Zooplankton Transport Estimates For State Water Project Incidental Take Permit Summer-Fall Habitat Requirements

Memorandum in response to the ITP Amendment 1 Effects Analysis

Department of Water Resources, April 2026

Purpose

The purpose of this communication is to present DWR's proposed method for estimating food production targets as required by Amendment 1 of the State Water Project (SWP) Incidental Take Permit (ITP). DWR's two-fold approach was the following 1) reproduce the '*Food Transport from Outflow Actions*' analysis to understand the technical basis for how the new requirement to supplement zooplankton was developed, and 2) to propose an alternative calculation that DWR believes represents SWP responsibility for off-ramping from Fall X2 mitigation measures.

Summary

In Amendment 1 to the Incidental Take Permit (ITP), reissued on Sep. 29, 2025, to the California Department of Water Resources (DWR) by the California Department of Fish and Wildlife (CDFW), the Fall X2 action for Delta Smelt habitat (Condition 9.1.3) was off-ramped for Water Year 2025. In lieu of the action, DWR was required to implement 10 additional days of Suisun Marsh Salinity Control Gates (SMSCG) operation and to implement a three-year "Food and Habitat Enhancement Program" requirement. The Food and Habitat Enhancement Program requires DWR to ensure that 6,000 kg of Delta Smelt food (zooplankton) be added to the Suisun Marsh Region each year during June-October of 2026, 2027, and 2028. The 6,000 kg target was developed by calculating the average monthly biomass of the copepod *Pseudodiaptomus forbesi* transported from the Delta to Suisun Marsh and Suisun Bay during June, July, and August of an Above Normal water year with a Fall X2 action. However, the analysis did not compare biomass that was transported during a Fall X2 action to biomass transported in a no-action scenario, which DWR believes would have been the most appropriate analysis to evaluate the impact of the proposed action. DWR conducted an analysis to quantify the difference in zooplankton transport with and without a Fall X2 action. By replicating the analyses conducted by CDFW as

closely as possible, we found that the difference between a Fall X2 action and a no- Fall X2 action was approximately 1,126 kg across all three months (June, July, and August). We also found several ways this analysis could be improved for a more realistic portrayal of zooplankton transport by the entire Fall X2 action period, which resulted in a difference in transport of 796 kg of zooplankton across the entire June-October period. Given that the Fall X2 action was a joint action by DWR and the Bureau of Reclamation, DWR believes its proportional share of the zooplankton requirement should be 159 kg.

Background

High outflow during the summer and fall has long been hypothesized to benefit Delta Smelt survival and population growth due to increased habitat suitability, increased area of the low salinity zone, and increased food supply (Feyrer et al. 2011, Bever et al. 2016, Hassrick et al. 2023). In particular, increased transport of the calanoid copepod, *Pseudodiaptomus forbesi* (a key prey item for Delta Smelt), has the potential to increase growth of juvenile Delta Smelt in the often food-limited low salinity zone (Hammock et al. 2015; Smith and Nobriga 2023).

The Fall X2 requirement was included in the 2008 Biological Opinion as a reasonable and prudent alternative (RPA) to avoid jeopardy. At the time, the action was based on new science at the time showing that there was a decline in area of suitable habitat in the fall that corresponded to changes in State Water Project (SWP) and Central Valley Project (CVP) operations (Feyrer et al. 2007). A weak trend between fall habitat area and the Delta Smelt Fall Midwater Trawl (FMWT) index also existed (Feyrer et al. 2011), leading to the hypothesis that improving habitat in the fall would improve Delta Smelt populations. It is important to note the Fall X2 action was designed as an adaptive management action, subject to change based on new science and information[1]. Recent findings from Polansky et al. (2024) now demonstrate that summer outflow, not fall outflow, was more strongly correlated to Delta Smelt summer survival and population growth. Due to the low importance of fall outflow on smelt survival and status of the wild population, DWR obtained an amendment proposed to off-ramp from the Fall X2 requirement (to maintain X2 less than or equal to 80 km during the months of September and October following a

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[1] 2008 FWS Biological Opinion states "To address uncertainties about the efficiency of the Action, it will be adaptively managed under the supervision of the Service. Adaptive management is a mode of operation that provides for learning and feedback to adjust an action undertaken in the face of uncertainty. To improve the efficiency of the Action and align its management more closely with the general plan articulated in Walters (1997) and endorsed by the independent peer review of this BO, the Service will supervise the implementation of a formal adaptive management process

Wet or Above Normal water year) from the 2024 ITP with an amendment issued September 29, 2025.

