Appendix C

Winter-Run Chinook Salmon Cohort Report (Brood Year 2024)

Cover Photo: Male Chinook Salmon on Clear Creek (Credit: Brandon Honig, USFWS)

Background

Sacramento River winter-run Chinook salmon (Oncorhynchus tshawytscha) are a federal- and state- listed endangered species. Adults typically arrive in the Upper Sacramento in December-January, with spawning occurring in the Upper Sacramento River and its tributaries between April and August, and redds beginning to form in June. Juveniles begin to enter the Delta in the Fall, when Old and Middle River (OMR) Flow Management Season starts. This summary describes select biological metrics for the upstream life stages of winter-run Chinook salmon, providing context for observations in the Delta during OMR Flow Management Season.

Water year 2024 was designated as above normal for the Sacramento Valley based on the Sacramento Valley Index and was a Tier 1 year for the duration of water temperature management season (Sufficient volume of cold water to target 53.5°F or lower starting May 15 through October 31). In early May, the Sacramento River Temperature Task Group (SRTTG) recommended delaying the start of temperature management season until May 24, 2024 based on environmental and biological information and modeling results (USBR 2024). See the 2024 Shasta Coldwater Pool Management Seasonal Report (USBR 2025, in prep) for additional background about environmental and biological conditions.

Escapement

Escapement estimates represent the number of natural-origin adult winter-run Chinook salmon that successfully migrated from the ocean upstream to natural spawning habitat or to the hatchery, and that are potentially able to spawn. Escapement does not take into account pre-spawn mortality (Azat and Killam 2025). Estimates are summarized on GrandTab from escapement survey data collected by the California Department of Fish and Wildlife (CDFW), including numerous methodologies such as carcass and aerial redd surveys, video surveys, and snorkel surveys. For BY 2024, Sacramento River system-wide winter-run Chinook salmon survival (escapement) was 1,367. This value is lower than the 10-year average escapement value of 4,576, and lower than the previous four years.

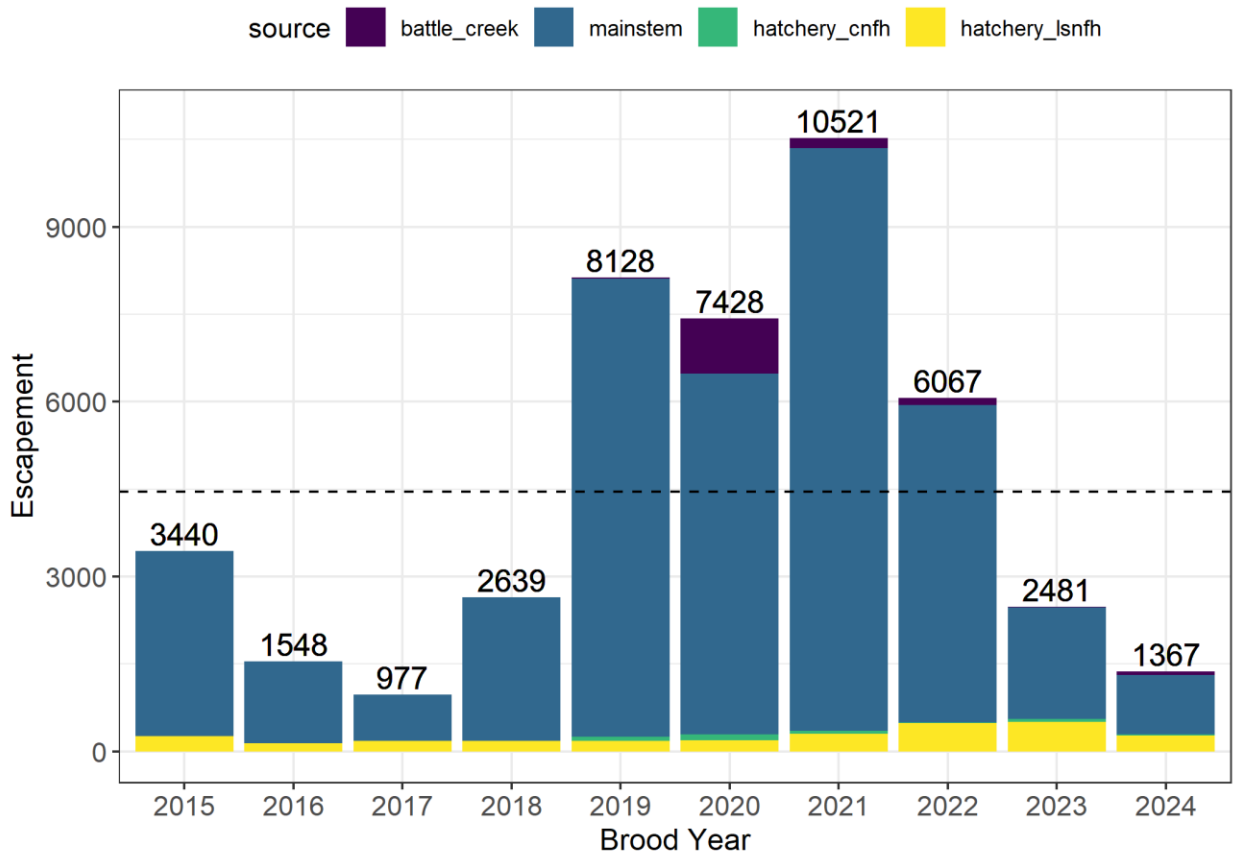

Figure 1. Winter-Run Chinook salmon Escapement Estimates, Brood Years 2015-2024. Winter-run escapement estimates are based on data from CDFW GrandTab (Azat 2025). Horizontal line indicates the 10-year average total escapement. Escapement numbers separated into Mainstem Sacramento River individuals upstream of Red Bluff Diversion Dam, Battle Creek individuals upstream of Coleman National Fish Hatchery (CNFH), Hatchery transfers from CNFH, and Hatchery transfers from Livingston Stone National Fish Hatchery (LSNFH).

Figure 1 is a bar chart comparing the escapement estimates for Winter-Run Chinook salmon for brood years 2015 to 2024. The escapement estimates are color coded by the following sources: Battle Creek (purpose), mainstem (blue), Coleman National Fish Hatchery (green), and Livingston Stone National Fish Hatchery (yellow). The source of the majority of escapement estimates is from the mainstem for all brood years. The highest escapement estimate was for Brood Year 2021 with 10,521 estimated.

