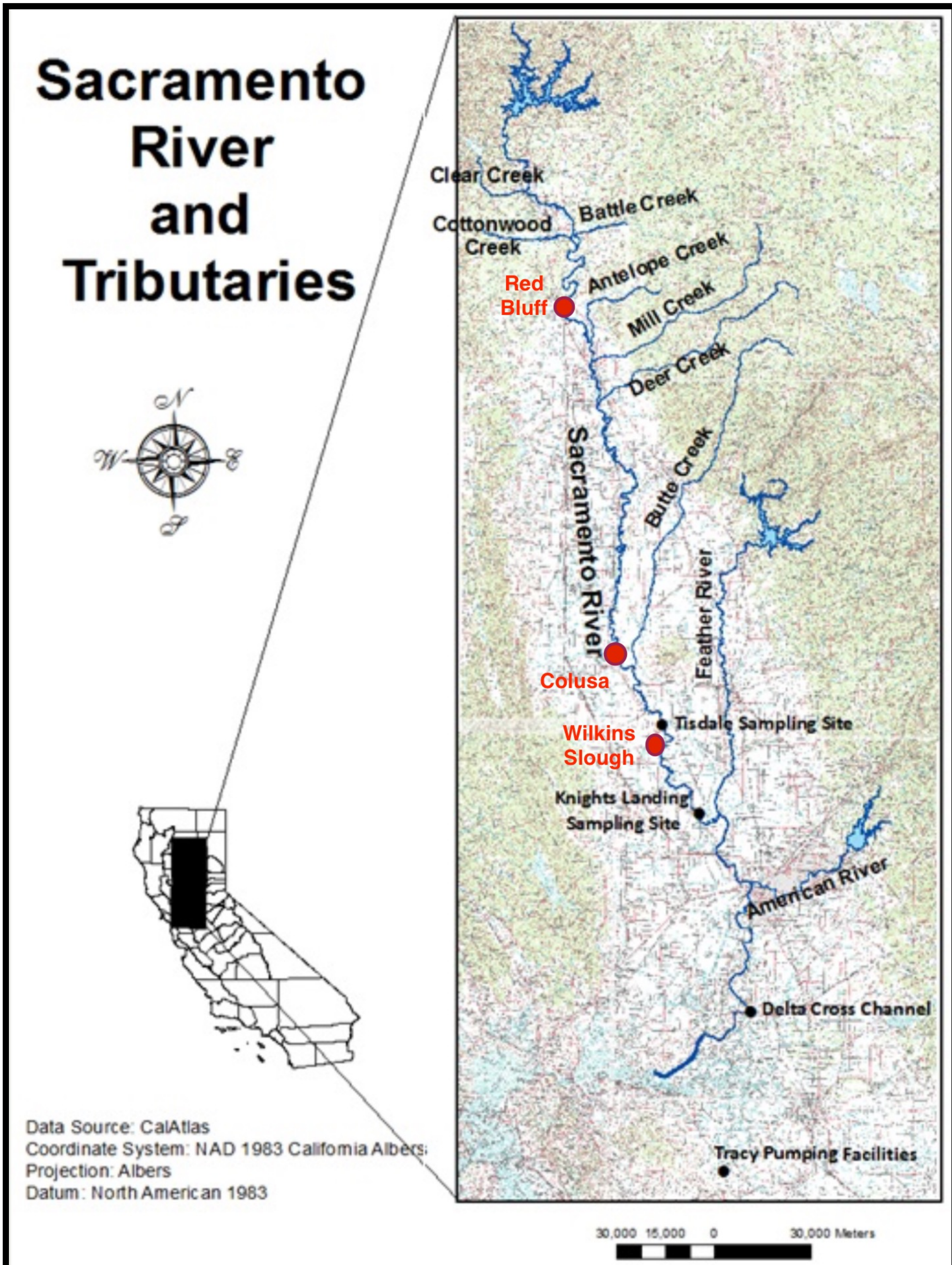

Map 1. The Lower Sacramento River and its major tributaries below Shasta Dam to the Delta.

Central Valley Salmon – Priority Actions for Late Spring, Summer, and Fall 2025

By Tom Cannon

Water year 2025 is the third consecutive wet year after the 2020-2022 drought. In wet years emigrating juvenile natural-born and hatchery salmon (winter, spring, and fall run) and immigrating adult natural-born and hatchery salmon (late fall, winter, spring, and fall run) gain survival advantage from good habitat conditions in late spring, summer, and fall in the Bay-Delta and Central Valley, especially in the lower Sacramento River and its tributaries (Maps 1 and 2). Hatchery smolts released to rivers, the Bay-Delta, and the coastal ocean benefit substantially from trucking in wet years as they do in dry years. Salmon brood-year recruitment is heavily dependent on the good survival and reproduction conditions provided in wet years. High brood year recruitment is critically important to populations presently near record low levels after three multiyear droughts in the past two decades. The future of salmon public trust resources depends on wet water years like 2025. Water year 2025 is of particular importance because salmon numbers are at or near their lowest levels in many decades despite fishery closures in

The future success of salmon brood 2024 and 2025 is dependent on good habitat conditions from spring to fall in wet year 2025. Brood years 2024 and 2025 success is especially important given they are the first offspring from the 2020-2022 drought-produced broods that have had good water conditions for them and their parents (in water years 2023 and 2024). Future population health and growth is thus highly dependent on providing good habitat conditions in 2025. With 2025 being a wet year, the necessary water resources are available for good habitat conditions.

