Readme

**Scripts**

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7. Natural Cohort Reconstruction.R - Cohort reconstruction code for natural origin cohorts. Calculates cohort abundance over time, natural-origin maturation, and impact rates.

8. Combined Cohort Reconstruction.R – Cohort reconstruction code for both hatchery and natural-origin fish. Only used for calculating collective spawner reduction rate.

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10. Maturation and productivity results – summarizing statistics, conducting tests, and presenting results on biological vital rates

# 1. Data Prep.R

## Data input

**CWTReleases FRH.csv**– coded wire batch data for fall-run Chinook salmon from Feather River Hatchery for brood year from 1972-2022. Obtained from RMIS database.

Variable descriptions

record\_code: marked/tagged (T) or unmarked (N)

tag\_code\_or\_release\_id: the batch code.

brood\_year: the fall in which eggs were laid.

hatchery\_location\_name: name of hatchery

cwt\_1st\_mark\_count: fish with CWT and Ad Clip.

cwt\_2nd\_mark\_count: fish with CWT and No clip.

non\_cwt\_1st\_mark\_count: fish with no CWT and Ad Clip.

non\_cwt\_2nd\_mark\_count: fish with no CWT and No Clip.

Total\_Released: total size of match, including marked and unmarked fish

Phi: proportion of batch marked.

**CWTReleases CNFH.csv**– coded wire batch data for fall-run Chinook salmon from Coleman National Fish Hatchery for brood year from 1974-2021. Obtained from RMIS database.

Variable descriptions

record\_code: marked/tagged (T) or unmarked (N)

tag\_code\_or\_release\_id: the batch code.

brood\_year: the fall in which eggs were laid.

hatchery\_location\_name: name of hatchery

cwt\_1st\_mark\_count: fish with CWT and Ad Clip.

cwt\_2nd\_mark\_count: fish with CWT and No clip.

non\_cwt\_1st\_mark\_count: fish with no CWT and Ad Clip.

non\_cwt\_2nd\_mark\_count: fish with no CWT and No Clip.

Total\_Released: total size of match, including marked and unmarked fish

Phi: proportion of batch marked.

**CWTReleases NFH.csv**– coded wire batch data for fall-run Chinook salmon from Nimbus Fish Hatchery for brood year from 1982-2021. Obtained from RMIS database.

Variable descriptions

record\_code: marked/tagged (T) or unmarked (N)

tag\_code\_or\_release\_id: the batch code.

brood\_year: the fall in which eggs were laid.

hatchery\_location\_name: name of hatchery

cwt\_1st\_mark\_count: fish with CWT and Ad Clip.

cwt\_2nd\_mark\_count: fish with CWT and No clip.

non\_cwt\_1st\_mark\_count: fish with no CWT and Ad Clip.

non\_cwt\_2nd\_mark\_count: fish with no CWT and No Clip.

Total\_Released: total size of match, including marked and unmarked fish

Phi: proportion of batch marked.

## Data output

**CWTReleased.csv** – CWT release information for all three hatchery. Used in *2. CWT Spawning Data Prep.R*, *4. CWT Harvest Data Prep R.,* and *5. CWT Cohort Reconstruction.R*

Variable descriptions

brood\_year: the fall in which eggs were laid.

hatchery\_location\_name: name of hatchery

tag\_code: the batch code.

Total\_Released: total size of match, including marked and unmarked fish

Phi: proportion of batch marked.

# 2. CWT Spawning Data Prep.R

## Data input

**CWTReleased.csv** – CWT release information for all three hatchery. From *1. Data Prep.R*

Variable descriptions

brood\_year: the fall in which eggs were laid.

hatchery\_location\_name: name of hatchery

tag\_code: the batch code.

Total\_Released: total size of match, including marked and unmarked fish

Phi: proportion of batch marked.

**CWTRecoveries CNFH.csv** – CWT recovery information for Coleman National Fish Hatchery from run year from 1977-2023. Obtained from RMIS database.

Variable descriptions

sampling\_agency: organization that collected the coded-wire tag information

run\_year: the year in which tag was recovered.

recovery\_date: the date in which tag was recovered.

fishery: 10 = commercial fishery; 40 = recreational fishery; 46 = in-river fishery 50 = hatchery; 54 = spawning ground.

recovery\_location\_code: recovery location code.

length: fork length in mm

sampling\_site: sampling site location code.

sex: M = male F = female.

tag code: the batch code.

estimated\_number: expanded tag value based on sampling effort.

recovery\_location\_name: recovery location name.

brood\_year: the year in which eggs were laid (the fall prior to release).

**CWTRecoveries NFH.csv** – CWT recovery information for Nimbus Fish Hatchery from run year from 1985-2023. Obtained from RMIS database.

Variable descriptions

sampling\_agency: organization that collected the coded-wire tag information

run\_year: the year in which tag was recovered.

recovery\_date: the date in which tag was recovered.

fishery: 10 = commercial fishery; 40 = recreational fishery; 46 = in-river fishery 50 = hatchery; 54 = spawning ground.

recovery\_location\_code: recovery location code.

length: fork length in mm

sampling\_site: sampling site location code.

sex: M = male F = female.

tag code: the batch code.

estimated\_number: expanded tag value based on sampling effort.

recovery\_location\_name: recovery location name.

brood\_year: the year in which eggs were laid (the fall prior to release).

**CWTRecoveries FRH.csv** – CWT recovery information for Feather River Hatchery from run year from 1976-2023. Obtained from RMIS database.

Variable descriptions

sampling\_agency: organization that collected the coded-wire tag information

run\_year: the year in which tag was recovered.

recovery\_date: the date in which tag was recovered.

fishery: 10 = commercial fishery; 40 = recreational fishery; 46 = in-river fishery 50 = hatchery; 54 = spawning ground.

recovery\_location\_code: recovery location code.

length: fork length in mm

sampling\_site: sampling site location code.

sex: M = male F = female.

tag code: the batch code.

estimated\_number: expanded tag value based on sampling effort.

recovery\_location\_name: recovery location name.

brood\_year: the year in which eggs were laid (the fall prior to release).