Juvenile Production Index

The Juvenile Production Index (JPI) is based on the number of fry-equivalents at Red Bluff Diversion Dam (RBDD) and takes into account the response of fish to

environmental conditions during spawning, egg incubation and outmigration, and that occur upstream of RBDD (NMFS 2024). For BY 2024, the natural-origin winter-run Chinook salmon JPI was 587,167 (Figure 2). This value was estimated on December 31, 2024. The JPI value is lower than the 10-year average value of approximately 1.34 million, and lower than the JPI from last year. Estimates from BY 2024 are obtained from National Marine Fisheries Service (NMFS) JPE letters, and estimates from previous brood years are obtained from the United States Fish and Wildlife Service (USFWS) Red Bluff Fish and Wildlife Office (RBFWO).

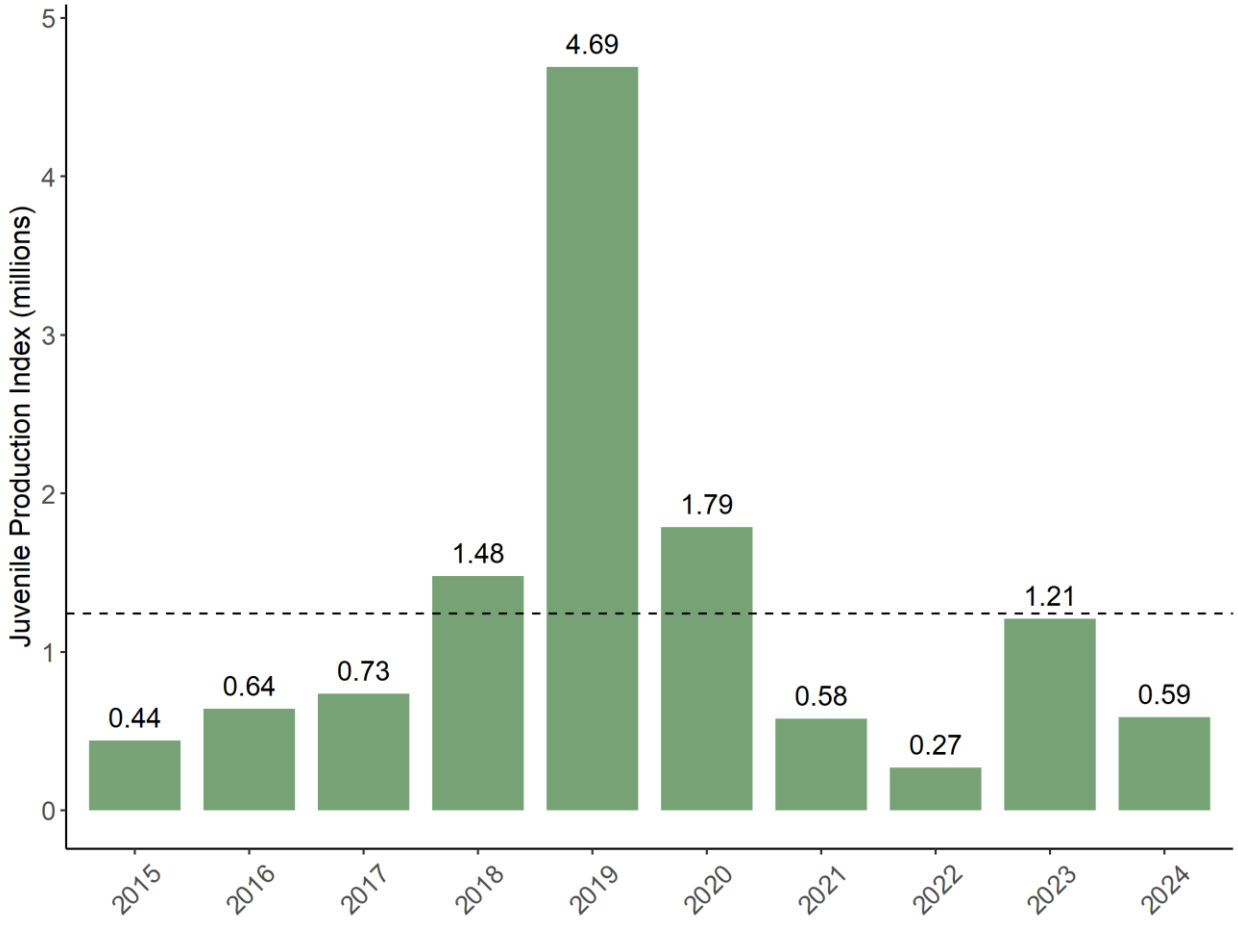

Figure 2. Winter-run Chinook salmon Juvenile Production Index, Brood Years (BY) 2015-2024. Estimates from BY 2024 are preliminary and from the NMFS JPE letters, while other estimates are from USFWS RBFWO. Horizontal line indicates the 10-year average JPI.

Figure 2 is a bar chart showing juvenile production index (in millions) on the y-axis and brood years (2015 – 2024) on the x-axis. The highest production occurred during the 2019 Brood Year with an estimated 4.69 million juvenile production index.

Egg-to-Fry Survival and Temperature-Dependent Mortality

Egg-to-fry (ETF) survival describes the survival rate from egg deposition to fry emergence and migration to RBDD rotary screw traps. Estimates are based on the estimated number of spawning females; estimated fecundity of the females derived from egg takes at Livingston Stone National Fish Hatchery (LSNFH), and the estimated number of fry equivalents passing RBDD derived from emigration monitoring using rotary screw traps at that location. Each year, a preliminary estimate is developed in the NMFS JPE letter, which is finalized later in the spring/summer. In BY 2024, preliminary ETF survival was estimated to be 28.9%, which was the greatest ETF survival since 2017 (Figure 3).