With Sacramento River and Bay-Delta flows near optimal for salmon in winter-spring of wet years 2023 and 2024, and now again in 2025 the odds of salmon recovery in the coming years are good. Winter-spring 2023 near-optimal conditions should have provided a strong fall-run spawning stock for 2025 as long as good late summer and fall river conditions are maintained. Natural and hatchery smolt production and survival to the ocean in late spring 2025 should be good with good spring late spring habitat conditions. Good habitat conditions include strong river flows and lower water temperatures at least through June as well as in late summer and fall.

Decades of review and analyses of Central Valley winter-spring water conditions indicate there is a flow regime that is near optimal for winter, spring, and fall-run salmon annual production. Maintaining an optimal flow and water temperature regime in 2025 will maximize survival and smolt production of winter, spring, and fall run salmon in the Central Valley, and contribute substantially toward Central Valley salmon recovery. With three wet years in a row and full reservoirs providing an optimal regime beginning in late spring, late summer, and fall to maximize survival of natural-born and hatchery brood year 2024 salmon smolts to the ocean and optimize survival and spawning success of brood year 2025 parents.

Late Spring River and Tributary Flows and Delta Inflow/Outflow

1. Late spring lower Sacramento River Flow and Pulse Flows

As wet water year 2025's flows start to ebb it is important to maintain minimum streamflows with some turbidity and low water temperatures to sustain movement and survival of brood year 2024 smolts from the rivers to the ocean. Smolt migration occurs through spring and into early summer of wet years. Snowmelt induced flow pulses from undammed tributaries offer added benefits, while dam releases to tailwaters and the mainstem support peak movement events (water year 2023 is shown in Figure 1). The following remedies are suggested to sustain optimal spring conditions for migrating juvenile salmon:

- Minimum lower Sacramento River flows above the mouth of the Feather River should be at least 10,000 cfs through spring as measured at the gage below Wilkins Slough. This will help maintain water temperatures in the 65-68°F range. (Note the water quality standard has been 68°F for more than three decades.)
- A pulse flow of 15,000-20,000 cfs (measured below Wilkins Slough) should be provided in the late April to early May period of peak Sacramento River fall-run hatchery and natural smolts emigration.

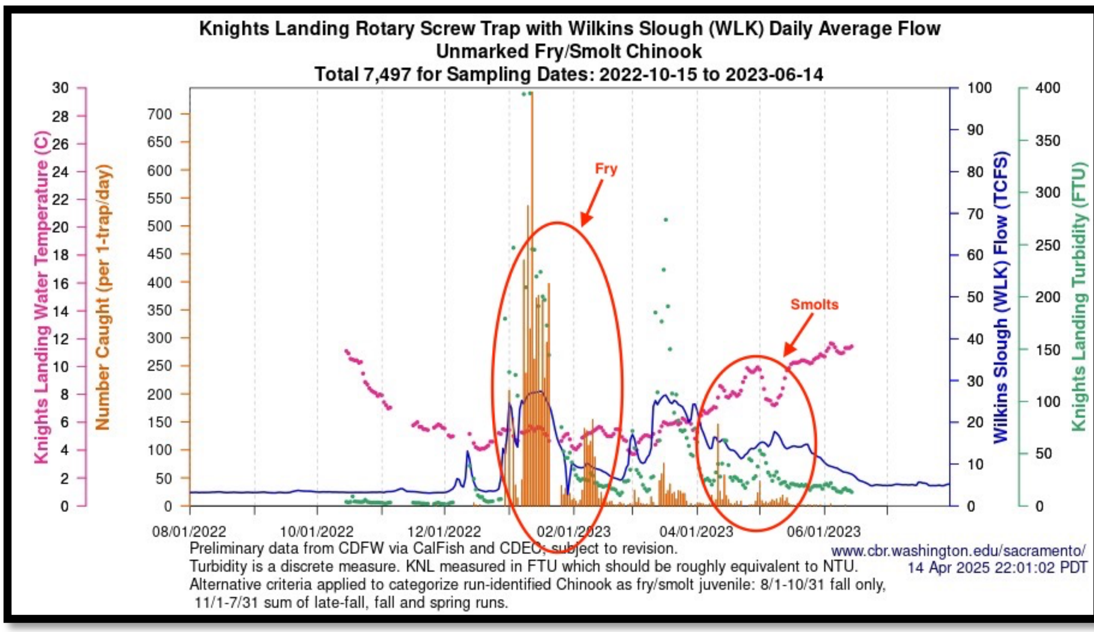

Figure 2. After a peak fry movement in February storm runoff, spring pulses of pre-smolts/smolts occur with spring runoff events.

