to be considerably improved by higher freshwater flows and Delta outflows that were closer to natural and unimpaired flow conditions.*" (McAllister, p. 19.) Dr. Miller pointed out the importance of supporting minority salmonid contingents and their different migration behaviors because of their contribution to population resilience (Miller, p. 7-8), which would be provided for with the unimpaired flow approach, including the use of targeted adaptive management of those flows.

Dr. Poff also found Conclusion 4 to be a scientifically sound inference supported by empirical data. (Poff, p. 3.) In his comments on Conclusion 3, Dr. Poff explained how the natural flow regime, "*is a widely accepted scientific principle that is extensively applied in the practice of environmental flow management and supported by published literature."* Dr. Poff goes on to note that "*a natural range of flow variability supports the widest range of species and historically prevailing ecosystem processes by providing a wide variety of habitat types (and connectivity between them*)…." He concluded by noting that a more natural flow pattern promotes better ecosystem conditions in general, thus capturing benefits that we may not be aware of. (Poff, p. 2.) This could include the minority contingents discussed by Dr. Miller.

The proposed narrative objective for the Sacramento River, its tributaries and Delta eastside tributaries would explicitly require maintaining inflow conditions that reasonably contribute toward maintaining viable native fish populations, including flows that more closely mimic the

natural hydrographic conditions to which native fish species are adapted. Use of unimpaired flow is intended to provide some of the natural variability in tributary flows and Delta outflow to which native fish species evolved and to support minority life history strategies. The program of implementation will require monitoring and periodic evaluations to assess compliance with the narrative objective. Changes in the implementation of the flow requirements will be recommended if monitoring demonstrates that the full range of salmonid life history types is not being protected.

In his comments, Dr. McAllister also suggested the use of life-stage explicit population dynamics models to further evaluate degradation in the remaining available freshwater habitat, including relative contributions of changes in marine conditions, fishery management, and other freshwater conditions. (McAllister, pp. 19-20.) We agree that marine survival rates should be considered when evaluating trends in freshwater production and survival of native Chinook salmon stocks. Where appropriate, this consideration will be incorporated into monitoring and reporting measures as the planning process moves forward.

Conclusion 5: Delta outflows that more closely mimic the natural flow and water quality conditions to which native migratory fish are adapted are needed year round to support the migration, spawning and rearing of native estuarine and anadromous species.

Dr. Miller found Conclusion 5 to be supported with a high degree of confidence, and stated that the Report provided "*clear justification that the recommended flows would provide the pattern of flow and afford a level that would, with high likelihood, afford appropriate conditions for native estuarine and anadromous species.*" (Miller, p. 8.) Similarly, Dr. Poff found that the Report provided strong evidence that increased Delta outflow will enhance native species. (Poff, p. 3.) Dr. McAllister found the scientific portion of the regulatory actions following from Conclusion 5 to be based on sound scientific knowledge, methods and practices. (McAllister, p. 23.) He did raise a minor concern that the catchability of some native fish species may be positively correlated with flow because higher flows could result in higher catchability, thereby skewing the results to show an apparent increase in population abundance. (McAllister, p.22.)

The Science Report used available data to estimate abundance indices that reflect best available information and is consistent with analyses conducted in peer reviewed studies. (Feyrer et al. 2007; Nobriga et al. 2008; Mac Nally et al. 2010; Thomson et al. 2010.) A recent publication on delta smelt showed that abundance indices in individual years differed from the standard abundance indices used in the Science Report because of tide-related effects on catchability, but the overall trend in inter-annual abundance was similar to estimates that did not include differences in catchability. (Polansky et al. 2017.)[2] In addition, a study evaluating the catchability of juvenile Chinook salmon in the Chipps Island trawl recommended that catchability

[2] Polansky, L., K. Newman, M. Nobriga and L. Mitchell. 2017. Spatial temporal models of an estuarine fish species to identify patterns and factors impacting their distribution and abundance. Estuaries and Coasts. doi 10.1007/s12237-017-0277-3.

should be assumed to be constant across time and varying environmental conditions until compelling evidence was obtained to the contrary. (Pyper et al. 2013).[3]

Conclusion 6: Cold water habitat is needed below reservoirs to compensate for natural cold water salmonid habitat lost by reservoir construction above dams.

Dr. Poff found Conclusion 6 to be well supported, noting that the timing of cold water releases may be inconsistent with the natural timing of flows but nonetheless serve a priority management goal. (Poff, p. 3.) Dr. Poff underscored this issue by stating that *"Long-term sustainability of species dependent on temperature impaired habitats (e.g. winter-run Chinook) will require both thermal management (local) and flow continuity (whole basin)."* Dr. Miller also found that Conclusion 6 was supported with a high degree of confidence and he had moderate confidence that lost "*habitats can be replaced by equivalent habitats below existing dams if releases from the dams are managed to replicate environmental conditions required by specific life history stages.*" (Miller, p. 8.) Finally, Dr. McAllister found that "*coordinated measures that provide cold water flows below Sacramento River and tributary dams in summer and fall months are based on sound scientific knowledge, methods and practices."* (McAllister, p. 24.) He found that an adaptive management approach for cold water release manipulations was "*entirely appropriate*" and indicated that management will benefit from experiments to test the outcome of various cold water releases on salmon population responses (McAllister, p. 24.) State Water Board staff agrees with Dr. McAllister's recommendations regarding science based adaptive management of cold water.

