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BEFORE THE

CALIFORNIA 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 WATER FIX	TESTIMONY OF MICHELLE L. WORKMAN (Hearing Part 2)

I, Michelle L. Workman, do hereby declare:

I. INTRODUCTION AND OVERVIEW OF TESTIMONY

My name is Michelle Workman. I am a fisheries biologist with over 24 years of professional experience working on anadromous fish issues in the Central Valley. I have spent 17 of those years on the Mokelumne River working in every aspect of fisheries management, research and monitoring. I am currently the Supervising Fisheries Biologist in the Lodi Fisheries and Wildlife Office of the East Bay Municipal Utility District (EBMUD). In that position, which I have held since February 2014, I direct the implementation of EBMUD's Lower Mokelumne River Water Quality and Resource Monitoring Program including salmonid migration monitoring and assessment. From 2009 to 2014, I worked as a supervising fisheries biologist for the United States Fish and Wildlife Service (USFWS) on the San Joaquin River Restoration Program and on the Merced and Tuolumne Rivers, managing habitat restoration for salmonids and participating in FERC relicensing processes to develop license provisions that provided protective measures for anadromous fisheries. From 1993 to 2009, I was employed by EBMUD as a Fisheries Biologist and Fisheries and Wildlife Technician. I have a Bachelor of Science and a Master of Science in Biology with a concentration in Conservation from California State University, Sacramento. My thesis work analyzed the environmental variables that influence juvenile salmonid migration characteristics. I have authored or co-authored a number of relevant publications and reports related to Lower Mokelumne River salmonids. As a result of my work, I have a deep knowledge of the Mokelumne River fishery ecosystem and the Mokelumne-origin anadromous fishery.[1]

I believe the WaterFix Project, if approved on Petitioners' proposed terms, may increase mortality within the interior Delta of juvenile salmonids outmigrating from the Mokelumne River. The potential for increased fish mortality arises from the likelihood

[1] A true and correct copy of my statement of qualifications is submitted as Exhibit EBMUD-130.

that WaterFix operations may lead to increased exports from the Jones and Banks Pumping Plants (South Delta Facilities) during the Spring salmonid outmigration season. There is an existing problem of entrainment at the South Delta Facilities of outmigrating juvenile fall run Chinook salmon and yearling steelhead smolts from the Mokelumne River. Petitioners' modeling of WaterFix Project operations, which they prepared for this hearing,[2] shows the rate and frequency of pumping at the South Delta Facilities could increase (relative to the No Action Alternative or "NAA") during the crucial April-May salmonid outmigration window.[3] While increased South Delta pumping would not occur under every WaterFix operational scenario, Petitioners' modeling indicates it could occur in certain operational scenarios that fall within the modeled boundary conditions.

I believe an increase in exports from the South Delta Facilities during the Mokelumne River salmonid outmigration would be likely to increase the mortality of outmigrating Mokelumne River fish by exacerbating the existing entrainment issue at the South Delta Facilities and by delaying the Mokelumne River salmonids' migration, which would increase their exposure time to predators, to unscreened diversions, and to harmful water quality conditions in the interior Delta. I believe significant population level effects could occur if South Delta pumping increases in consecutive dry years, which Petitioners' modeling indicates could occur. In my opinion, this increased mortality of Mokelumne River salmonids could be avoided by conditioning any order approving Petitioners' change petition in a manner that addresses those impacts during the most crucial portion of the Mokelumne River salmonid outmigration window.

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[2] Petitioners performed modeling of WaterFix Project operations in support of their change petition and made it available to the parties to this hearing. That modeling was admitted to the record in this proceeding as Exhibit DWR-500. All references to "Petitioners' modeling" in my testimony refer to Exhibit DWR-500.

[3] Dr. Benjamin Bray assisted me with locating the model output data discussed in my testimony, and he prepared certain figures plotting model output data which are included as part of my testimony. *See* Exhibit EBMUD-157, Testimony of Benjamin S. Bray, Ph.D., P.E. (Hearing Part 2).

II. BACKGROUND

The Lower Mokelumne River supports a substantial population of anadromous fish. Even though the Mokelumne is a small river that comprises approximately 1% of the Delta watershed, in most years Mokelumne River origin salmon make up approximately 15% to 20% of the ocean commercial and recreational catch off the California coast. Mokelumne River origin salmon significantly contribute to the Central Valley fall run Chinook salmon population and associated commercial and recreational sport fisheries. The Lower Mokelumne River also supports a population of federally threatened Central Valley steelhead. The Mokelumne River supports both naturally- and hatchery-produced populations of fall run Chinook and Central Valley steelhead. Natural production is supplemented by the Mokelumne River Fish Hatchery.[4]

Juvenile salmonids from the Lower Mokelumne River typically migrate to the ocean in the Spring. All available migration routes pass through the interior Delta because the Mokelumne River is an eastside tributary to the Delta. Difficult conditions in the interior Delta affect the survival rate of juvenile Mokelumne River salmonids. Mokelumne River juvenile salmonids migrating through the Delta may be exposed to predation, entrainment in export pumps, unscreened diversions, and water quality impacts. Naturally-produced salmonids cannot avoid these conditions; they must navigate the interior Delta to reach the ocean. Hatchery-produced fish may have the opportunity to bypass the interior Delta during their outmigration, depending on where they are released. Figure 1 depicts the known Delta migration routes of Lower Mokelumne River yearling hatchery steelhead and common hatchery release locations for both Chinook and steelhead east and west of the interior Delta.

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[4] Additional background information regarding the Mokelumne River and its anadromous fisheries is provided in the written testimony of Jose D. Setka (Exhibit EBMUD-155).

III. EXISTING IMPACTS OF SOUTH DELTA FACILITIES ON MORTALITY OF OUTMIGRATING JUVENILE MOKELUMNE RIVER SALMONIDS

The National Marine Fisheries Service (NMFS), in the biological opinion it prepared for the WaterFix project (WaterFix BiOp), recognized the vulnerability of juvenile salmonids migrating through the interior Delta.[5] NMFS explained in the WaterFix BiOp that Sacramento River salmonids which outmigrate through the interior Delta experience reduced survival rates, which NMFS said is most likely due to increased migration time and an associated increased risk of predation and entrainment into the South Delta Facilities.[6] NMFS concluded that "migratory route entrainment is considered a stressor that can affect individual survival and population abundance."[7]

Unfortunately, outmigrating Mokelumne River salmonids cannot avoid the interior Delta (see Figure 1). Based on substantial observational and correlative evidence discussed below, I believe losses at the South Delta Facilities include a substantial portion of Mokelumne River Chinook and steelhead outmigrants. Operation of the South Delta Facilities entrains Mokelumne River Chinook and steelhead. It also delays their migration, increasing their exposure time to stressors in the interior Delta. Even though the South Delta Facilities' adverse impacts on Mokelumne fisheries pre-dates the WaterFix project, the relationship between pumping and fish mortality highlights the need to ensure the WaterFix project is not operated in a way that increases South Delta exports, which would exacerbate the situation.

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[5] *See* Exhibit SWRCB-106, California WaterFix Biological Opinion, National Marine Fisheries Service, West Coast Region, June 16, 2017 (WaterFix BiOp), § 2.5.1.2.7 (Reduced In-Delta Flows), p. 598 et seq.

[6] *Id.* at § 2.5.1.2.7.2 (Outmigration Routing), p. 652 et seq.

[7] *Id.* at p. 652.

A. Correlation between Migration Timing of Mokelumne Origin Fall Run Chinook and Salvage Losses at the South Delta Facilities

1. Naturally-Produced Chinook

Most salvaged fall run Chinook salmon are unmarked, including all naturally-produced fall run Chinook, and so origin must be inferred. The likelihood that unmarked Mokelumne origin Chinook are entrained in the South Delta Facilities in significant numbers can be inferred by comparing the timing of the Lower Mokelumne River fall run Chinook migration with the timing of all unmarked fall run losses at the South Delta Facilities. Figure 2 depicts the following over the 1994-2014 period: (1) the average percentage of naturally-produced fall run Chinook captured during each month at downstream juvenile fish traps on the Lower Mokelumne River, and (2) the average percentage of fall run Chinook estimated losses of all origins in each month at the South Delta Facilities.[8] As Figure 2 illustrates, the timing of South Delta salvage is well-correlated with Mokelumne River migration timing. Stated another way, naturally-produced Chinook losses at the South Delta Facilities tend to occur most when the greatest number of Mokelumne naturally-produced Chinook are migrating through the Delta. This correlation indicates a significant portion of Mokelumne origin Chinook may be salvaged at the South Delta Facilities.

2. Hatchery Chinook

The Mokelumne River Fish Hatchery produces fall run Chinook salmon for two distinct purposes: habitat mitigation and ocean fishery enhancement. Fish produced for habitat mitigation are released as far upstream as feasible to provide homing cues that

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[8] Based on commonly accepted methodology, estimates of Chinook salmon loss are calculated based on fish salvage and operational data collected at the John E. Skinner Delta Fish Protective Facility (Skinner) and the Tracy Fish Collection Facility. Under this methodology, loss calculations utilize estimates based on Department of Fish and Wildlife studies of screening efficiency, handling and trucking mortality due to operation of the Skinner facility, and pre-screening losses occurring in Clifton Court Forebay and the intake channel. Chinook salmon losses used in these analyses were obtained at ftp://ftp.dfg.ca.gov/salvage/Salmon%20Loss%20Estimation/. Steelhead losses were calculated from salvage data using the calculation methods described in the available steelhead salvage tables obtained here: ftp://ftp.dfg.ca.gov/salvage/DOSS_Salvage_Tables/.

help fish navigate and return to their natal streams. In contrast, ocean enhancement fish are released as far downstream as feasible, because their release strategy is to maximize their survival to the ocean.

Over the years, Mokelumne hatchery Chinook have been released as far upstream as the base of Camanche Dam and as far downstream as San Pablo Bay. Before 2007, most mitigation salmon were released in the Lower Mokelumne River above tidal influence or on the northeast corner of the Lower Mokelumne River where it splits into the North and South Forks. Fish released in those locations must migrate through the interior Delta and may experience pumping impacts from the South Delta Facilities. These juvenile fish are migrating to the ocean, in search of flow cues to continue their downstream migration. When net flows are larger to the south than to the west, these fish may become entrained into migration routes that lead directly into the South Delta Facilities to the south, or at a minimum, become delayed in their migration through the interior Delta while searching for westward flow which may be masked by flows to the south. Entrainment leads to direct losses, while delay leads to indirect losses by way of increased exposure to predators, unscreened Delta diversions, and the potential for encountering poor water quality conditions.

A portion of Chinook produced at the Mokelumne River Fish Hatchery are marked with a coded wire tag that identifies their river of origin and release information. The documented salvage of these marked fish is direct evidence that Mokelumne origin salmonids are vulnerable to entrainment in the South Delta Facilities. As shown on Figure 3, between 1992 and 2006, 332 coded wire tagged juvenile Chinook salmon originating from the Mokelumne River Fish Hatchery were captured in salvage or predation samples at the South Delta Facilities.[9] These data also indicate that Mokelumne origin Chinook released during April, May and June are most often captured at the South Delta Facilities between 14-16 days after release. Some salmon were detected at the South Delta Facilities just six days after their release.

[9] Salvage data is available at http://www.dfg.ca.gov/delta/apps/salvage/Default.aspx.

To reduce juvenile hatchery Chinook losses in the interior Delta and improve adult return numbers, fishery experts from EBMUD and the California Department of Fish and Wildlife jointly decided in 2007 to move all mitigation releases of hatchery-produced juvenile salmon downstream to Sherman Island, west of the interior Delta. Smaller-scale experimental releases continued east of the Delta at times. Since that 2007 decision, only three coded wire tagged mitigation Chinook released from Sherman Island have shown up at the South Delta Facilities (see Figure 3). Except for those three individuals, all coded wire tagged salmon captured in 2007 or later (n=194) originated from experimental on-site releases at the hatchery. In all, ninety-two percent of all Mokelumne origin Chinook captured at the South Delta Facilities between 1992 and 2014 were from in-river releases, while only the remaining 8% of captures were from releases made west of the interior Delta at Sherman Island. Releases from Sherman Island are significantly underrepresented in these capture totals, which is further evidence that Mokelumne origin salmon that must traverse the interior Delta are much more likely than fish released farther west to be entrained in the South Delta Facilities.

The 2007 decision to alter the release location to the west, and the corresponding decline in salvage, highlights the significant risk the South Delta Facilities pose to migrating fish in the interior Delta. Moving the release point to Sherman Island has helped reduce losses of hatchery salmon to the South Delta Facilities, but simply releasing all Mokelumne fish west of the interior Delta is not a feasible long-term management strategy. First, the practice of off-site releases is under considerable scrutiny based on the recommendations of the 2012 Hatchery Scientific Review Group. The recommendations call for on-site releases of all hatchery-produced fish to reduce the impact of straying to other systems, which is presumed to be exacerbated by off-site releases. Second, the naturally-produced population that outmigrates from the Lower Mokelumne River does not have the same advantage of bypassing the Delta to improve survival to the ocean. Mokelumne origin salmon are likely to continue to depend on the interior Delta as a migration pathway, and therefore sustainable, long-term improvement in survival rates requires Delta conditions that support survival and success of outmigrating fish.

B. Entrainment of Central Valley Steelhead

I believe there is a high probability that the existing operations of the South Delta Facilities result in significant entrainment of outmigrating Lower Mokelumne River steelhead in the export pumps. I base my opinion on evidence of a notable correlation between the similarity of timing and size of outmigrating naturally- and hatchery-produced Mokelumne steelhead, and the timing and size of naturally- and hatchery-produced steelhead at the South Delta Facilities. I also base my opinion on direct evidence of the entrainment of coded wire tagged Mokelumne hatchery steelhead in the South Delta Facilities.

1. Similarity of Migration Timing and Size of Mokelumne Outmigrating Steelhead to Timing and Size of Steelhead Entrained in the South Delta Facilities

The Lower Mokelumne River supports a Central Valley steelhead population of both hatchery and natural origin. Naturally-produced steelhead are distinguished from hatchery steelhead by their intact adipose fin, which is clipped from all hatchery steelhead before their release. Naturally-produced Mokelumne origin steelhead was listed as federally threatened in 1998 as part of the Central Valley Distinct Population Segment (DPS). NMFS recently recommended the addition of Mokelumne River Fish Hatchery steelhead stock to the federally threatened Central Valley DPS.[10] It is anticipated the hatchery stock will be included in the listing in the near future.