2. Lower Sacramento River Floodplain and Bypasses

Winter-spring wet-water-year streamflow pulses are important to ensure juvenile salmon transport rates, with some turbidity and low water temperatures to sustain movement and survival of juvenile salmon leaving spawning areas of the upper river and tributaries. Fry rear in the floodplain of the rivers and tidewaters of the Bay-Delta before entering the ocean as smolts. Smolt migration occurs from nursery areas in winter through spring and into early summer of wet years. Snowmelt and rainfall induced streamflow pulses from undammed tributaries offer added benefits, while dam releases to tailwater and mainstem support peak movement events. Streamflows in the mainstem lower Sacramento River in winter-spring 2025 are shown in Figure 3.

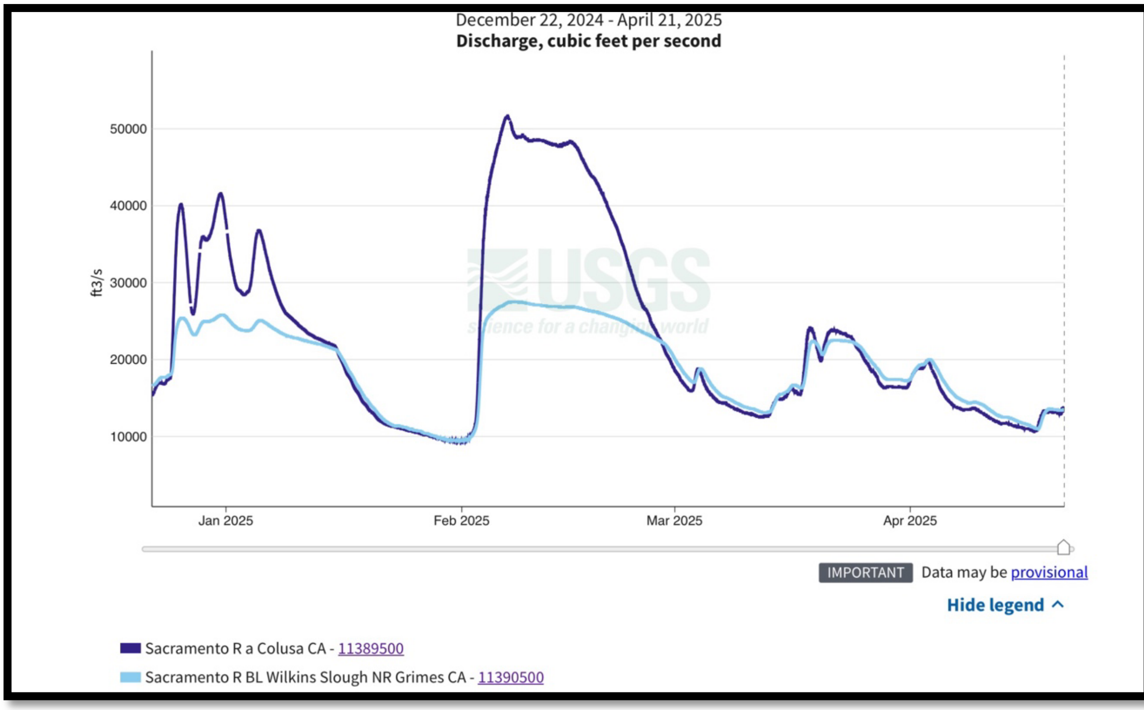

Figure 3. Streamflow in the Sacramento River at Colusa and Wilkins Slough (see Map 1), Jan-Apr 2025. The difference at high river flow is the result of flow into the Sutter Bypass.

The large differences in streamflow between the Colusa gage and the Wilkins Slough gage in Figure 3 are indicative of Sacramento River flood-stage overflow eastward into the Butte Basin and Sutter Bypass. Returning Sutter Bypass outflow and the Feather River and Yuba River streamflows entering the Sacramento River mainstem overflow to the west into the Yolo Bypass just below Knights Landing. Overflows in wet years may exceed 50% of the total lower Sacramento River inflow.

High streamflows and associated water levels provide access of fry salmon to the warmer and more productive floodplain habitats that benefit fry salmon growth and survival. However, the abrupt end to overflows to the floodplains may lead to stranding of the young salmon and rapidly deteriorating habitat conditions - mainly intolerably high water temperatures and excessive predation by birds and non-native fishes. Floodplains may also warm beyond the tolerance of salmon in late spring. The following remedies are suggested to sustain optimal spring conditions for migrating juvenile salmon:

- Maintain higher streamflow in the Sacramento River at Colusa to extend overflow through the Butte Basin and the Sutter Bypass to allow juvenile salmon to volitionally leave the floodplain habitats. Overflow weir notches or gates have been proposed to supplement overflows from the lower Sacramento River.
- Maintain higher streamflow in the lower Sacramento River at Knights Landing to sustain some overflow through the Yolo Bypass to allow juvenile salmon to volitionally leave the floodplain habitats and exit the west Delta via Cache Slough. Newly constructed notches in the Fremont Weir near the confluence of the Feather River and Sutter Bypass outlet may be opened to supplement overflows from the lower Sacramento River into the Yolo Bypass.