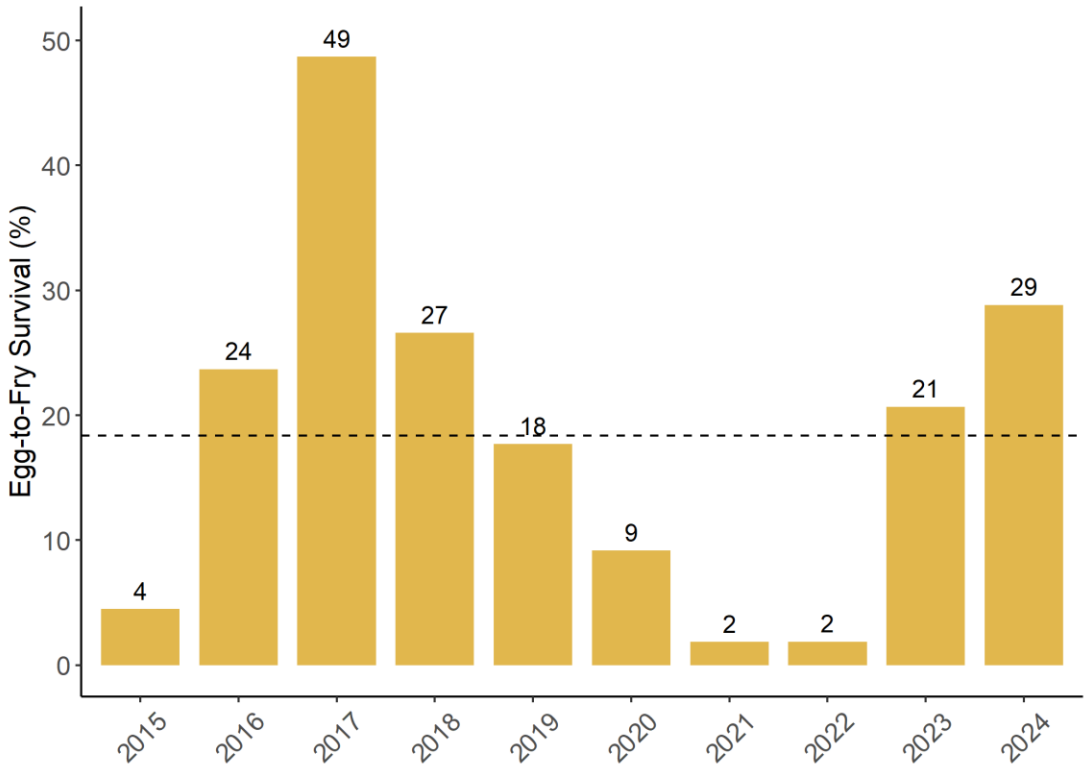

Figure 3. Winter-run Chinook salmon Egg-to-Fry Survival, Brood Years (BY) 2015-2024. Estimates from 2024 are preliminary and from the NMFS JPE letters, while other estimates are from USFWS. Horizontal line indicates the 10-year average Egg-to-Fry Survival.

Figure 3 is a bar chart comparing Egg-to-Fry survival (as a percentage) for brood years 2015 – 2024. Brood year 2017 supported the largest egg-to-survival with 49%. Brood years 2023 and 2024 egg-to-fry survival percentage is 21 and 29%, respectively.

Temperature-dependent mortality (TDM) is a modeled estimate that describes mortality at the egg stage that can occur due to water temperature. The water temperature exceeded the Sacramento River above Clear Creek (CCR) compliance target of 53.5°F on 19 days between May 24 (the start of temperature management season) and October 31 of 2024 (Figure 4). TDM estimates are used for preseason planning of temperature management actions and later as a performance metric. TDM estimates depend on redd location, incubation timing, and water temperature data within the winter-run spawning habitat of the Sacramento River.

Reclamation's forecasted TDM estimates in the final Temperature Management Plan for winter-run were similar to hindcast TDM estimates. Forecasted TDM was 0.4% using the Martin model (stage-independent) and 0.5% for Anderson model (stage-dependent) using the 90% exceedance forecast. Hindcast winter-run TDM was 0.06% for Anderson (stage-dependent) model and 0.03% for the Martin (stage-independent) model. The preliminary SWFSC TDM hindcast estimate was 0% for BY 2024, which was the same as BY 2023, and lower than the 10-year average of 18.6% (Figure 5). For more information on TDM seasonal hindcast assumptions, refer to Shasta Cold Water Pool Seasonal Report (USBR 2025, in prep).