Figure 4 shows the close temporal relationship between Mokelumne naturally-produced steelhead outmigration and estimated naturally-produced steelhead losses at the South Delta Facilities. For the period 1998-2013, Figure 4 shows the percentage of naturally-produced yearling steelhead (adipose fin intact) outmigrating from the Lower Mokelumne River in each month, and the percentage of estimated naturally-produced

[10] National Marine Fisheries Service West Coast Region. 5-Year Review: Summary and Evaluation California Central Valley Steelhead Distinct Population Segment (May 5, 2016), § 2.1.4 (p. 9).

steelhead (adipose fin intact) losses of all origins at the South Delta Facilities in each month. The highest proportion of naturally-produced steelhead losses occur in the late winter and early spring (February through April), which is the same part of the year when the majority of Mokelumne origin naturally-produced yearling steelhead are outmigrating through the Delta.

Figure 5 shows a similar close temporal relationship between outmigration and losses with respect to hatchery-produced steelhead. Hatchery steelhead are consistently released as yearling smolts on the Mokelumne River east of the Central Delta, with the majority of releases occurring at Thornton (New Hope Landing) at River Mile 19, or further upstream. Figure 5 depicts the relationship between yearling hatchery steelhead released on the Lower Mokelumne River and estimated losses of hatchery steelhead at the South Delta Facilities in all years between 2000 and 2013 when yearling hatchery steelhead were released below Woodbridge Dam. Even though the timing of releases varied from year to year on the Mokelumne River, as Figure 5 indicates, each year demonstrates a notable pattern of losses of hatchery steelhead at the South Delta Facilities peaking shortly after releases on the Mokelumne River. The size of each peak in losses correlates with the size of the Mokelumne hatchery release immediately preceding it. Together, Figure 4 and Figure 5 illustrate the close relationship between Mokelumne steelhead migration timing and South Delta steelhead losses. I believe this relationship supports my opinion that a portion of steelhead losses at the pumps are of Mokelumne origin.

Fork length data provides additional evidence of this relationship. Fork lengths are a measure of fish size and are an indicator of age in juvenile steelhead. Based on their fork lengths, most steelhead losses in the South Delta Facilities appear to be yearling-sized fish. Salvaged naturally-produced steelhead have fork lengths similar to those observed on outmigrating naturally-produced Mokelumne yearling steelhead. Figure 6 plots the correlation between naturally-produced Mokelumne origin steelhead fork lengths (at the time of their outmigration), and the fork lengths of naturally-produced steelhead salvaged at the export pumps. There is a similar correlation between hatchery-produced Mokelumne origin steelhead fork lengths (at the time of their release) and the fork lengths of clipped steelhead salvaged at the export pumps, which is plotted in Figure 7. Considered together, the timing and fork length similarities between outmigrating Mokelumne steelhead and salvage or estimated losses of steelhead at the South Delta Facilities support the conclusion that Lower Mokelumne River steelhead comprise a portion of steelhead losses at the South Delta Facilities.

2. Direct Evidence of Mokelumne Steelhead Entrainment

While the timing and fork length data is a good indicator of the likelihood of Mokelumne River steelhead entrainment at the South Delta Facilities, there is also direct observational evidence of Mokelumne steelhead entrainment in the export pumps. Currently, hatchery steelhead are not coded wire tagged as are Chinook. However, EBMUD experimentally coded wire tagged hatchery steelhead between 2004 and 2006 and released the tagged fish on the Lower Mokelumne River at Thornton (New Hope Landing) at River Mile 19 between early February and early March. In each of those years, tagged steelhead from these release groups were recovered at the South Delta Facilities within one to ten weeks.

Dates Released	Dates Recovered in Salvage	First Release to First Salvage (Days)	Last Release to Last Salvage (Days)	Number Recovered in Salvage
2/2/2004 – 2/5/2004	2/12/2004 – 4/3/2004	10	58	93
2/7/2005 – 3/10/2005	2/24/2005 – 4/27/2005	17	48	30
2/22/2006 – 2/27/2006	2/28/2006 – 3/28/2006	6	29	23

Table 1. Salvage of coded wire tagged Mokelumne hatchery origin steelhead at South Delta Facilities (2004-06).

The coded wire tag salvage evidence, in conjunction with the correlative data discussed above, demonstrate that both naturally- and hatchery-produced yearling steelhead on the Lower Mokelumne River are vulnerable to entrainment at the South Delta Facilities at existing levels of export pumping.

C. Delayed Migration and Resulting Increased Risk of Mortality

Entrainment in the export pumps is not the only mortality risk to juvenile Mokelumne salmonids associated with the South Delta Facilities. Operation of the South Delta Facilities also tends to prolong the outmigration of salmonids, even at existing pumping levels. The more time juvenile salmonids spend in the Delta, the more susceptible they are to numerous stressors in the interior Delta. Outmigrating salmonids in the Delta are generally following a flow path to make their way the ocean. This migratory path can be altered based on a number of factors, including magnitude and direction of flow.[11] In the Central and South Delta, operations at the South Delta Facilities can create an artificial southerly net flow, altering the natural flow cues that migrating salmon rely on to reach the ocean. The southerly net flow may alter behavioral selection and lead to route entrainment into routes that may delay the migration process. If the southerly net flow is strong enough, the fish may follow it all the way to the export pumps. Even when the export pumps exert a lesser influence, they may still create complex flow dynamics that are confusing for salmon. In either case, the export pumps prolong the time salmon must spend in the interior Delta.

The increased time spent in the interior Delta adversely affects survival. With more time in the interior Delta, the salmonids have greater exposure to native and non-native predators, entrainment into unscreened agricultural diversions, and poor water quality conditions such as high water temperatures. An article authored in 2010 by Russell W. Perry and others provides a comprehensive review of literature addressing the mortality risks and factors associated with juvenile salmon migration through the interior Delta.[12] The WaterFix BiOp cites Perry's survival modeling extensively.[13] Perry's

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[11] Collaborative Science and Adaptive Management Program, January 2017 final report: Effects of Water Project Operations on Juvenile Salmonid Migration and Survival in the South Delta. Prepared for: Collaborative Adaptive Management Team Prepared by: Salmonid Scoping Team: January 2017. Appendix D. Juvenile Salmonid Migration Route Selection, p. D-14.

[12] Perry, R.W., J.R. Skalski, P.L. Brandes, P.T. Sandstrom, A.P. Klimley, A. Ammann, and B. MacFarlane. 2010. Estimating Survival and Migration Route Probabilities of Juvenile Chinook Salmon in the Sacramento–San Joaquin River Delta, N. Amer. J of Fish. Mgmt. 30(1):142-156. A true and correct copy of that article is submitted with my testimony as Exhibit EBMUD-183. Studies summarized therein include

2010 article notes that juvenile salmon in the interior Delta must traverse longer migration routes than Sacramento River fish that can bypass the interior Delta, and that survival of these fish decreases as water exports increase.[14] Decreased survival could be the result of increasing migration times through the interior Delta, with an accompanying increase in predator encounter rates and increased entrainment into the South Delta Facilities or into unscreened Delta diversions.

Based on Perry's work and other migration studies discussed in the WaterFix BiOp,[15] it is widely recognized that salmonids from the Sacramento River experience much lower survival when they outmigrate through the interior Delta rather than the Sacramento River. I believe Mokelumne River salmonids experience the same general threats to their survival when transiting through the interior Delta. I also believe they are affected by route entrainment due to changes in velocity and directional flow cues caused by export pumping in the same manner as the Sacramento River salmonids discussed by Perry. If the operation of the WaterFix project results in increased South Delta exports during the outmigration season, I believe the result would be a longer outmigration for Mokelumne salmonids, which I would expect to be associated with worse survival outcomes.

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Brandes and McLain (2001), Newman and Rice (2002), Newman (2003), Kimmerer (2008), and Newman and Brandes (2009) (see Perry article for full citations).

[13] *See* Exhibit SWRCB-106, WaterFix BiOp, *passim*. For an example of the WaterFix BiOp's use of Perry's work, *see id.* at § 2.5.1.2.7.1 (starting on p. 600) [discussing relationship between travel time and mortality].

[14] Perry, *supra* n.12, at p. 144, citing Brandes and McLain (2001) and Newman (2003), et al. (see Perry article for full citations).

[15] *See*, *e.g.*, Exhibit SWRCB-106, WaterFix BiOp, § 2.5.1.2.7.4.3.7.3 ["In recent years, telemetry studies of smolt movement through the Delta have revealed how flow influences migration rate (travel time), migratory routes used and overall survival (Perry 2010, Perry et al. 2012, Michel et al. 2013). These telemetry studies greatly increase our scientific understanding of migratory success or failure of smolts in the San Joaquin-Sacramento Delta and we have emphasized these finding *(sic)* throughout this Opinion."]

IV. POTENTIAL OF THE WATERFIX PROJECT TO INCREASE MORTALITY OF OUTMIGRATING JUVENILE MOKELUMNE RIVER SALMONIDS DUE TO MODELED INCREASE IN SOUTH DELTA EXPORT PUMPING

Thus far in my testimony, I have focused on the relationship between the South Delta Facilities and Mokelumne origin juvenile salmonid mortality under *existing* pumping conditions. In this section of my testimony, I will consider the WaterFix project's potential to exacerbate the existing impacts, which are already significant. Petitioners' modeling of WaterFix operations indicates the WaterFix project could be operated in a manner that results in increased exports through the South Delta Facilities in the crucial outmigration months of April and May. If pumping does in fact increase at the South Delta Facilities during that portion of the year, I believe the mortality impacts to juvenile Mokelumne salmonids would be likely to worsen.

A. Petitioners' Modeling Indicates that WaterFix Operations May Result in Increased Spring Pumping at the South Delta Facilities.

The WaterFix project includes an adaptive management process. The scenarios modeled in Petitioners' modeling fall within the range of foreseeable outcomes of that adaptive management process.[16] Petitioners' modeling shows that the range of foreseeable operational scenarios includes scenarios which may worsen the existing impacts of the South Delta Facilities on the survival of outmigrating Mokelumne juvenile fall run Chinook salmon and yearling steelhead.

In support of their water rights change petition, Petitioners modeled Water Years 1922 through 2003 for five scenarios: two boundary scenarios (B1 and B2), two additional action scenarios (H3 and H4), and a NAA. The modeled South Delta diversions in each of the five scenarios are plotted as a time series for each of the four months with the highest number of outmigrating Mokelumne salmonids (March, April, May, and June) on Figures 8, 9, 10, and 11, respectively. The same model output data

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[16] *See* Exhibit SWRCB-102 "Bay Delta Conservation Plan/California WaterFix Final Environmental Impact Report / Environmental Impact Statement," December 2016, § 5.3.4.2 (p. 5-167) ["Conveyance facilities would be operated under an adaptive management range represented by Boundary 1 and Boundary 2… ."]

is plotted in exceedance curve format for April (Figures 12 and 13) and May (Figures 14 and 15). For the exceedance curves, the model data has been separated into two groups – "wet years" and "dry years" – to illustrate impacts in different hydrological conditions.[17]

Increased South Delta diversions (compared to the NAA) are modeled to occur in April and May in both wet years and dry years (see Figures 9–10 and Figures 12–15). Increased diversions occur persistently in April and May under the Boundary 1 scenario, a significant percentage of the time under H3, and even under H4 to a lesser extent. When the model output data is disaggregated into "wet years" and "dry years," more scenarios show increased pumping rates and frequency compared to the NAA. The potential for increased South Delta diversions in the WaterFix operational scenarios (compared to the NAA) appears to be particularly acute in dry years during April, when excess South Delta diversions are modeled to occur in three different modeled WaterFix operational scenarios: 100% of the time in the Boundary 1 scenario, about 45% of the time in the H3 scenario, and approximately 40% of the time in the H4 scenario (see Figure 13). Therefore, the risk of increased South Delta diversions (and the consequential impacts to Mokelumne salmon and steelhead) is by no means limited to the boundary operational scenario. To the contrary, increased diversions and fishery impacts may well occur during the critical migration window even if actual WaterFix project operations more closely resemble H3 or H4.

It should be noted that the increased South Delta diversions in the WaterFix operational scenarios are not modeled to occur uniformly throughout the entire Mokelumne salmonid outmigration period. Generally speaking, March and June feature

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[17] For these purposes, "wet years" are Wet, Normal and Below Normal year types from the Sacramento River Index, and "dry years" are Dry and Critically Dry year types from the Sacramento River Index. Over the 82-year modeled period (Water Years 1922 through 2003), there were 50 "wet years" and 32 "dry years." The "wet years" are 1922-23, 1927-28, 1936, 1938-43, 1945-46, 1948, 1951-54, 1956-59, 1962-63, 1965-75, 1978, 1980, 1982-86, 1993, 1995-2000, and 2003. The "dry years" are 1924-26, 1929-35, 1937, 1944, 1947, 1949-50, 1955, 1960-61, 1964, 1976-77, 1979, 1981, 1987-92, 1994, and 2001-02.

reduced South Delta diversions in each of the four WaterFix project scenarios, as compared with the NAA (see Figure 8 and Figure 11).

B. Potential Impacts to Mokelumne Chinook and Steelhead from Increased South Delta Diversions in WaterFix Operational Scenarios

Petitioners' modeling results illustrate the potential for WaterFix project operations to cause actual harm to Mokelumne juvenile salmonids migrating through the Delta. Current pumping rates already entrain juvenile Chinook and yearling steelhead and delay their migration through the Delta, increasing their exposure to interior Delta stressors, as explained in Section III of this testimony. If pumping increases during this period of outmigration for Mokelumne young of year Chinook and yearling steelhead – which Petitioners' modeling indicates is within the potential range of adaptive management outcomes – I believe the result would be an opportunity for even more entrainment and losses from these populations.

The impacts would be most acute if WaterFix operations resemble the Boundary 1 scenario. That scenario is associated with a consistent, significant increase in South Delta pumping during the crucial months of April and May. The increased exports would be likely to have a direct impact on steelhead mortality. Figure 16 depicts the correlation between export pumping volumes and steelhead losses. That figure plots daily South Delta exports against estimated steelhead losses at the South Delta Facilities over the period 1993-2016. The plot shows that losses increase steadily as export volumes increase. Because Mokelumne steelhead are vulnerable to entrainment in the South Delta Facilities, increased pumping at those facilities would likely lead to an increase in Mokelumne steelhead entrainment.

Mokelumne Chinook may be impacted by increased South Delta exports similarly to steelhead. The relationship between export flows and Chinook salmon salvage is

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depicted on Figure 17, which originally appeared in Kimmerer (2008).[18] Figure 17 shows that the estimated proportion of migrating Chinook salvaged at the export facilities increases with increasing export flow. This evidence suggests the increased South Delta exports that appear in the WaterFix model results will likely lead to increased entrainment for Mokelumne Chinook in addition to Mokelumne steelhead.