## Data output

**CWT Hatchery.csv** – CWT recovered at all 3 hatcheries and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. Used in *5. CWT Cohort Reconstruction.R* and *8. Combined Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Hat: Age 1 spawners to hatchery

Age2Hat: Age 2 spawners to hatchery

Age3Hat: Age 3 spawners to hatchery

Age4Hat: Age 4 spawners to hatchery

**CWT Hatchery CNFH.csv** – CWT recovered at Coleman National Fish Hatchery and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. Used in *5. CWT Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Hat: Age 1 spawners to hatchery

Age2Hat: Age 2 spawners to hatchery

Age3Hat: Age 3 spawners to hatchery

Age4Hat: Age 4 spawners to hatchery

**CWT Hatchery FRH.csv** – CWT recovered at Feather River Hatchery and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. Used in *5. CWT Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Hat: Age 1 spawners to hatchery

Age2Hat: Age 2 spawners to hatchery

Age3Hat: Age 3 spawners to hatchery

Age4Hat: Age 4 spawners to hatchery

**CWT Hatchery NFH.csv** – CWT recovered at Nimbus Fish Hatchery and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. Used in *5. CWT Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Hat: Age 1 spawners to hatchery

Age2Hat: Age 2 spawners to hatchery

Age3Hat: Age 3 spawners to hatchery

Age4Hat: Age 4 spawners to hatchery

**Escape to Hatchery by hatchery.csv** – Hatchery-origin escapement to each hatchery. Estimated age-specific number of fish marked and with CWTs and estimated number of age-specific number of hatchery fish (marked and unmarked). Used in *6. Natural Age Specific Escapement.R*

Variable descriptions

run\_year: the year in which tag was recovered.

recovery\_location\_name: name of river

Age2Sp\_CWT: Age 2 hatchery origin spawners to hatchery with CWTs

Age3Sp\_CWT: Age 3 hatchery origin spawners to hatchery with CWTs

Age4Sp\_CWT: Age 4 hatchery origin spawners to hatchery with CWTs

Age5Sp\_CWT: Age 5 hatchery origin spawners to hatchery with CWTs

Age2Sp\_Hatchery: Age 2 hatchery origin spawners to hatchery

Age3Sp\_Hatchery: Age 3 hatchery origin spawners to hatchery

Age4Sp\_Hatchery: Age 4 hatchery origin spawners to hatchery

Age5Sp\_Hatchery: Age 5 hatchery origin spawners to hatchery

**CWT Spawning Grounds.Rds –** Age-specific escapement from all 3 hatcheries by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *5. CWT Cohort Reconstruction.R* and 8. *Combined Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Sp: CWT Age 1 spawners to spawning ground

Age2Sp: CWT Age 2 spawners to spawning ground

Age3Sp: CWT Age 3 spawners to spawning ground

Age4Sp: CWT Age 4 spawners to spawning ground

Age5Sp: CWT Age 5 spawners to spawning ground

**CWT Spawning Grounds CNFH.Rds –** Age-specific escapement from Coleman National Fish Hatchery by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *5. CWT Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Sp: CWT Age 1 spawners to spawning ground

Age2Sp: CWT Age 2 spawners to spawning ground

Age3Sp: CWT Age 3 spawners to spawning ground

Age4Sp: CWT Age 4 spawners to spawning ground

Age5Sp: CWT Age 5 spawners to spawning ground

**CWT Spawning Grounds FRH.Rds –** Age-specific escapement from Feather River Hatchery by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *5. CWT Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Sp: CWT Age 1 spawners to spawning ground

Age2Sp: CWT Age 2 spawners to spawning ground

Age3Sp: CWT Age 3 spawners to spawning ground

Age4Sp: CWT Age 4 spawners to spawning ground

Age5Sp: CWT Age 5 spawners to spawning ground

**CWT Spawning Grounds NFH.Rds –** Age-specific from Nimbus Fish Hatchery by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *5. CWT Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Sp: CWT Age 1 spawners to spawning ground

Age2Sp: CWT Age 2 spawners to spawning ground

Age3Sp: CWT Age 3 spawners to spawning ground

Age4Sp: CWT Age 4 spawners to spawning ground

Age5Sp: CWT Age 5 spawners to spawning ground

**Escape to Spawning Grounds by river.Rds –** Hatchery-origin escapement to natural spawning grounds. Estimated age-specific number of fish marked and with CWTs and estimated number of age-specific number of hatchery fish (marked and unmarked). A list with 1000 items, each representing a bootstrapped sample. Used in *6. Natural Age Specific Escapement.R*

Variable descriptions

run\_year: the year adults returned

recovery\_location\_name: name of river

Age2Sp\_CWT: number of age-2 coded-wire tagged fish present

Age3Sp\_CWT: number of age-3 coded-wire tagged fish present

Age4Sp\_CWT: number of age-4 coded-wire tagged fish present

Age5Sp\_CWT: number of age-5 coded-wire tagged fish present

Age2Sp\_Hatchery: number of age-2 hatchery fish present

Age3Sp\_Hatchery: number of age-3 hatchery fish present

Age4Sp\_Hatchery: number of age-4 hatchery fish present

Age5Sp\_Hatchery: number of age-5 hatchery fish present

# 3. Size at Age.R

## Data input

**CWTRecoveries CNFH.csv** – CWT recovery information for Coleman National Fish Hatchery from run year from 1977-2023. Obtained from RMIS database.

Variable descriptions

sampling\_agency: organization that collected the coded-wire tag information

run\_year: the year in which tag was recovered.

recovery\_date: the date in which tag was recovered.

fishery: 10 = commercial fishery; 40 = recreational fishery; 46 = in-river fishery 50 = hatchery; 54 = spawning ground.

recovery\_location\_code: recovery location code.

length: fork length in mm

sampling\_site: sampling site location code.

sex: M = male F = female.

tag code: the batch code.

estimated\_number: expanded tag value based on sampling effort.

recovery\_location\_name: recovery location name.

brood\_year: the year in which eggs were laid (the fall prior to release).

**CWTRecoveries NFH.csv** – CWT recovery information for Nimbus Fish Hatchery from run year from 1985-2023. Obtained from RMIS database.

Variable descriptions

sampling\_agency: organization that collected the coded-wire tag information

run\_year: the year in which tag was recovered.

recovery\_date: the date in which tag was recovered.

fishery: 10 = commercial fishery; 40 = recreational fishery; 46 = in-river fishery 50 = hatchery; 54 = spawning ground.

recovery\_location\_code: recovery location code.

length: fork length in mm

sampling\_site: sampling site location code.

sex: M = male F = female.

tag code: the batch code.

estimated\_number: expanded tag value based on sampling effort.

recovery\_location\_name: recovery location name.

brood\_year: the year in which eggs were laid (the fall prior to release).

