KATHERINE POOLE (SBN 195010)
DOUGLAS ANDREW OBEGI (SBN 246127)
NATURAL RESOURCES DEFENSE COUNCIL
111 Sutter Street, 21st Floor
San Francisco, CA 94104
Telephone: (415) 875-6100
Facsimile: (415) 875-6161
kpoole@nrdc.org; dobegi@nrdc.org

Attorneys for Natural Resources Defense Council,
The Bay Institute, and Defenders of Wildlife

BEFORE THE STATE WATER RESOURCES CONTROL BOARD

HEARING IN THE MATTER OF CALIFORNIA DEPARTMENT OF WATER RESOURCES AND UNITED STATES BUREAU OF RECLAMATION REQUEST FOR A CHANGE IN POINT OF DIVERSION FOR CALIFORNIA WATERFIX	**TESTIMONY OF DR. JONATHAN ROSENFIELD IN PART 2 OF THE WATERFIX HEARING**

I, Jonathan Rosenfield, do hereby declare:

INTRODUCTION

My name is Jonathan Rosenfield. I am the Lead Scientist for The Bay Institute (TBI), the research and policy division of Bay.Org, a non-profit organization that seeks to protect, restore and inspire conservation of the ecosystems of San Francisco Bay and its watershed, from the Sierra to the sea. I have been employed at TBI since the summer of 2008.

My chief responsibilities at TBI are to manage acquisition and analyses of scientific data on fish populations and water quality in the San Francisco Bay watershed and to translate those analyses into management recommendations aimed at protecting and restoring ecosystem function throughout the Bay's vast watershed, including populations of its many desirable fish and wildlife populations.

I earned a Master's in Resource Ecology and Management from the University of Michigan in 1996, a Ph.D. in Ecology, Evolution, and Behavior from the University of New Mexico in 2001, and conducted post-doctoral research at the University of California at Davis. In each case, I conducted independent research regarding the evolution, behavior, and/or ecology of fishes. I have authored or co-authored ten papers published in peer-reviewed journals as well as numerous peer-reviewed reports published in a variety of venues. Other details of my qualifications are outlined in the attached curriculum vitae, which is included as Exhibit NRDC-11.

Here, I offer a synthesis of my analysis and professional judgment of the effects of the "California Water Fix" (WaterFix) on the San Francisco Bay Estuary, including the Sacramento-San Joaquin Delta, as well as watersheds upstream. I have neither reviewed nor discussed with anyone the written testimony to the State Water Board of any other party or any hearing recordings, webcasts, or transcripts regarding these proceedings, as was a condition of the extension of my testimony-filing deadline (*see,* December 29, 2017 letter from CA WaterFix Hearing Team re: Natural Resources Defense Council et al.'s Second Request for Extension of Time).

My earlier analyses of this project have been detailed in previous comments, including those submitted during the EIR/EIS process for both WaterFix (see, NRDC et al. 2015) and its predecessor, the Bay Delta Conservation Plan (BDCP, see Defenders of Wildlife et al. 2014). I incorporate those comments fully by reference.

SUMMARY OF TESTIMONY

The San Francisco Bay Estuary (including the Delta) is the largest inland estuary on the Pacific Coast of the Americas. It is home to a wide variety of unique native organisms and, historically, supported an incredibly abundant and productive ecosystem. For example, San Francisco Bay's fisheries, including Chinook Salmon, Pacific Halibut, Starry Flounder, various smelt species, Pacific Herring, and Green and White Sturgeon, supported human populations from pre-European colonization through the middle of the 20^{th} Century. Today, remnant (though economically important) commercial and sport fisheries remain.

The Bay Estuary ecosystem now shows numerous signs of collapse. Six unique native fish populations are officially listed as threatened or endangered under the federal and/or state Endangered Species Acts. Many public fisheries are heavily restricted, closed, and/or highly degraded. Water quality in the estuary's tributary streams and rivers are impaired and, in some parts of the Delta, may be lethal to small to medium-sized animals at various times of year.

These indicators of ecosystem decline are in large part related to human development of resources, particularly water resources, in the Central Valley and Delta. Most of the once-extensive wetland habitats in the Estuary and its watershed were destroyed by the mid-20^{th} century. Furthermore, the volume and timing of freshwater flows to the estuary (both of which are defining characteristics of estuaries) have been radically altered by human water development and flood control infrastructure and operations. These modifications to the volume and timing of flow entering the San Francisco Bay Estuary and its watershed began with European colonization of the watershed and have continued to intensify to the present day. Indeed, in a typical year, more than 50% of the freshwater runoff destined for the Bay during the ecologically critical winter and spring months is diverted before it reaches the Bay (TBI 2016). This large-scale diversion of freshwater, combined with the alteration in the natural timing of flow, has been a major driving force in the decline of ecosystems throughout the San Francisco Bay Estuary and watershed, including the endangerment or near-endangerment of many of its native fish species. The diversion of fresh water and alteration of natural flow patterns has become more severe in recent years and decades; as a result, populations of many native fish species have declined precipitously.

It is in this context that I have evaluated WaterFix, a proposal to add new diversions that would take water, via tunnel, from the Sacramento River to existing water export facilities in the south Delta.

Based on my review of project documents and those relating to permits necessary to build and operate the project, I can only conclude that WaterFix will harm native species, valuable fisheries, and ecosystem processes in the San Francisco Bay Estuary and its watershed. Both WaterFix proponents' analyses of the project and regulatory agencies' documentation that form the basis of the project's existing permits clearly demonstrate that WaterFix will generate severe impacts to critically imperiled species and critical ecosystem processes (I identified and commented on many of these problems in earlier iterations of the Project). Furthermore, many of the analyses used to describe and permit WaterFix underestimate the likely negative effects of the project. Other analyses are not based in the best available science and provide misleading information about the likely future of San Francisco Bay and its watershed under WaterFix operations.

Below, I describe some of the documented and likely negative effects of WaterFix on species such as the Central Valley's four runs of Chinook Salmon, Central Valley Steelhead, Longfin Smelt, and Delta Smelt. In addition, I describe ecosystem-level effects that will have negative consequences for most native fish and wildlife species that rely on the San Francisco Bay Estuary.

Finally, I provide recommended operational limitations and requirements that should govern operation of new north Delta diversions, should the State Water Board issue a permit for this new point of diversion.

I. <u>WaterFix Would Cause Significant Adverse Impacts to Central Valley Chinook Salmon and Steelhead</u>

The Sacramento River Valley is home to four unique populations of Chinook Salmon (more than any other single Chinook salmon-bearing river in North America) and Central Valley Steelhead (anadromous Rainbow Trout). Two of the four Chinook Salmon runs and the Steelhead are listed under the California Endangered Species Act (CESA) and/or the federal ESA (ESA) and another run of Chinook Salmon has been identified as a species of special concern. The fourth population of Chinook Salmon (the fall run) is the main contributor to the commercial and sport fishery for Chinook salmon in California and parts of Oregon.

The best available science shows that the construction and operation of WaterFix would significantly reduce the survival of juvenile Chinook Salmon and Steelhead migrating from the Sacramento River and tributaries through the Delta. Under the status quo, survival of migrating juvenile salmon through the Delta is extremely low and threatens the viability of our native salmon runs. According to its project documents and permits, WaterFix would further reduce through-Delta survival of migrating juvenile salmon compared to conditions today. Furthermore, the models and analyses used in the 2017 NMFS biological opinion fail to adequately consider and synthesize the adverse effects of WaterFix on salmon, rely on speculative measures whose implementation is uncertain, and fail to provide protections specifically for fall run and late-fall run of Chinook salmon (i.e., the non-endangered runs). A thorough analysis of the best available scientific information makes clear that WaterFix will cause significant and adverse impacts to fish and wildlife.

A. Background and Current Status of the Central Valley's Unique Chinook Salmon Runs and Steelhead

For millennia, Chinook salmon have been extremely successful and productive throughout most of western North America. Historically, this species colonized and maintained populations in most tributaries to the Pacific Ocean north of the Ventura River in Southern California and the southern tip of the Kamchatka Peninsula (Auegerot 2005). Their productivity (intrinsic population growth rates) are very high compared to most other fish of their size and their success is particularly impressive given that adults spawn after dying (they are "semelparous"). For a semelparous fish species to maintain self-sustaining, largely independent populations in so many different watersheds over so many generations, its spawning and juvenile rearing habitats must reliably generate excellent conditions that support high survival rates; if eggs and juveniles in freshwater experienced high mortality, even periodically, these populations could not have persisted. Indeed, freshwater survival rates between the egg and smolt (ocean-ready migrant) stage in modern times are estimated to average about 10%, even in modern, non-pristine river systems (Healy 1991; Quinn 2005).

The Sacramento River is home to four temporally-distinct runs (populations) of Chinook salmon, more than any other single river in North America. Each run is named for the season when they migrate as adults from the ocean back to Central Valley rivers to spawn. Winter-run Chinook salmon are listed as endangered under both CESA and the ESA, and NOAA Fisheries have previously identified winter run as one of the most endangered fish species in the United States (NOAA 2016). The <u>only population of winter-run</u> Chinook in the wild spawns in the Sacramento River below Shasta and Keswick dams where population abundance has declined precipitously since the 1960s. The drastic reduction in this population's size and geographic extent of its spawning range represent grave dangers to the continued existence of this unique population (an "evolutionary significant unit" or "species," as defined under ESA).