Given that the best available science and information indicates that fall outflow did not significantly affect wild Delta Smelt survival or population growth, DWR's amendment application only proposed additional SMSCG operation days in early September and a commitment to better understand zooplankton production during the summer months as a key hypothesis as to why summer was an important period for wild Delta Smelt. In DWR's 2024 ITP amendment application, it was noted that there is uncertainty with how the hatchery population would respond to summer-fall habitat actions. DWR proposed to conduct studies to better understand how the hatchery Delta Smelt population would respond to conditions during the summer and fall.

CDFW's amendment included a provision to establish "Food and Habitat Enhancement Program", and requiring:

The Program shall ensure that at least 6,000 kg of Delta Smelt food resources are provided, as demonstrated through an analysis approved in writing by CDFW, within the Suisun Marsh region in each year (2026, 2027, 2028)

CDFW arrived at the 6,000 kg target number via an analysis using two representative Above Normal water years (2016 and 2024, with modified hydrology), particle tracking using DSM2 (Delta Simulation Model II), and average biomass of *P. forbesi* in the Delta during the months of June, July, and August. CDFW found that there was an average transport of 5,983 kg per month (June, July, and August) during a summer before a Fall X2 action (which occurs September and October), leading to the required 6,000 kg per year for three years to correspond to the three months of the summer. With this food transport analysis and subsequent ITP requirement, there is the implicit assumption that without a Fall X2 action there would be no zooplankton transport. However, Delta outflow would not be zero even in the absence of a Fall X2 action, and thus a more appropriate analysis would be a comparison of a Fall X2 action scenario to a no-Fall X2 action scenario to determine the relative difference in zooplankton transport from baseline conditions.

DWR understands that CDFW adaptively adjusted their effects analysis approach, shifting focus from fall to summer given the recent science supporting potential summer outflow/X2 benefits to Delta Smelt survival, and DWR's proposed amendment to off-ramp Fall X2. CDFW shifted the Fall X2 action to different summer outflow scenarios that were developed in spring of 2025, in coordination with DWR, and included an adjusted summer 'Fall X2 equivalent' scenario. However, DWR does not believe this analysis represents the SWP responsibility for off-ramping from the currently required Fall X2 mitigation measure.

Additionally, CDFWs adaptive summer analysis lacked contrast to a no-action scenario that is needed to determine the relative difference in zooplankton transport from baseline conditions, and considerations of realistic proportional share effects.

Here we reproduce the '*Food Transport from Outflow Actions'* analyses conducted by CDFW to better understand the methodology including inputs, assumptions, and comparisons. Additionally, we compare food transport with a Fall X2 action scenario to a no-Fall X2 action scenario to provide an alternative calculation of compensatory mitigation that is more technically defensible. We further suggest improvements to the analytical framework that would provide a more realistic quantification of potential zooplankton transport.

Methods

We conducted two versions of the food transport analysis; 1) an attempted replication of the CDFW amendment analysis, with the addition of a no-action scenario, and 2) where we made several changes to improve the technical basis (i.e. realism) of the results. Information to reproduce CDFW analyses was derived from the '2025 Summer-Fall Habitat Amendment No.1 Effects Analysis', and subsequent communications with CDFW staff.

For the first analysis, we used DSM2 to estimate the transport of passive particles from seven different locations upstream in the Delta to Suisun Bay and Suisun Marsh (Figure 1). We released particles at the start of June, July, and August, and tracked the particles for 90 days, then calculated the number of particles transported to Suisun Bay, Suisun Marsh, entrained by the CVP and SWP, or remaining in the Delta. We used hydrology from 2016 (a Below Normal water year modified to replicate operations in an Above Normal water year) and 2024 (an Above Normal year), with boundary conditions to simulate two scenarios: one with a Fall X2 action at 80 km in September and October, and one without any Fall X2 requirement. Modifications to the hydrology were developed by DWR in spring of 2025 for evaluation of different summer outflow scenarios.

