# The Sacramento River winter Chinook Juvenile Production Estimate (JPE)

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# What is the JPE?

- A forecast of Winter Chinook juveniles entering the Sacramento/San Joaquin Delta
- JPE forecasts are used to determine the level of incidental take at state and federal pumping facilities
- Separate JPE forecasts are made for natural and hatchery-origin Winter Chinook
- These forecasts are developed by the Inter Agency Ecological Program's Winter Run Project Work Team, which transmits their findings to NMFS
- NFMS transmits the JPE forecasts and the authorized levels of incidental take while operating the CVP/SWP Delta pumping facilities to the Bureau of Reclamation (Jan-Feb)

# JPE methods have changed over time

- Prior to Brood Year (BY) 2015, a variety of JPE forecast models were considered
- For BY 2015 (water year 2016) the “JPI” method was employed
  - JPI stands for Juvenile Production Index and is an estimate of the natural-origin juveniles passing Red Bluff Diversion Dam (in fry-equivalent units)
- Since BY 2019 a model, referred to as Model 2, has been used

# Basic Approach – natural-origin winter run

$$\widehat{\mathrm{JPE}}_{n,t} = \widehat{\mathrm{JPI}}_{t-1} \times \hat{f} \times \hat{s}_n$$

JPE = natural-origin winter run to the delta in year *t*

JPI = fry-equivalent abundance at RBDD in year *t-1*

(~ 97 % of fry passage at RBDD occurs by December 31)

*f* = fry-to-smolt survival rate

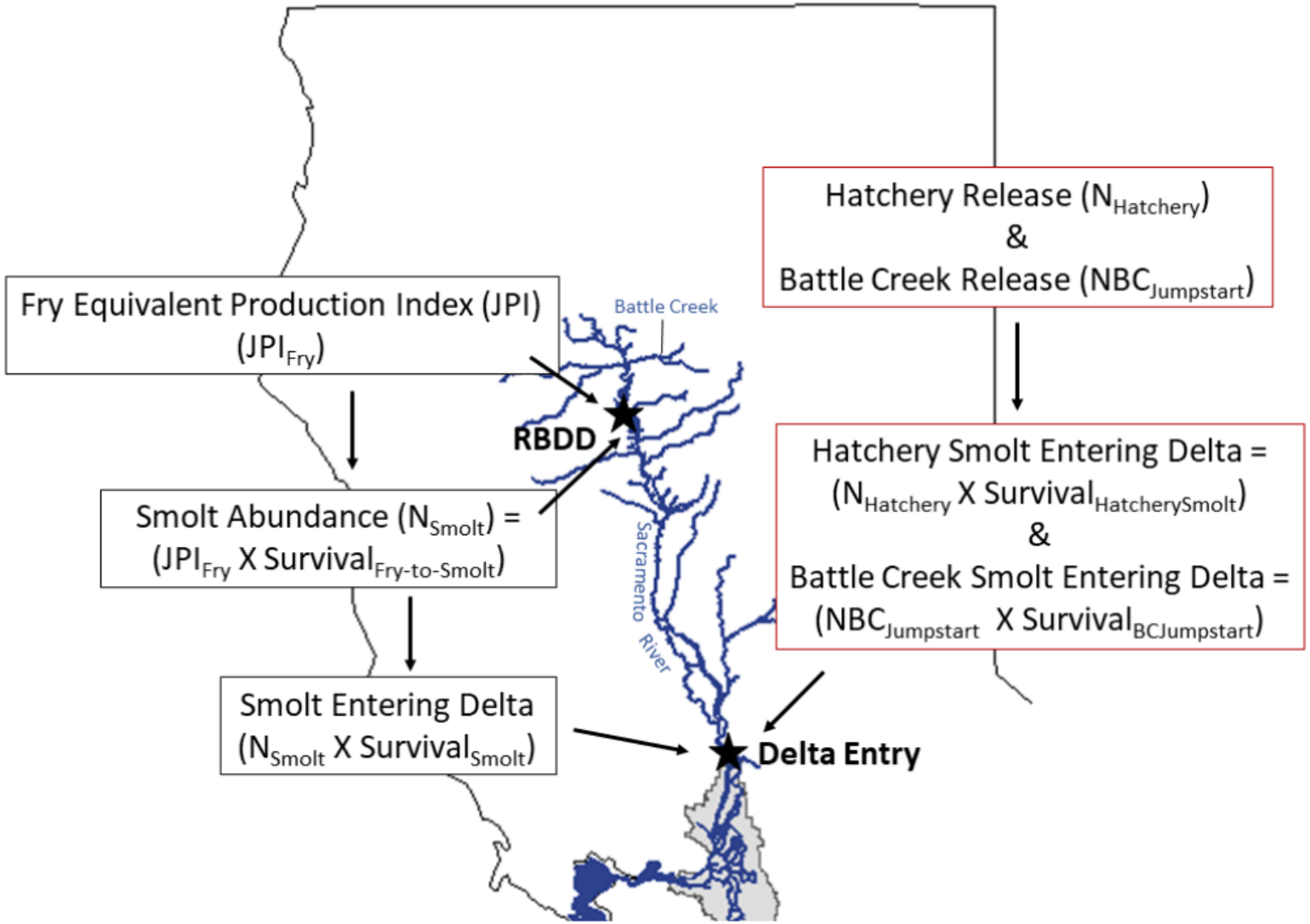
*S* = forecasted smolt survival rate from RBDD to the Delta