WaterFix may cause these impacts to Chinook and steelhead even if it is operated to the H3 or H4 scenarios, rather than the Boundary 1 scenario. The increased South Delta diversions modeled to occur in three different modeled project scenarios in April of dry years are especially worrisome. Under the H3 scenario, South Delta exports would increase as a result of WaterFix operations roughly half the time. This result is problematic for two reasons. First, it shows that a middle-of-the-road operational scenario may lead to increased South Delta exports at key times. Second, it shows that increased South Delta pumping would not just occur in wet years when the WaterFix project is taking a "big gulp" of excess water. To the contrary, the additional pumping in April would be most pronounced in *dry* years (compare Figure 12 with Figure 13), which is when outmigrating Mokelumne salmonids would be least able to adapt to increased pumping. Migrating juvenile salmonids are under particularly great stress in dry years, when reduced streamflow and increased temperatures reduce habitat quality and quantity, which renders the fish ill-equipped to handle difficult Delta conditions. I believe significant population-level effects could result if South Delta exports increase in Spring months of consecutive dry years during the outmigration season.

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[18] Kimmerer, W.J. 2008. Losses of Sacramento River Chinook salmon and delta smelt to entrainment in water diversions in the Sacramento–San Joaquin Delta. San Francisco Estuary and Watershed Science 6(2): article 2.

V. MITIGATING CONDITIONS

A. Petitioners' Proposed Mitigation Actions are Insufficient to Protect Outmigrating Mokelumne River Origin Salmonids.

Petitioners have not committed to any mitigation that would protect against WaterFix-caused exacerbation of Delta impacts to Mokelumne River juvenile salmonids. Petitioners have provided no specific operations plan for WaterFix and appear to propose that a water rights approval only require compliance with existing BiOp and Water Quality Control Plan requirements.[19] While the existing BiOps in their present form would appear to prevent immediate operation to the Boundary 1 scenario, due to the need to meet Fall X2 requirements, existing requirements can change over time and, in my opinion, are not a sufficient substitute for permanent water rights conditions that are appropriate and necessary to protect against harm to fisheries.

I found no analysis in the WaterFix BiOp directed specifically at WaterFix operational impacts on Mokelumne River fall run Chinook or steelhead fisheries. The WaterFix BiOp, and Petitioners' environmental documents, do discuss South Delta entrainment in general terms,[20] but the mitigation measures proposed in those documents would be unlikely to benefit the Mokelumne fisheries. Petitioners' WaterFix environmental document "reiterates commitments to certain non-operational habitat and related actions that are part of the NMFS 2009 OCAP BiOp RPA."[21] Those actions were intended to "reduc[e] juvenile salmon entry into the interior Delta" by removing barriers,

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[19] September 8, 2017 letter from Tripp Mizell and Amy Aufdemberge to Hearing Officers Felicia Marcus and Tam Doduc responding to August 31, 2017 ruling regarding scheduling of Part 2 and other procedural matters.

[20] *See* Exhibit SWRCB-108 "Developments After Publication of the Proposed Final Environmental Impact Report," July 2017, pp.160-161, and Exhibit SWRCB-106, National Marine Fisheries Service (NMFS) Biological Opinion for the California WaterFix Project, June 2017.

[21] Exhibit SWRCB-108, "Developments After Publication of the Proposed Final Environmental Impact Report," July 2017, p. 106.

improving access to the Yolo Bypass, and other engineering-based measures.[22] Discouraging fish entry to the interior Delta may help protect Sacramento River fish, but Mokelumne origin fish, unlike fish from the Sacramento River, have no choice but to migrate through the interior Delta (see Figure 1). Engineering-based mitigation measures designed to keep migrating fish out of the interior Delta are insufficient to protect the Mokelumne River's anadromous fisheries. Instead, operational restrictions are required to prevent increased South Delta pumping.

B. <u>The State Water Board Should Condition Any WaterFix Project Approval to Reduce Impacts to Outmigrating Mokelumne River Salmonids.</u>

The public trust and the health of the Mokelumne River anadromous fisheries require that steps be taken to ensure the *modeled* increase in April-May South Delta exports will not translate into an *actual* increase during that sensitive time. NMFS has recognized the importance of reducing exports to prevent entrainment. NMFS's 2009 BiOp for the Operations Criteria and Plan (OCAP) called for reduced exports from the South Delta Facilities, "when large numbers of juvenile Chinook salmon are migrating into the upper Delta region, at risk of entrainment into the Central and South Delta and to the export pumps in the following weeks."[23] Unfortunately, this mitigation measure does not adequately protect Mokelumne fish because it is designed and implemented in a manner tailored to Sacramento River fisheries.

However, I believe the Mokelumne River fisheries could and should receive similar protection against increased South Delta exports through water rights conditions included in any approval of Petitioners' change petition. Conditions should be adopted that (1) ensure reverse flows in the south Delta do not exceed a level that is protective of migrating juvenile salmonids, and (2) develop scientific and practical information

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[22] *Id.*; *see also* Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project, National Marine Fisheries Service, Southwest Region, June 4, 2009 (2009 NMFS OCAP BiOp), RPA Action Suite I.6 (pp. 607-610), and RPA Actions I.7 and IV.1.3 (pp. 611, 640-641).

[23] 2009 NMFS OCAP BiOp, RPA Action IV.3 (pp. 652-653).

needed to improve the ability to address potential impacts of WaterFix operations through adaptive management of the Mokelumne River Chinook and steelhead fisheries.

EBMUD requests that the State Water Board include the following water right conditions in any approval of Petitioners' requested change petition:

1. To protect outmigrating juvenile salmonids affected by changes in the direction of flows, exports from the Jones and Banks Pumping Plants shall be reduced as necessary to maintain Old and Middle River (OMR) flows between April 1 and May 31 that are not more negative than the OMR flow criteria specified for April and May in Table 3.3-1 on page 3-84 of Appendix A2 of the California WaterFix Biological Opinion issued by the National Marine Fisheries Service on June 16, 2017.

2. To develop scientific and practical information needed to further improve management of Mokelumne River Chinook and steelhead fisheries, Petitioners shall fund and participate in the development and implementation of two research actions: (1) a six-year interim trap-and-barge plan designed to determine whether a trap-and-barge program is a feasible means to improve survival rates and offset potential WaterFix impacts to outmigrating Mokelumne salmonids, and (2) a ten-year monitoring plan designed to determine how migration of tagged Mokelumne River salmonids through the Delta is affected by operations of certain of Petitioners' water conveyance facilities under the existing condition and under WaterFix operations. Both research actions shall be implemented substantially as described in Exhibit EBMUD-184.

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VI. <u>CONCLUSION</u>

Juvenile Chinook and steelhead migrating from the Mokelumne River are impacted by operations of the South Delta Facilities. Those impacts may worsen if WaterFix is approved, according to Petitioners' modeling. Because the mitigation actions Petitioners have proposed are insufficient to protect outmigrating Mokelumne River salmonids, any approval of Petitioners' change petition should include specific, enforceable conditions to protect Mokelumne fisheries.

Executed this 29th day of November, 2017 in Lodi, California.

Michelle L. Workman

MICHELLE L. WORKMAN

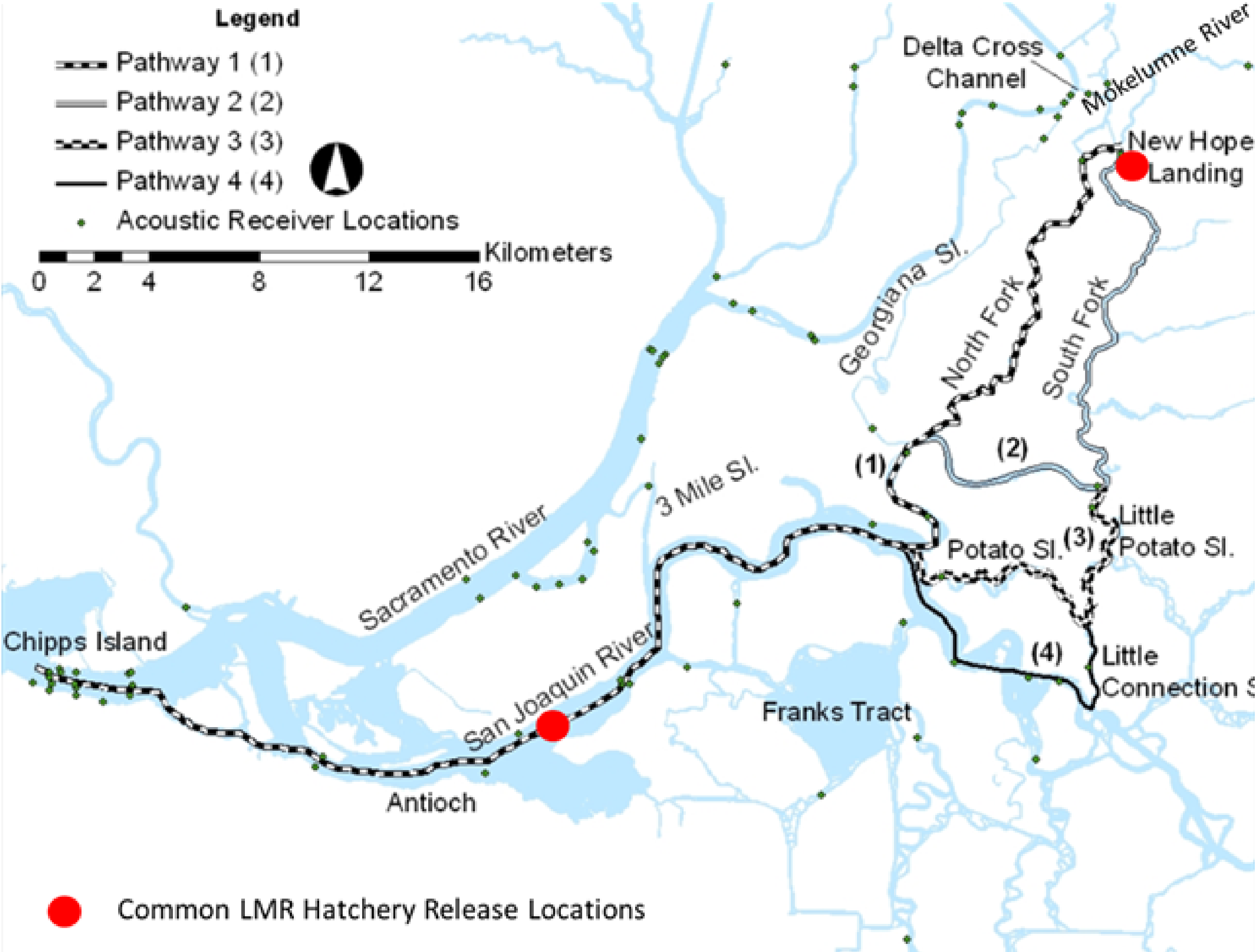


Figure 1. Common release sites for Mokelumne River Chinook salmon and steelhead and known migration routes used by yearling steelhead smolts. Graphic depicts that natural origin Lower Mokelumne River salmonids must navigate through the interior Delta to exit to the ocean, while hatchery releases may have the opportunity to bypass the interior Delta to survive to the ocean.

Source: Del Real, S.C., M.L. Workman, and J.E. Merz. 2011. Migration characteristics of hatchery and natural-origin Oncorhynchus mykiss from the lower Mokelumne River, California. Environ. Biol. Fishes 94:363–375.

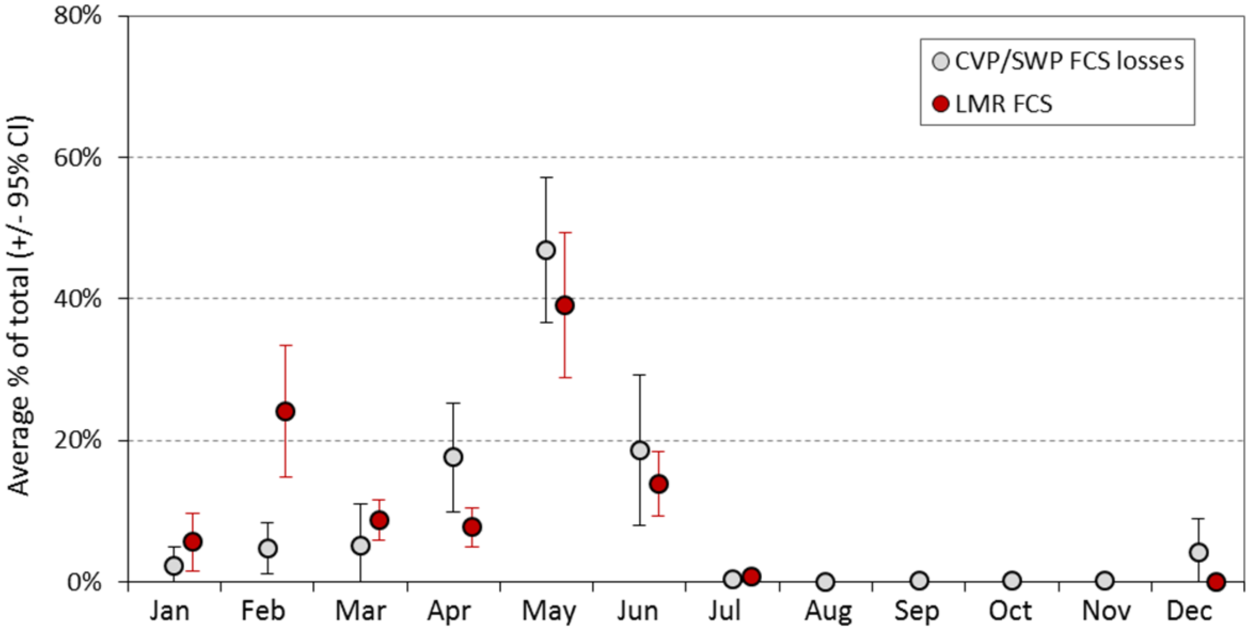


Figure 2. Average monthly percentage (+/– 95% CI) of natural origin fall run Chinook salmon captured at the downstream juvenile fish traps on the Lower Mokelumne River at River Mile 38 and the estimated fall-run Chinook salmon losses at the export facilities of all origins (evaluated from 1994-2014). Figure depicts the correlation of timing of fish leaving the Mokelumne River with arrival of all Chinook salmon at the South Delta Facilities.