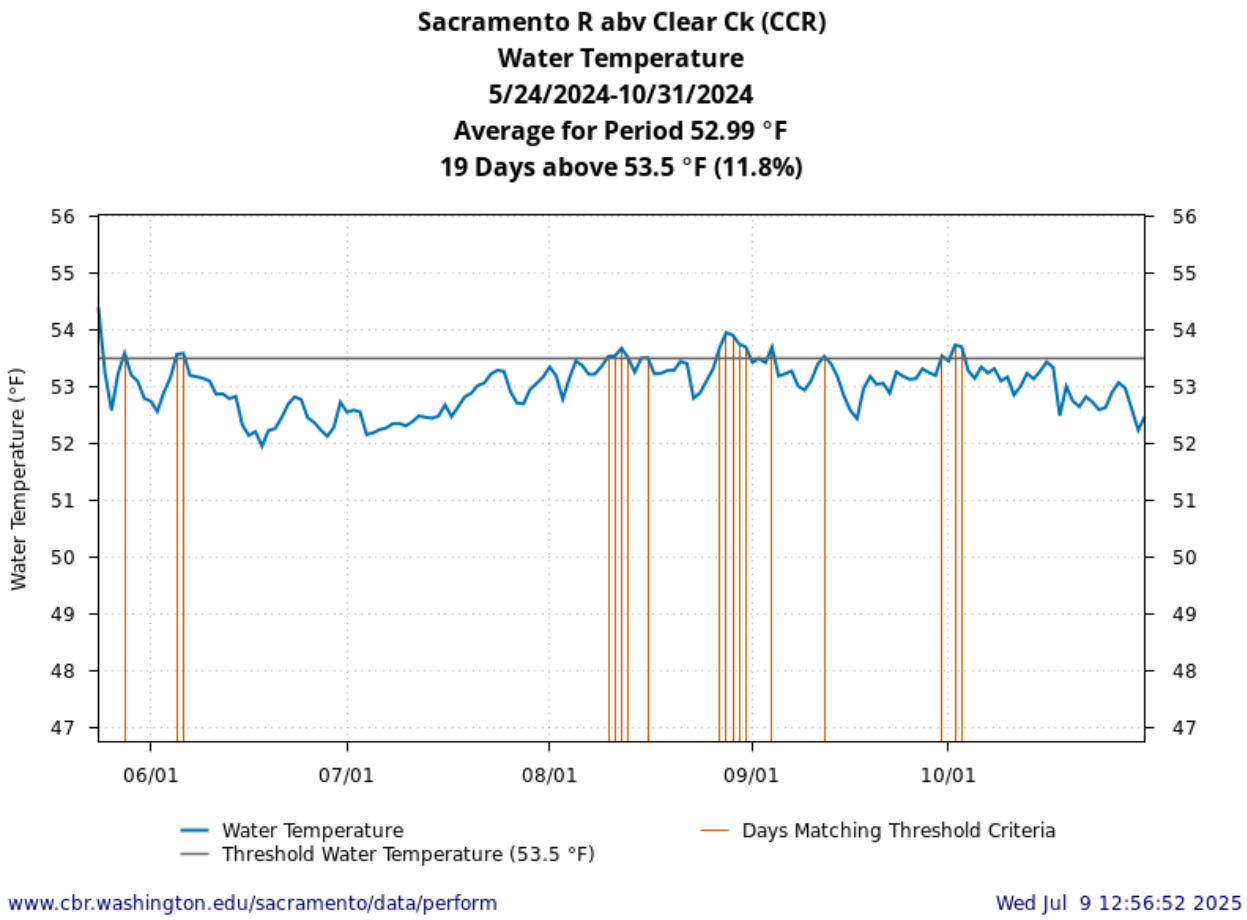

Figure 4. Water Temperature at Sacramento River above Clear Creek, May 24 – October 1, 2024. The horizontal line marks the temperature compliance threshold. Plot created by University of Washington on SacPAS.

Figure 4 is a line graph depicting water temperature (in degrees Fahrenheit) on the Sacramento River above Clear Creek from May 24th 2024 to October 31st 2024. Water temperature is shown by a blue line, the threshold water temperature (53.5° F) is shown as a grey horizontal line, and days with matching temperature threshold criteria are shown as orange vertical lines. Several days in August, September, and October met the water temperature criteria.

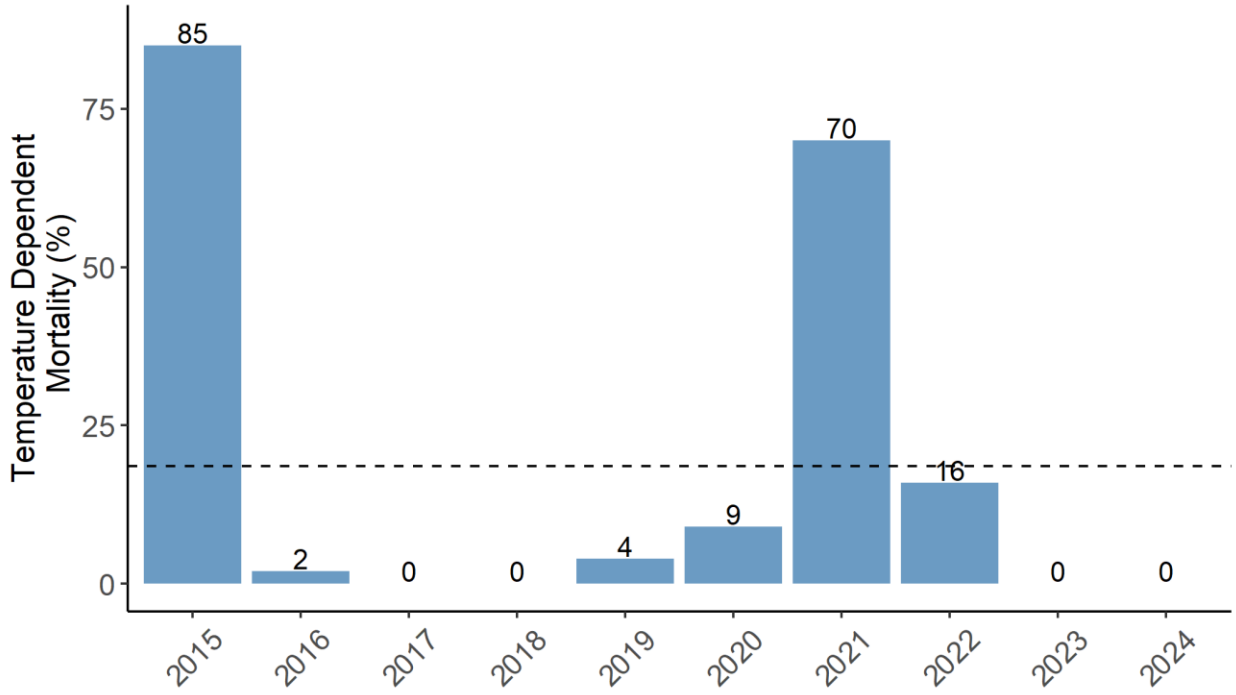

Figure 5. Winter-run Chinook salmon Temperature Dependent Mortality (TDM) Hindcast Estimate, Brood Years 2015-2024. Horizontal dashed line indicates the 10-year average TDM.

Figure 5 is a bar chart showing temperature dependent mortality (as a percentage) for brood years 2015 to 2024. The chart shows TDM for brood year 2015 to be the highest at 85%. Brood year 2021 had the next highest TDM at 70%.

The estimates for temperature-dependent mortality, egg-to-fry survival, and unattributed mortality (which represents other mortality factors upstream of RBDD) for BY 2015 – 2024 are shown as point estimates and do not incorporate uncertainty (Figure 6). Uncertainty in these point estimates include the abundance of fry equivalents passing Red Bluff, variation in fecundity of spawning females, viability of eggs, and temperature and background mortality rates. The unattributed mortality occurs during the egg incubation and free swimming life stages, while the temperature-dependent egg mortality is estimated only when eggs are in the gravel. There may be water temperature impacts outside of the egg incubation life stage. When temperature-dependent egg mortality was lower, there may be additional mortality from other sources.