We then used zooplankton densities from long-term monitoring programs to weigh the results of the particle tracking models. Using the 'zooper' package (Bashevkin et al. 2022), we gathered data on *P. forbesi* (adults), and *Pseudodiaptomus* spp. (copepodites and nauplii – which are not resolved to species) catch per unit effort from the Summer Townet Survey, 20-mm survey, Fall Midwater Trawl Survey, and Environmental Monitoring Program from 1995-2020. We converted these values to biomass per unit effort (BPUE) by multiplying catch per unit volume (in cubic meters) by the average biomass of an adult *P. forbesi* (3.27 μg carbon, Kayfetz et al. 2020). While nauplii and copepodites are much smaller than adults, the adult mass was used for all life stages due to the potential for growth during the transport simulation (as per CDFW communications on analysis).

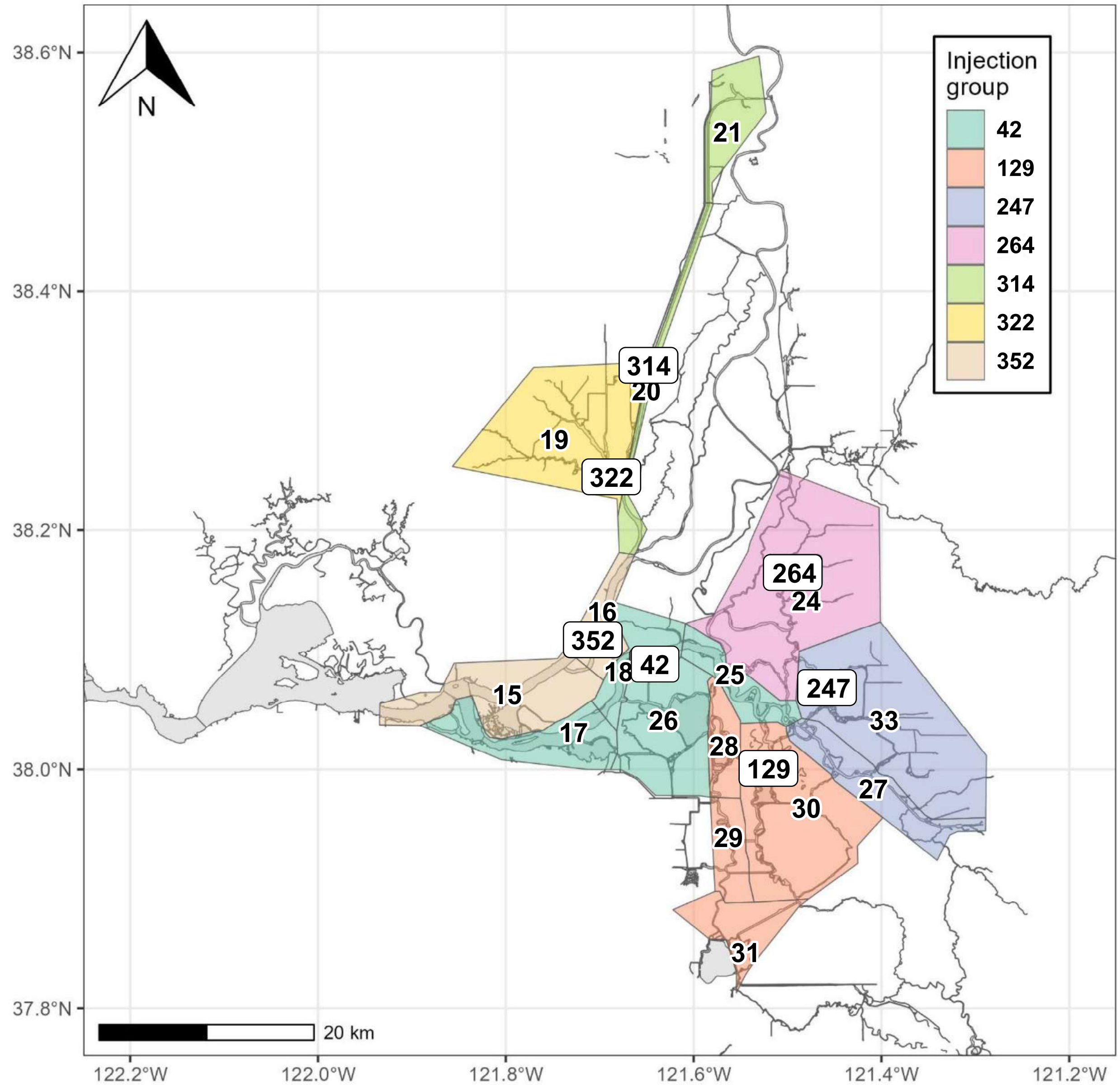

Figure 1. Map of regions of the upper San Fransico Estuary used for zooplankton particle tracking. Particle injection points are noted in white boxes. Zooplankton biomass was summarized by region and mapped to injections points as noted in Table 1.

Table 1. Regions used for zooplankton analysis, with corresponding DSM2 injection points, estimated water volume, and monthly average zooplankton biomass per cubic meter (based on average CPUE from above normal water years, 1995-2020, with biomass of adults, juveniles, and nauplii calculated separately based on average weights for each life stage). "NA" indicates months when no sampling occurs in the relevant region.

				Monthly Average *Pseudodiaptomus* biomass (µg) per meter cubed				
Region Number	**Name**	**Injection node**	**Volume (km3)**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**
15	Lower Sacramento River	352	0.0538	4,085	3,986	2,655	6,030	2,627
16	Sacramento River near Rio Vista	352	0.073	6,060	4,655	2,543	7,617	5,827