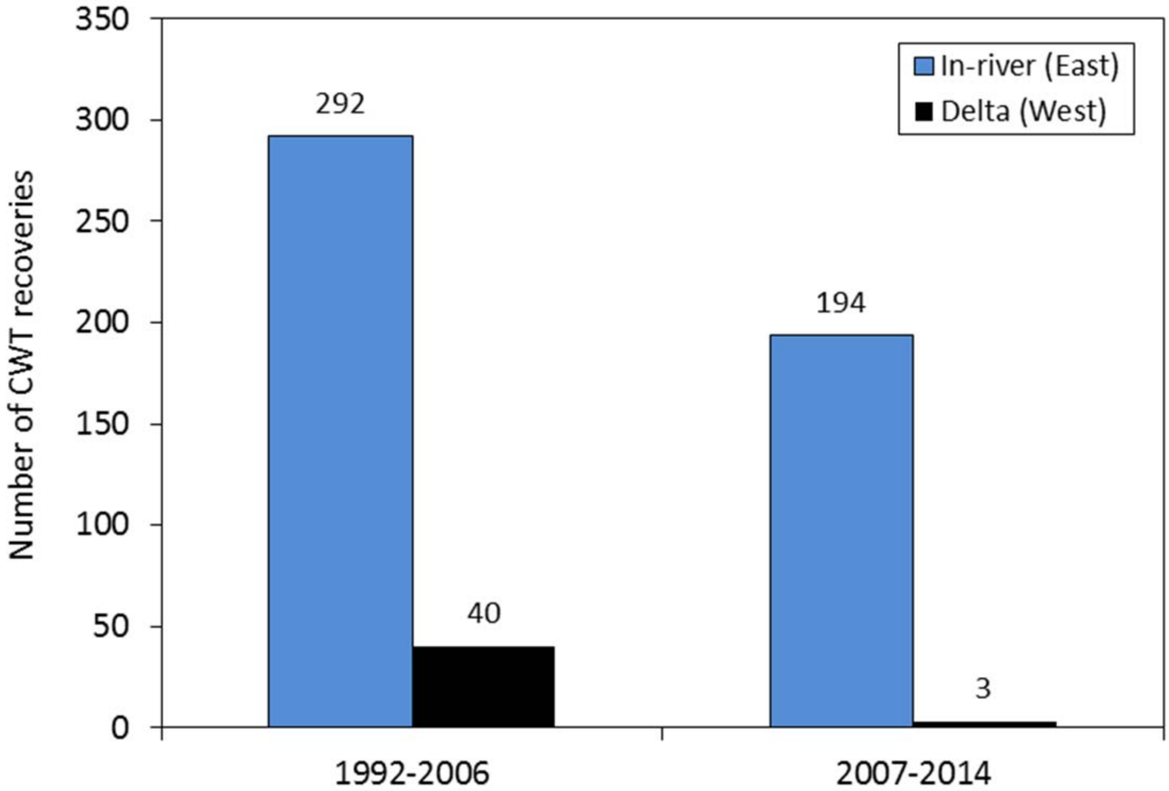


Figure 3. The number of Mokelumne origin coded wire-tagged Chinook salmon recoveries at the CVP/SWP export facilities before and after the year 2007. Blue bars indicate salvaged Mokelumne River Fish Hatchery (MRFH) Chinook salmon released at locations within the lower Mokelumne River (east of the Delta). Black bars indicate MRFH Chinook released at locations within the Delta, west of the lower Mokelumne River. Starting in 2007, MRFH Chinook have generally been released within the Delta and have been released east of the Delta only on an experimental basis, yet salvage continued to consist almost exclusively of Chinook released east of the Delta.

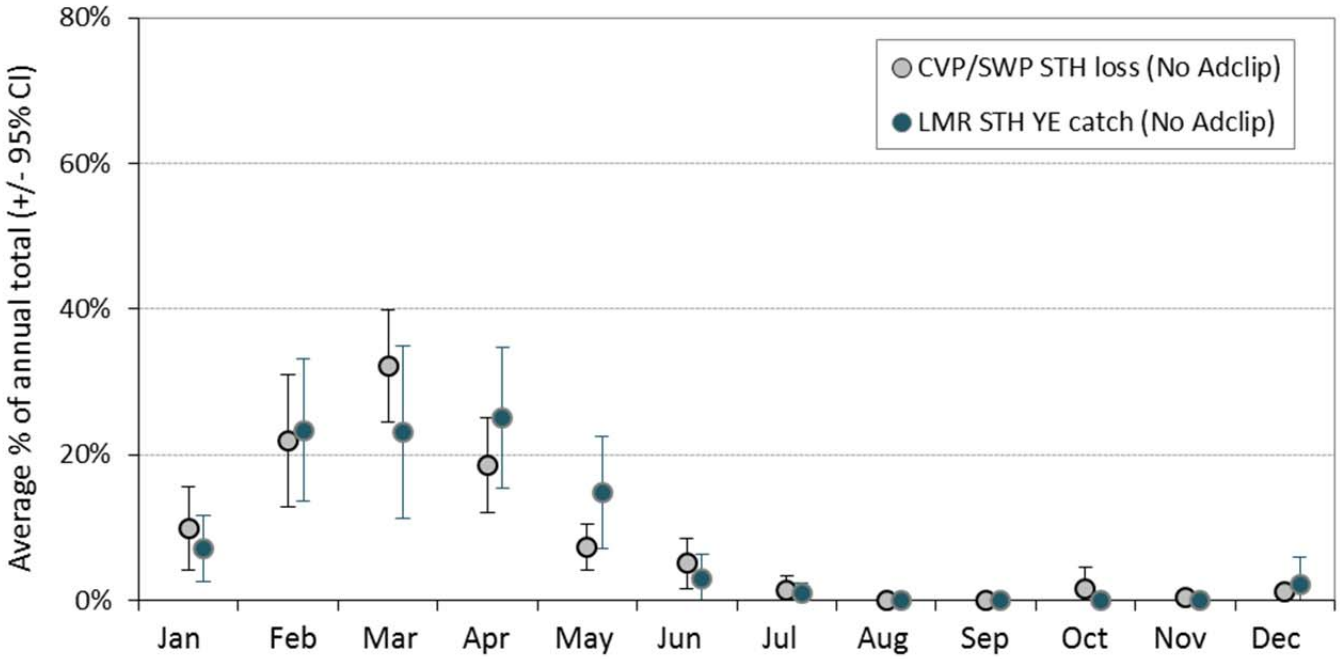
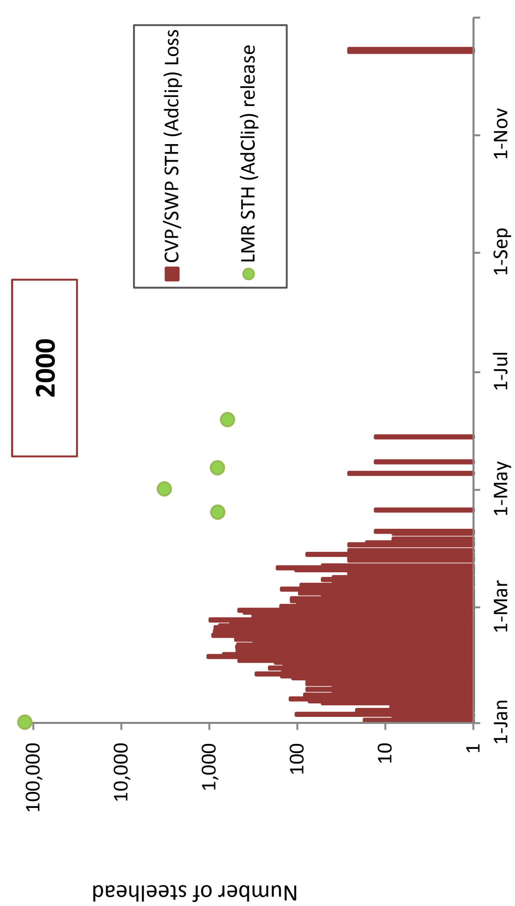
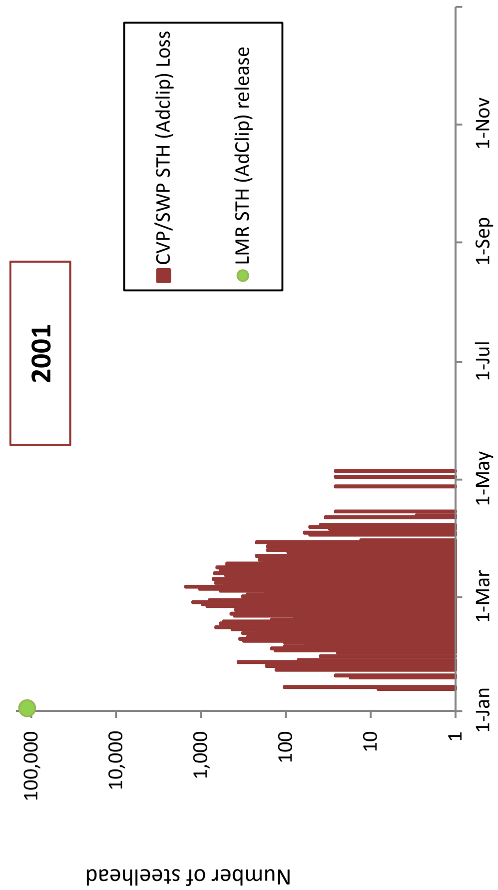
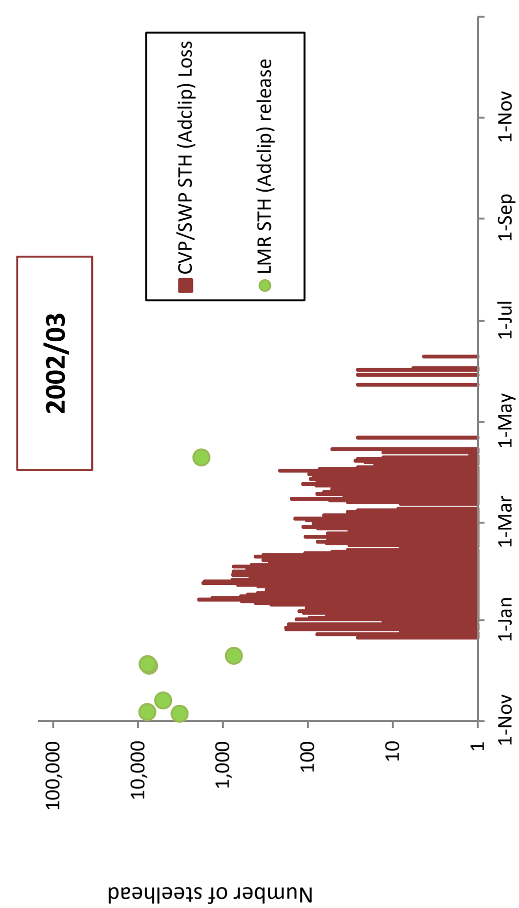


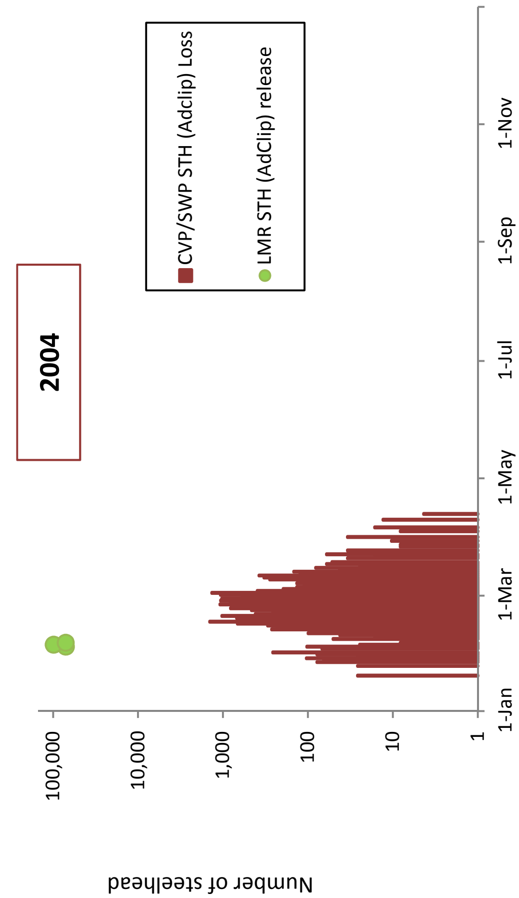
Figure 4. Average monthly timing (+/– 95% CI) of naturally produced Lower Mokelumne River steelhead (STH) yearlings and adults captured at the downstream rotary screw traps and estimated naturally produced steelhead losses at the South Delta Facilities (1998-2013). No Adclip indicates the presence of an adipose fin, possessed by naturally produced steelhead. The adipose fin is removed from all hatchery produced steelhead prior to their release.

EBMUD-156


2000
CVP/SWP STH (Adclip) Loss
LMR STH (AdClip) release
Number of steelhead
100,000
10,000
1,000
100
10
1
1-Jan
1-Mar
1-May
1-Jul
1-Sep
1-Nov


2001
CVP/SWP STH (Adclip) Loss
LMR STH (AdClip) release
Number of steelhead
100,000
10,000
1,000
100
10
1
1-Jan
1-Mar
1-May
1-Jul
1-Sep
1-Nov


2002/03
CVP/SWP STH (Adclip) Loss
LMR STH (Adclip) release
Number of steelhead
100,000
10,000
1,000
100
10
1
1-Nov
1-Jan
1-Mar
1-May
1-Jul
1-Sep
1-Nov


2004
CVP/SWP STH (Adclip) Loss
LMR STH (AdClip) release
Number of steelhead
100,000
10,000
1,000
100
10
1
1-Jan
1-Mar
1-May
1-Jul
1-Sep
1-Nov