- In drier years when water supplies are reduced it may be possible to defer late spring irrigation diversions from the Sacramento River upstream of Knights Landing to allow higher streamflows to sustain river corridor and Bypass habitat - help maintain water temperatures in the 65-68°F range and allow juvenile salmon to escape from floodplain habitats. This would improve survival and production in the natural upper river fall-run population.
- In drier years when water temperatures are too high in spring in the main stem and lower tributaries capture natural-born fry, pre-smolts (parr), and smolts and transport them to cool water habitats in the Bay or coastal ocean. Also transport hatchery smolts to the Bay and coastal waters.
- Maintain individual tributary flows and water temperatures optimal for salmon where possible with reservoir releases and limitations on water diversions.

3. Delta Inflow at Freeport and Mossdale should be sufficient to maintain constant net downstream flows and lower water temperatures in Delta channels through spring.

Delta inflows from the Sacramento River (Freeport gage) and San Joaquin River (Mossdale gage) are needed to support smolt transport and lower water temperature through the tidal Delta in the spring emigration season. Salmon smolt residence and migration through the Delta occurs through the spring. Natural-born smolts migrate and reside in Delta channels through spring (Figures 4 and 5).

- Minimum Delta inflow at the Freeport gage in the Sacramento River channel should be at least 20,000 cfs through spring. This will help maintain water temperatures in the 68-70°F range and provide higher transport rates through the Delta.
- Minimum Delta inflow at the Mossdale gage in the San Joaquin River channel should be at least 2,000 cfs through spring. This will help maintain water temperatures in the 68-72°F range within the Delta channels as well as transport rates of salmon smolts from the San Joaquin River through the Delta to the Bay.

4. Delta outflow below the confluence of the Sacramento River and San Joaquin River channels is important in maintaining smolt migration from the Delta to and through the Bay. Survival of hatchery smolt releases to the Bay is highest at Delta outflows greater that 10,000 cfs (Figure 6).
    - Total Delta Outflow (DTO parameter) should be at least 10,000 cfs through spring to sustain smolt transport and lower water temperatures through the tidal Delta to the Bay.
    - Delta water diversions including south Delta exports and in-Delta water diversions should be no more than 10,000 cfs to ensure outflow remains at a minimum of 10,000 cfs and river pulse flows are sustained through the Delta (and not exported).

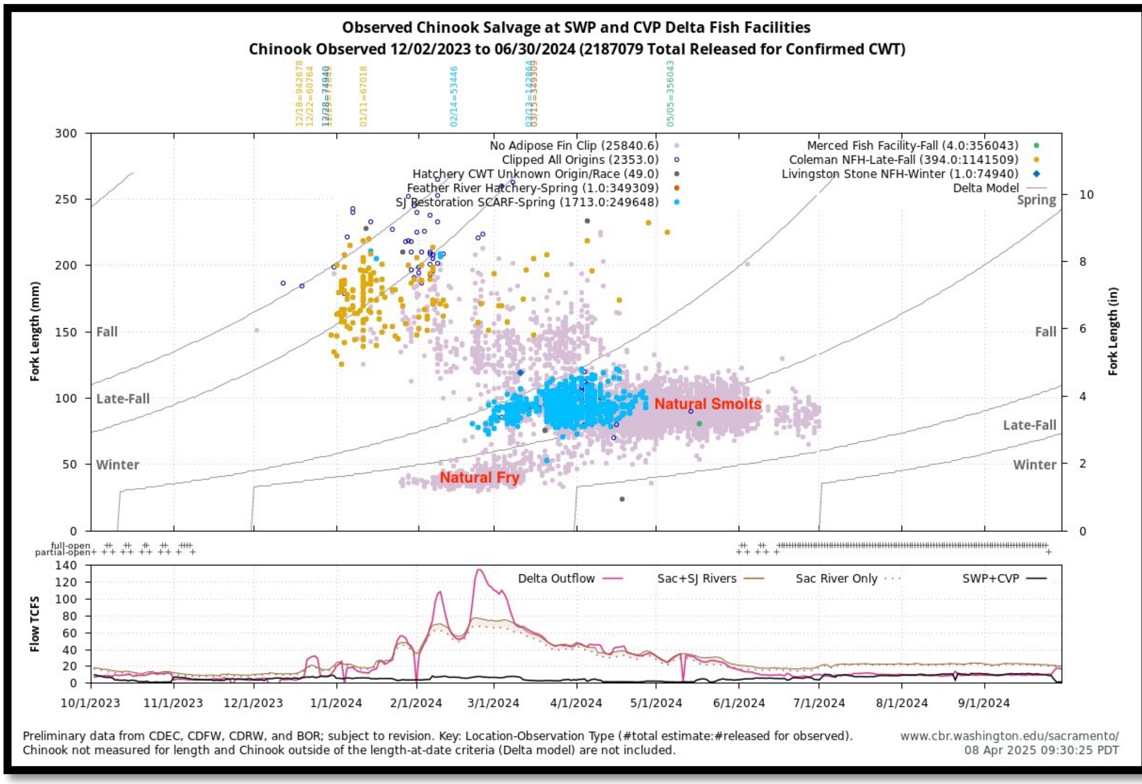

Figure 4. Size, timing, and source of salmon salvage at south Delta export facilities in winter-spring 2024. Hatchery release groups are noted at top of chart by color code. Hydrologic conditions are noted in bottom chart.