**CWTRecoveries FRH.csv** – CWT recovery information for Feather River Hatchery from run year from 1976-2023. Obtained from RMIS database.

Variable descriptions

sampling\_agency: organization that collected the coded-wire tag information

run\_year: the year in which tag was recovered.

recovery\_date: the date in which tag was recovered.

fishery: 10 = commercial fishery; 40 = recreational fishery; 46 = in-river fishery 50 = hatchery; 54 = spawning ground.

recovery\_location\_code: recovery location code.

length: fork length in mm

sampling\_site: sampling site location code.

sex: M = male F = female.

tag code: the batch code.

estimated\_number: expanded tag value based on sampling effort.

recovery\_location\_name: recovery location name.

brood\_year: the year in which eggs were laid (the fall prior to release).

**Site Codes.csv** – The region or Location in which each sampling site belongs to. Provided by NOAA Fisheries.

Variable descriptions

sampling\_agency: agency that uses the code.

sampling\_site: sampling code

Location: region of the coast with unique fishery regulations. MO = Monterey, SF = San Francisco, FB = Fort Bragg, KC = Klamath Area – California, KO = Klamath Area – Oregon, CO = Central Oregon, NO = Northern Oregon, WA = Washington, CAN = Canada, AK = Alaska

**Size limits.csv** –Size limit (inches) associated with each fishery type, location, and time. Provided by NOAA Fisheries.

Variable descriptions

run\_year: the year in which tag was recovered.

fishery: 10 = commercial fishery; 40 = recreational fishery

location = region of recovery. MO = Monterey, SF = San Francisco, FB = Fort Bragg, KC = Klamath Area – California, KO = Klamath Area – Oregon, CO = Central Oregon, NO = Northern Oregon, NF = North of Falcon (Washington, Canada, Alaska).

Month: month of recovery

limit: size limit (total length, inches)

## Data output

**Sizeatage year.csv** –length at age (total length) of Sacramento River Fall Run Chinook salmon for each year-age-month combination when it was possible to estimate length at age. Used in *4. CWT Harvest Data Prep.R.*

Variable descriptions

run\_year: the year in which tag was recovered.

Month: month of recovery

Age: run year minus brood year

mu: mean total length (in inches)

sd: standard deviation of total length (in inches)

**Sizeatage general.csv** –length at age (total length) of Sacramento River Fall Run Chinook salmon for each age-month combination with sufficient data available. Used in *4. CWT Harvest Data Prep.R..*

Variable descriptions

Month: month of recovery

Age: run year minus brood year

mu: mean total length (in inches)

sd: standard deviation of total length (in inches)

# 4. CWT Harvest Data Prep.R

## Data input

**CWTReleased.csv** – CWT release information for all three hatchery. From *1. Data Prep.R*

Variable descriptions

brood\_year: the fall in which eggs were laid.

hatchery\_location\_name: name of hatchery

tag\_code: the batch code.

Total\_Released: total size of match, including marked and unmarked fish

Phi: proportion of batch marked.

**CWTRecoveries CNFH.csv** – CWT recovery information for Coleman National Fish Hatchery from run year from 1977-2023. Obtained from RMIS database.

Variable descriptions

sampling\_agency: organization that collected the coded-wire tag information

run\_year: the year in which tag was recovered.

recovery\_date: the date in which tag was recovered.

fishery: 10 = commercial fishery; 40 = recreational fishery; 46 = in-river fishery 50 = hatchery; 54 = spawning ground.

recovery\_location\_code: recovery location code.

length: fork length in mm

sampling\_site: sampling site location code.

sex: M = male F = female.

tag code: the batch code.

estimated\_number: expanded tag value based on sampling effort.

recovery\_location\_name: recovery location name.

brood\_year: the year in which eggs were laid (the fall prior to release).

**CWTRecoveries NFH.csv** – CWT recovery information for Nimbus Fish Hatchery from run year from 1985-2023. Obtained from RMIS database.

Variable descriptions

sampling\_agency: organization that collected the coded-wire tag information

run\_year: the year in which tag was recovered.

recovery\_date: the date in which tag was recovered.

fishery: 10 = commercial fishery; 40 = recreational fishery; 46 = in-river fishery 50 = hatchery; 54 = spawning ground.

recovery\_location\_code: recovery location code.

length: fork length in mm

sampling\_site: sampling site location code.

sex: M = male F = female.

tag code: the batch code.

estimated\_number: expanded tag value based on sampling effort.

recovery\_location\_name: recovery location name.

brood\_year: the year in which eggs were laid (the fall prior to release).

**CWTRecoveries FRH.csv** – CWT recovery information for Feather River Hatchery from run year from 1976-2023. Obtained from RMIS database.

Variable descriptions

sampling\_agency: organization that collected the coded-wire tag information

run\_year: the year in which tag was recovered.

recovery\_date: the date in which tag was recovered.

fishery: 10 = commercial fishery; 40 = recreational fishery; 46 = in-river fishery 50 = hatchery; 54 = spawning ground.

recovery\_location\_code: recovery location code.

length: fork length in mm

sampling\_site: sampling site location code.

sex: M = male F = female.

tag code: the batch code.

estimated\_number: expanded tag value based on sampling effort.

recovery\_location\_name: recovery location name.

brood\_year: the year in which eggs were laid (the fall prior to release).

**Site Codes.csv** – The region or Location in which each sampling site belongs to. Provided by NOAA Fisheries.

Variable descriptions

sampling\_agency: agency that uses the code.

sampling\_site: sampling code

Location: region of the coast with unique fishery regulations. MO = Monterey, SF = San Francisco, FB = Fort Bragg, KC = Klamath Area – California, KO = Klamath Area – Oregon, CO = Central Oregon, NO = Northern Oregon, WA = Washington, CAN = Canada, AK = Alaska

**Size limits.csv** –Size limit (inches) associated with each fishery type, location, and time. Provided by NOAA Fisheries.