Unsustainable operations of Shasta Dam regularly cause very high mortality of this endangered species. According to the Anadromous Fish Restoration Program's ChinookProd database (2016), average production of winter-run salmon declined by approximately 89% from 54,439 (1967-1991 period) to 6,090 (1992-2016). It is worth noting that during the latter period, the state and federal governments expended great effort to achieve a shared goal of doubling the population from its 1967-1991 baseline. In particular, a temperature control device was added to Shasta Dam during this period in order to improve coldwater habitat conditions for incubating winter-run Chinook salmon eggs. Yet, NOAA Fisheries estimated temperature dependent mortality of eggs and juveniles below Shasta Dam reached 77% in 2014 and 85% in 2015. Overall, in both years, less than 5% of eggs survived to become fry that passed Red Bluff Diversion Dam (NMFS WaterFix biological opinion at 891-92; hereafter, "NMFS biop"). The most recent draft estimate from CDFW of the total number of adult winter run returning to spawn ("escapement"[1], including both wild and hatchery-spawned adults) in 2017 is 1,115, the second lowest since counting techniques were revised in 2003 (see, January 29, 2018 Letter from Maria Rea, NMFS West Coast Region to Mr. Jeff Ricker, US Bureau of Reclamation, Central Valley Operations).

Spring-run Chinook salmon are listed as threatened under CESA and the ESA. Once one of the largest salmon runs in the Central Valley, the natural production of spring-run Chinook salmon

[1] "Natural production" is an estimate of the number of adult salmon that were spawned in the wild which are available for harvest in the ocean. The estimate is related to "escapement", the number of adult salmon that return to a given river system to spawn. Escapement includes both naturally and hatchery spawned fish. Natural production is the metric applied by the Central Valley Project Improvement Act; CVPIA's doubling goal refers to natural production, not escapement.

has also declined substantially in recent decades. According to SWRCB 2017, average natural production of spring run declined from 34,374 (1967-1991 period) to 13,385 (1992-2015), a 61% decline from the baseline period. The abundance of this unique species, and survival of migrating juvenile spring-run Chinook salmon, declined substantially during the recent drought (Klimley et al 2017). Not surprisingly, CDFW's Grandtab reports that 2016 escapement of spring-run Chinook salmon was very low, particularly in Battle Creek, Clear Creek, Deer Creek and Mill Creek.

Fall-run and late-fall run Chinook salmon are not listed under CESA or the ESA. These runs are the backbone of the state's salmon fishery, supporting thousands of fishing jobs across California. State and federal hatcheries release nearly 32 million juvenile fall-run Chinook salmon each year. Despite this massive hatchery production, the SWRCB concluded in its Final Phase II Scientific Basis Report that the natural production of fall-run has declined by more than 50% in recent decades, as compared to the 1967-1992 baseline period (SWRCB 2017). Late-fall run Chinook salmon are listed by NMFS as a "species of special concern." Average natural production of late-fall run Chinook salmon has also declined by more than 50% since the 1967-1991 baseline period, according to CDFW's ChinookProd. Again, funds and efforts under the CVPIA were intended to double the natural (wild, not hatchery, spawned) production of fall and late-fall run Chinook salmon over the baseline period.

Juvenile salmon from one or more of these four runs are generally found rearing in, or migrating through, the Delta from the months of October to June (CDFW 2010). Juvenile winter run generally enter the Delta as early as October; according to NMFS, the first fall or winter storm that results in flows of 14,000 cfs at Wilkins Slough generally correlates with approximately 50% of the juvenile winter run migrating past Knights Landing (Del Rosario 2013; NMFS biop). NMFS estimates that juvenile spring run generally enter the Delta from December to May, and typically migrate past Chipps Island between them months of March and May (NMFS biop at 626). The juvenile migration window for fall-run Chinook salmon is generally from December to June, although it can rarely extend to August (NMFS biop at 641).

Central Valley Steelhead are the anadromous (migratory) form of *Oncorhynchus mykiss* (the resident form are commonly known as Rainbow Trout). Central Valley Steelhead are listed as threatened under the ESA. Unlike Chinook salmon, there is no dedicated escapement survey for Central Valley Steelhead. However, where counts are available they show only a few adult Steelhead returning in any given year, and no fish returning in some years (e.g., McEwan 2001; Moyle 2002). *O. mykiss* often exist in larger numbers as the resident rainbow life history form in the tailwaters below the major rim dams, but the anadromous life history is extremely rare. Juvenile steelhead migrate through the Delta, generally between December and June (NMFS biop at 632).

B. Current Threats to the Persistence and Recovery of Central Valley Salmon and Steelhead

All four runs of salmon and the Steelhead face significant threats to their survival and recovery in the Central Valley. Major threats to salmon in the Central Valley include:

- Dams blocking access to historic spawning habitat;
- Unsustainable water temperatures that cause temperature dependent mortality to fish that spawn and/or rear below dams;
- Water diversions that entrain juveniles in the diversions, impinge them on fish screens, increase predation around in water structures, or alter and reduce instream and through-Delta flows (which reduces survival);
- Hatchery management practices; and,
- Loss of rearing habitat, particularly periodically inundated “floodplain” habitats.

This section of my testimony focuses primarily on impacts to migrating juvenile Chinook salmon and Steelhead occurring in the lower Sacramento River and Delta. TBI has made identical or similar points in various public letters and comments on WaterFix (e.g., NRDC et al. 2015) and its predecessor, the Bay Delta Conservation Plan (e.g., Defenders of Wildlife et al. 2014).

Delta inflows and outflows have a significant effect on the survival of migrating salmon, with higher survival occurring when higher flows correspond with outmigration timing (i.e., during winter and spring). Recent scientific studies have demonstrated that the survival of migrating juvenile salmon down the Sacramento and San Joaquin Rivers and through the Delta is extremely low, except in wet years when freshwater flow volumes are higher than average – during these years, in river and through-Delta survival of Chinook salmon are significantly higher than average. For instance, Michel et al (2015) evaluated the survival of acoustically tagged late-fall run Chinook salmon released in the upper Sacramento River between 2007 and 2011; they found that through-Delta survival was highest during the wet year of 2011 (70.6% in 2011 vs 43.1-63% in other years). Survival in the Sacramento River was significantly higher in 2011 compared to drier years (63.2% in 2011 versus 15.5-31.9% in other years). Overall survival in their study areas was highest (15.7%) in 2011 versus compared to other years studied (2.8-5.9% survival). The authors concluded:

> Our study has demonstrated remarkably low survival rates for late-fall run Chinook salmon smolts in the Sacramento River. The Sacramento River is also home to three other runs of Chinook salmon that migrate at smaller sizes and later in the season (Fisher 1994), when water temperatures are higher and predators may be more active. These other runs may therefore be experiencing even lower survival.

Michel et al 2015.

Similarly, Klimley et al. (2017) documented significantly lower survival of acoustically tagged spring-run Chinook salmon in the Sacramento River at lower flows, and much higher survival in higher flows. In 2015, the survival of acoustically tagged hatchery spring run salmon was monitored in two groups from release sites to a recapture location near the City of Sacramento; survival was only 5.3% (first group) and 8% (second group). In 2016, during higher flow conditions, approximately 27% of the acoustically tagged spring run Chinook salmon survived this portion of the downstream migration (Klimley et al 2017). Klimley et al's study occurred upstream of the proposed WaterFix diversions; however, there is no reason to believe the results would be qualitatively different in that lower stretch of river.

Low survival through the Delta is a threat to the survival and recovery of Central Valley Chinook Salmon and Steelhead. In 2013, as part of its work to establish interim survival objectives for the Bay Delta Conservation Plan, NMFS stated, "[…] because it is well established that the magnitude of mortality during Delta passage can be high (e.g., Brandes and McLain 2001, VAMP studies), it is highly unlikely that CV salmonids can be recovered without major improvement in Delta survival" (BDCP Appendix G at 11). NMFS also acknowledged that, "Climate change was not explicitly considered in developing these Interim Survival Objectives, but it may necessitate changes in the objectives at some future point. For example, if higher river temperatures reduce instream survival or ocean survival decreases, then higher Delta survival would be required to maintain the status quo" (BDCP Appendix G at 12).

In addition, the 2014 Recovery Plan by NOAA Fisheries sets minimum "through-Delta survival objectives of 57% for winter-run, 54% for spring-run, and 59% for steelhead originating from the Sacramento River; and 38% for spring-run and 51% for steelhead originating from the San Joaquin River" (NMFS recovery plan at 127). Current estimated survival rates for each of these species are well below these levels.

C. Adverse Effects of WaterFix on Chinook Salmon and Steelhead

The best available science demonstrates that the construction and operation of WaterFix will significantly reduce the survival of juvenile salmon as they migrate into and through the Delta; returns of adult salmon are also projected to decline as a result of the overall effects of WaterFix. The NMFS biological opinion concludes that the adverse effects of the new WaterFix diversions exceed the benefits of reduced pumping from the South Delta, resulting in lower survival overall –

and that assessment is based on OMR constraints that may not actually be met under real time operations (*see* e.g., ITP Table 9.9.4-1 and associated footnotes). Furthermore, the models used in the biological opinion conclude that reduced juvenile survival is primarily the result of reduced flow below the new WaterFix intakes on the Sacramento River, however, they fail to adequately consider and synthesize all of the adverse effects of WaterFix on juvenile salmon survival. Indeed, NMFS concludes that impingement and entrainment of juvenile fish passing the screens of the WaterFix north Delta diversion can be expected to adversely affect all outmigrating juvenile Chinook salmon from the Sacramento River basin (NMFS biop at 1214). As a result of the failure to incorporate additional mortality that occurs at the north Delta diversions, as well as other anticipate negative effects, the biological opinion may significantly understate the adverse effects of WaterFix on through-delta survival of juvenile Chinook salmon.