Conclusion 7: Interior Delta flow requirements help protect resident and migratory species from entrainment and related effects in the southern Delta associated with CVP and SWP diversion activities.

Dr. McAllister found the scientific portion of the regulatory actions following from Conclusion 7 to be based on sound scientific knowledge, methods and practices stating that *"[t]he field scientific and analytical methods that were applied to investigate the effect of different rates and directions of flow in the Delta are also in my view appropriate and the results credible.*" (McAllister, p. 25.) Dr. McAllister also found that the scientific analyses establishing limits on water export rates and regulations for the timing of the closure of the Delta Cross Channel (DCC) gates were appropriate and credible, stating that "*[t]hese correspond to the months in which the bulk of juvenile salmon and two smelt species are migrating through and resident in the Delta area.*" Dr. Poff agreed that "*[d]ata presented clearly demonstrate that reducing flow reversals is likely to diminish mortality (salvage) of affected fish species."* (Poff, p. 4.) Dr. Miller found that the complexity of flows associated with the DCC gate closures, Old and Middle River (OMR) reverse flows, and export constraints made an assessment with a high degree of confidence difficult, and suggested that the addition of holistic integrated models to assess

[3] Pyper, B., T. Garrison and S. Cramer 2013. Analysis of trawl efficiency at Chipps Island using coded-wire-tagged release of juvenile Chinook salmon. Cramer Fish Science Report 97 pp.

alternative hypotheses would help. Dr. Miller did acknowledge that reductions in OMR reverse flows mitigate for the effects of entrainment at the CVP and SWP export facilities. (Miller, pp. 8-9.)

There was general agreement amongst the reviewers that entrainment and salvage increases with increasingly negative OMR reverse flow and that reverse flow reductions are needed when vulnerable life stages of native fish are present. However, Dr. McAllister requested clarification on how the determination of the proposed negative 1,250 and 5,000 cubic feet per second regulatory limits were derived. (McAllister, pp. 10-11.) Reductions in OMR reverse flows to avoid jeopardy were determined by the U.S. Fish and Wildlife Service (USFWS) (2008) and by the National Marine Fisheries Service (NMFS) (2009) in their biological opinions for delta smelt and salmonids and by CDFW (2009) in its incidental take permit for longfin smelt. Both biological opinions underwent independent scientific peer review and all substantive recommendations were incorporated into the two documents (NMFS 2009; USFWS 2008). The Science Report describes the rationale and general methods for how these flows were derived by NMFS and USFWS but does not create any additional analyses or provide alternate models or explanations for mortality in the interior Delta as both the methods and science upon which the flow recommendations were based has already been peer reviewed in the biological opinions.

Conclusion 8: Other aquatic ecosystem stressors have negative effects on fish and wildlife beneficial uses and non-flow actions are needed for ecosystem recovery.

Dr. McAllister found that "*the scientific methodologies and practices documented to evaluate the different aquatic ecosystem stressors and formulate new monitoring and new 'non-flow' regulatory management actions to address the different aquatic ecosystem stressors are appropriate and the findings obtained credible*." (McAllister, p. 27.) Dr. Miller found Conclusion 8 to be supported with a high degree of certainty while noting that "*the degree and magnitude of the individual negative effects can be quantified with only low precision.*" (Miller, p. 9.) Dr. Miller again suggested the use of holistic integrated assessment models to fully understand factors leading to declines. He noted that the section on climate change introduces uncertainties into the timeframe over which recommended flows are applicable.

Staff agrees with these comments and the Report acknowledges areas of uncertainty and opportunities to further the scientific understanding of the Bay-Delta ecosystem as planning and implementation efforts move forward. While perfect science is not available and exact mechanisms behind flow-related functions and other stressors are not fully understood, there is a significant and compelling amount of information supporting the need for new and modified flow and related measures to protect fish and wildlife beneficial uses in the Bay-Delta and for those changes to be made in a meaningful time frame. Adaptive management and implementation processes are proposed to ensure flexibility in managing flows on both a real-time and long-term basis to best protect beneficial uses and to better respond to evolving scientific information and changing conditions.

Staff also agrees, and the Report acknowledges, that there are uncertainties associated with the ongoing impacts of climate change. Existing Bay-Delta Plan requirements were written in a rigid

and largely unadaptable manner requiring a lengthy multi-step process to adjust that presented challenges to implement effectively at the watershed level. The proposed changes to the Bay-Delta Plan are meant to address these issues while also retaining some of the more rigid backstops from the current Bay-Delta Plan. The proposed inflows and the inflow-based outflow requirements scale to water availability in a watershed that may change as a result of climate change, allowing the Board to reasonably protect the environment while considering other uses of water. The proposed Bay-Delta Plan amendments provide a range of environmental flows to allow for adjustments that may be needed to provide more protection for the environment or more consideration of limited water availability due to droughts. In addition, cold water habitat requirements are proposed and emphasized in response to these same issues. The Report also acknowledges that non-flow actions are needed to address climate change. Potential non-flow management actions include purchasing land to prepare tidal marshes and other habitats for sea level rise and developing plans for changing water temperature controls at dams and other infrastructures facilities to accommodate increases in water temperature that may occur in the future.

In conclusion, State Water Board staff sincerely appreciates the time and many thoughtful comments submitted by the peer reviewers. These comments will be considered and incorporated into the further development of the Bay-Delta Plan amendments as the planning process continues, particularly for monitoring and adaptive management elements.