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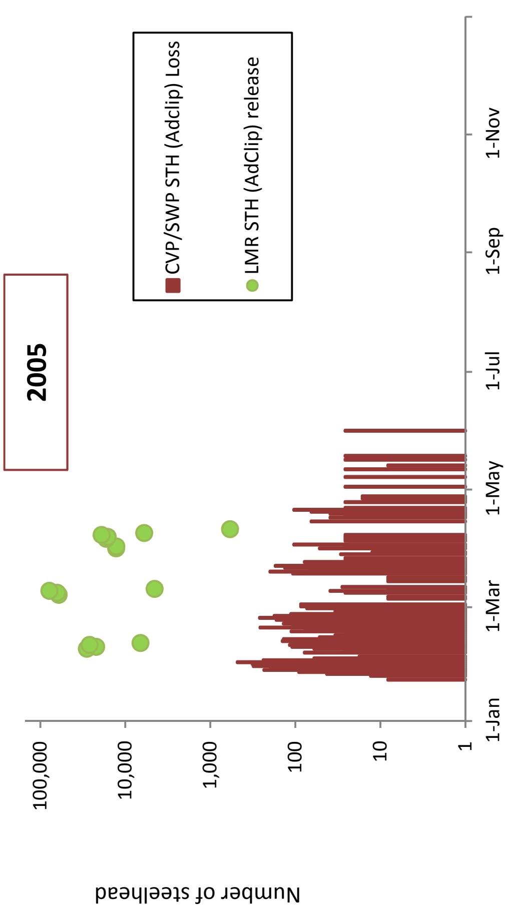
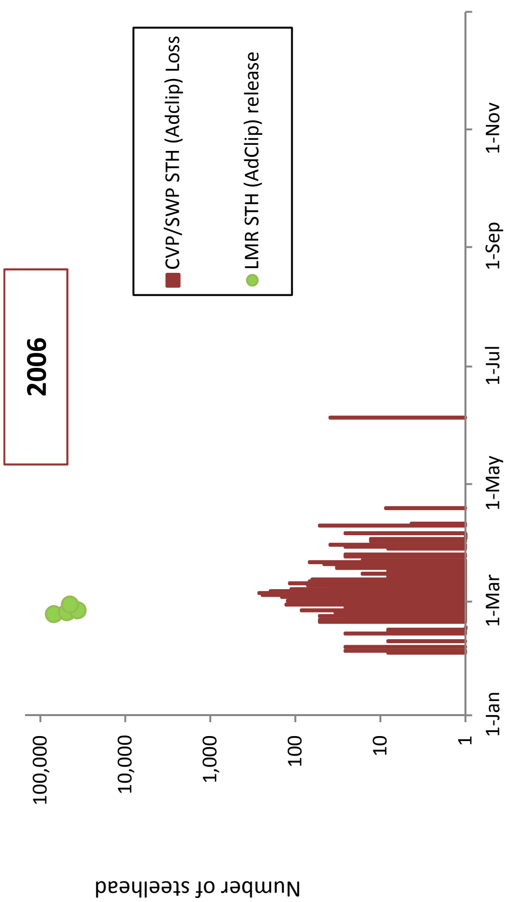
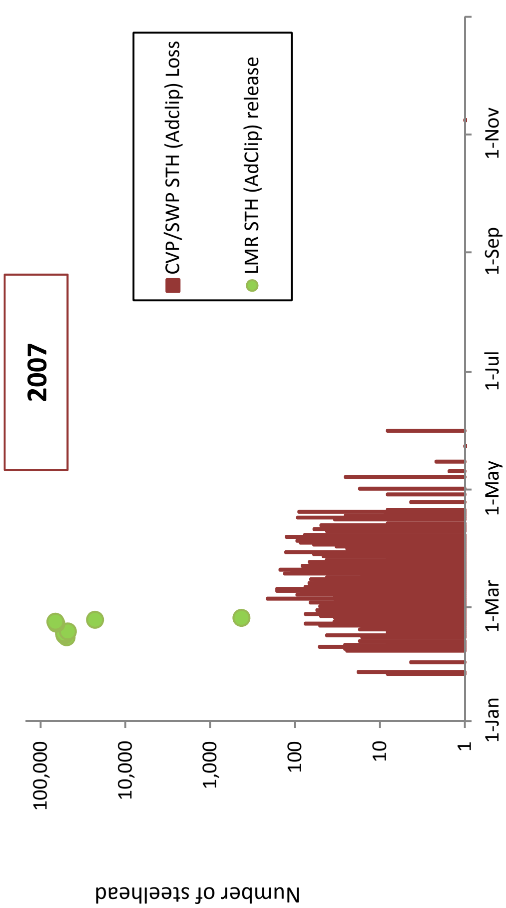
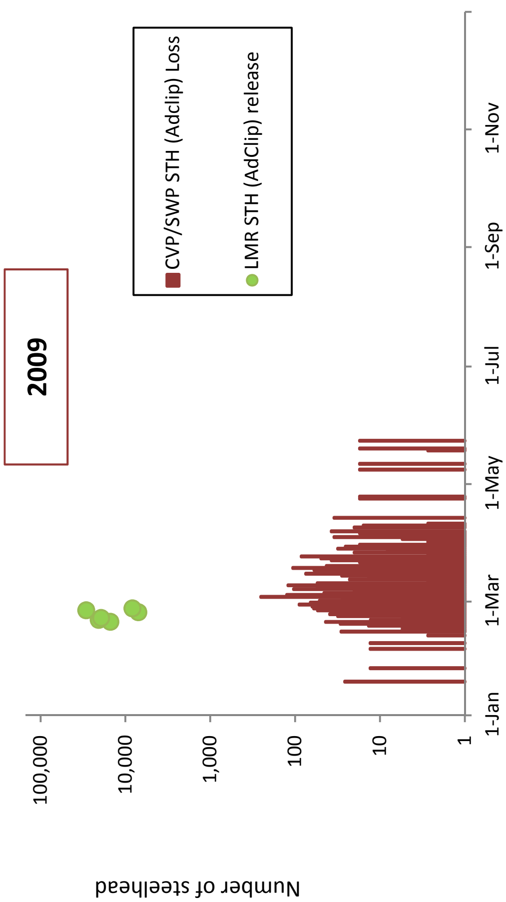
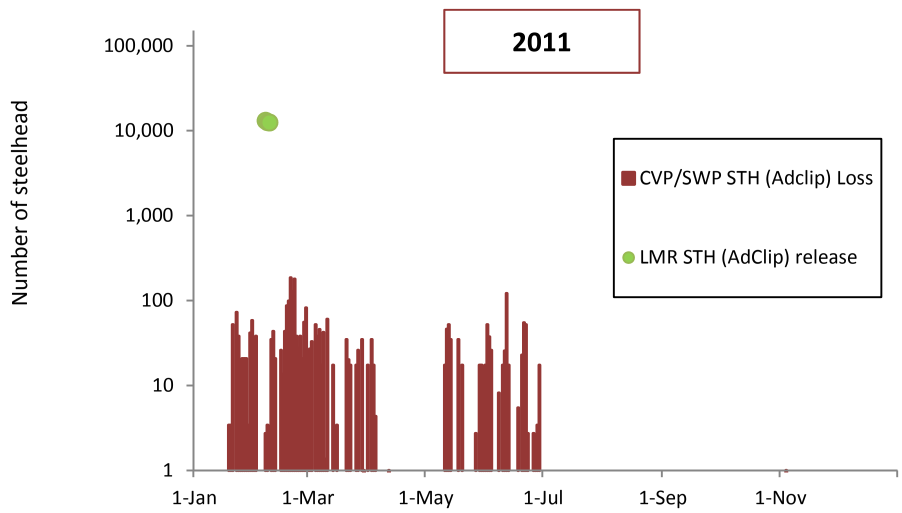
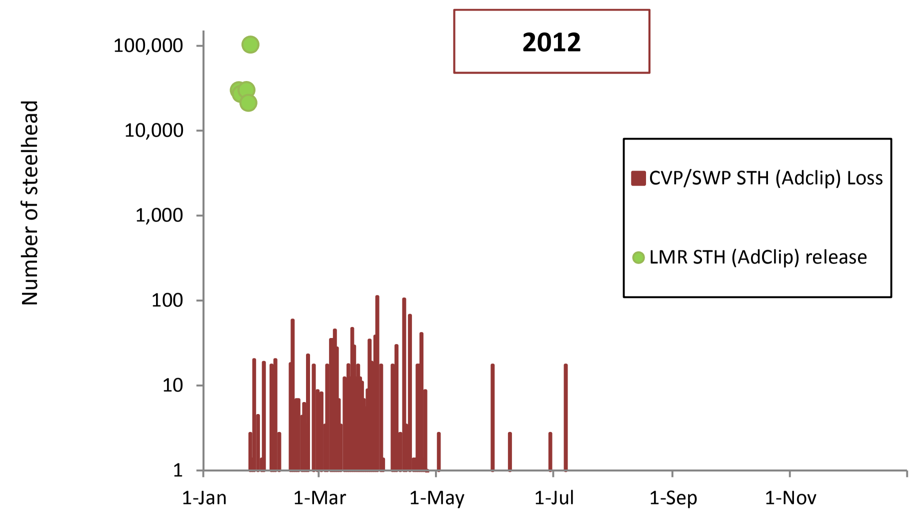

2005
CVP/SWP STH (Adclip) Loss
LMR STH (AdClip) release
Number of steelhead
100,000
10,000
1,000
100
10
1
1-Jan
1-Mar
1-May
1-Jul
1-Sep
1-Nov


2006
CVP/SWP STH (Adclip) Loss
LMR STH (AdClip) release
Number of steelhead
100,000
10,000
1,000
100
10
1
1-Jan
1-Mar
1-May
1-Jul
1-Sep
1-Nov


2007
CVP/SWP STH (Adclip) Loss
LMR STH (AdClip) release
Number of steelhead
100,000
10,000
1,000
100
10
1
1-Jan
1-Mar
1-May
1-Jul
1-Sep
1-Nov


2009
CVP/SWP STH (Adclip) Loss
LMR STH (AdClip) release
Number of steelhead
100,000
10,000
1,000
100
10
1
1-Jan
1-Mar
1-May
1-Jul
1-Sep
1-Nov





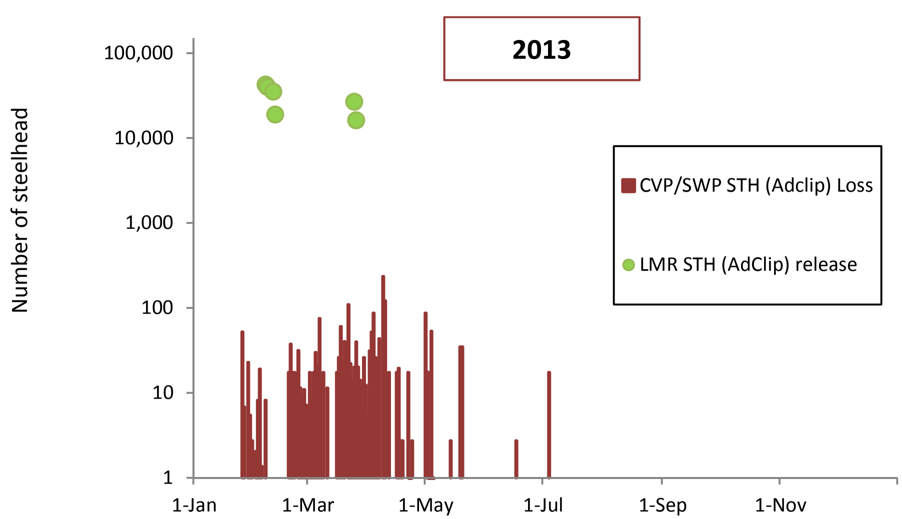


Figure 5. Graphs on these three pages depict the relationship between hatchery steelhead (STH) releases on the Lower Mokelumne River (LMR) and estimated losses of hatchery steelhead at the South Delta Facilities (CVP/SWP), 2000-2013. LMR steelhead releases depict yearling releases below Woodbridge Dam. The years 2008 and 2010 are excluded because in those years, yearling steelhead releases were made upstream of Woodbridge, just below Camanche Dam.

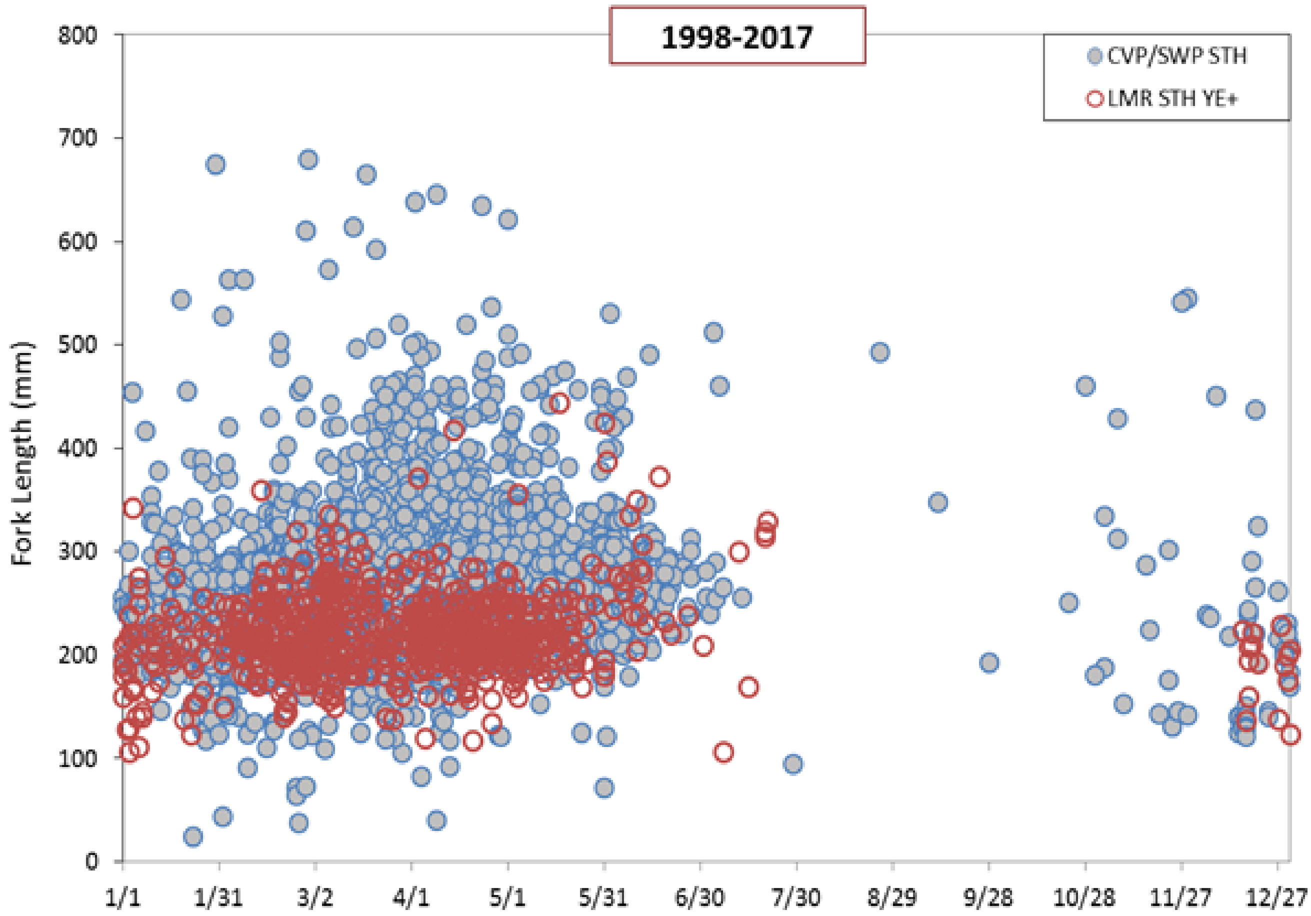


Figure 6. The fork length of naturally produced Lower Mokelumne River steelhead (STH) yearlings and adults (YE+) captured at downstream traps on the Mokelumne River compared with the fork length of all natural origin steelhead recoveries at the Central Valley Project (CVP) and State Water Project (SWP) export facilities (1998-2017). No Adclip indicates the presence of an adipose fin, possessed by naturally produced steelhead. The adipose fin is removed from all hatchery produced steelhead prior to their release.