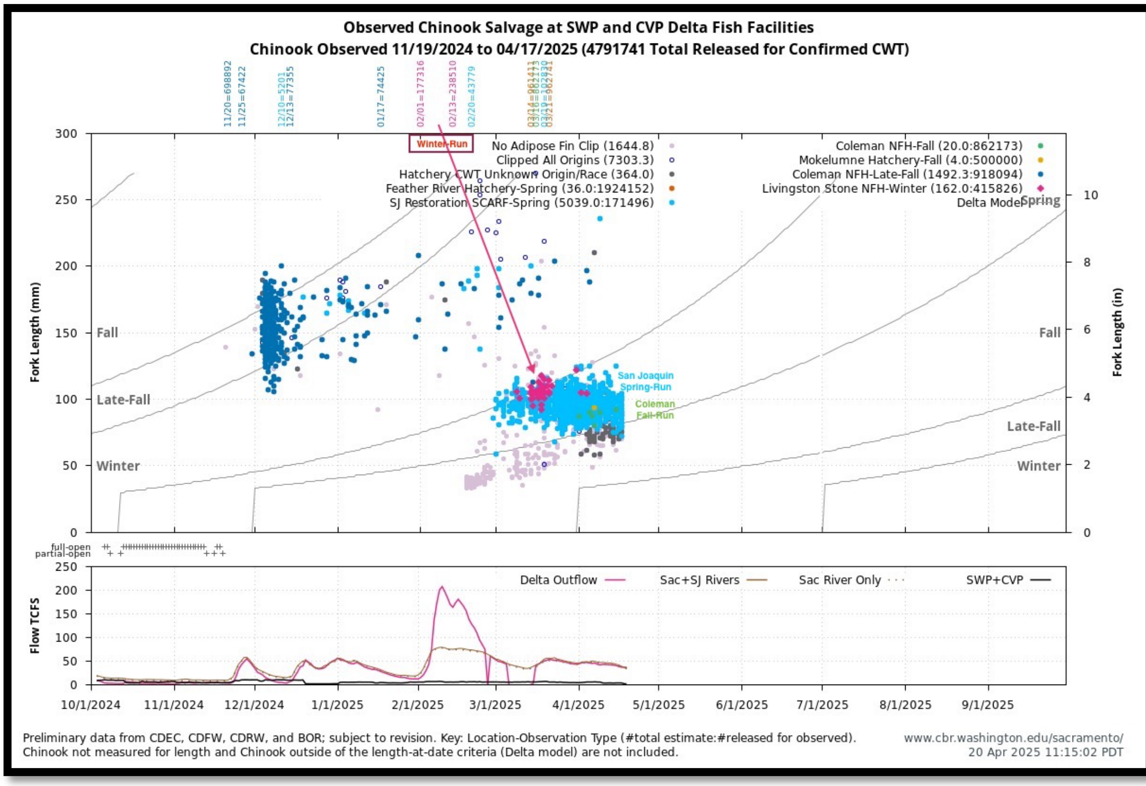

Figure 5. Size, timing, and source of salmon salvage at south Delta export facilities in winter-spring 2025. Hatchery release groups are noted at top of chart by color code. Hydrologic conditions are noted in bottom chart.