Variable descriptions

run\_year: the year in which tag was recovered.

fishery: 10 = commercial fishery; 40 = recreational fishery

location = region of recovery. MO = Monterey, SF = San Francisco, FB = Fort Bragg, KC = Klamath Area – California, KO = Klamath Area – Oregon, CO = Central Oregon, NO = Northern Oregon, NF = North of Falcon (Washington, Canada, Alaska).

Month: month of recovery

limit: size limit (total length, inches)

**Release Mortality Rates.csv** – Release mortality rates associated with each fishery type, location, and time. Provided by NOAA Fisheries.

Variable descriptions

run\_year: the year in which tag was recovered.

fishery: 10 = commercial fishery; 40 = recreational fishery

location: region of recovery. SF = San Francisco; CO = Central Oregon; KC = Klamath, California, KO = Klamath, Oregon, FB = Fort Bragg; NO = Northern Oregon; SO = Southern Oregon, MO = Monterrey

Month: month of recovery

Release.mort.rate: release mortality rate

**Sizeatage year.csv** –length at age (total length) of Sacramento River Fall Run Chinook salmon for each year-age-month combination when it was possible to estimate length at age. From *3.* *Size at Age.R.*

Variable descriptions

run\_year: the year in which tag was recovered.

Month: month of recovery

Age: run year minus brood year

mu: mean total length (in inches)

sd: standard deviation of total length (in inches)

**Sizeatage general.csv** –length at age (total length) of Sacramento River Fall Run Chinook salmon for each age-month combination with sufficient data available. From *3.* *Size at Age.R.*

Variable descriptions

Month: month of recovery

Age: run year minus brood year

mu: mean total length (in inches)

sd: standard deviation of total length (in inches)

## Data output

**CWT River Harvest.Rds –** Age-specific in-river harvest of all hatcheries sorted by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *5. CWT Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the summer prior to release).

InRiver2: CWT Age 2 harvest

InRiver3: CWT Age 3 harvest

InRiver4: CWT Age 4 harvest

InRiver5: CWT Age 5 harvest

**CWT River Harvest CNFH.Rds –** Age-specific in-river harvest of Coleman National Fish Hatchery fish sorted by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *5. CWT Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the summer prior to release).

InRiver2: CWT Age 2 harvest

InRiver3: CWT Age 3 harvest

InRiver4: CWT Age 4 harvest

InRiver5: CWT Age 5 harvest

**CWT River Harvest FRH.Rds –** Age-specific in-river harvest of Feather River Hatchery fish sorted by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *5. CWT Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the summer prior to release).

InRiver2: CWT Age 2 harvest

InRiver3: CWT Age 3 harvest

InRiver4: CWT Age 4 harvest

InRiver5: CWT Age 5 harvest

**CWT River Harvest NFH.Rds –** Age-specific in-river harvest of Nimbus Fish Hatchery fish sorted by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *5. CWT Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the summer prior to release).

InRiver2: CWT Age 2 harvest

InRiver3: CWT Age 3 harvest

InRiver4: CWT Age 4 harvest

InRiver5: CWT Age 5 harvest

**Impact CWT Bootstrap.Rds –** Ocean fishery impact (n) by brood year and month. Unrecovered tags in harvested fish were resampled 1000 times to generate 1000 estimates of fishery impact (including drop-off mortality and release mortality). Used in *5. CWT Cohort Reconstruction.R* and *9. Combined Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid.

Remaining column variables: Month and age of ocean fishery encounters

**Impact CWT Bootstrap CNFH.Rds –** Ocean fishery impact (n) by brood year and month for Coleman National Fish Hatchery. Unrecovered tags in harvested fish were resampled 1000 times to generate 1000 estimates of fishery impact (including drop-off mortality and release mortality). Used in *5. CWT Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid.

Remaining column variables: Month and age of ocean fishery encounters

**Impact CWT Bootstrap FRH.Rds –** Ocean fishery impact (n) by brood year and month for Feather River Hatchery. Unrecovered tags in harvested fish were resampled 1000 times to generate 1000 estimates of fishery impact (including drop-off mortality and release mortality). Used in *5. CWT Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid.

Remaining column variables: Month and age of ocean fishery encounters

**Impact CWT Bootstrap NFH.Rds –** Ocean fishery impact (n) by brood year and month for Nimbus Fish Hatchery. Unrecovered tags in harvested fish were resampled 1000 times to generate 1000 estimates of fishery impact (including drop-off mortality and release mortality). Used in *5. CWT Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid.

Remaining column variables: Month and age of ocean fishery encounters

**Harvest CWT Bootstrap.Rds –** Ocean fishery harvest (n) by brood year and month. Unrecovered tags in harvested fish were resampled 1000 times to generate 1000 estimates of fishery harvest (excludes drop-off mortality and release mortality). Used in *5. CWT Cohort Reconstruction.R* and *9. Comparison with SI.R*

Variable descriptions

brood\_year: the year in which eggs were laid.

Remaining column variables: Month and age of ocean fishery encounters

# 5. CWT Cohort Reconstruction.R

## Data input

**CWTReleased.csv** – CWT release information for all three hatchery. From *1. Data Prep.R*

Variable descriptions

brood\_year: the fall in which eggs were laid.

hatchery\_location\_name: name of hatchery

tag\_code: the batch code.

Total\_Released: total size of match, including marked and unmarked fish

Phi: proportion of batch marked.

**CWT Spawning Grounds.Rds –** Age-specific escapement from all 3 hatcheries by brood year. A list with 1000 items, each representing a bootstrapped sample. From *2. CWT Spawning Data Prep.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Sp: CWT Age 1 spawners to spawning ground

Age2Sp: CWT Age 2 spawners to spawning ground

Age3Sp: CWT Age 3 spawners to spawning ground

Age4Sp: CWT Age 4 spawners to spawning ground

Age5Sp: CWT Age 5 spawners to spawning ground

**CWT Spawning Grounds CNFH.Rds –** Age-specific escapement from Coleman National Fish Hatchery by brood year. A list with 1000 items, each representing a bootstrapped sample. From *2. CWT Spawning Data Prep.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Sp: CWT Age 1 spawners to spawning ground

Age2Sp: CWT Age 2 spawners to spawning ground

Age3Sp: CWT Age 3 spawners to spawning ground

Age4Sp: CWT Age 4 spawners to spawning ground

Age5Sp: CWT Age 5 spawners to spawning ground

**CWT Spawning Grounds FRH.Rds –** Age-specific escapement from Feather River Hatchery by brood year. A list with 1000 items, each representing a bootstrapped sample. From *2. CWT Spawning Data Prep.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Sp: CWT Age 1 spawners to spawning ground