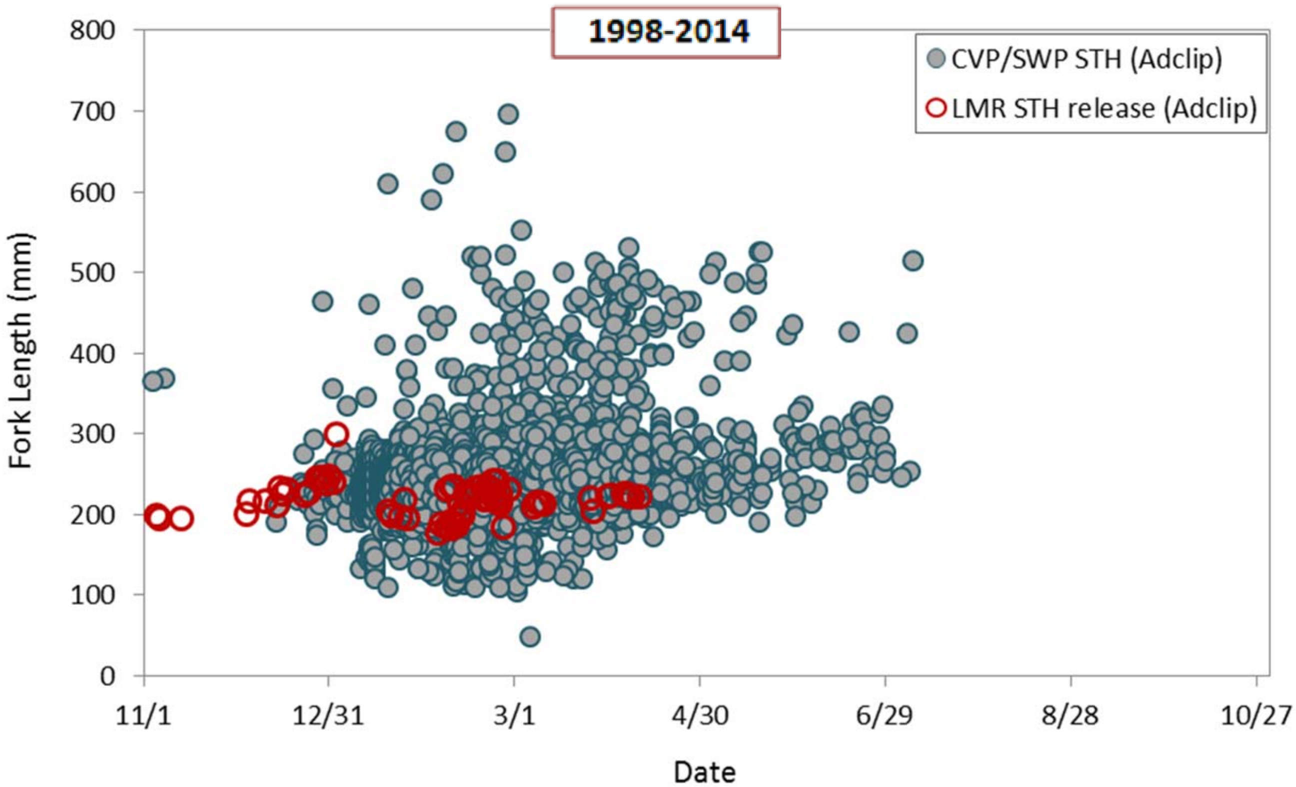


Figure 7. The estimated fork lengths of Mokelumne River hatchery steelhead release groups and the fork lengths of all hatchery steelhead (Adclip) recoveries at the CVP/SWP export facilities from 1998 through 2014.

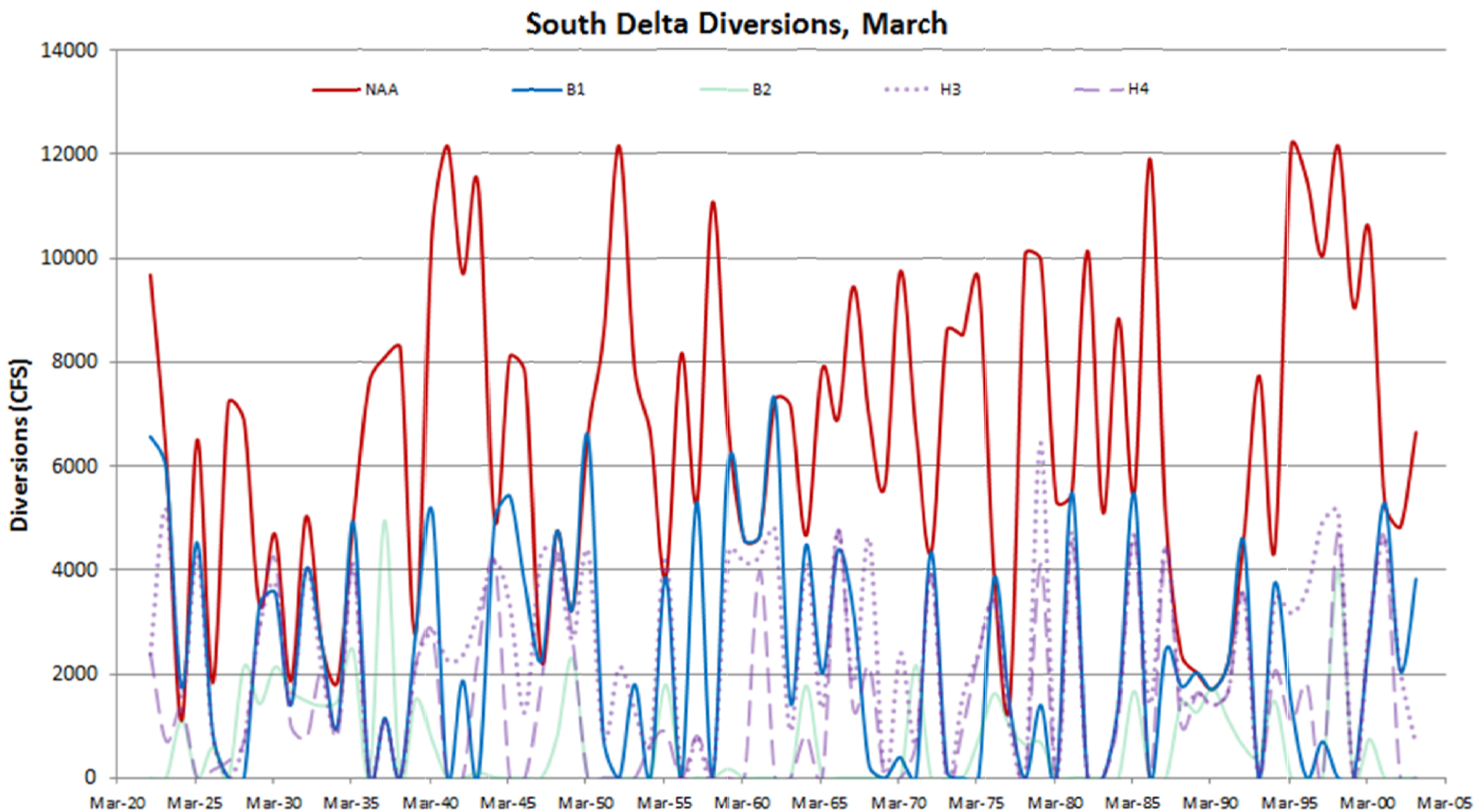


Figure 8. Simulated Diversions from the South Delta, March timeseries 1921-2003, WaterFix Hearing Scenarios: No Action Alternative (NAA), and Proposed Actions B1, B2, H3, and H4.

Source: Model output data released by Petitioners in May 2016 in support of their water rights change petition (Exhibit DWR-500).

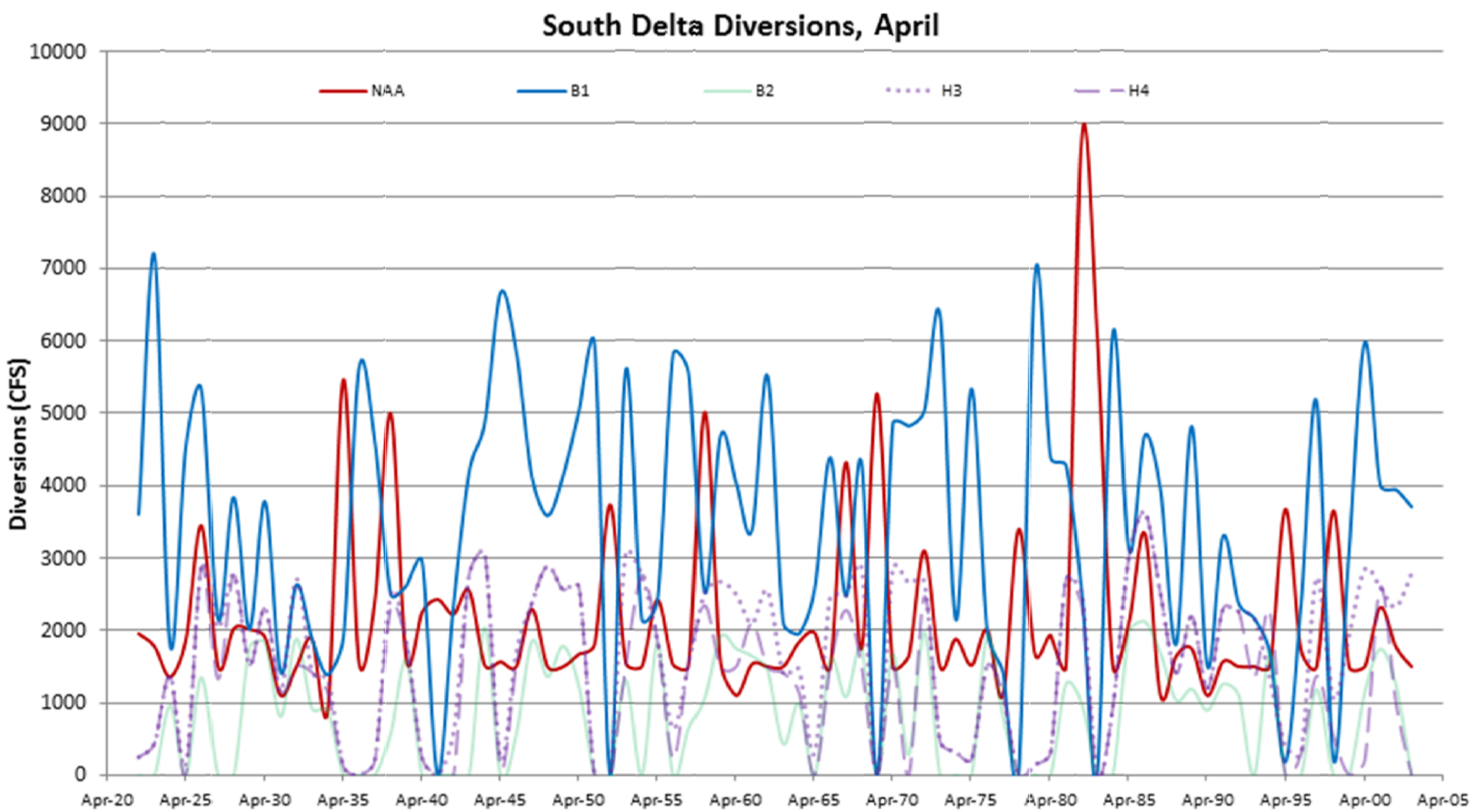


Figure 9. Simulated Diversions from the South Delta, April timeseries 1921-2003, WaterFix Hearing Scenarios: No Action Alternative (NAA), and Proposed Actions B1, B2, H3, and H4.

Source: Model output data released by Petitioners in May 2016 in support of their water rights change petition (Exhibit DWR-500).

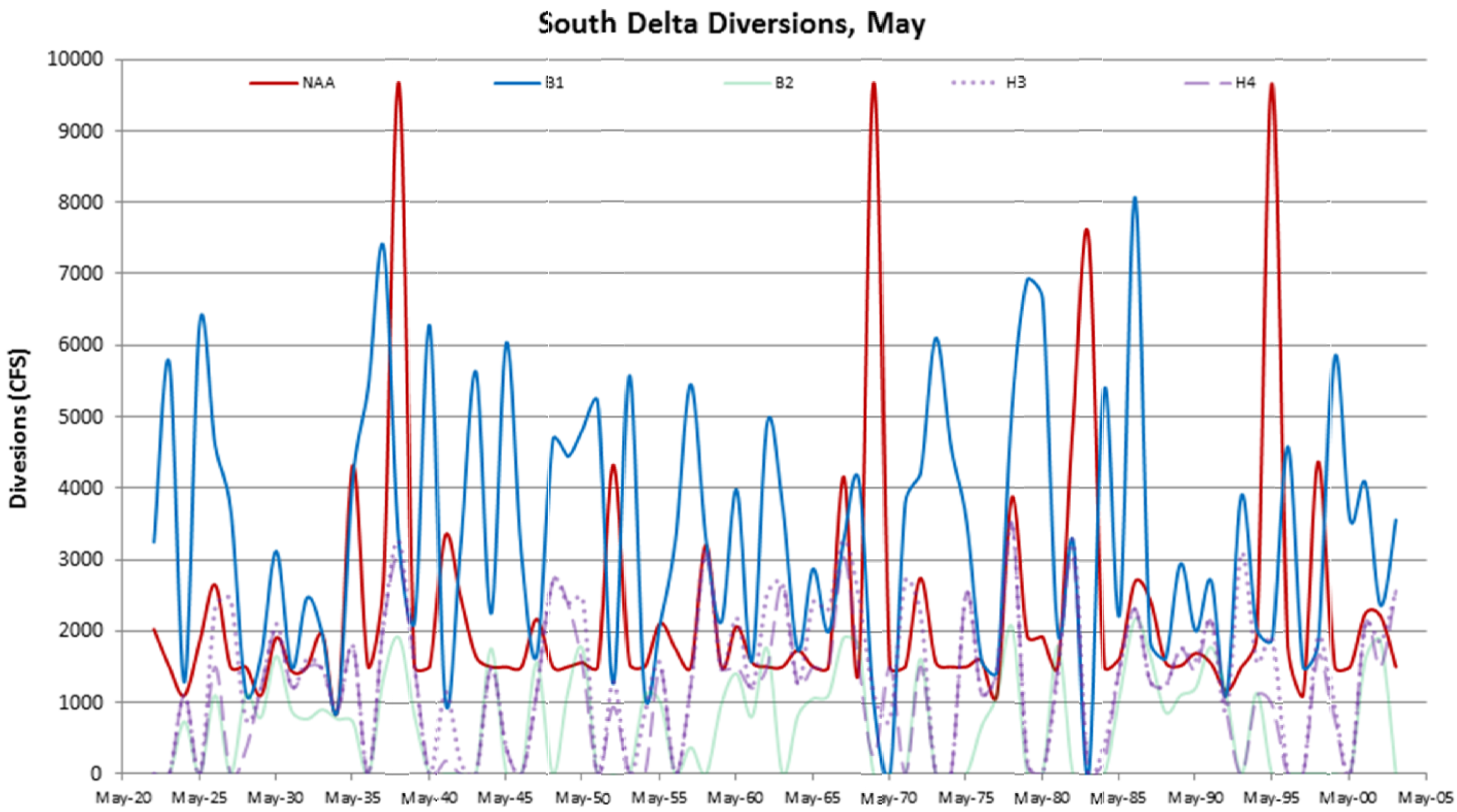


Figure 10. Simulated Diversions from the South Delta, May timeseries 1921-2003, WaterFix Hearing Scenarios: No Action Alternative (NAA), and Proposed Actions B1, B2, H3, and H4.