17	Lower San Joaquin River	42	0.152	13,136	7,694	2,698	4,721	3,299
18	San Joaquin River at Twitchell Island	42	0.0808	13,172	11,389	8,600	8,117	5,664
19	Cache Slough and Liberty Island	322	0.0307	18,343	18,020	5,022	27,664	7,992
20	Lower Sacramento River Ship Channel	314	0.2257	10,888	9,010	9,357	13,893	8,362
21	Upper Sacramento River Ship Channel	314	0.0588	4,937	5,830	12,433	385	4,177
24	North and South Forks Mokelumne River	264	0.051	12,012	2,658	6,991	3,470	1,711
25	San Joaquin River at Prisoners Pt	42	0.0805	13,248	15,191	15,478	14,390	9,842
26	Franks Tract	42	0.0654	17,248	15,135	9,247	5,680	2,503
27	San Joaquin River near Stockton	247	0.0415	20,681	21,416	26,577	22,326	14,052
28	Holland Cut	129	0.0283	13,092	13,895	9,448	9,590	6,125
29	Old River	129	0.0141	13,710	12,693	12,460	17,640	NA
30	Middle River	129	0.0643	33,691	24,177	14,881	62,532	NA
31	Victoria Canal	129	0.0107	11,842	17,415	12,789	NA	NA
33	Disappointment Slough	247	0.0165	16,825	20,907	22,246	41,643	16,489

We spatially aggregated the zooplankton samples based on the station designations from Slater et al. (2023) and grouped the stations to the nearest injection point within the particle-tracking model. Table 1 shows how the monitoring stations are grouped into injection points, provides water volumes in each region, and provides average *Pseudodiaptomus* spp. biomass per cubic meter of water with weights for adults calculated separately from juveniles (1.15 µg) and nauplii (0.10 µg). With the estimated *Pseudodiaptomus* spp. densities for each injection point (measured in biomass per volume), we scale those estimates by the volume of each station (Slater et al. 2023), providing a value for total *Pseudodiaptomus* spp. biomass throughout the Delta. These biomass estimates are then incorporated into the particle tracking model results to calculate the fates of the total *Pseudodiaptomus* spp. biomass under the two different outflow scenarios.