(Delta entry:Tower Bridge in Sacramento)

# Basic approach – hatchery-origin winter run

$$\widehat{\mathrm{JPE}}_{h,t} = \mathrm{P}_t \times \hat{S}_h$$

$P_t$= hatchery-origin pre-smolts released in calendar year *t*
$S_h$= forecasted survival rate from release to Delta entry




- Livingston Stone National Fish Hatchery releases generally occur in the Sacramento River near Redding (~ February)

- In recent years, some hatchery releases occur in Battle Creek as part of a "jumpstart" program

Figure is from the BY 2023 JPE letter

# Alternative Juvenile Production Estimate (JPE) Forecast Approaches for Sacramento River Winter-Run Chinook Salmon

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## ABSTRACT

Sacramento River winter-run Chinook Salmon are listed under the Endangered Species Act as Endangered, and there are substantial efforts to estimate, predict, and limit mortalities at various stages of their life cycle. One such effort is the annual forecast of the number of juvenile winter-run entering the Sacramento–San Joaquin Delta. The natural-origin juvenile production estimate (JPE) is defined as the number of winter-run juveniles produced from natural spawning areas that enter the Delta, and its forecast is used to determine the allowable level of winter-run incidental take at the state and federal pumping facilities located in the South Delta. Current monitoring programs in the Sacramento River basin do not allow the JPE to be directly estimated, and thus various methods have been used to forecast this value annually. Here, we describe three alternative methods for forecasting the natural-origin JPE. The methods range from the status quo approach (Method 1), which expresses the JPE forecast only as a point estimate, to two other methods that account for forecast uncertainty to various degrees. A comparison of JPE forecasts for 2018 across the three methods indicates that relative to Method 1, Methods 2 and 3 result in lower JPE forecasts, by 24% and 18%, respectively, primarily because of lower forecasts of the fry-to-smolt transition and the smolt survival rate that occurs downstream of Red Bluff Diversion Dam. Because post hoc estimates of juvenile winter-run abundance at the entrance to the Delta do not currently exist, we are unable to evaluate forecast skill among the three methods.

## KEY WORDS

Chinook Salmon, Sacramento River, winter-run, juvenile production estimate, forecast, incidental take

## INTRODUCTION

Management of fish and wildlife populations relies upon data generated from monitoring programs and analytical tools that use these data to inform decisions. For imperiled species, the need for robust monitoring and models is particularly acute

$$\widehat{\mathrm{JPE}}_{n,t} = \widehat{\mathrm{JPI}}_{t-1} \times \hat{f} \times \hat{s}_n$$

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# Method 1

- Status quo approach (JPI model)

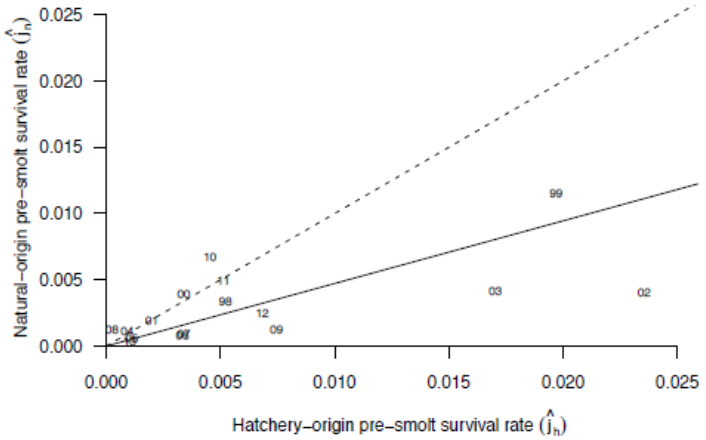
- Fry-to-smolt survival rate *f* was a constant value (0.59), attributed to work by Hallock (undated)
  - Based on Fall Chinook survival at the Tehama-Colusa spawning channel

- Smolt survival rate was based on a variance weighed mean of survival estimates from acoustic tagging studies
  - Binomial model
  - Does not account for detection probabilities

$$\widehat{\mathrm{JPE}}_{n,t} = \widehat{\mathrm{JPI}}_{t-1} \times \hat{f} \times \hat{s}_n$$