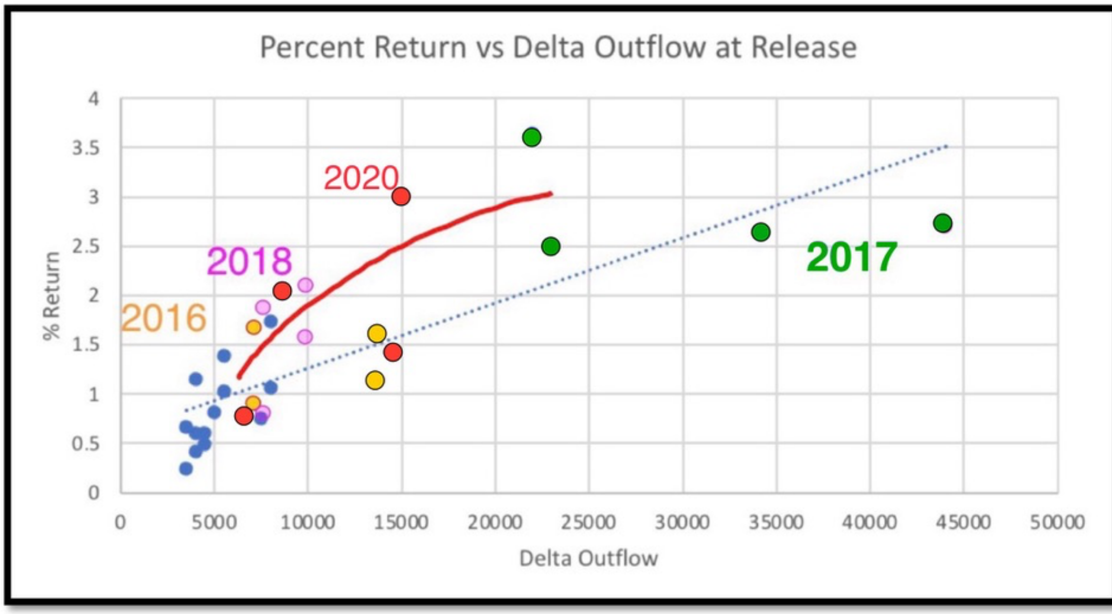

Figure 10. Fall-run adult salmon survival percentage from Bay releases vs Delta outflow to the Bay at the time of release. The years noted are the percent returns for the below normal years 2016 and 2018, and the wet year 2017 under normal rules. Blue dots with outflow below 5000 cfs are from 2014 and 2015 (TUCP applied drought years). The red line is the hypothesized relationship. Returns under normal rules are approximately double to triple the returns under TUCP drought year rules.

Figure 6. Percent return for American River Hatchery smolts released to the Bay as a function of Delta Outflow.

Hatchery Releases

There are over 30 million hatchery smolt releases annually from Central Valley hatcheries to rivers, the Bay-Delta, and the coast. The are many possible actions that increase their survival and return-rate to the ocean and inland fisheries and eventual escapement/return to spawning streams and hatcheries. Figures 7-9 depict survival of Feather River Hatchery return rates from code-wire-tagged smolts.

1. Transport hatchery smolts to net pens in the Bay and coast for release in spring.
2. Grow smolts to yearling size/age for release in winter – larger smolt size and cool waters of winter increase survival and contributions to fisheries and escapement.
3. Transport hatchery smolts in summer to acclimation pens in the Bay or coast. Note this was a successful common practice for the Feather River Hatchery 40-50 years ago (Figure 9).
4. Release hatchery fry to river net pens, floodplains, or rice fields for grow-out. Fry hatchery production capacity often exceeds smolt rearing capacity at hatcheries.
5. Minimize smolt releases to upper river and tributaries near hatcheries because of poor potential survival and competition with and predation on natural-born juvenile salmon, sturgeon, and steelhead. Hatchery smolts also attract predators like striped bass to areas frequented by natural-born salmon.

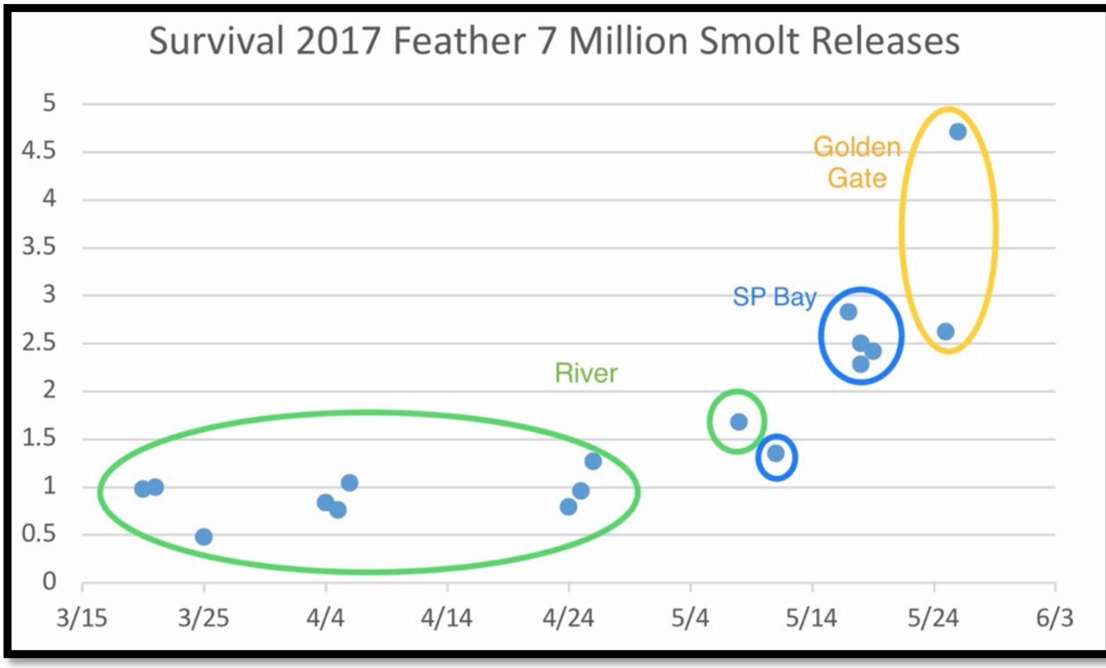

Figure 7. Percent return for Feather River Hatchery tagged smolt groups released in-river, to San Pablo Bay, and to the coast as a function of date of release in 2017.