1. <u>Inadequate Bypass Flows for the New North Delta Diversion Will Significantly Reduce Salmon Survival</u>

The NMFS biological opinion utilizes several different models to analyze the effect of WaterFix on the survival of juvenile salmon from the Sacramento River, including the Delta Passage Model (DPM) and Perry Survival Model. These models demonstrate that through-Delta survival of juvenile salmon is lower under WaterFix than under the status quo, notwithstanding the very low survival under the status quo.

For winter-run Chinook salmon, the Delta Passage Model concludes that, "Overall, the absolute mean reduction in smolt survival is 1% to 2% for the PA, resulting in a relative survival reduction of 2-7% depending on water year type when compared to NAA" (NMFS Biop at 735). The Delta Passage Model shows that through-Delta survival of juvenile winter-run Chinook salmon was reduced in all water year types, with the largest reduction in Below Normal and Dry water year types (NMFS Biop, Table 5.4-13).

For spring-run Chinook salmon, DPM indicates that through-Delta survival is reduced in all water year types, with the largest reduction in survival in below normal and dry years (NMFS biop at 736; Table 5.4-14). The biological opinion concludes that, “Overall, the absolute mean reduction in smolt survival is 0% to 1% for the PA, resulting in a relative survival reduction of 1-4% depending on water year type when compared to NAA” (NMFS biop at 738). DPM suggests that survival of spring-run Chinook through the Delta is already lower than survival of winter run (compare Table 5.4-14 with 5.4-13).

For fall-run Chinook salmon, DPM demonstrates that survival of juveniles migrating through the Delta is reduced from the status quo under the proposed action (NMFS biop at 739-740). DPM results show fall run survival is already very low, and is lower than the through-Delta survival estimates for winter-run Chinook salmon and spring-run Chinook salmon; this is likely related to the fact that fall-run tend to migrate at smaller body size and later in the year, when water is warmer and predator are more active, than winter-run Chinook salmon. As with winter-run and spring-run Chinook salmon, DPM shows that WaterFix would reduce through-Delta survival of fall-run by 1-3%, with the largest reductions in survival in Wet and Above Normal years (NMFS biop Table 5.E-10).

The NMFS biological opinion also demonstrates that survival of juvenile steelhead migrating through the Delta from the Sacramento River will be reduced under WaterFix compared to the status quo (NMFS biop at 738).

There are significant flaws with the DPM, and we summarized some of these flaws in our prior comments on BDCP and WaterFix (Defenders of Wildlife et al. 2014; NRDC et al. 2015). In addition to the concerns previously expressed, DPM:

- does not account for reduced survival as a result of increased predation at the new North Delta Diversion, nor does it account for the reductions in survival as a result of impingement and entrainment at the fish screens. For example, NMFS has estimated that, "combined injury and mortality from impingement would be [less than] 9%," (NMFS biop at 905), *in addition to* increased mortality from predation at the permanent in-water structures for the north delta diversion facilities. In fact, the California Department of Fish and Wildlife's ITP would permit a 5% reduction from current survival rates in the very short reach of the river, and the ITP does not demonstrate how it would prevent even higher mortality. These reductions in survival would be in addition to the reductions observed in the DPM.
- does not account for the likelihood that changes in flow patterns (including reduced river depth, reduced turbidity) below the North Delta intakes will increase exposure to predators (e.g., via increased light penetration and concentration of juvenile salmon and their predators in a smaller volume of water) and thus, increase mortality of migrating salmon.

As a result, DPM likely significantly underestimates the probable reductions in survival of migrating juvenile Chinook salmon related to WaterFix operations.

The Perry Survival Model analyzes survival of salmon below the proposed north Delta intakes, based on data from acoustically tagged salmon in recent years. This model also demonstrates that through Delta survival of salmon is reduced by WaterFix for nearly all months and water year types (NMFS biop at 749-755; Appendix E). The Perry Model concludes that "Survival is reduced under operations of the either PA or L1 because reduced Sacramento River flow at Freeport results in lower survival rates for outmigrating smolts (Perry et al. 2010; Perry 2016; Newman 2003)" (NMFS biop at 750).

The Perry Survival Model was also run with "unlimited pulse protection" ("UPP"), which allows the fishery agencies to limit any use of the North Delta intakes if winter-run Chinook salmon or spring-run Chinook salmon are detected migrating downstream in monitoring programs. If fish density triggers are met, then bypass flows of 35,000 cfs may be required. However, even with UPP, the Perry Model demonstrates that through-Delta survival of winter-run Chinook salmon, spring-run Chinook salmon, and fall-run Chinook salmon is likely to be reduced by WaterFix compared to the status quo (NMFS biop at 791). Whereas UPP may result in less impact on salmon survival compared to the originally proposed operations, median survival through the Delta is still significantly lower than the unsustainable status quo (NMFS biop at 775-76, 791, Appendix E).[2]

The NMFS biological opinion explains that the empirical data used in developing the Perry Survival Model shows that salmon survival is generally not reduced as long as flows below the North Delta Diversion (measured at Freeport) are higher than 35,000 cfs (NMFS biop at 772). When Sacramento River flows at Freeport are greater than 35,000 cfs, reverse flows at Georgiana Slough generally do not occur (NMFS biop at 606). As the biological opinion explains:

> The mechanism in which the UPP scenario mitigates for adverse effects on winter-run and spring-run Chinook salmon juveniles evident under the PA and L1 scenarios can be evaluated as follows: the new operating scenario (UPP) will be at low-level pumping (or ≥35,000 cfs bypass flow) when primary juvenile winter-run and spring-run Chinook salmon migration is occurring.

NMFS biop at 771.

The Perry Model also fails to consider several important adverse effects of WaterFix on juvenile through-Delta survival, and as a result the model underestimates WaterFix's adverse effects on migrating salmon. As with DPM, the Perry Model is unable to account for mortality due to impingement and injury from the fish screens or increased mortality from predation at the permanent in-water structures for the north delta diversion facilities that NMFS acknowledges are likely to occur (NMFS biop at 742; 905).

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[2] The biological opinion did not analyze the effects of unlimited pulse protection using any of the other models or analyses.

In addition, the biological opinion admits that it overestimates survival from UPP using the Perry Model because it assumes that monitoring programs will be 100% accurate to inform real time operations – this is an entirely unrealistic assumption. As the biological opinion acknowledges, "there is a high probability that a proportion of a target species will go undetected and therefore unprotected under real-time operations" (NMFS biop at 751). The analysis of unlimited pulse protection using the Perry Model "relies on real-time detection of salmonids to inform adjustments to the north Delta diversion" (NMFS biop at 771). However, the biological opinion admits that existing monitoring programs are inadequate for these purposes, and that the reliance on existing monitoring programs could underestimate both abundance and temporal extent of winter and spring run Chinook salmon (NMFS biop at 772). In addition, "…UPP would cease when capture of fish is fewer than 5 winter-run or spring-run Chinook sized fish for five consecutive days, thereby exposing any fish still present near or downstream of the intakes to the more adverse L1, L2, or L3 operating scenarios" (NMFS biop at 772-773, 776). Furthermore, the triggers for real time operations using UPP have not been identified: "Under the revised PA, specific fish abundance trigger criteria will be developed as part of the adaptive management and monitoring program of the PA" (NMFS biop at 772). If triggers result in less frequent use of UPP, through-Delta survival will be even lower than the biological opinion suggests. Of additional concern, the biological opinion does not authorize reductions in North Delta Diversion pumping based on the presence of fall run Chinook salmon, only for ESA listed salmon (winter run and spring run); this will result in impacts on fall run Chinook salmon and may even lead to increases in diversions (and associated impacts) during fall run migration beyond those that would have occurred if UPP were not employed.

Finally, there is ample recent evidence protective triggers based on "real time" monitoring results are unlikely to actually be implemented, and are not reasonably certain to occur. For instance, the 2009 NMFS biological opinion assumes that reductions in pumping will occur immediately upon receipt of appropriate monitoring data (NMFS 2009 biop). Given the bureaucratic and engineering considerations involved (e.g., it may take time to implement reduced export pumping rates), this is a poor assumption and one that cuts against protection of the migrating juvenile fish. Reliance on real time monitoring and operations are inadequate to protect salmon from adverse effects of WaterFix.

To summarize, both the Perry Model and Delta Passage Model used in the NMFS biological opinion show that WaterFix will reduce survival of winter-run Chinook salmon, spring-run Chinook salmon, fall-run Chinook salmon, and steelhead. Both models also underestimate the adverse effects of WaterFix because they do not incorporate all of the adverse effects of the project on salmon, such as impingement on fish screens, increased predation mortality at the North Delta Diversion facility, or further impairments to water quality. Current through-Delta survival is unacceptably low, yet WaterFix will reduce survival even further. The proposed bypass flows, even with UPP, are not adequate to protect salmon from unreasonable impacts.