Age2Sp: CWT Age 2 spawners to spawning ground

Age3Sp: CWT Age 3 spawners to spawning ground

Age4Sp: CWT Age 4 spawners to spawning ground

Age5Sp: CWT Age 5 spawners to spawning ground

**CWT Spawning Grounds NFH.Rds –** Age-specific escapement from Nimbus Fish Hatchery by brood year. A list with 1000 items, each representing a bootstrapped sample. From *2. CWT Spawning Data Prep.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Sp: CWT Age 1 spawners to spawning ground

Age2Sp: CWT Age 2 spawners to spawning ground

Age3Sp: CWT Age 3 spawners to spawning ground

Age4Sp: CWT Age 4 spawners to spawning ground

Age5Sp: CWT Age 5 spawners to spawning ground

**CWT Hatchery.csv** – CWT recovered at all 3 hatcheries and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. From *2. CWT Spawning Data Prep.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Hat: Age 1 spawners to hatchery

Age2Hat: Age 2 spawners to hatchery

Age3Hat: Age 3 spawners to hatchery

Age4Hat: Age 4 spawners to hatchery

**CWT Hatchery CNFH.csv** – CWT recovered at Coleman National Fish Hatchery and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. From *2. CWT Spawning Data Prep.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Hat: Age 1 spawners to hatchery

Age2Hat: Age 2 spawners to hatchery

Age3Hat: Age 3 spawners to hatchery

Age4Hat: Age 4 spawners to hatchery

**CWT Hatchery FRH.csv** – CWT recovered at Feather River Hatchery and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. From *2. CWT Spawning Data Prep.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Hat: Age 1 spawners to hatchery

Age2Hat: Age 2 spawners to hatchery

Age3Hat: Age 3 spawners to hatchery

Age4Hat: Age 4 spawners to hatchery

**CWT Hatchery NFH.csv** – CWT recovered at Nimbus Fish Hatchery and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. From *2. CWT Spawning Data Prep.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the summer prior to release).

Age1Hat: Age 1 spawners to hatchery

Age2Hat: Age 2 spawners to hatchery

Age3Hat: Age 3 spawners to hatchery

Age4Hat: Age 4 spawners to hatchery

**Impact CWT Bootstrap.Rds –** Ocean fishery impact (n) for all three hatcheries by brood year and month. Unrecovered tags in harvested fish were resampled 1000 times to generate 1000 estimates of fishery impact (including drop-off mortality and release mortality). From *4. CWT Harvest Data Prep.R*

Variable descriptions

brood\_year: the year in which eggs were laid.

Remaining column variables: Month and age of ocean fishery encounters

**Impact CWT Bootstrap CNFH.Rds –** Ocean fishery impact (n) by brood year and month for Coleman National Fish Hatchery. Unrecovered tags in harvested fish were resampled 1000 times to generate 1000 estimates of fishery impact (including drop-off mortality and release mortality). From *4. CWT Harvest Data Prep.R*

Variable descriptions

brood\_year: the year in which eggs were laid.

Remaining column variables: Month and age of ocean fishery encounters

**Impact CWT Bootstrap FRH.Rds –** Ocean fishery impact (n) by brood year and month for Feather River Hatchery. Unrecovered tags in harvested fish were resampled 1000 times to generate 1000 estimates of fishery impact (including drop-off mortality and release mortality). From *4. CWT Harvest Data Prep.R*

Variable descriptions

brood\_year: the year in which eggs were laid.

Remaining column variables: Month and age of ocean fishery encounters

**Impact CWT Bootstrap NFH.Rds –** Ocean fishery impact (n) by brood year and month for Nimbus Fish Hatchery. Unrecovered tags in harvested fish were resampled 1000 times to generate 1000 estimates of fishery impact (including drop-off mortality and release mortality). From *4. CWT Harvest Data Prep.R*

Variable descriptions

brood\_year: the year in which eggs were laid.

Remaining column variables: Month and age of ocean fishery encounters

**Harvest CWT Bootstrap.Rds –** Ocean fishery harvest (n) by brood year and month. Unrecovered tags in harvested fish were resampled 1000 times to generate 1000 estimates of fishery harvest (excludes drop-off mortality and release mortality). From *4. CWT Harvest Data Prep.R.*

Variable descriptions

brood\_year: the year in which eggs were laid.

Remaining column variables: Month and age of ocean fishery encounters

## Data output

**Maturation Uncertainty CWT.csv –** Age 2, 3, and 4 maturation rates for all hatchery-origin fish and their 95% confidence intervals and standard deviation across bootstrapped iterations. Used in *10. Maturation and productivity results.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the summer prior to release).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty CWT CNFH.csv –** Age 2, 3, and 4 maturation rates for Coleman National Fish Hatchery and their 95% confidence intervals and standard deviation across bootstrapped iterations. Used in *10. Maturation and productivity results.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the summer prior to release).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty CWT FRH.csv –** Age 2, 3, and 4 maturation rates for Feather River Hatchery and their 95% confidence intervals and standard deviation across bootstrapped iterations. Used in *10. Maturation and productivity results.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty CWT NFH.csv –** Age 2, 3, and 4 maturation rates for Nimbus Fish Hatchery and their 95% confidence intervals and standard deviation across bootstrapped iterations. Used in *10. Maturation and productivity results.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Impact Uncertainty CWT.csv –** age-specific impact rates for all hatchery-origin fish and their 95% confidence intervals. Used in *9. Comparison with SI.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

ImpLower: lower bound of 95% confidence interval of age-specific impact rate

ImpMean: mean age-specific impact rate

ImpUpper: upper bound of 95% confidence interval of age-specific impact rate.