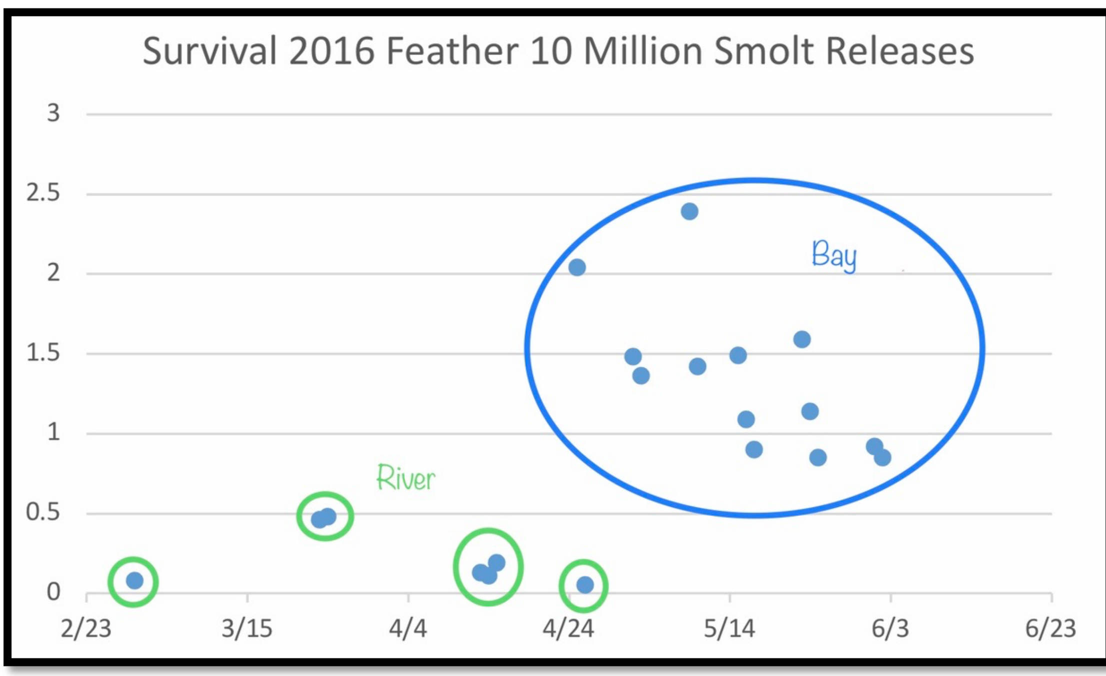

Figure 8. Percent return for Feather River Hatchery smolt tag groups released in-river and to the Bay, as a function of date of release in 2017.

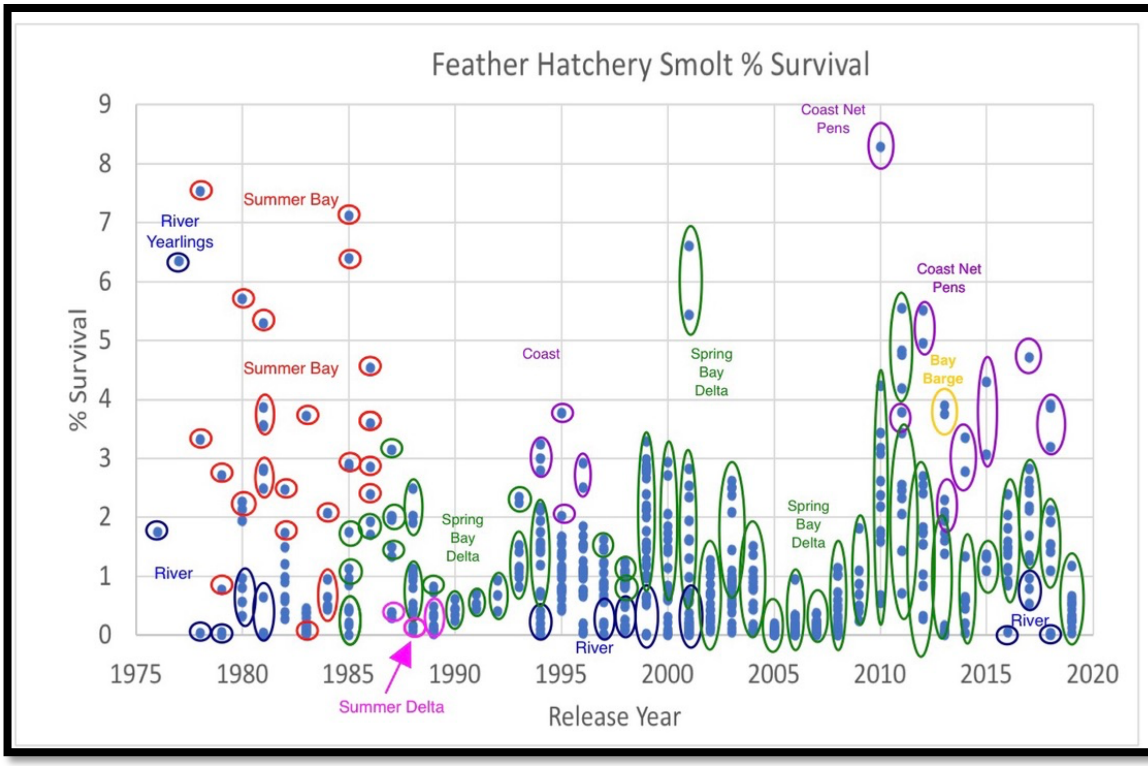

Figure 9. Percent return for Feather River Hatchery smolt tag groups released in-river, to the Bay, and to the coast as a function of water year and release strategy.