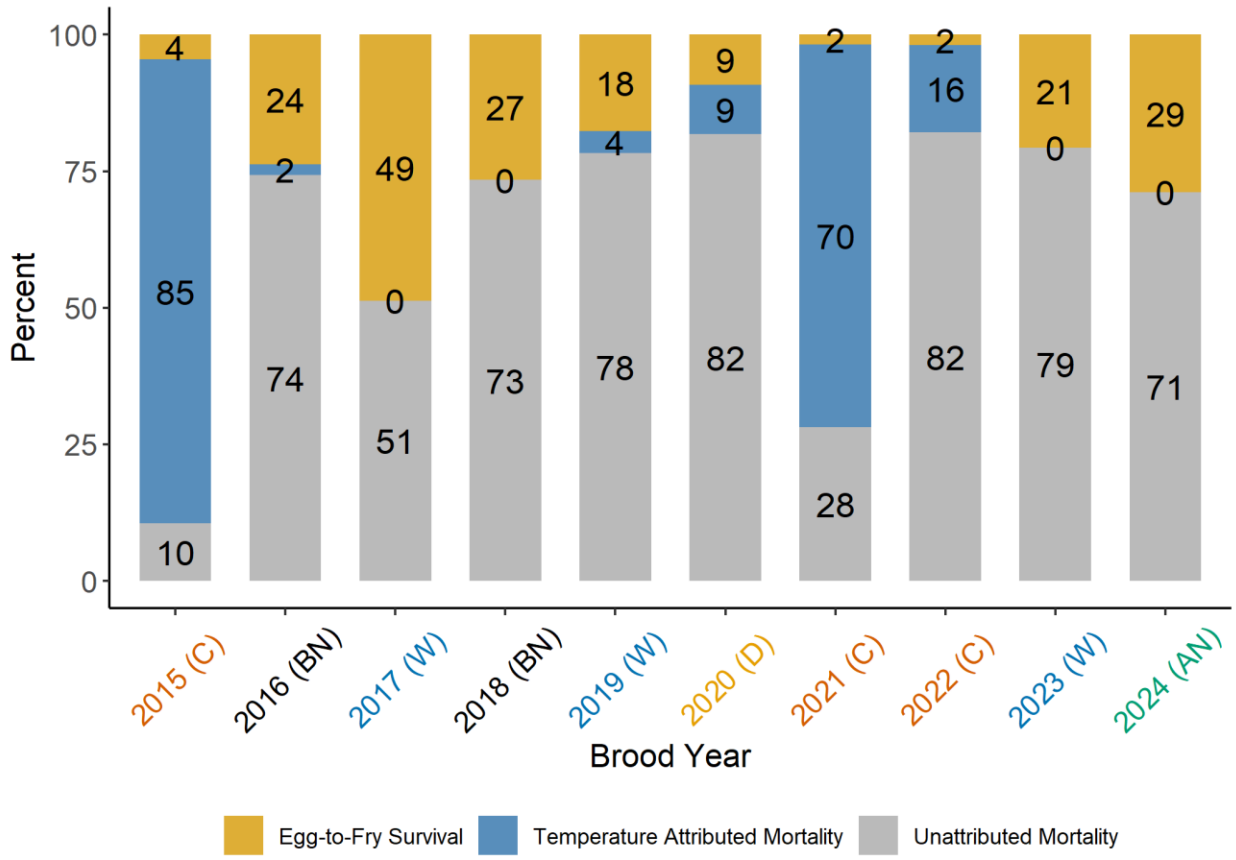

Figure 6. Winter-run Chinook salmon temperature attributed mortality.

Figure 6 is a bar graph depicting winter-run Chinook salmon temperature attributed mortality (i.e., temperature-dependent egg mortality; %; in blue), unattributed mortality (%; in gray), and egg-to-fry survival (%; in yellow) for BY 2015 through 2024. Temperature dependent mortality (i.e., temperature attributed mortality) estimates obtained from NOAA-Southwest Fisheries Science Center and are based on the Martin Model. Final egg-to-fry survival for BY 2015 to 2023 were provided by USFWS. Preliminary egg-to-fry survival estimates for BY 2024 obtained from the NMFS JPE letters. Unattributed mortality (which represents other mortality factors upstream of RBDD) was derived from subtracting temperature attributed mortality from total mortality.

River and Delta Survival

Acoustic Telemetry

To obtain estimates of survival and improve abundance estimates, USFWS implants acoustic transmitters into juvenile Livingston Stone National Fish Hatchery (LSNFH) and tracks survival through the Delta. On February 1, 2025, 451 fish were released

at Bonnyview Boat Ramp on the Sacramento River and on February 13, 2025, 437 fish were released at Posse Grounds Boat Ramp (other sites were inaccessible) on the Sacramento River. Survival estimates are calculated using the Cormack Jolly-Seber method. Preliminary survival from release to delta entry at Tower Bridge for BY2024 was 38% (95% CI: 34.4-41.6%), which was above the 5-year average of 20.7% (Figure 7). Preliminary through-Delta Survival for BY 2024 was 64.1% (95% CI: 58.5-69.3%), which was above the 5-year average of 53.2% (Figure 7). Survival to Benicia Bridge East Span was 26.7% (95% CI: 23.8-29.7%), which was above the 7-year average of 15.9% (Figure 7). For additional information about each year's tagging results and final estimates can be found on the CalFishTrack Central Valley Enhanced Acoustic Tagging Project website. The final report is anticipated by Fall 2025.