For the second analysis, we used the same approach as in the first analysis but refined the modeling framework in order to integrate more realistic biological and hydrological parameters. We repeated the DSM2 particle tracking model for the Fall X2 scenario and no-action scenario (from June to October) but only tracked the particles for 30 days instead of 90 days, to better conform with typical copepod life spans. The life span of *P. forbesi* under laboratory conditions is approximately 60 days (Teh et al. 2011) and typical adult life spans for calanoid copepods in the wild are 30-40 days, depending on conditions (Kimmerer et al 2024). While we weighted the particle tracking results similarly to the first analysis, we kept the age-structure of the zooplankton population intact in the second analysis, using lower biomass values for copepodites (1.15 µg), and removing nauplii from the analysis as nauplii are typically not consumed by juvenile Delta Smelt due to their small size (Slater and Baxter 2014; Slater et al. 2019). We also only used data from Above-Normal water years (2000, 2003, 2005, 2016 [actually Below Normal, but used as Above Normal in simulation] and 2024).

Results

When replicating CDFW's food transport analysis, we found that the average June-August monthly transport of *Pseudodiaptomus spp*. with a Fall X2 action was 5,438 kg per month (Figure 2), very similar to the 5,983 kg found by CDFW. The discrepancy between the two analyses is most likely due to the difference in Suisun Marsh Salinity Control Gate operations and potentially a different version of DSM2. The average *Pseudodiaptomus spp.* transport in a no-action scenario from June to August was 5,062 kg per month. When the differences from each month were added up for the entire summer and averaged across the two representative years, the difference between an action and no-action scenario was 1,126 kg of zooplankton.

When refining the transport analysis by only using zooplankton densities from Above-Normal water years, including a more realistic stage-structured zooplankton population, and only running the model for 30 days, transport values were over 80% lower (Figure 3). The average *Pseudodiaptomus spp.* transport under a no-action scenario from June to

October was 1,047 kg per month, while the average June to October transport under a Fall X2 action scenario was 1,206 kg per month (as compared to 5,062 and 5,438 kg, respectively, in the initial analysis approach). The total difference in transport between action and no-action scenarios for all of June-October in this refined analysis was 796 kg *Pseudodiaptomus spp*.

During a Fall X2 action, outflow requirements are jointly met by the CVP and SWP. Approximately 80% of the additional outflow required to meet the regulatory standard for Fall X2 is provided by the CVP through our Coordination Operations Agreement (COA)-the SWP is responsible for approximately 20% of the additional outflow required. Therefore, DWR believes that its share of the zooplankton transport should only be 20% of the difference in zooplankton transport between an X2 and a no-X2 year. Under this calculation, SWP share would therefore be 225.2 kg of zooplankton based on the CDFW analysis approach or alternatively, 159 kg based on DWR's adjusted calculation.

DWR is currently preparing to implement managed wetland food subsidy experiments in summer of 2026 to meet its Amendment 1 requirement. DWR believes these experiments provide the best scientifically supportable framework for generating food that meets the species needs consistent with the peer-reviewed literature on likely mechanisms underlying summer survival (see Polansky et al. 2024). DWR proposes that we take information gained from these studies to best inform how food web production can be generated to subsidize Delta Smelt during the summer. At the conclusion of the studies, DWR proposes to work with CDFW to re-evaluate the magnitude of food production, along with other factors, that will generate the optimal conditions intended to support positive population growth rate in the Delta Smelt population.