Source: Model output data released by Petitioners in May 2016 in support of their water rights change petition (Exhibit DWR-500).

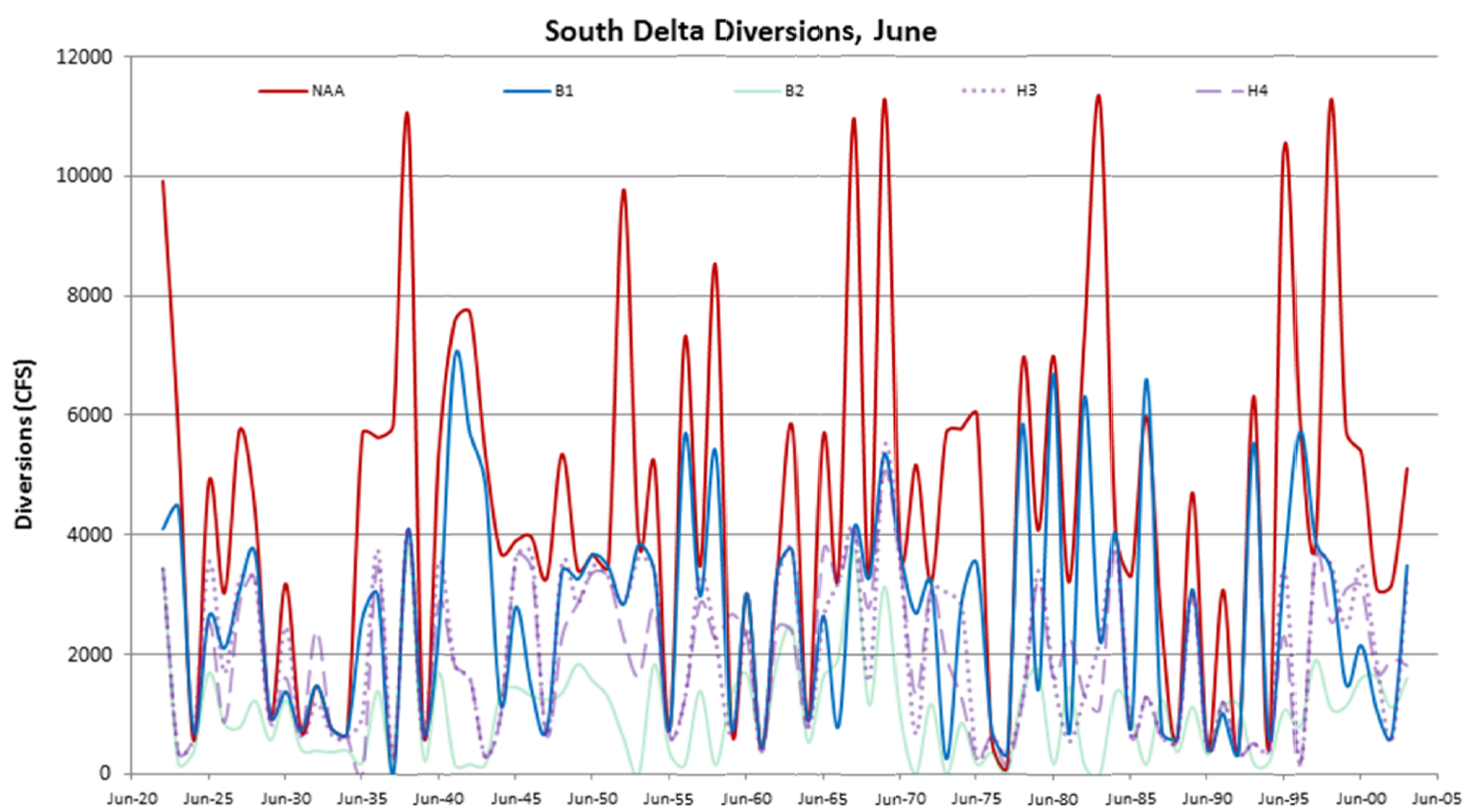


Figure 11. Simulated Diversions from the South Delta, June timeseries 1921-2003, WaterFix Hearing Scenarios: No Action Alternative (NAA), and Proposed Actions B1, B2, H3, and H4.

Source: Model output data released by Petitioners in May 2016 in support of their water rights change petition (Exhibit DWR-500).

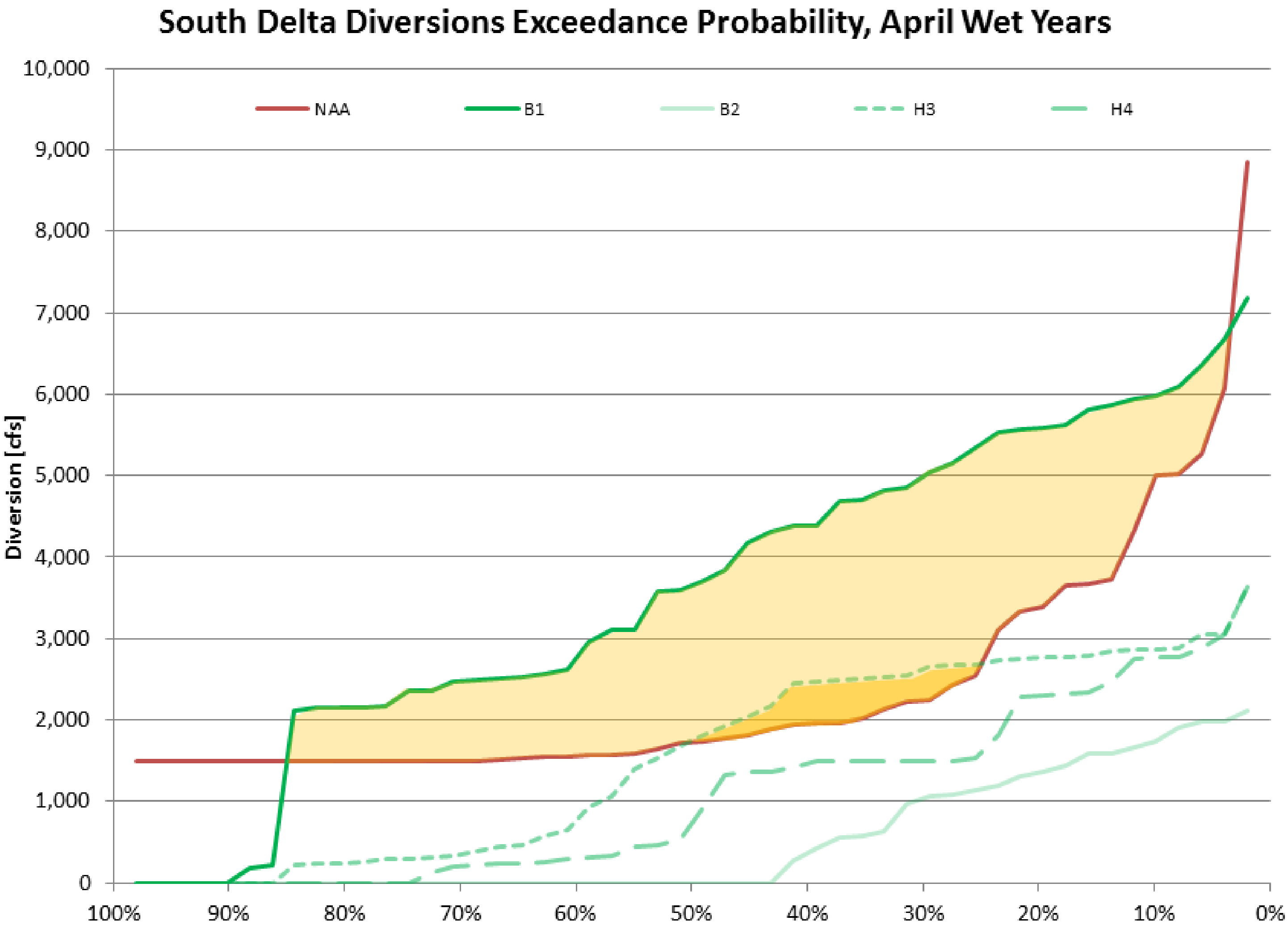


Figure 12. Exceedance Probability of Preferential South Delta Diversions, Wet Years, April 1922-2003 (N=50), WaterFix Hearing Scenarios: No Action Alternative (NAA), and Proposed Actions B1, B2, H3, and H4.

Source: Model output data released by Petitioners in May 2016 in support of their water rights change petition (Exhibit DWR-500).

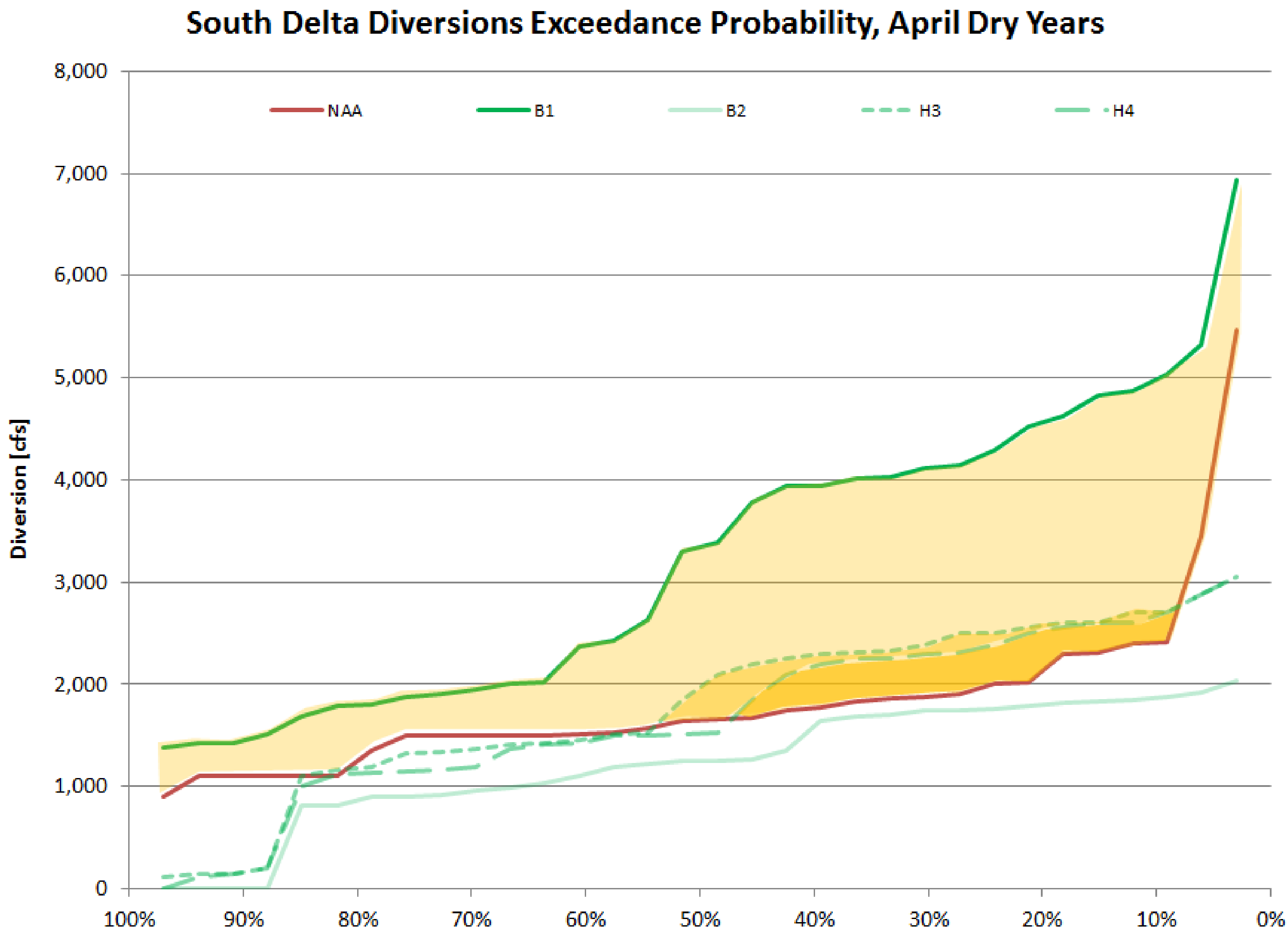


Figure 13. Exceedance Probability of Preferential South Delta Diversions, Dry Years, April 1922-2003 (N=32), WaterFix Hearing Scenarios: No Action Alternative (NAA), and Proposed Actions B1, B2, H3, and H4.

Source: Model output data released by Petitioners in May 2016 in support of their water rights change petition (Exhibit DWR-500).