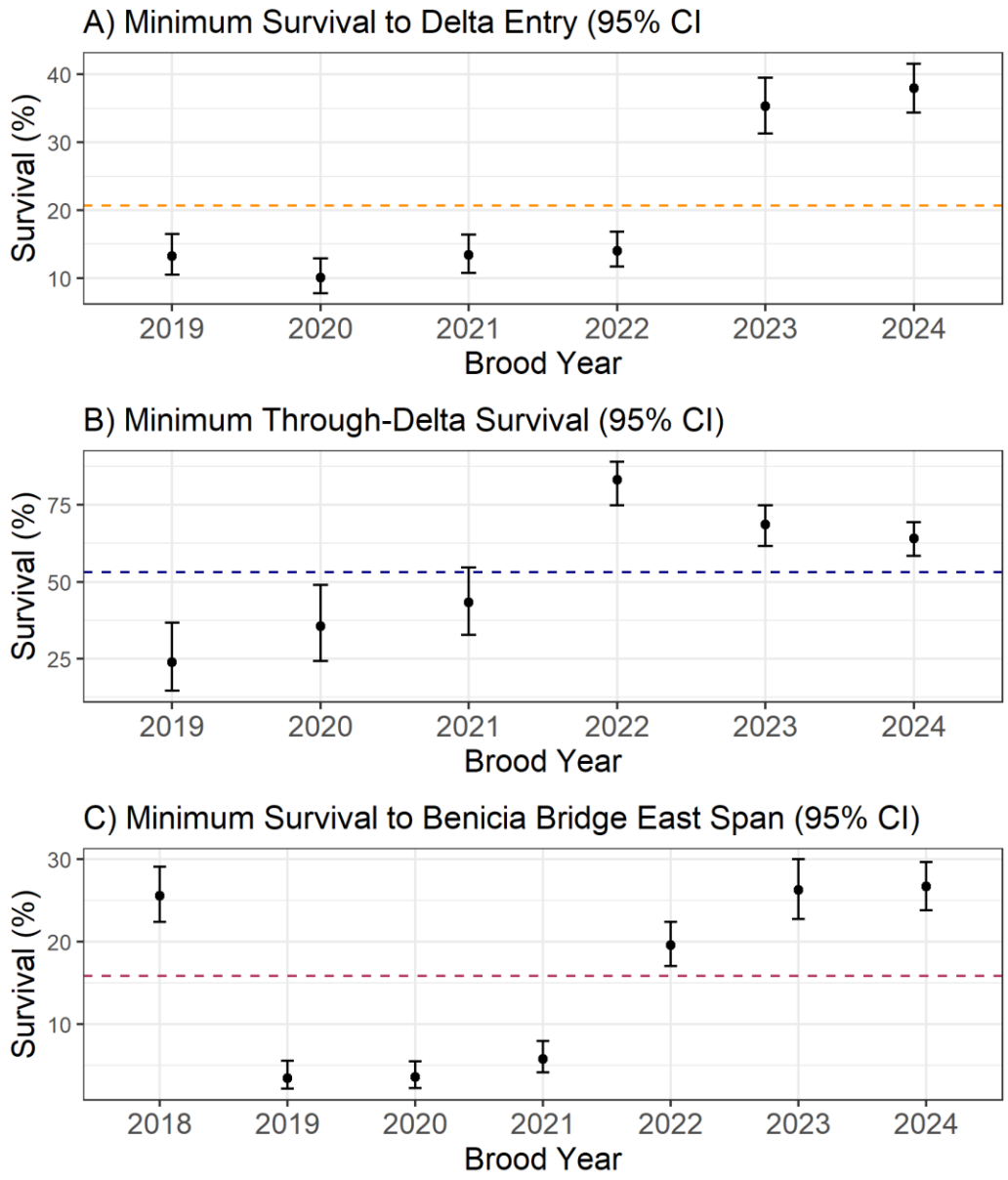

Figure 7. Preliminary Hatchery-origin winter-run Chinook salmon Survival and 95% Confidence Interval Estimates for A) Through-Delta Survival and B) Survival to Benicia Bridge East Span. Estimates from the CalFishTrack Central Valley Enhanced Acoustic Tagging Project website.

Figure 7 is a series of three plots summarizing the minimum survival to Delta Entry, Through-Delta, and to Benicia Bridge East Span with a 95% confidence interval. Each plot includes minimum and maximum range for survival percentage.

STARS Survival Model

STARS is the San Francisco Bay Delta's 'Survival, Travel time, and Routing Simulation' Survival Model. It is a series of simulations that predicts late-fall and winter-run through delta survival and routing based on environmental covariates and relationships developed in past telemetry studies. The simulation tool is available on the San Francisco Bay Delta Survival, Travel time, and Routing Simulation (STARS) website.

Predicted through-delta survival in WY 2025 appears higher than most years, dropping off in mid-April (Figure 8A) Interior Delta survival was also higher than most other years, but comparatively lower in parts of January and after March (Figure 8B). As illustrated in Figure 8, through-delta survival and interior delta survival is highest in those months and years in which routing probability into the interior delta is lowest. The median arrival date of acoustically-tagged hatchery winter-run Chinook salmon, which were released February 1 and February 13, at Georgiana Slough was March 6 (range: February 23-April 2) during the period of high apparent survival and low Georgiana Slough routing.

Figure 8a.

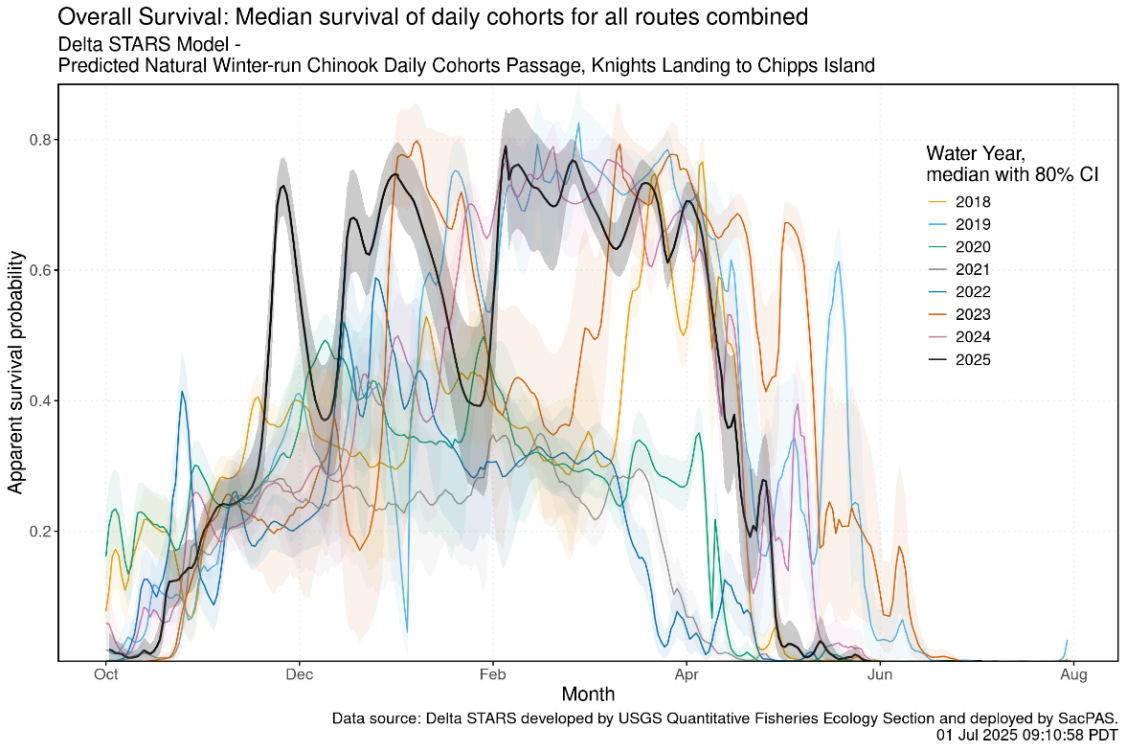

Figure 8b.