Age: age for which impact is reported calculated by run year minus brood year

**Unfished3 CWT.csv –** mean hatchery-origin age3+ ocean abundance on September 1 if the stock was never fished and the 95% confidence intervals. Used in *9. Comparison with SI.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Unfished3Lower: lower bound of 95% confidence interval of Sept 1 abundance

Unfished3Mean: mean Sept 1 abundance

Unfished3Upper: upper bound of 95% confidence interval of Sept 1 abundance

**Nofishing3 CWT.csv –** mean hatchery-origin age3+ ocean abundance on September 1 if the stock was not fished in the current run year and the 95% confidence intervals. Used in *9. Comparison with SI.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Nofishing3Lower: lower bound of 95% confidence interval of Sept 1 abundance

Nofishing 3Mean: mean Sept 1 abundance

Nofishing 3Upper: upper bound of 95% confidence interval of Sept 1 abundance

**SRR CWT.csv –** hatchery-origin spawner reduction rate by fisheries in cumulative years by run year and the 95% confidence intervals. Used in *9. Comparison with SI.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

SRRLower: lower bound of 95% confidence interval of the spawner reduction rate

SRRMean: mean spawner reduction rate

SRRUpper: upper bound of 95% confidence interval of the spawner reduction rate

**SRRy CWT.csv –** hatchery-origin spawner reduction rate by fisheries in the management year of the run year and the 95% confidence intervals. Used in *9. Comparison with SI.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

SRRyLower: lower bound of 95% confidence interval of the spawner reduction rate

SRRyMean: mean spawner reduction rate by fisheries in the management year of the run year

SRRyUpper: upper bound of 95% confidence interval of the spawner reduction rate

**Sept1 CWT.csv –** mean hatchery-origin age3+ ocean abundance on September 1 in the current run year and the 95% confidence intervals.

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Sept1Lower: lower bound of 95% confidence interval of Sept 1 abundance Sept1Mean: mean Sept 1 abundance

Sept1Upper: upper bound of 95% confidence interval of Sept 1 abundance

**Outmigration Survival.csv –** mean hatchery-origin survival from release to age-2 and the 95% confidence intervals.

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

OutSLower: lower bound of 95% confidence interval of the outmigration and early ocean survival

OutSMean: mean outmigration and early ocean survival

OutSUpper: upper bound of 95% confidence interval of the outmigration and early ocean survival

**CWT monthly impact rates.Rds –** monthly impact rates and age-specific river impact rates for CWT fish by brood year. Used in *7. Natural Cohort Reconstruction.R* and *8. Combined Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the summer prior to release).

Remaining column variables: Impact rate at age and month.

ImpRiv5: In-river fisheries impact rate at age 5

ImpRiv4: In-river fisheries impact rate at age 4

ImpRiv3: In-river fisheries impact rate at age 3

ImpRiv2: In-river fisheries impact rate at age 2

# 6. Natural Age Escapement.R

## Data input

**Hatchery Escapement.csv –** Escapement of spawners to each hatchery and the proportion of them that were natural-origin. From CalFish Grandtab Azat (2024).

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Count: Total escapement to the hatchery

Hatchery: name of hatchery

**River Escapement.csv –** Escapement of spawners to each river. From CalFish Grandtab Azat (2024).

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Count: Total escapement to the natural spawning grounds

River: River surveyed with spawning grounds

**Escape to Spawning Grounds by river.Rds –** Hatchery-origin escapement to natural spawning grounds. Estimated age-specific number of fish marked and with CWTs and estimated number of age-specific number of hatchery fish (marked and unmarked). A list with 1000 items, each representing a bootstrapped sample. From *2. CWT Spawning Data Prep.R*

Variable descriptions

run\_year: the year adults returned

recovery\_location\_name: name of river

Age2Sp\_CWT: number of age-2 coded-wire tagged fish present

Age3Sp\_CWT: number of age-3 coded-wire tagged fish present

Age4Sp\_CWT: number of age-4 coded-wire tagged fish present

Age5Sp\_CWT: number of age-5 coded-wire tagged fish present

Age2Sp\_Hatchery: number of age-2 hatchery fish present

Age3Sp\_Hatchery: number of age-3 hatchery fish present

Age4Sp\_Hatchery: number of age-4 hatchery fish present

Age5Sp\_Hatchery: number of age-5 hatchery fish present

**Escape to Hatchery by hatchery.csv** – Hatchery-origin escapement to each hatchery. Estimated age-specific number of fish marked and with CWTs and estimated number of age-specific number of hatchery fish (marked and unmarked). From *2. CWT Spawning Data Prep.R*

Variable descriptions

run\_year: the year in which tag was recovered.

recovery\_location\_name: name of river

Age2Sp\_CWT: Age 2 hatchery origin spawners to hatchery with CWTs

Age3Sp\_CWT: Age 3 hatchery origin spawners to hatchery with CWTs

Age4Sp\_CWT: Age 4 hatchery origin spawners to hatchery with CWTs

Age5Sp\_CWT: Age 5 hatchery origin spawners to hatchery with CWTs

Age2Sp\_Hatchery: Age 2 hatchery origin spawners to hatchery

Age3Sp\_Hatchery: Age 3 hatchery origin spawners to hatchery

Age4Sp\_Hatchery: Age 4 hatchery origin spawners to hatchery

Age5Sp\_Hatchery: Age 5 hatchery origin spawners to hatchery

**scale ages.csv –** age of samples based on coded-wire tags when present and scale aging when conducted. Provided by California Department of Fish and Wildlife Ocean Salmon Project.

Variable descriptions

River: River or hatchery sample was recovered

CWT.Age: known age from coded-wire tag

Reader.Age: estimated age through scale aging

run\_year: year sample was recovered

Supplement: Yes (Y) or No (N) whether scale is an out of sample supplement to assess reader accuracy

CWT.Code: coded-wire tag code from sample if present. NA means No coded-wire tag present.

## Data output

**Natural SpawnersAdjusted Sac.Rds –** Natural-origin age specific escapement to the Sacramento River mainstem (above and below RBDD) by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *7. Natural Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted Feather. Rds –** Natural-origin age specific escapement to the Feather River spawning grounds by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *7. Natural Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted American. Rds –** Natural-origin age specific escapement to the American River spawning grounds by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *7. Natural Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted Clear. Rds –** Natural-origin age specific escapement to the Clear Creek by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *7. Natural Cohort Reconstruction.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted Yuba. Rds –** Natural-origin age specific escapement to the Yuba River by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *7. Natural Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted Battle. Rds –** Natural-origin age specific escapement to the Battle Creek and Coleman National Fish Hatchery by brood year. A list with 1000 items, each representing a bootstrapped sample. *7. Natural Cohort Reconstruction.R*.