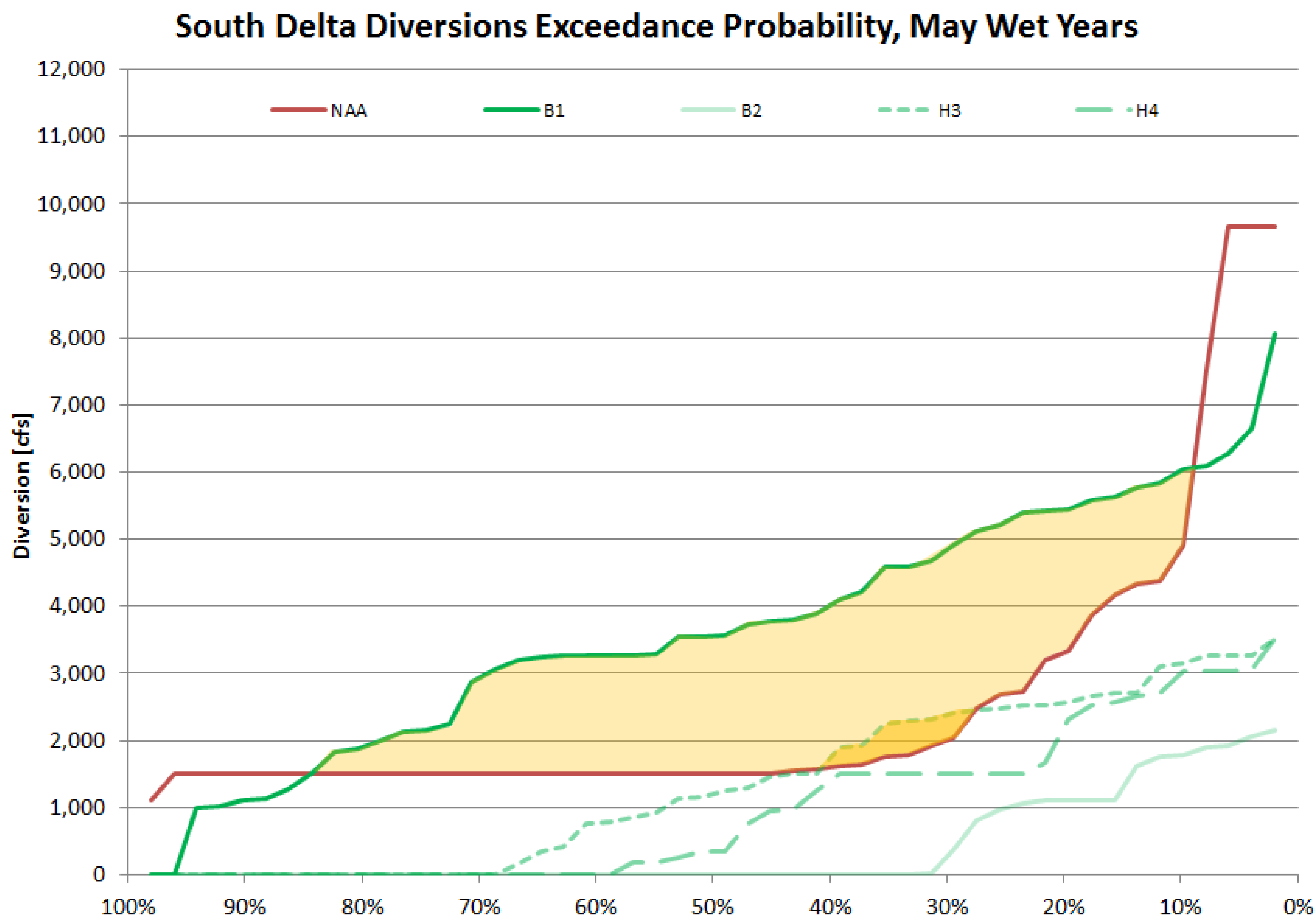


Figure 14. Exceedance Probability of Preferential South Delta Diversions, Wet Years, May 1922-2003 (N=50), WaterFix Hearing Scenarios: No Action Alternative (NAA), and Proposed Actions B1, B2, H3, and H4.

Source: Model output data released by Petitioners in May 2016 in support of their water rights change petition (Exhibit DWR-500).

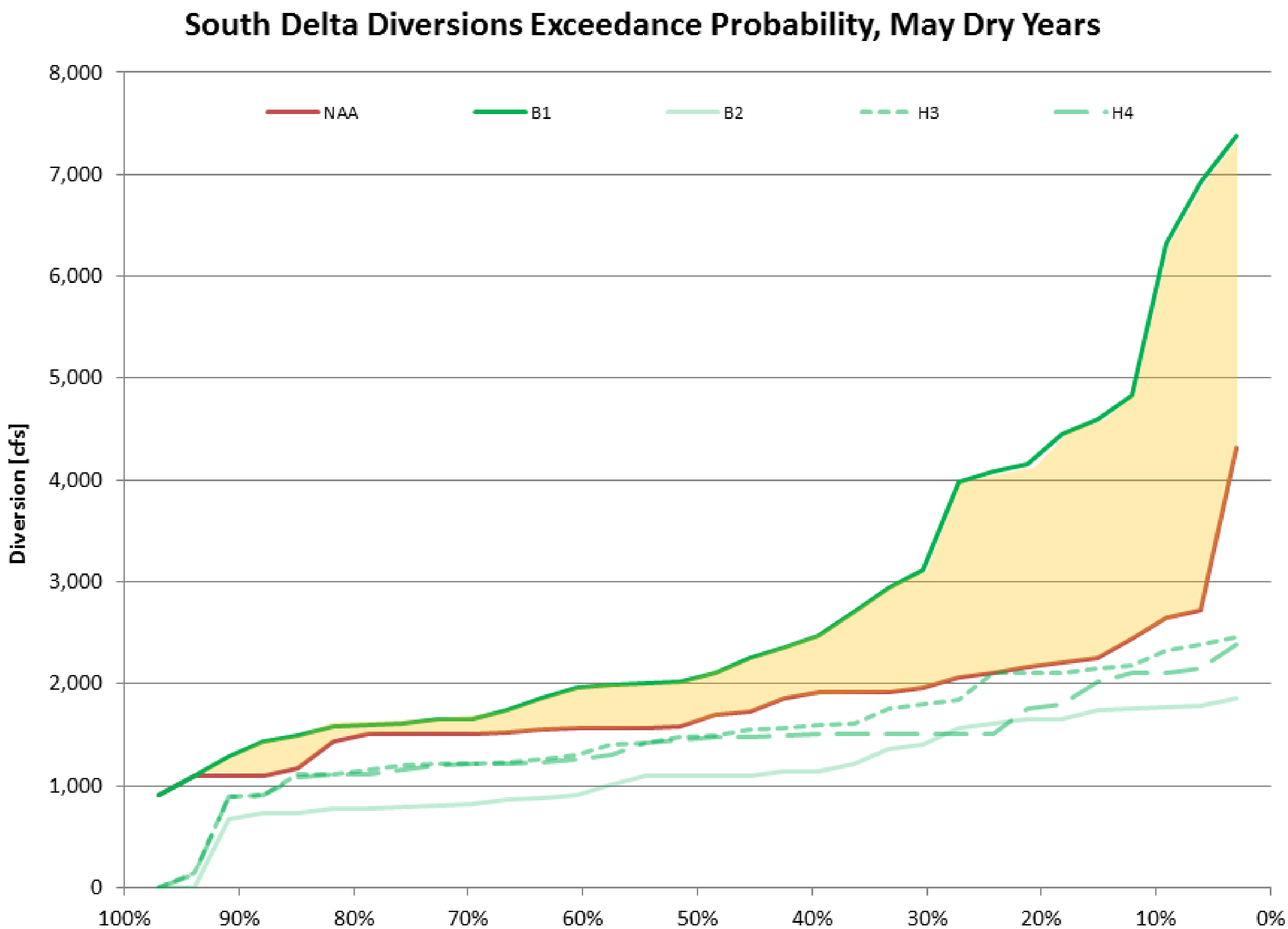


Figure 15. Exceedance Probability of Preferential South Delta Diversions, Dry Years, May 1922-2003 (N=32), WaterFix Hearing Scenarios: No Action Alternative (NAA), and Proposed Actions B1, B2, H3, and H4.

Source: Model output data released by Petitioners in May 2016 in support of their water rights change petition (Exhibit DWR-500).

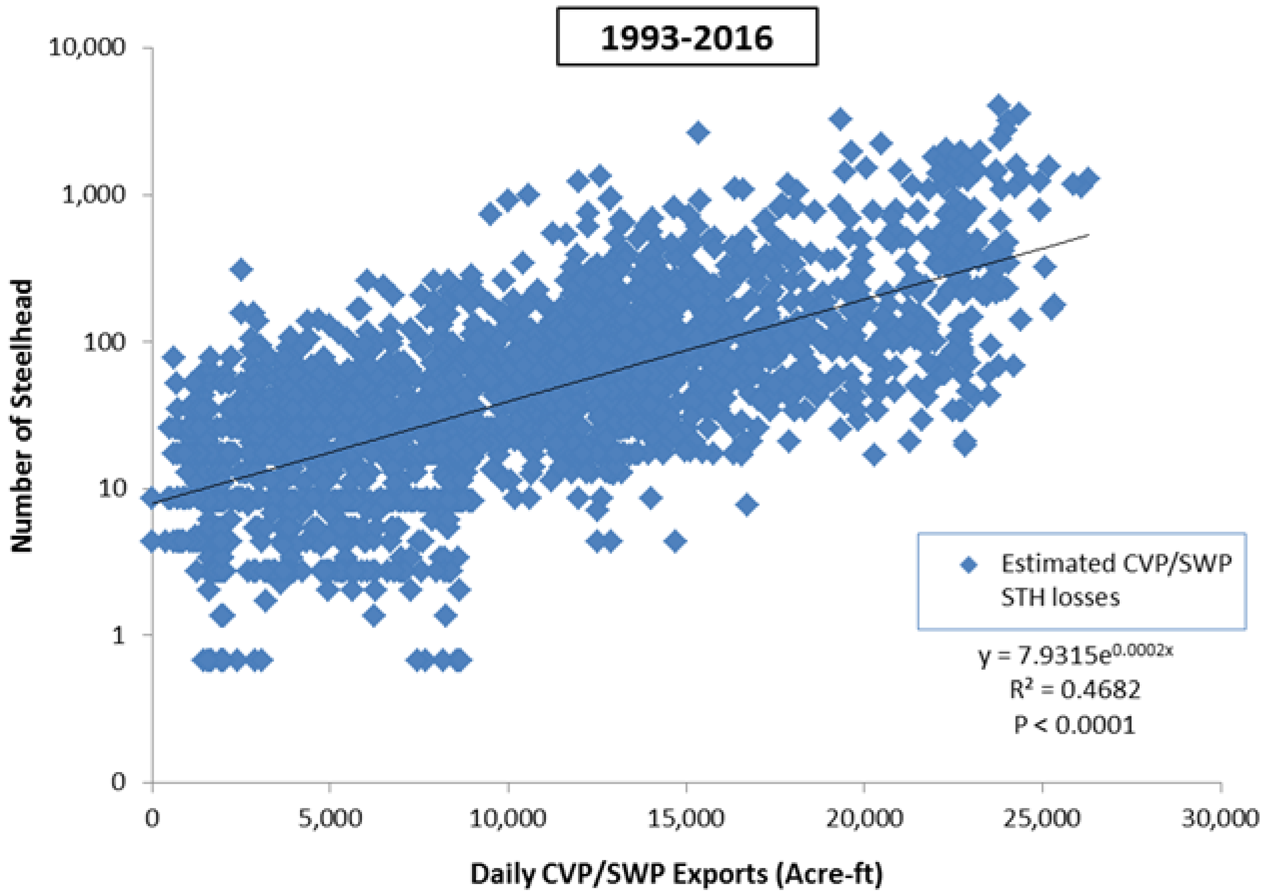


Figure 16. The relationship between export volumes and steelhead (STH) losses at the South Delta Facilities.

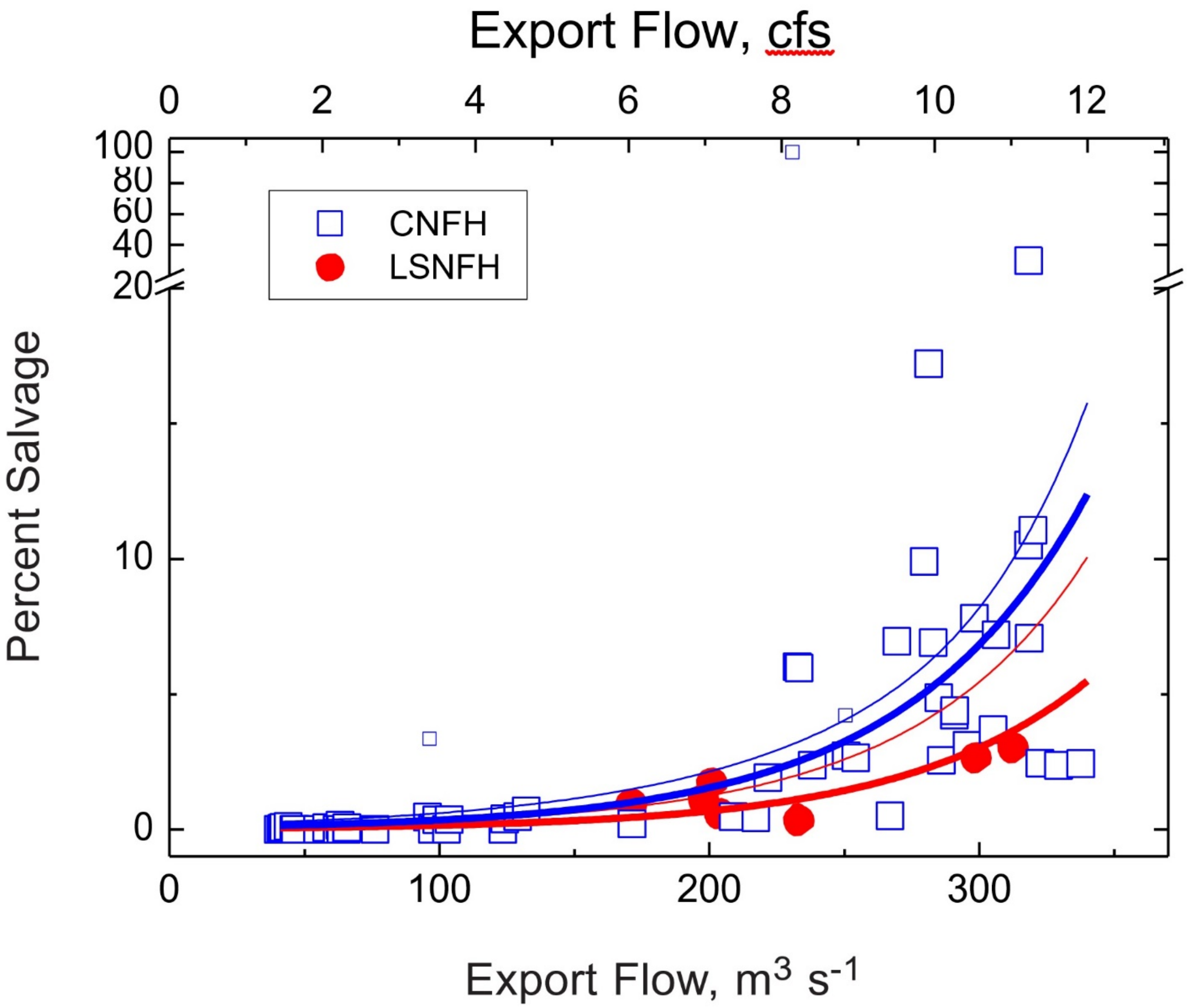


Figure 17. This graph depicts the relationship of estimated proportional salvage of tagged smolts at the fish facilities (expressed as percent salvage) to export flow. Small symbols represent data based on six or fewer fish caught, which were not used in determining the line. Lines are from a generalized linear model with log link function and variance proportional to the mean ($p < 0.0001$, 57 df), with source of fish as a categorical variable. Thick lines are predictions for fish from each hatchery; thin lines are upper 90% confidence limits of the predicted mean values.

Source: Kimmerer, W.J. 2008. Losses of Sacramento River Chinook salmon and delta smelt to entrainment in water diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 6(2): article 2.