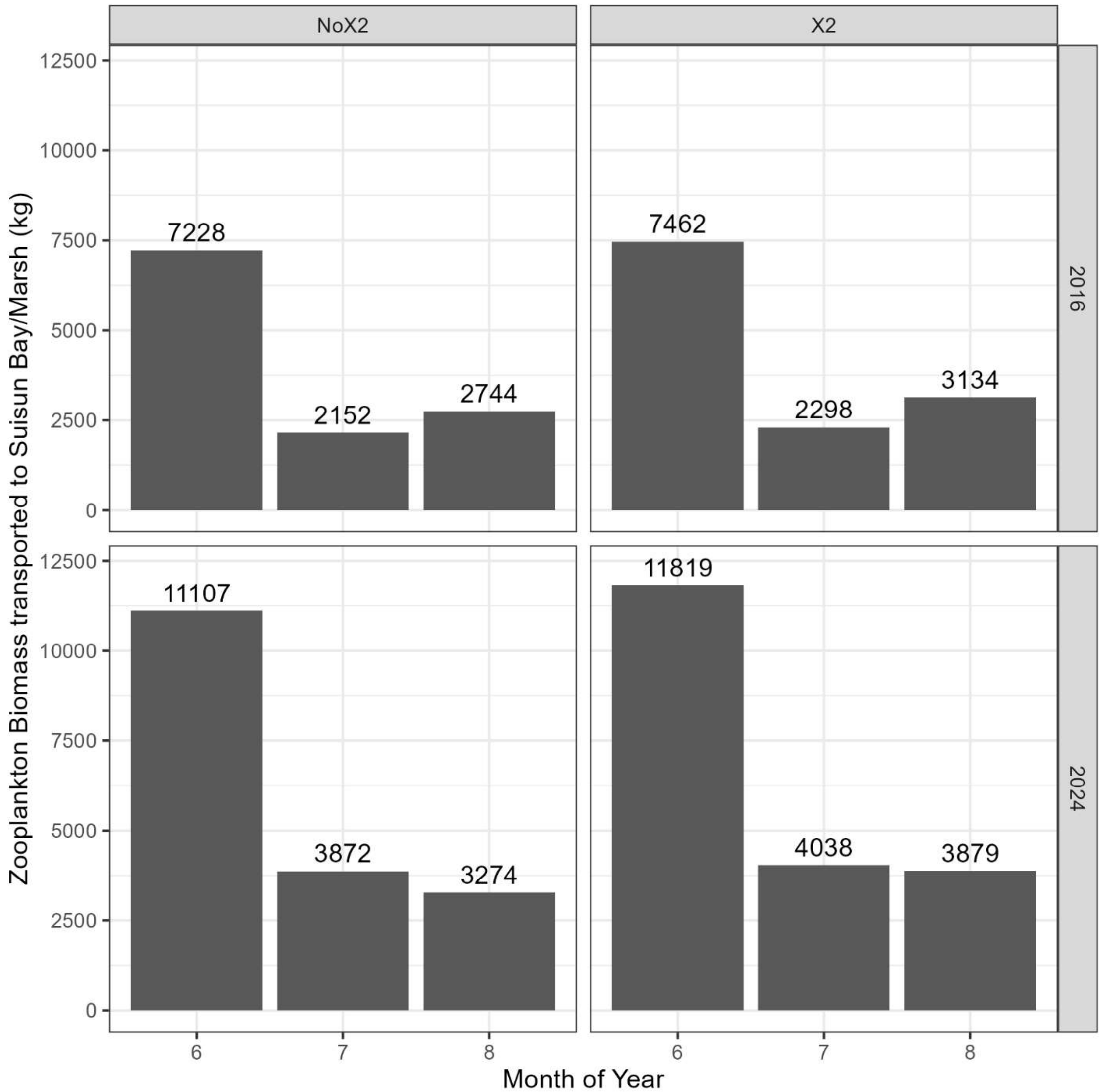

Figure 2. Estimated monthly transport of Pseudodiaptomus sp. biomass (kg) from the Delta to Suisun Bay and Suisun Marsh in 2016 and 2024 after 90 days with and without a fall X2 action. This analysis repeats that analysis conducted by CDFW in the 2025 ITP amendment as closely as possible, except it includes a scenario without an X2 action.