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted Other. Rds –** Natural-origin age specific escapement to Cottonwood Creek, Cow Creek, Mill Creek, Deer Creek, and Butte Creek by brood year. A list with 1000 items, each representing a bootstrapped sample. *7. Natural Cohort Reconstruction.R*.

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted FRH. Rds –** Natural-origin age specific escapement to Feather River Hatchery by brood year. A list with 1000 items, each representing a bootstrapped sample. *7. Natural Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted NFH.Rds –** Natural-origin age specific escapement to Nimbus Fish Hatchery by brood year. A list with 1000 items, each representing a bootstrapped sample. *7. Natural Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted.Rds –** Total natural-origin age specific escapement by brood year. A list with 1000 items, each representing a bootstrapped sample. *7. Natural Cohort Reconstruction.R* and *8. Combined Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

# 7. Natural Cohort Reconstruction.R

## Data input

**Natural SpawnersAdjusted Sac.Rds –** Natural-origin age specific escapement to the Sacramento River mainstem (above and below RBDD) by brood year. A list with 1000 items, each representing a bootstrapped sample. From *6. Natural Age Specific Escapement.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted Feather.Rds –** Natural-origin age specific escapement to the Feather River spawning grounds by brood year. A list with 1000 items, each representing a bootstrapped sample. From *6. Natural Age Specific Escapement.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted American.Rds –** Natural-origin age specific escapement to the American River spawning grounds by brood year. A list with 1000 items, each representing a bootstrapped sample. From *6. Natural Age Specific Escapement.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted Clear.Rds –** Natural-origin age specific escapement to the Clear Creek by brood year. A list with 1000 items, each representing a bootstrapped sample. From *6. Natural Age Specific Escapement.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted Yuba.Rds –** Natural-origin age specific escapement to the Yuba River by brood year. A list with 1000 items, each representing a bootstrapped sample. From *6. Natural Age Specific Escapement.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted Battle.Rds –** Natural-origin age specific escapement to the Battle Creek and Coleman National Fish Hatchery by brood year. A list with 1000 items, each representing a bootstrapped sample. From *6. Natural Age Specific Escapement.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted Other.Rds –** Natural-origin age specific escapement to Cottonwood Creek, Cow Creek, Mill Creek, Deer Creek, and Butte Creek by brood year. A list with 1000 items, each representing a bootstrapped sample. From *6. Natural Age Specific Escapement.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted FRH.Rds –** Natural-origin age specific escapement to Feather River Hatchery by brood year. A list with 1000 items, each representing a bootstrapped sample. From *6. Natural Age Specific Escapement.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted NFH.Rds –** Natural-origin age specific escapement to Nimbus Fish Hatchery by brood year. A list with 1000 items, each representing a bootstrapped sample. From *6. Natural Age Specific Escapement.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**Natural SpawnersAdjusted.Rds –** Total natural-origin age specific escapement by brood year. A list with 1000 items, each representing a bootstrapped sample. From *6. Natural Age Specific Escapement.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**CWT monthly impact rates.Rds –** monthly impact rates and age-specific river impact rates for CWT fish by brood year. From *5. CWT Cohort Reconstruction.*

Variable descriptions

brood\_year: the year in which eggs were laid (the summer prior to release).

Remaining column variables: Impact rate at age and month.

ImpRiv5: In-river fisheries impact rate at age 5

ImpRiv4: In-river fisheries impact rate at age 4

ImpRiv3: In-river fisheries impact rate at age 3

ImpRiv2: In-river fisheries impact rate at age 2

**CWT monthly harvest rates.Rds –** monthly harvest (which does not include non-landed mortality) rates for CWT fish by brood year. From *5. CWT Cohort Reconstruction.*

Variable descriptions

brood\_year: the year in which eggs were laid (the summer prior to release).

Remaining column variables: Harvest rate at age and month.

**River Escapement.csv –** Escapement of spawners to each river. From CalFish Grandtab Azat (2024).

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Count: Total escapement to the natural spawning grounds

River: River surveyed with spawning grounds

## Data output

**Maturation Uncertainty Natural.csv –** Age 2, 3, and 4 maturation rates for all natural-origin fish and their 95% confidence intervals and standard deviation across bootstrapped iterations. Used in *10. Maturation and productivity results.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural Sac.csv –** Age 2, 3, and 4 maturation rates for natural-origin fish returning to the Sacramento River and their 95% confidence intervals and standard deviation across bootstrapped iterations. Used in *10. Maturation and productivity results.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural Feather.csv –** Age 2, 3, and 4 maturation rates for natural-origin fish returning to the Feather River and Feather River Hatchery and their 95% confidence intervals and standard deviation across bootstrapped iterations. Used in *10. Maturation and productivity results.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural American.csv –** Age 2, 3, and 4 maturation rates for natural-origin fish returning to the American River and Nimbus Fish Hatchery and their 95% confidence intervals and standard deviation across bootstrapped iterations. Used in *10. Maturation and productivity results.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural Battle.csv –** Age 2, 3, and 4 maturation rates for natural-origin fish returning to Battle Creek and Coleman National Fish Hatchery and their 95% confidence intervals and standard deviation across bootstrapped iterations. Used in *10. Maturation and productivity results.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural Clear.csv –** Age 2, 3, and 4 maturation rates for natural-origin fish returning to Clear Creek and their 95% confidence intervals and standard deviation across bootstrapped iterations. Used in *10. Maturation and productivity results.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural Yuba.csv –** Age 2, 3, and 4 maturation rates for natural-origin fish returning to the Yuba River and their 95% confidence intervals and standard deviation across bootstrapped iterations. Used in *10. Maturation and productivity results.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural Other.csv –** Age 2, 3, and 4 maturation rates for natural-origin fish returning to Cottonwood Creek, Cow Creek, Mill Creek, Deer Creek, and Butte Creek and their 95% confidence intervals and standard deviation across bootstrapped iterations. Used in *10. Maturation and productivity results.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Unfished3 Natural.csv –** mean natural-origin age3+ ocean abundance on September 1 if the stock was never fished and the 95% confidence intervals. Used in *9. Comparison with SI.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Unfished3Lower: lower bound of 95% confidence interval of Sept 1 abundance