# Method 2

- Variance associated with observation error is estimated for the JPI, fry-to-smolt survival rate, and smolt survival rate
- Allows for derivation of a variance estimate for $\widehat{\mathrm{JPE}}_{n,t}$
- New approach to forecasting $\hat{f}$ was developed

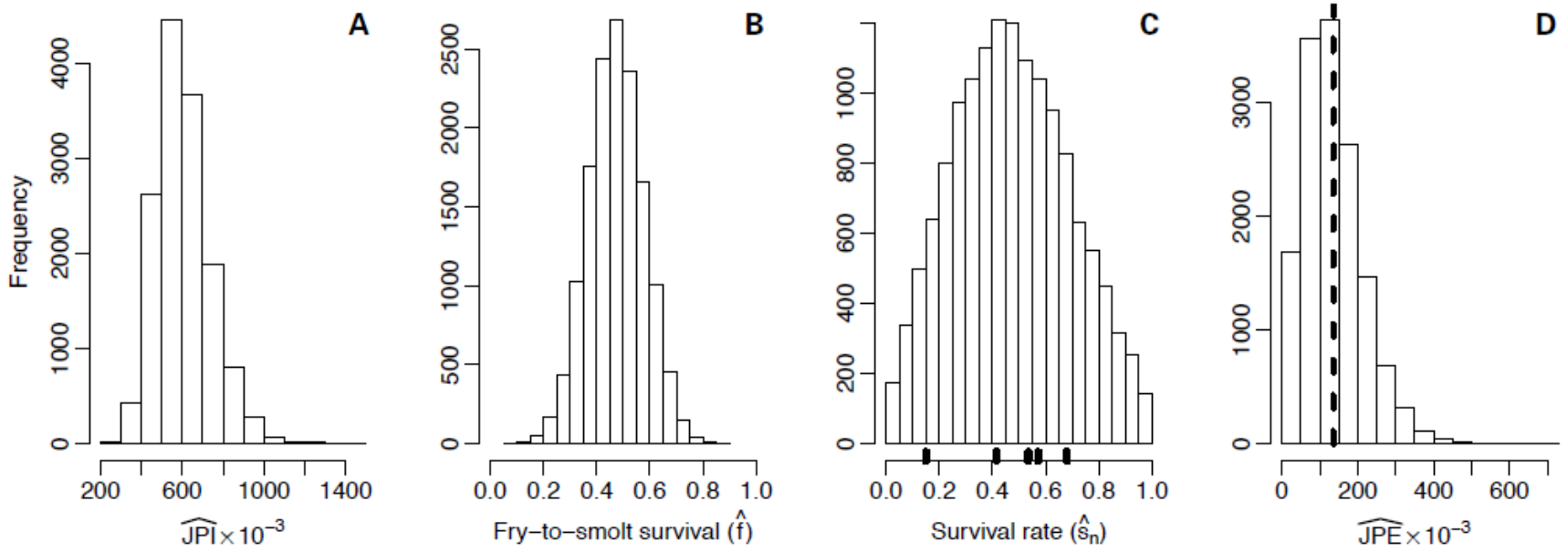



- Smolt survival rates were based on the variance-weighted mean of survival rates estimated by the Cormack-Jolly-Seber model
- CJS model accounts for detection probabilities

$$\widehat{\mathrm{JPE}}_{n,t} = \widehat{\mathrm{JPI}}_{t-1} \times \hat{f} \times \hat{s}_n$$

# Method 3

- Each of the JPE components are expressed as probability distributions
- Accounts for observation error in $\widehat{\mathrm{JPI}}_{t-1}$ and $\hat{f}$
- The distribution of $\hat{s}_n$ is derived from a Bayesian hierarchical model



# Conclusions and Outcomes

- The JPE work resulted in three alternative models that differed in the estimation of uncertainty
- A postseason estimate of the number of  winter run juveniles entering the Delta is not available
  - Assessing forecast skill is thus not feasible
- Method 2 has been recommended for JPE forecasting
  - Accounts for observation error
  - Reproducible/documented fry-to-smolt survival estimate
  - Uses smolt survival rates estimated by a mark-recapture model
- Method 2 first used for JPE forecasting in for brood year 2019
- Remains in use through brood year 2023

# Potential improvements?

- We used an indirect approach to estimate the fry-to-smolt survival rate
  - Cannot verify accuracy
  - It may now be possible to implant acoustic tags to fish captured at RBDD
  - This would allow for the JPE to be forecast without explicitly accounting for a fry-to-smolt survival rate
- Postseason estimates of the JPE are currently not feasible
  - However, we understand that potential new monitoring could provide such estimates