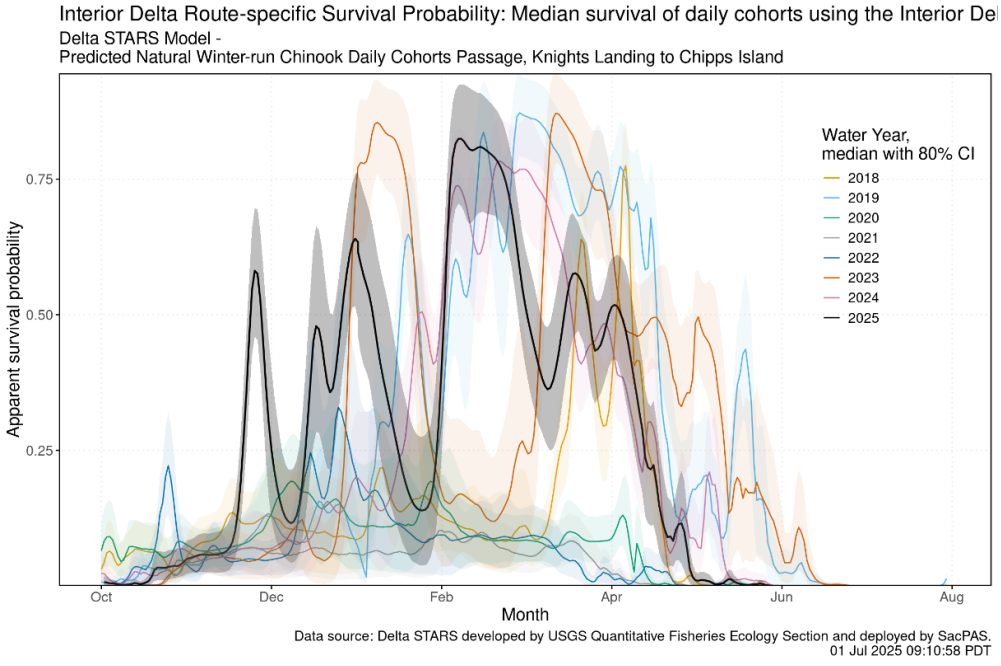

Figure 8c.

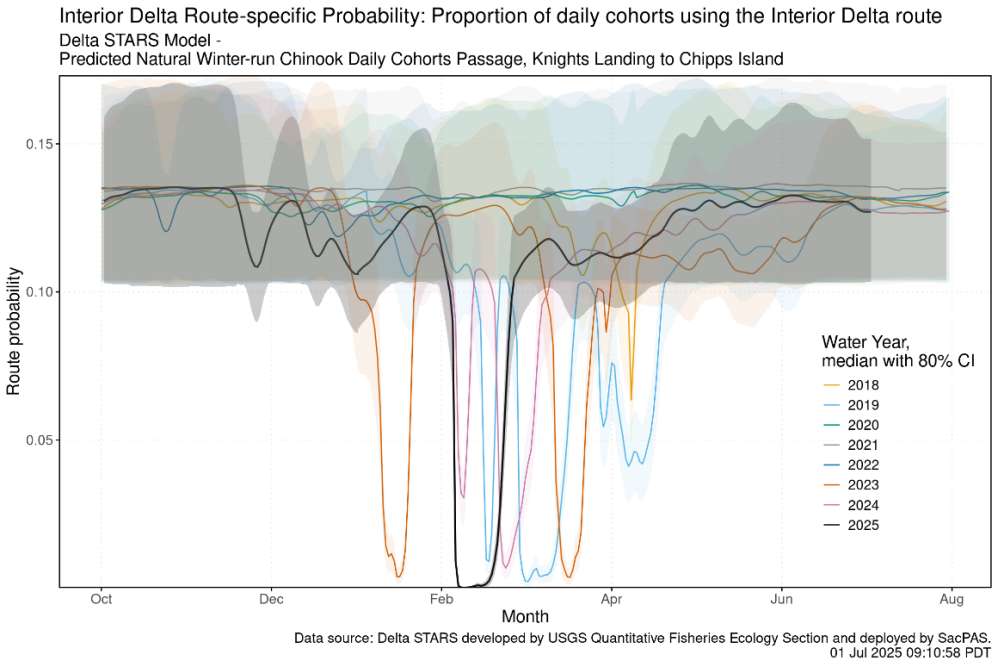

Figure 8. STARS model predicted survival.

Figure 8 is a collection of three line graphs. Predicted overall survival (A), interior delta survival (B), and interior delta routing (C) of winter-run from the STARS model derived from analysis of telemetry results of hatchery-origin winter-run Chinook Salmon from WY 2018-2025. Figures from SacPAS.

Salvage and Loss

Historic trends in salvage and loss were assessed using salvage and loss data at export facilities. All hatchery-origin winter-run loss data was queried from the salvage and loss detail page on SacPAS and include WYs 1999-2025. Genetically confirmed natural-origin Winter-run Chinook salmon loss data was partially queried from SacPAS from 2020-2025 with data from older years (2010-2019) originating from a dataset provided by DWR. Compared to historic years, cumulative loss of natural-origin winter-run in WY 2025 was relatively low, surpassing only a few years between 2010 and 2024 (Figure 10). In contrast, loss of hatchery-origin winter-run was high in WY 2025 surpassing all but two years between 1999 and 2024 (Figure 10). Timing of loss for both natural and hatchery-origin winter-run were comparable to historic years with the majority of loss occurring in March with

moderate loss in both February and April and little to no loss in other months (Figure 9).