Spring Smolt Loss to Water Diversions

Spring exports from the south Delta reduce survival of natural-born and hatchery salmon smolts. Smolts are directed away from their route to the ocean and lost at salvage facilities. Salmon smolts are at risk through spring (see Figure 4).

1. The Delta Cross Channel (Map 1) should not be opened in spring to minimize movement of Sacramento River smolts to the interior Delta.
2. South Delta exports (Tracy in Map 1) should be restricted in spring as they were under State Board D1485 regulations pre-1995.
3. Salmon smolts salvaged at south Delta export facilities (see Figures 4 and 5) should not be transported to Delta sites for release, instead they should be transported to appropriate Bay locations depending on conditions.

Conclusion

The above recommendations actions focus on the most import factors related to salmon hatchery and natural-born smolt survival in the Central Valley. Many of the actions have proven successful at some point in many decades of salmon management. Many of the recommended actions directly relate to manageable hydrodynamics and infrastructure presently controlled by federal, state, and local water projects. In most cases, the actions require planning, funding, permitting, and coordination, as well as adaptive management, monitoring, reporting, and stakeholder involvement.

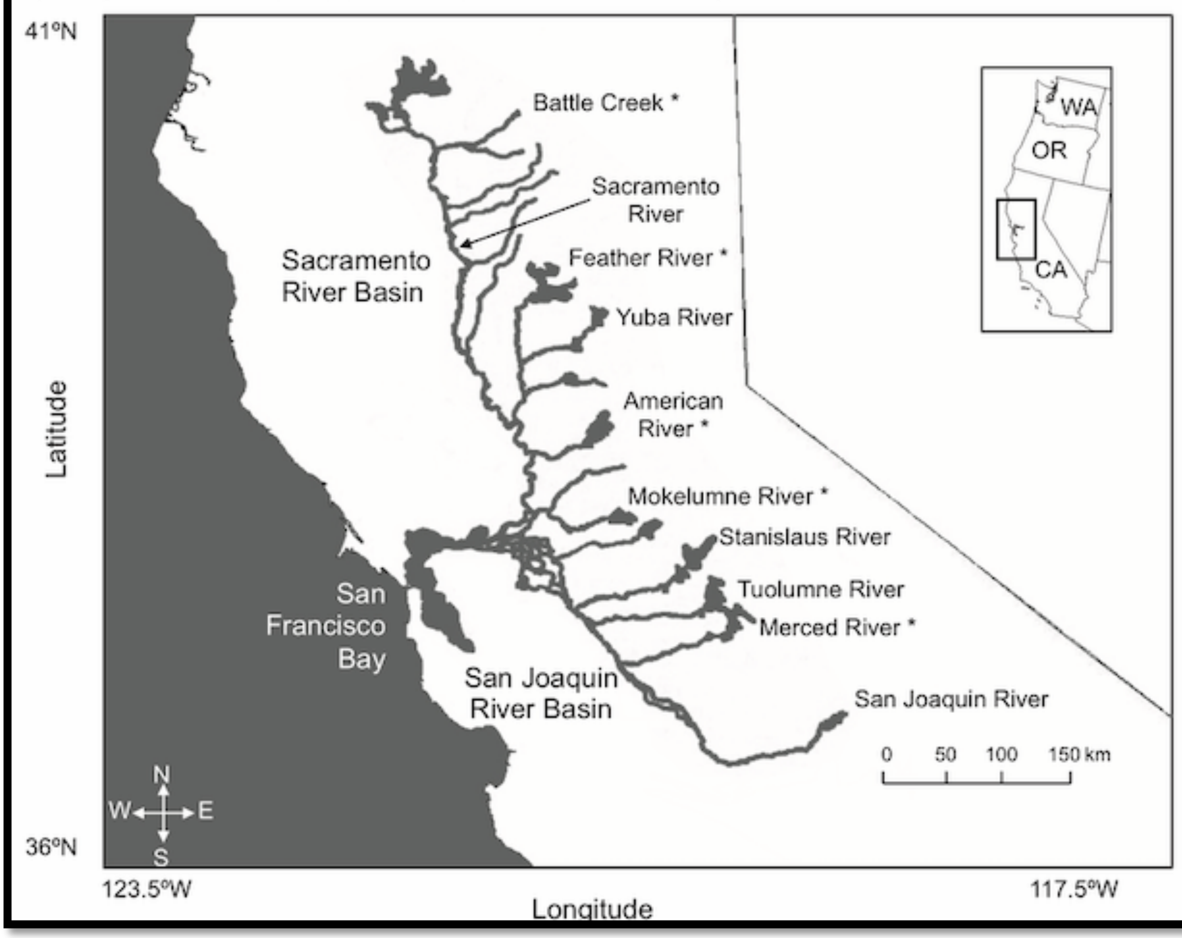

Fig. 1. Map of the Central Valley study system and major fall Chinook salmon-bearing rivers. Rivers marked with asterisks have hatcheries.

Map 2. Source: Satterthwaite and Carlson 2015