2. <u>Life Cycle Models Demonstrate that Overall Abundance and Escapement Would Be Lower under WaterFix than Under the Status Quo</u>

The biological opinion also utilizes life cycle models to analyze the impacts of WaterFix on winter-run Chinook salmon. The life cycle models used in the biological opinion indicate that escapement (adult abundance) of winter-run Chinook salmon will be lower under WaterFix than under the no action alternative. Indeed, the IOS model estimates escapement will be 25% lower under WaterFix, with the reduction in survival through the Delta the cause of lower escapement (NMFS biop at 795).

NMFS' Southwest Fishery Science Center Winter Run Life Cycle Model (NMFS Life Cycle Model) estimates that the no action alternative to WaterFix will lead to higher winter run abundances than Water Fix under all of the scenarios analyzed; cohort replacement rates (a measure of productivity) would be 7-8% lower under WaterFix than the status quo (NMFS biop at 799; 801). Based on the NMFS Life Cycle Model results, the biological opinion concludes, "The probability that there would be higher abundance in the PA relative to the NAA at the end of the 82-year time series was approximately 0" (NMFS biop at 799). It is important to remember that:

- Winter-run Chinook salmon abundance is near historic lows;
- the status quo for this population represents significant near-term risk of extinction; and
- population recovery (i.e., significant increases in abundance and distribution) is both federal and state policy under ESA, CESA, the CVPIA, and the Bay-Delta Water Quality Control Plan.

In addition to projecting winter-run Chinook salmon abundance and productivity declines under WaterFix, there are several ways in which the NMFS Life Cycle Model underestimates the adverse effect of WaterFix on this endangered species. As with models described above, the NMFS Life Cycle Model does not incorporate the negative effect of increased predation mortality or impingement mortality at the WaterFix diversion facilities, although the authors note that the model can be modified to incorporate these effects (NMFS biop, Appendix H, at 30). Regarding the NMFS Life Cycle Model, the NMFS biological opinion acknowledges that, "The potential implications of the PA scenario is that when active diversion of freshwater occurs, a number of salmon fry and smolt may become entrained in this flow, and abrade against the screens, thereby reducing their survivability significantly. The locations of the intakes may also become predator hotspots. Finally, the reduced freshwater flow may reduce the quality of the habitat, and intensify the effect of predation, and migratory confusion." This would result in a "sustained population level effect on a large moderate proportion of the population," which would result in reduced survival for migrating juvenile winter-run Chinook salmon (NMFS biop at 905). As noted above, the CDFW ITP anticipates a 5% reduction in winter-run survival through this small stretch of river (although it provides no mechanism for preventing exceedance of this limit). These adverse effects are not considered in the NMFS Life Cycle Model, and thus the model significantly understates the adverse effect of WaterFix on migrating winter-run Chinook salmon.

3. The Reduction of Delta Outflows in the Winter and Spring Will Cause Significant Adverse Impacts to Salmon

Reductions in Delta outflow during the winter and spring will also harm salmon. In 2010, NMFS submitted evidence to the SWRCB that the survival of juvenile winter-run Chinook salmon through the Delta was strongly correlated with Delta outflow, with lower juvenile survival at lower outflows and higher juvenile survival at higher outflows. NMFS concluded that:

> The hydrology of the Sacramento River drives winter-run smolt abundance and emigration patterns in the Delta. The annual cumulative winter run smolt abundance is highly dependent on the amount of flows in the Sacramento River, such that higher volume of water flowing in the river during the winter run emigration period results in greater abundance of winter run smolts both entering the Delta at Knights Landing (multiple regression, $R^2=0.76$, $F=12.6$, $p=0.003$), and subsequently exiting the Delta at Chipps Island (multiple regression, $R^2=0.93$, $F=53.7$, $p<0.0001$; Figure 1).

NMFS 2010.

Similarly, the SWRCB's final scientific basis report for the Phase II update of the Bay Delta Water Quality Control Plan concluded that increased outflow between February and June would increase the survival of juvenile winter run Chinook salmon migrating through the Delta, and that reduced outflow results in lower survival (SWRCB 2017).

In contrast, WaterFix would reduce Delta outflow in the November to February period, and proposes to maintain the currently impaired Delta outflows from March to May below 44,500 cfs and reduce Delta outflows above this level. In fact, actual operations of WaterFix may prove more damaging than the flow and diversion rates modeled for the NMFS biological opinion. The biological opinion assumes the implementation of operating criteria in the biological assessment, including less negative OMR values in wetter years. Even with implementation of less negative OMR flows as proposed, the biological opinion concludes that South Delta operations will result in a high magnitude adverse population level impact on fall-run and late fall-run Chinook salmon (NMFS biop at 1101), steelhead (NMFS biop at 1013), spring-run Chinook salmon (NMFS biop at 954), and winter-run Chinook salmon (NMFS biop at 906). However, language in the ITP and biological opinion suggests that these OMR restrictions might not be implemented during real time operations (*see* e.g., ITP Table 9.9.4-1), meaning there may be no reduction in the severity of reverse flows in the South Delta compared with the status quo. More negative OMR flows than modeled in the biological opinion would be expected to increase the adverse effects of WaterFix.

4. Other Adverse Effects of WaterFix on Salmon and Steelhead

The NMFS biological opinion fails to adequately consider several other adverse effects of WaterFix on Chinook Salmon and Steelhead, which leads the biological opinion to underestimate the adverse effects of north delta pumping on migrating juvenile salmonids.

a. *Inadequate flows in the Sacramento River and upstream tributaries:*

WaterFix proposes to maintain, and in some cases worsen, currently impaired flows in the Sacramento River and upstream tributaries controlled by SWP and CVP reservoir operations. Currently impaired flows significantly reduce salmon survival. (Michel et al 2015, Klimley et al 2017, SWRCB 2017).

b. *Temperature dependent mortality at Shasta Reservoir and other upstream reservoirs:*

NMFS admits that temperature modeling in its biological opinion likely underestimates adverse effects, in part because the models use weekly temperature model inputs, whereas fish are responding to thermal conditions on a much shorter timestep (NMFS biop at 840). Although NMFS concluded that temperature mortality of juvenile winter run Chinook salmon below Shasta Dam would not be significantly worse under WaterFix than under the status quo, the biological opinion emphasizes that there is currently significant temperature-dependent mortality of winter-run Chinook salmon, particularly during critically dry years (NMFS biop at 282). Similarly, the biological opinion admits that adequate water temperatures for spawning, rearing, and fry development are not being met in drier years (NMFS biop at 840), and that “Temperature effects place a high magnitude stress on the species and accounts for a large amount of mortality” (NMFS biop at 904).

During the recent drought, the Bureau of Reclamation failed to maintain adequate temperature control at Shasta and Keswick dams, resulting in the near complete loss of two separate year classes of juvenile winter run. The NMFS biological opinion for WaterFix assumes implementation of the revised Shasta Reservoir RPA, which is intended to increase carryover storage, use more protective water temperature thresholds based on more recent scientific information, and set biological objectives for mortality and survival (NMFS Biop at 14). However, the Bureau of Reclamation has not committed to implement this revised RPA, nor has it been finalized. Moreover, in the coming decades, the effects of climate change will make it even more important to ensure adequate water temperatures below Shasta and Keswick dams, as well as on other rivers in the Central Valley. The NMFS biological opinion admits that it does not analyze the effects of climate change after the year 2030 (NMFS biop at 283). For spring-run Chinook salmon, the NMFS biological opinion indicates that WaterFix is likely to increased exceedances of temperature thresholds, and “substantial degradation to spawning PBFs in critically dry years” (NMFS biop at 841). For fall-run chinook salmon, the biological opinion likewise admits that “The combined effect of PA implementation when added to the environmental baseline and modeled climate change impacts is expected to result in significant adverse effects to FR eggs and alevin" (NMFS biop at 1097).

c. *Redd dewatering below upstream reservoirs:*

In addition to increased temperature dependent mortality, the biological opinion also indicates that WaterFix will increase redd dewatering for many salmon runs and that in combination with baseline conditions, will result in significant Chinook salmon egg mortality. It concludes that the project will increase redd dewatering of winter-run Chinook salmon in *all water year types* (NMFS biop at 841). In addition, the biological opinion indicates a very significant increase in redd dewatering of spring-run Chinook salmon, including up to a 30% increase in wet, above normal and below normal water year types (NMFS biop at 842). For fall-run Chinook salmon, the biological opinion states that, "The percentage of dewatered redds under the PA ranges between 15% and 36% across all river segments" (NMFS biop at 1098).

d. *Increased predation, entrainment, and impingement at the North Delta intakes*:

As discussed above, the North Delta Diversion facilities are likely to increase predation of migrating juvenile winter-run Chinook salmon, by providing in-river structures where predators prefer to congregate and prey upon salmon migrating past the long fish screens. Other runs are likely to experience the same negative effects. Similarly, other runs will be exposed to entrainment and impingement mortality, though run-specific loss rates may vary based on seasonal flow and temperature conditions and juvenile body size/swimming competence differences among runs. Current modeling does not demonstrate that WaterFix operations will comply with existing relevant sweeping and approach velocity standards. If CDFW's and NMFS's standards are not achieved, mortality is likely to be significantly higher than estimated in the biological opinion. Even if those sweeping and approach velocity standards are achieved, NMFS estimates that impingement on the fish screens will reduce survival below that estimated in the biological opinion. The NMFS biological opinion states that, "Impacts associated with impingement and entrainment and increased predation at NDD for fall run and late fall-run Chinook salmon described in Section 2.5.1.2 Operations Effects are expected as a result of PA operations. Mortality rates of 7% for fish passing the NDD screen (impingement), along with additional mortality resulting from increased predation around the new permanent structures, is expected to reduce survival and fitness of fall-run and late fall-run Chinook salmon (Table 2-265)" (NMFS biop at 812). Elsewhere the biological opinion estimates that combined injury and mortality from impingement would be less than 10% (fall run) and less than 17% (late fall run; NMFS biop at 1100).