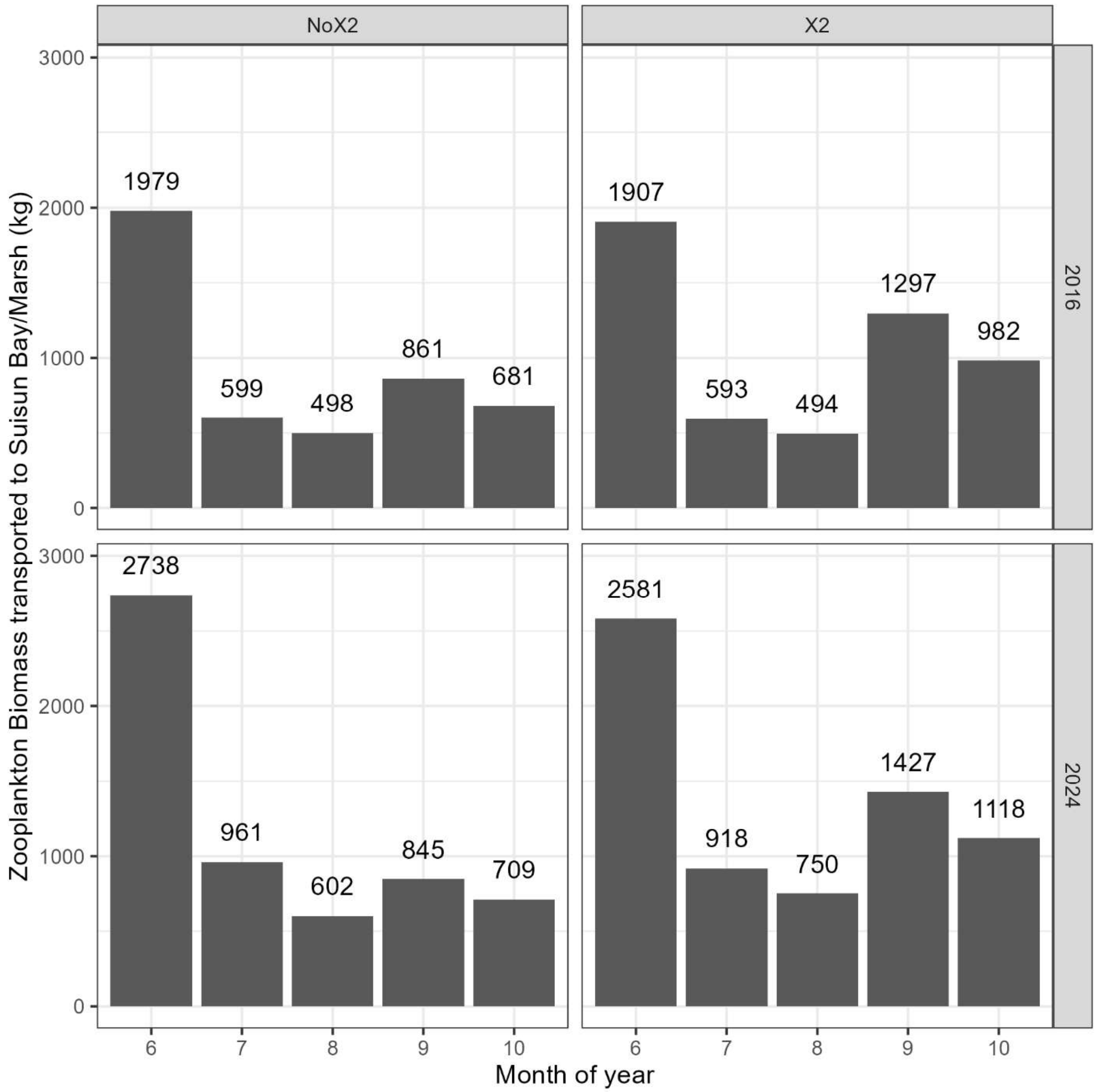

Figure 3. Estimated monthly transport of Pseudodiaptomus sp. biomass (kg) from the Delta to Suisun Bay and Suisun Marsh in 2016 and 2024 after 30 days with and without a fall X2 action. This refined analysis provides a more realistic quantification of zooplankton biomass by incorporating different biomass estimates for adults and juveniles, simulated particle transport for 30 days instead of 90 days, and including September and October when the largest difference in Delta Outflow with and without Fall X2 occurs.

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