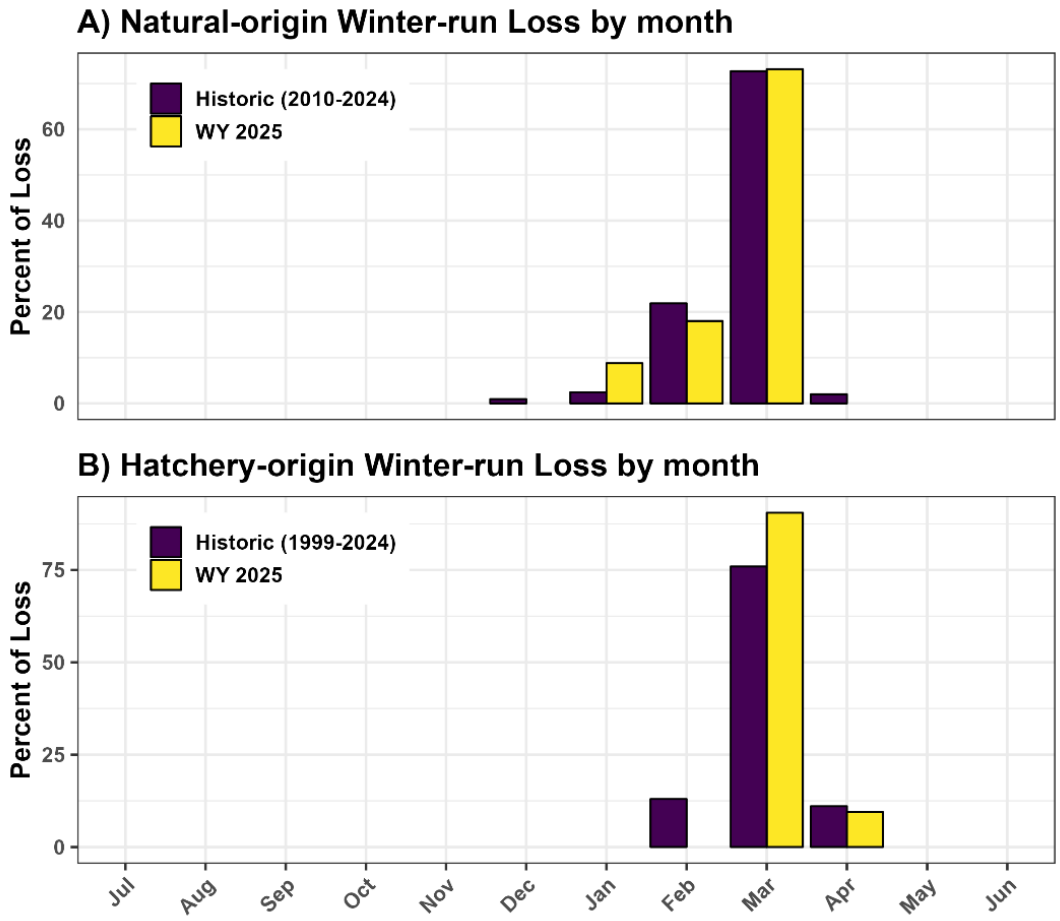

Figure 9. Natural- and Hatchery-origin winter-run Chinook salmon loss.

Figure 9 consists of two bar charts. Natural-origin (top) and Hatchery-origin (bottom) winter-run Chinook salmon loss by month for historic years (1999-2024 combined, shown as blue) compared to WY 2025 loss (shown as yellow). Loss shown as percentage of combined loss per water year.

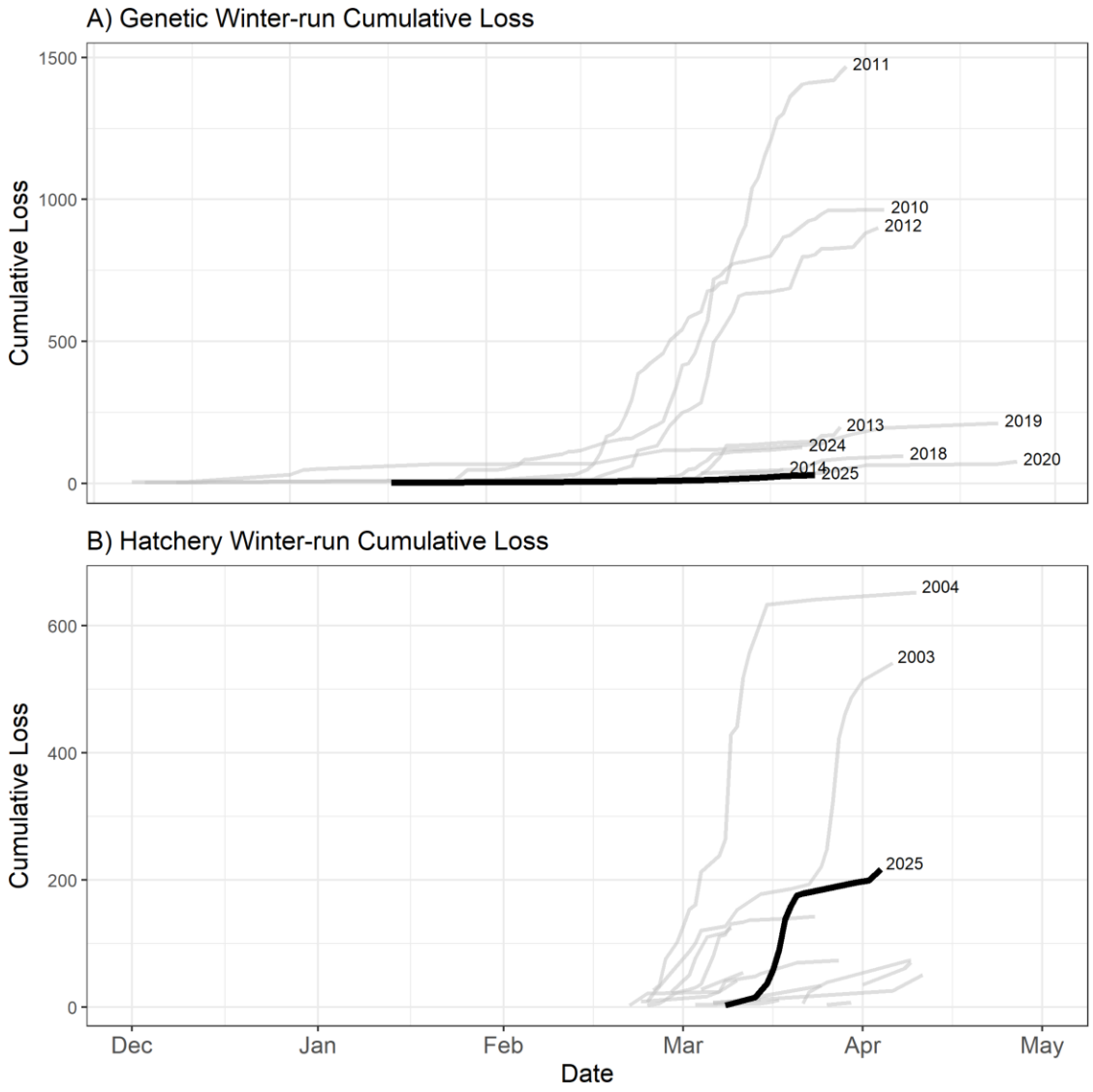

Figure 10. Cumulative loss of natural- and hatchery-origin winter-run Chinook salmon.

Figure 10 is a line graph showing cumulative loss of natural-origin (top) and hatchery-origin (bottom) winter-run Chinook salmon in WY 2025 (bold black line) compared to historic years (grey lines). Only historic years that have cumulative loss greater than WY 2025 are labeled.

References

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