e. *Adverse ecosystem effects:*

Proposed WaterFix operations will alter the Delta and larger San Francisco Estuary ecosystems in ways that harm juvenile salmonids. For example, juvenile Chinook Salmon prefer relatively high turbidity habitats, which provide cover from predators (Gregory 1993; Gregory and Levings 1998); yet WaterFix is very likely to reduce turbidity levels in the Delta. This effect combined with increased Delta residence times (the time it takes for a molecule of water to exit the Delta) are likely to contribute to increased frequency of harmful algal blooms like *Microcystis* spp., which may be toxic to Chinook Salmon, Steelhead, and their prey items. Furthermore, many of the same effects of WaterFix that are detrimental to Chinook Salmon (e.g., reduced turbidity, reduced Delta in-, through-, and outflow) will tend to suppress productivity of the estuarine food web that Steelhead, in particular, depend upon. Because they will affect multiple species, these ecosystem effect mechanisms are discussed separately below.

f. *Waiver of environmental protections during droughts*:

Finally, all estimates of Chinook Salmon and Steelhead through-Delta survival rates assume implementation of relevant flow requirements, including objectives in the Bay-Delta Water Quality

Control Plan. If these objectives are waived or not enforced (or both) during the relevant months for salmonid migration, then juvenile survival will be further reduced beyond the unacceptable levels identified in the biological opinion. During the most recent drought sequence (WY 2012-2016), the SWRCB waived water quality objectives numerous times. In addition, some objectives were not complied with at all, and the SWRCB did not remedy the situation through enforcement actions (TBI 2016). This undoubtedly reduced survival for juvenile salmonids (SWRCB 2015), pushing the endangered species closer to extinction and leading to a heavily restricted fishing season for fall run Chinook Salmon. WaterFix project documents and state and federal permits under CESA and ESA do not account for the likelihood and impacts of such actions; thus, to the extent that water quality objectives and other requirements modeled in the WaterFix documents may be waived or not enforced in the future, these documents seriously underestimate the population-level effects of WaterFix on Central Valley salmonids and other desirable fish and wildlife species.

II. WaterFix Would Cause Significant Adverse Impacts to Longfin Smelt

The best available science shows that planned WaterFix operations will negatively affect the San Francisco Bay Estuary's Longfin Smelt population because WaterFix will significantly reduce the productivity and abundance of this species in the Estuary. Longfin Smelt is listed as threatened in California under the California Endangered Species Act (CESA), and USFWS has determined that listing of Longfin Smelt is warranted under the federal ESA, though listing is precluded at this time. In addition, Longfin Smelt historically are believed to have be an important forage fish species —a major prey source for other fish and wildlife in the estuary, including commercial fisheries, such as Starry Flounder— thus, their continued decline would affect other estuarine fish and wildlife populations, including those in the nearshore ocean.

The strong, significant, and persistent influence of winter-spring Delta outflow on abundance of Longfin Smelt in the subsequent fall is one of the best documented relationships in this estuary

(Jassby et al. 1995; Kimmerer 2002; Rosenfield and Baxter 2007; Sommer et al. 2007; Kimmerer et al. 2009; CDFW 2010a; Rosenfield 2010; Thomson et al. 2010; Mac Nally et al. 2010; Nobriga and Rosenfield 2016; SWRCB 2017). The environmental status quo has caused dramatic declines in the Estuary's Longfin Smelt population, punctuated by brief increases in the population during very wet years when diversions and Delta exports are overwhelmed by Central Valley runoff. Maintenance of status quo flow conditions threatens the continued existence and recovery of Longfin Smelt populations in this estuary.

Because WaterFix would degrade environmental conditions in the Estuary and reduce winter-spring Delta outflow, WaterFix will be worse than the status quo for this species. WaterFix would increase total exports from the Delta (see, e.g., Biological Assessment, Appendix 5A. Fig 5.A.A.3-20), reducing the volume of water flowing from the Central Valley through the Delta to the San Francisco Bay complex in the winter and spring months. Furthermore, the models and analyses used to evaluate WaterFix impacts on this population in the state's Incidental Take Permit (ITP) and application for the ITP (ITP Application) under CESA fail to incorporate the best available scientific understanding of the species' population dynamics in the Estuary, fail to adequately consider and synthesize the adverse effects of WaterFix on Longfin Smelt, rely on speculative measures that are not reasonably certain to be implemented, and fail to provide adequate protections for this population. As a result, WaterFix will cause unreasonable impacts to this species.

A. Adverse Effects of Reduced Delta Outflow on Longfin Smelt

WaterFix proposes to reduce winter-spring Delta outflow compared to the status quo. This will significantly harm the species and impair Longfin Smelt abundance and productivity in the Estuary. According to the California Department of Fish and Wildlife's (CDFW's) CESA Incidental Take Permit for WaterFix, "Indirect effects on [Longfin Smelt] in the form of annual reductions in juvenile recruitment are likely to occur as a result of Project operational effects on winter-spring

Delta outflow." (CESA Findings at 312). Even after applying spring outflow criteria (Condition of Approval 9.9.4.3), CDFW found that the estuary's Longfin Smelt population is still projected to decline further as a result of reduced Delta outflow.

WaterFix includes March-May outflow criteria that would degrade existing conditions for Longfin Smelt because they will not maintain current levels of outflow during the late-winter and spring. Specifically, they would do nothing to maintain outflows in excess of 44,500 cfs, which provide important benefits for Longfin Smelt –the relationship between Longfin Smelt abundance and flow is continuous, including when flows exceed 44,500cfs. WaterFix does not include any outflow criteria for January and February, despite the fact that the best available scientific information indicates that this population responds positively to increases in Delta outflow through at least the January-May period (e.g., Rosenfield and Baxter 2007; CDFW 2010; Rosenfield 2010; CDFW ITP; Nobriga and Rosenfield 2016).

There are three reasons why the proposed spring outflow criteria will not mitigate for increased diversions in January-February or reduced outflow in March-May. First, the status quo for this species is persistent and dramatic decline in abundance that is tied to inadequate levels of winter-spring outflows (Rosenfield and Baxter 2007; CDFW 2010; Rosenfield 2010; Nobriga and Rosenfield 2016; SWRCB 2010; SWRCB 2017). Second, there is no evidence that maintaining Delta outflows in Mar-May (at a reduced level compared to the status quo, as noted above) will compensate for decreasing Delta outflows in Jan-Feb. Indeed, the state repeatedly identifies Jan-Jun Delta outflow as an indicator of conditions for Longfin Smelt (e.g., CDFW 2010; CDFW 2016; CDFW ITP; SWRCB 2017); there is no compelling evidence that conditions in any of those months are more or less important than conditions in other months in the winter-spring period (Nobriga and Rosenfield 2016). Third, the Mar-May outflow criteria allow for reductions in Delta outflow when flows are above 44,500 cfs; however, the population currently receives critical benefits from flows that exceed this level (Rosenfield and Baxter 2007; Kimmerer et al. 2009; Rosenfield 2010; Nobriga and Rosenfield 2016; SWRCB 2017). Thus, limiting the magnitude, duration, and frequency of flows >44,500 cfs will deny the Longfin Smelt population the opportunity to rebound when Delta outflows would otherwise have exceeded this level between January and June.

The agencies' estimates of the adverse effects of reduced Delta outflow resulting from WaterFix on Longfin Smelt (*see e.g.,* CESA Findings; ITP Application; WaterFix RDEIR/SDEIS) are not based on the best available scientific understanding of Longfin Smelt population dynamics in the Bay-Delta Estuary. As modeled, WaterFix documents underestimate likely impacts of increased water diversions on future Longfin Smelt populations. The ITP relies on a modification of the of the X2-Longfin Smelt abundance regression produced by Kimmerer et al. (2009); we have critiqued the state's application of this modeling approach numerous times during the development of the Bay Delta Conservation Plan (e.g., Defenders of Wildlife et al. 2014 at 136-141) and WaterFix (e.g., NRDC et al. 2015, at pp. 34-35). This model assumes that Longfin Smelt abundance in any year is a function of average springtime X2 (an indicator of the position of the estuarine low salinity zone). However, the ITP acknowledges that the mechanisms underlying the historical X2-abundance regression are unknown and may be more closely related to the many other ecosystem processes that are driven by freshwater flow out of the estuary (see also Rosenfield 2010); for example, the findings of Kimmerer et al. (2009) did not find support for the hypothesis that the size of the low salinity zone (which is related to its position) drives the X_2-abundance relationship for Longfin Smelt.

Furthermore, the Kimmerer et al. regression does not incorporate the effect of spawning population size in Longfin Smelt population dynamics; it predicts the same annual abundance index value for any given value of X_2, regardless of the number of spawning females present in the previous generation. In fact, were the modeled Longfin Smelt population to go extinct in one year (because X_2 was very high, i.e., far upstream from the Golden Gate), the model would predict a reappearance of the population in the next year when X2 was low enough (i.e., significantly further downstream) to generate a positive population size. This approach to predicting future Longfin Smelt population size in this estuary is overly simplistic and more recent studies of the Longfin Smelt population decline include a variable to account for population size in the previous generation (Thomson et al. 2010; Nobriga and Rosenfield 2016).

As applied by the WaterFix documents, the Kimmerer et al. model accounts for error in a simple, linear X_2-abundance relationship by postulating periodic step-changes in that relationship; the ITP application applies an additional step change parameter that partially accounts for Longfin Smelt population declines subsequent to the publication of Kimmerer et al. (2009). In a more explicit study of Longfin Smelt population trends, Thomson et al. (2010) found support for different timings of the Longfin Smelt population step-declines than those applied by Kimmerer et al. (2009) and the ITP. The division of the Longfin Smelt abundance index data set into different periods between hypothesized step-declines (a) makes the recent relationship between Delta outflows and Longfin Smelt abundance seem weaker than it is, and (b) will affect the predicted abundance at a given average springtime X_2 within any time period. Furthermore, the X_2-Longfin Smelt abundance relationship is likely to experience similar "step declines" in the future if the spawning population decreases, but the ITP's model does not allow one to predict the size, timing, or frequency of such apparent "step" declines. Thus, the Kimmerer et al. (2009) approach (which was never intended to predict future Longfin Smelt abundance), as adopted by the ITP application and ITP will not accurately predict the Longfin Smelt population response to declining outflows under WaterFix because the size of any given cohort is affected by both Delta outflows and the size of the spawning population (see also SWRCB 2017). The ITP's use of the Kimmerer et al. 2009 approach will overestimate Longfin Smelt abundance at any given flow as long as the population of spawning adults is lower than it was in those years used to construct the Longfin Smelt X_2-abundance relationship. Indeed, as of this writing, the Longfin Smelt population has declined substantially compared to the period from which the ITP derived its X2-Longfin Smelt abundance regression.

In their recent analysis, Nobriga and Rosenfield (2016) explicitly analyzed the role of available spawning adults ("stock") on Longfin Smelt population dynamics in the Bay-Delta estuary. By accounting for the size of the spawning population and disaggregating the effect of flow on two different life stages, their study found a very strong effect of flow on production of juvenile Longfin Smelt that does not appear to have changed over the length of the data series (i.e., after accounting for the size of the parental generation, no step-change (or continuous change) was detected in the strong relationship between Dec-May Delta outflow and the abundance of juvenile Longfin Smelt). This study did detect declining survival between the Longfin Smelt juvenile and adult life stages, but:

a. The decline in juvenile to adult survival played a relatively small role in the change in Longfin Smelt abundance from one generation to the next;
b. The forces driving this decline in juvenile-adult survival are unknown, but likely operate where Longfin Smelt spend most of their time between juvenile and adult sampling (i.e., well downstream of the Delta and Suisun Bay);
c. Modeling could not distinguish a step-change in juvenile-to-adult survival rates from a gradual decline in survival rates; and
d. The years in which a putative step-change in juvenile-to-adult survival was best supported were not the same as that used by Kimmerer et al. 2009.

B. Adverse Effects of Entrainment on Longfin Smelt

Predictions of Longfin Smelt decline in the WaterFix analyses are likely to underestimate the true impact of Project operations on this threatened species. The methods used to evaluate Longfin

Smelt population response to WaterFix operations do not incorporate the negative effect of other changes that are expected to occur as a result of WaterFix construction or operation. The state's analyses of WaterFix indicate that other sources of Longfin Smelt mortality are likely to change relative to current conditions. For example, project proponents' estimates of Longfin Smelt abundance under WaterFix operations (which are based on the regression approach used by Kimmerer et al. 2009) do not account for changes to entrainment/salvage that may occur under WaterFix operations.

Entrainment of juvenile Longfin Smelt under WaterFix may increase dramatically, according to DWR's modeling (ITP Application, Appendix 4.A, e.g., Table 4.A-11; Figure 4.A-31). Modeled entrainment of juvenile Longfin Smelt (which is based on the measured relationship between salvage and OMR flow documented by Grimaldo et al. 2009) increases by 29%, 3%, and 14% in Below Normal, Dry, and Critically Dry year types, respectively. This increase in juvenile Longfin Smelt entrainment is not surprising given that OMR reverse flow rates during April-June (the months of highest juvenile entrainment; Grimaldo et al. 2009; Rosenfield 2010) of drier year types are not expected to improve and may actually be worse (more negative) under WaterFix than they are under the No Project Alternative (Biological Assessment, Appendix 5A).

This is of particular concern both because entrainment mortality is already highest in drier year types (Grimaldo et al. 2009) and because the Longfin Smelt population tends to decline in drier years, meaning juvenile entrainment mortality may have a proportionately larger impact in those year types (Rosenfield 2010). It is possible that entrainment of Longfin Smelt could be reduced if OMR flows were significantly more positive than the status quo (e.g., Grimaldo et al. 2009) or Delta outflows were substantially improved during the April-Jun period of drier years (Rosenfield 2010), but such improvement in outflows are not reasonably certain to occur (see e.g., ITP Table 9.9.4-1).

Thus, the impacts of juvenile entrainment on the Longfin Smelt population may be proportionately greater under WaterFix, particularly during drought sequences when the population is most at risk.

In contrast to salvage of juveniles, WaterFix documents predict decreases in larval Longfin Smelt entrainment rates under the proposed project. Larval Longfin Smelt entrainment is not well-studied because larval salvage at Project export facilities is poorly documented and the impact on the population of larval entrainment is completely unknown both in absolute terms and relative to impacts to other life stages. WaterFix modeling of Longfin Smelt larval entrainment is based on flawed, unverified, and/or unlikely assumptions. For example, the model assumes that larval Longfin Smelt behave like particles over a 45-day period, despite acknowledging that Longfin Smelt larvae are capable of manipulating their position in the water column (and thus using gravitational circulation patterns to adjust or maintain their horizontal position) much earlier than 45-days after hatching[3].

Furthermore, the modeling of WaterFix's likely effects on larval entrainment is flawed because it assumes the same distribution of larval Longfin Smelt regardless of hydrological conditions. Specifically, the particle tracking model begins with a static distribution of larval fish across "injection" locations, based on the average of six years of data from the Smelt Larval Sampling Program. However, the distribution of Longfin Smelt larvae is believed to change based on hydrological and other conditions (e.g., Dege and Brown 2004; Rosenfield 2010). Indeed, the ITP application acknowledges that "…overall larval Longfin Smelt abundance in the [Smelt Larval Survey] is lowest during wet years…." This is almost certainly because larval Longfin Smelt are distributed further downstream during wet years (recall that the subsequent Longfin Smelt

[3] See also the ITP Application where DWR states at 2.A.1-6: "Once their air bladder is developed (~12 mm SL) [Longfin Smelt] are capable of controlling their position in the water column by undergoing reverse diel vertical migrations (Bennett et al. 2002)."

abundance index, measured in the fall, increases dramatically during wet years). Thus, the ITP's finding that the largest modeled "declines" in larval entrainment are expected in Wet and Above Normal year types during February and March (ITP Application, Appendix 4.A. Table 4.A-7) is very misleading. Under wet year conditions, the distribution of larval Longfin Smelt is further downstream than in drier year types (Dege and Brown 2004; Grimaldo et al 2009); thus, the larvae would be less susceptible to entrainment mortality in wet years. In other words, had the ITP modeled larval distributions that reflected hydrological conditions, it is likely that modeled larval salvage would be very low in wet years, with or without WaterFix, and that the net effect of WaterFix on larval Longfin smelt entrainment would be much lower than what has been reported.

WaterFix assumes that no Longfin Smelt entrainment, impingement, or predation mortality will occur at the new North Delta diversions. This assumption is not supported by the recent distribution of Longfin Smelt detected by CDFW sampling programs, many of which frequently find Longfin Smelt distributed at the most upstream points in their sampling regime on the Sacramento River. Indeed, in justifying the June 1 through October 1 work window for NDD construction, CDFW found: "Adult DS and LFS migrate upstream into and through the NDD intake reach of the Sacramento River from early winter through late spring (CDFG 2009, Merz et al 2011, Merz et al 2013) …" (CESA Findings at 268). If these fish migrate in to the NDD intake reach currently, then the assumption that they won't be directly affected (entrained, impinged, disoriented, depredated) as a result of WaterFix operations is unfounded.

Thus, due to modeling assumptions it is likely that WaterFix overstates the benefit, if any, from reduced larval entrainment. The project documents ignore the real potential for the NDD to become a new source of entrainment mortality for larval Longfin smelt. Similarly, the WaterFix analysis ignores the projected increase in juvenile Longfin Smelt entrainment under WaterFix. Finally, none of the potential changes in entrainment rates has been incorporated into the overall assessment of potential population impacts to Longfin Smelt that may arise from WaterFix operations. Because the state failed to adequately consider and synthesize all of the adverse effects of WaterFix on Longfin Smelt survival, the ITP significantly understate the adverse effects of WaterFix on Longfin Smelt populations.

C. Adverse Effects of Ecosystem Alterations on Longfin Smelt

Proposed WaterFix operations will alter the Delta and greater San Francisco Estuary ecosystems in ways that harm Longfin Smelt. For example, like Delta smelt, Longfin Smelt are believed to prefer relatively high turbidity habitats (Mahardja et al. 2017); yet WaterFix is very likely to reduce turbidity levels in the Delta. This effect combined with increased Delta residence times (the time it takes for a molecule of water to exit the Delta) are likely to contribute to increased frequency of harmful algal blooms like *Microcystis* spp., which may be toxic to Longfin Smelt and their prey items. Furthermore, many of the same effects of WaterFix that are detrimental to Longfin Smelt (e.g., reduced turbidity, reduced Delta outflow) will tend to suppress productivity of the estuarine food web that Longfin Smelt depend upon. Because they will affect multiple species, these ecosystem effect mechanisms are discussed separately below.

III. WaterFix Causes Significant Adverse Impacts to Delta Smelt

Delta Smelt is listed as endangered under CESA, and threatened under the federal ESA. The 2017 population abundance index for Delta Smelt was the lowest ever recorded and the past four indices are the lowest four values ever recorded. The environmental status quo has caused a catastrophic decline in this endemic population. Maintenance of status quo conditions threatens the continued existence and recovery of Delta Smelt.

The best available science shows that planned WaterFix operations will negatively affect Delta Smelt because WaterFix will limit the extent and suitability of rearing habitat for larval and juvenile Delta Smelt in many years and fails to substantially reduce entrainment mortality risks. We have analyzed WaterFix effects on Delta Smelt extensively in the past (Defenders of Wildlife et al. 2014; NRDC et al. 2015). Here we focus on recent research and findings of the current project documents and permits.

A. Adverse Effects of Reduced Delta Outflow on Delta Smelt

Recent studies indicate a strong, significant influence of Delta outflow on survival of Delta Smelt to subsequent life stages (MAST 2015; CDFW 2016; USFWS 2016a). Years in which flows are higher than average for a given month tend to be years in which the Delta Smelt population grows. The relationship holds for flows in nearly every month of the year.

Nevertheless, WaterFix proposes to reduce Delta outflow in winter, spring, and summer months compared to the status quo. This will harm Delta Smelt and impair the population's ability to recover. As described above regarding Longfin Smelt, WaterFix includes March-May outflow criteria that fail to maintain current levels of outflow during the late-winter and spring. WaterFix does not include any outflow criteria for January and February, despite the fact that the best available scientific information indicates that Delta Smelt responds positively to increases in Delta outflow throughout the year (e.g.; USFWS 2016a). Furthermore, WaterFix will reduce Delta outflows in summer months, despite mounting evidence that Delta outflows during the summer are currently inadequate (CDFW 2016; USFWS 2016a).

As a result, the USFWS WaterFix biological opinion concludes that, "[l]ower outflow will increase salinity and limit extent and suitability of western parts of critical habitat. [Low salinity zone] located in higher estuary with degraded habitat extent and suitability" (Table 9.2.3.4 at 325)[4].

[4] This table, while informative, exemplifies major problems of WaterFix analyses in general, and analyses of Delta Smelt, in particular. First, putative effects of the Project Alternative are presented relative to the No Project Alternative, but there is no indication of whether any improvement expected under the Project will be large enough to be detectable or to contribute meaningfully to the conservation and recovery of the species. Second, the effects are presented by life stage with no effort to integrate the findings across life stages. Thus, the reader is mistakenly led to believe that a positive effect, such as "SJR flows will improve larval/juvenile transport," is independent of negative results that occur at other points in the life cycle (e.g., that rearing habitat will be limited and degraded). Such piecemeal analyses obscure

Reductions in flow over the status quo also run counter to USFWS/Department of Interior statements that *additional Delta outflow*, particularly during late-spring and summer, will be necessary to conserve Delta Smelt in the near term (USDOI 2017; USFWS 2016a, b).

B. Adverse Effects of Entrainment on Delta Smelt

Mortality related to entrainment of Delta Smelt in water export infrastructure is understood to be an episodic driver of population declines in this species (e.g., Kimmerer 2008), and ongoing stress related to entrainment mortality is a significant barrier to recovery of this unique species. Yet, WaterFix operations are expected to maintain high levels of entrainment mortality in drier years, exactly the year types when the population is most stressed and can least tolerate added human-induced mortality. The CESA Findings of Fact explain:

> Two approaches were used to estimate entrainment of larval and young juvenile [Delta Smelt] as a result of Project operations. First, percentage entrainment loss regression equations, similar to those used in USFWS (2008), were used to estimate differences in potential larval and juvenile (< 20 mm) DS entrainment at the south Delta export facilities based on CalSim II simulations of Project operations (ICF International 2016, Section 6.A.3.1.2). <u>These analyses indicate that the percentage entrainment of larval and juvenile DS will tend to be very similar under the Project and the NAA scenarios (ICF International, Table 4.1-15, Table 4.1-16, Figure 4.1-12, Figure 4.1-13; Figure 4.1-14; Figure 4.1-15),</u> <u>except in drier years when entrainment is expected to be greater because OMR flows are more negative as a result of Project operations</u>.

CESA Findings of Fact at 306 (emphasis added). The CESA Findings go on to explain that the second method of estimating larval/juvenile Delta Smelt entrainment at the south Delta export facilities produced results consistent with those described above. CESA Findings of Fact at 306-307.

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the fact that there is not likely to be a benefit of "improving transport" of larval and juvenile Delta Smelt to rearing habitats (for example) if those habitats are shrunken and degraded.

WaterFix project documents and related analyses by regulatory agencies frequently and inappropriately portray most impacts of the project as "average" results, which skews the overall impacts of the project. These "average" results are based upon the premise that good years balance bad years; this premise is flawed. For example, Delta Smelt generally live for 1-year and are semelparous (they spawn and die). The conditions that determine whether the population persists or recovers are those that occur in the worst years. It does not matter if "average" conditions or "best conditions" improve if the population is irreparably damaged in a string of "bad" (e.g., dry) years.

C. Adverse Ecosystem Effects on Delta Smelt

Proposed WaterFix operations will alter the Delta and greater San Francisco Estuary ecosystems in ways that harm Delta Smelt. Delta Smelt are believed to prefer habitats with relatively high turbidity (e.g., Mahardja et al. 2017); yet WaterFix is very likely to reduce turbidity levels in the Delta. This effect combined with increased Delta residence times (the time it takes for a molecule of water to exit the Delta) are likely to contribute to increased frequency of harmful algal blooms like *Microcystis* spp., which may be toxic to Delta Smelt and their prey items. Furthermore, many of the same effects of WaterFix that are detrimental to Delta Smelt (e.g., reduced turbidity, reduced Delta outflow) will tend to suppress productivity of the estuarine food web that this species depends upon. Because they will affect multiple species, these ecosystem effect mechanisms are discussed separately below.

IV. Adverse Ecosystem Level Effects of WaterFix Diversions

The extraction of more water from the Delta (and the greater San Francisco Estuary ecosystem in which it is situated) as a result of a new North Delta diversion will have wide-ranging ecosystem-level effects that will negatively affect a variety of creatures including, but not limited to, those detailed above. Although the depth of these effects is often difficult to quantify (and estimates of the impact are subject to the accuracy and assumptions of complex models), the breadth of these ecosystem effects represents a significant threat to public trust uses of the Delta and San Francisco Estuary.

A. Adverse Effects of Reduced Delta Turbidity

Turbidity (cloudiness) of the water column is an important habitat element for aquatic organisms. Many of the San Francisco Estuary's native fish aggregate in areas of relatively high turbidity, including Delta smelt and Longfin Smelt (Nobriga et al. 2008; Mahardja et al. 2017). Fish, and juveniles in particular, are believed to select environments with relatively high turbidity as they provide cover from visual predators (Shoup and Wahl 2009; Gregory 1993; Gregory and Leavings 1996). Increasing water clarity is recognized as a significant impact on Delta Smelt and other native fisheries in the Delta. Elevated turbidity also appears to repress the frequency of harmful algal blooms (Berg and Sutula 2015). Also, turbidity in the form of suspended sediment is important in the maintenance of key estuarine edge habitats, such as mudflats and tidal marshes.

The San Francisco Estuary ecosystem already suffers from a deficit of sediment and turbidity as a result of prior human activities (e.g., gold mining, dams). The RDEIR/SDEIS indicates that WaterFix operations will reduce sediment supply to the estuary by 8-9%. Other findings indicate the reduction will be 10% (CESA Findings of Fact at 318). Habitat restoration activities in the Delta are expected to further reduce the available sediment supply. Indeed, one of the guiding principles of WaterFix adaptive management is to design operational criteria that promote increased turbidity in areas and at times where it will benefit Delta smelt (USFWS WaterFix biop at 13); however, these operational criteria do not yet exist and there are no performance criteria to determine the adequacy of future operations. In addition, the project documents and permits mention future development of a "sediment reintroduction plan" that will describe how sediment captured by WaterFix diversions will be reintroduced to the Estuary (e.g., USFWS WaterFix biop; ITP). However, this plan is not currently available so its likely efficacy cannot be evaluated; initial estimates are that less than 1/10th

of sediments captured by the north Delta diversions will be available for reuse (January 29, 2015 Memo from ICF International to Department of Water Resources). Thus, WaterFix operations are likely to reduce habitat availability and degrade remaining habitats for native fish and wildlife species because the new water diversions will remove sediment from the Sacramento River along with the water they divert. This concern has been expressed previously, by TBI and other commenters, as well as by the Delta Science Program (2014) and BCDC (2014).

B. Adverse Effects of Increased Frequency of Harmful Algal Blooms

Harmful algal blooms are outbreaks of cyanobacteria that can generate powerful neurotoxins, which can kill zooplankton and fish (Lehman et al. 2009), and even small mammals. A reduction in turbidity in the Delta is likely to increase the frequency of harmful algal blooms, including *Microcystis* (RDEIR/SDEIS Appendix A at 8-45 to 8-46; Berg and Sutula 2015). If Delta temperatures increase (as is expected under climate change scenarios) and Delta residence times increase (as is expected due to sea level rise, habitat restoration plans, and, in some months, WaterFix operations), then the risk of more frequent harmful algal blooms increases. The RDEIR/RDEIS acknowledges this potential (see, RDEIR/SDEIS at 4.3.4-67 to -68) as do the CESA findings of Fact, which state (at 317):

> If *Microcystis* blooms increase in duration and intensity as a result of Project operations, in part from longer residence times, it is possible that there will be overlap between the timing of larval and juvenile life stages of [Delta Smelt] in the Delta and *Microcystis* blooms early in the year. Additionally, warm periods in late fall-early winter could result in *Microcystis* blooms that may affect migrating adult DS and LFS. Additionally, longer residence times due to Project operations could create an overlap between potential *Microcystis* blooms during Project operations and DS occurrences in the low-salinity zone. Because *Microcystis* can be toxic to copepods there is potential for the higher residence times in this region to intensify blooms that harm or kill DS directly, by killing their prey, or by increasing toxin concentrations within their prey (Ger et al. 2009; 2010; Lehman et al. 2010; Acuña et al. 2012; Brooks et al. 2012). If the lower Sacramento River temperatures increase over time due to climate change, and become clearer due to Project operations or other factors, *Microcystis* blooms could also expand into this important DS rearing area.

WaterFix underestimates this potential and fails to incorporate it into overall estimates of project impacts because it downplays sediment reduction due to WaterFix (inappropriately relying on a sediment reduction plan that does not exist yet), models residence time poorly (see NRDC et al 2015), and fails to model temperature conditions in the Delta beyond 2030 (NMFS biop at 283), *i.e.*, too early to capture the likely effects of climate change on Delta temperatures. The potential for adverse impacts from harmful algal blooms is real and WaterFix should account for this potential by providing for increased through-Delta flows (i.e., decreased residence times) and managing those flows in a way that minimizes reductions in sediment transport and Delta turbidity.

C. Adverse Effects of Impaired Food Web Productivity

Diversion of water by WaterFix will exacerbate food shortages for aquatic organisms of interest, including (but not limited to) the species described above. The WaterFix screens are not designed to prevent diversion of phytoplankton or small zooplankton from the system. Furthermore, reductions in freshwater flows into, through, and out of the Delta caused by WaterFix operations are likely to reduce productivity and abundance of important zooplankton prey species in the Delta. For example, *Crangon* shrimp display a strong, persistent, and significant positive relationship with spring Delta outflows; this relationship did not change with the introduction of *Corbula* clams to this ecosystem in the mid-1980's (Jassby et al. 1995; Kimmerer 2002). Spring populations of the copepod *Eurytemora*, a key prey species for most small juvenile pelagic fish in this ecosystem, also show a significant positive relationship with Delta outflow (negative relationship with X_2, Kimmerer 2002). In fact, all of the fish species for which positive flow: abundance relationships are known to exist (e.g., Longfin Smelt, Delta Smelt, Chinook Salmon, White Sturgeon, American Shad, etc.) represent food for other species in the greater San Francisco Estuary ecosystem. Removal of phytoplankton and zooplankton at the WaterFix intakes combined with reduced Delta spring outflows expected under WaterFix operations represent a significant adverse effect to the aquatic food web of the San Francisco Estuary.

V. Proposed Operational Requirements and Conditions for WaterFix if the Petition is Approved

As I have documented here and elsewhere (e.g., Defenders of Wildlife et al. 2014; NRDC et al. 2015), the proposed WaterFix project would harm endangered species, public trust fisheries and other biological resources, ecosystem processes, and water quality of the San Francisco Bay Estuary and its watershed. As a result, I conclude that the SWRCB should reject the WaterFix petition.

Should the SWRCB nevertheless approve the WaterFix petition, additional terms and conditions would need to be applied in order to minimize harm to the ecosystem from this project. To protect salmonids and other migratory fishes (including, but not limited to Green and White Sturgeon), WaterFix operational requirements should include improved bypass flows for the North Delta Diversion. These improved bypass flows should not be subject to frequent changes based on real-time monitoring results because monitoring technology is not accurate or timely enough to allow the fine-scale adjustments envisioned by project proponents. Rather, monitoring should be used to identify the onset and end of the larger migratory window so that the full range of life histories (e.g., timing of migration) can be protected by adequate flows past the North Delta Diversions. The CVP and SWP should also be required to reduce temperature-related mortality and redd dewatering upstream to levels that are well below the status quo. Furthermore, flows from the Sacramento River into, through, and out of the Delta should be increased over the current status quo in order to improve survival of juvenile salmonids, and other desirable migratory fish species.

Delta outflow requirements for WaterFix should be substantially higher than those currently identified in the permit application, in order to avoid continued declines of numerous pelagic and migratory species and potential extinction of Longfin Smelt. The SWRCB should impose terms and conditions that significantly increase Delta outflow from December to June. Increased Delta outflow during these months will also reduce or avoid impacts to Green and White Sturgeon, Starry Flounder, Chinook Salmon, numerous sportfish, and several zooplankton prey species.

In order to avoid unreasonable impacts to Delta Smelt and other pelagic species from WaterFix, the SWRCB should require increased Delta outflow in the spring and summer, and it should incorporate fall outflow requirements from the USFWS fall outflow RPA. Increased Delta outflow requirements in the winter and spring should also reduce entrainment of Delta Smelt and Longfin Smelt, particularly in drier year types, to levels that are well below the status quo. Finally, entrainment of sediment in the North Delta Diversion should be limited and the effect of sediment reduction from combined CVP/SWP operations must be fully mitigated.

Below, I provide additional detail regarding the requirements and conditions that in my professional judgment the SWRCB should impose on WaterFix if the petition is approved.

A. Minimum Requirements and Conditions for Operation of California WaterFix

1. *NDD Bypass flows -- Minimum bypass flow of 35,000 cfs from November 1 to June 1:*

Bypass flows above 35,000 cfs are generally believed to avoid reverse flows at Georgiana Slough; as a result, such bypass flows are expected to minimize reductions in salmon survival below the WaterFix intakes. As described above, the best available science demonstrates that real time modification of bypass flows will not adequately protect migrating juvenile salmonids. As such, the bypass flow requirements should be calendar-based beginning on Nov 1 and extending to June 1. During the shoulder periods (October 1 – October 30 and June 1 – June 30), the 35,000 cfs bypass flow would be triggered by the presence of salmon (any run) at Knights Landing. Protection of early and late migrations is critical to maintaining the life history diversity that is a central component of Chinook Salmon success in this watershed.

Additionally, bypass flows would also be triggered in June if monitoring shows Delta Smelt in the vicinity of the intakes.

2. *<u>Delta Outflow</u>:*

Severe declines in numerous fish and wildlife species correspond to dramatically reduced Delta outflows. Through the combined diversions of the existing south Delta CVP/SWP facilities and the proposed North Delta Diversions, WaterFix proposes to reduce Delta outflows even further. This would lead to catastrophic results for unique, imperiled, and valuable species of the San Francisco Bay Estuary; water quality would also be jeopardized by reduced Delta outflows. I propose that the following requirements be applied to any WaterFix permit.

a. *Maintain December to June outflows at or above 67-75% of unimpaired Delta Outflow:*

Flows of this magnitude are necessary to protect Longfin Smelt and will provide much-needed support for Chinook Salmon, Green Sturgeon, White Sturgeon, Delta Smelt, Starry Flounder, *Crangon* shrimp and other pelagic prey items, and other species. This requirement should be applied on a relatively short temporal window (e.g., a 7-d running average of unimpaired flows) as this will retain some of the natural flow variability (e.g., pulses) that benefit many native fish species and ecosystem processes.

b. Maintain July to August outflows at or above 7,100 cfs

This level of flow has been identified by USFWS and CDFW as necessary to maintain the estuarine low salinity zone in a location where Delta Smelt can find adequate habitat conditions. Such flow levels correspond to improved over-summer survival rates and improved abundance in the subsequent Fall Midwater Trawl survey.

c. Maintain September to November outflows at or above 11,400 cfs in Wet & Above and 7,400 cfs in other year types.

Fall flows of this level position the estuarine salinity zone in a location where Delta Smelt habitat conditions are adequate to support survival.

3. *Turbidity*: *Limit WaterFix-induced reduction of sediment inputs to the Delta to less than 5%:*

Although the WaterFix documents identify sediment entrainment as a concern (e.g., there calls to develop a sediment reintroduction plan), there is no identified performance metric that will indicate when sediment entrainment by WaterFix has been sufficiently controlled. Limiting sediment entrainment to ≤5% of the Sacramento River's daily load provides a basis for adaptive management of this impact.

4. *Carryover storage: Implement the revised Shasta RPA:*

This will be essential to protect winter-run Chinook salmon and other coldwater-dependent resources of the Sacramento River. Implementing the necessary outflow requirements described above cannot substitute for maintaining adequate coldwater-pool resources upstream (and vice-versa).

5. *Floodplain inundation: Achieve the Yolo bypass RPA acreage and inundation criteria:*

These critical components of the RPA have not yet been implemented. When they are, inundated areas of the Yolo Bypass will benefit various salmonid populations, Sacramento Splittail, and, potentially, other Delta species.

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