Unfished3Mean: mean Sept 1 abundance

Unfished3Upper: upper bound of 95% confidence interval of Sept 1 abundance

**Nofishing3 Natural.csv –** mean natural-origin age3+ ocean abundance on September 1 if the stock was not fished in the current run year and the 95% confidence intervals. Used in *9. Comparison with SI.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Nofishing3Lower: lower bound of 95% confidence interval of Sept 1 abundance

Nofishing 3Mean: mean Sept 1 abundance

Nofishing 3Upper: upper bound of 95% confidence interval of Sept 1 abundance

**SRR Natural.csv –** natural-origin spawner reduction rate by fisheries in cumulative years by run year and the 95% confidence intervals. Used in *9. Comparison with SI.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

SRRLower: lower bound of 95% confidence interval of the spawner reduction rate

SRRMean: mean spawner reduction rate

SRRUpper: upper bound of 95% confidence interval of the spawner reduction rate

**Sept1 Natural.csv –** mean natural-origin age3+ ocean abundance on September 1 in the current run year and the 95% confidence intervals. Used in *9. Comparison with SI.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Sept1Lower: lower bound of 95% confidence interval of Sept 1 abundance Sept1Mean: mean Sept 1 abundance

Sept1Upper: upper bound of 95% confidence interval of Sept 1 abundance

**Productivity.csv –** mean productivity (age-2 fish produced per adult spawner) and the 95% confidence intervals. Used in *10. Maturation and productivity results.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

ProdLower: lower bound of 95% confidence interval of productivity

ProdMean: mean productivity

ProdUpper: upper bound of 95% confidence interval of productivity

Age2Lower: lower bound of 95% confidence interval of age-2 recruits

Age2Mean: mean age-2 recruits

Age2Upper: upper bound of 95% confidence interval of age-2 recruits

ParentLower: lower bound of 95% confidence interval of run abundance

ParentMean: mean run abundance

ParentUpper: upper bound of 95% confidence interval of run abundance

**Impact Natural Bootstrap.Rds –** Estimated age-specific impact (N) of natural origin fish (using hatchery-origin impact rates) by brood year. Used in *9. Comparison with SI.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the summer prior to release).

Imp2: Age-2 impact

Imp3: Age-3 impact

Imp4: Age-4 impact

**Harvest Natural Bootstrap.Rds –** Estimated age-specific harvest (N), which excludes non-landed mortalities, of natural origin fish (using hatchery-origin impact rates) by brood year. Used in *9. Comparison with SI.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the summer prior to release).

Har2: Age-2 harvest

Har3: Age-3 harvest

Har4: Age-4 harvest

# 8. Combined Cohort Reconstruction.R

## Data input

**CWT Spawning Grounds.Rds –** Age-specific escapement from all 3 hatcheries by brood year. A list with 1000 items, each representing a bootstrapped sample. From 2*. CWT Spawning Data Prep.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Sp: CWT Age 1 spawners to spawning ground

Age2Sp: CWT Age 2 spawners to spawning ground

Age3Sp: CWT Age 3 spawners to spawning ground

Age4Sp: CWT Age 4 spawners to spawning ground

Age5Sp: CWT Age 5 spawners to spawning ground

**CWT Hatchery.csv** – CWT recovered at all 3 hatcheries and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. From 2*. CWT Spawning Data Prep.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Age1Hat: Age 1 spawners to hatchery

Age2Hat: Age 2 spawners to hatchery

Age3Hat: Age 3 spawners to hatchery

Age4Hat: Age 4 spawners to hatchery

**Natural SpawnersAdjusted.Rds –** Total natural-origin age specific escapement by brood year. A list with 1000 items, each representing a bootstrapped sample. From *6. Natural Age Specific Escapement.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Age2Sp: Natural-origin age 2 spawners to spawning ground

Age3Sp: Natural-origin age 3 spawners to spawning ground

Age4Sp: Natural-origin age 4 spawners to spawning ground

**CWT monthly impact rates.Rds –** monthly impact rates and age-specific river impact rates for CWT fish by brood year. Used in *7. Natural Cohort Reconstruction.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Remaining column variables: Impact rate at age and month.

ImpRiv5: In-river fisheries impact rate at age 5

ImpRiv4: In-river fisheries impact rate at age 4

ImpRiv3: In-river fisheries impact rate at age 3

ImpRiv2: In-river fisheries impact rate at age 2

## Data output

**SRR.csv –** Spawner reduction rate (including both hatchery and natural-origin fish) by fisheries in cumulative years by run year and the 95% confidence intervals. Used in *9. Comparison with SI.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

SRRLower: lower bound of 95% confidence interval of the spawner reduction rate

SRRMean: mean spawner reduction rate

SRRUpper: upper bound of 95% confidence interval of the spawner reduction rate

**SRRy.csv –** Spawner reduction rate (including both hatchery and natural-origin fish) by fisheries in the management year of the run year and the 95% confidence intervals. Used in *9. Comparison with SI.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

SRRyLower: lower bound of 95% confidence interval of the spawner reduction rate

SRRyMean: mean spawner reduction rate by fisheries in the management year of the run year

SRRyUpper: upper bound of 95% confidence interval of the spawner reduction rate

# 9. Comparison with SI.R

## Data input

**SIdata.csv –** Information on the Sacramento Index reported in Table II-1 of the Pacific Fishery Management Council 2024 Preseason Report 1.

Variable descriptions

Year: the year of the fisheries

Jacks: Estimated escapement of age-2 spawners

PostSI: The post season estimate of the Sacramento Index, “the SI is the sum of (1) SRFC ocean fishery harvest south of Cape Falcon between September 1 and August 31, (2) SRFC impacts from non-retention ocean fisheries when they occur, (3) the recreational harvest of SRFC in the Sacramento River Basin, and (4) the SRFC spawner escapement.

OceanHarvest: The sum of troll and recreation harvest and non-retention fisheries (e.g. coho-only fisheries, non-retention GSI sampling) mortality.” – PFMC 2024

ExploitR: “Total ocean harvest, non-retention ocean fishery mortalities, and river harvest of SRFC as a percentage of the SI.” – PFMC 2024

**Unfished3 CWT.csv –** mean hatchery-origin age3+ ocean abundance on September 1 if the stock was never fished and the 95% confidence intervals. From *5. CWT Cohort Reconstruction.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Unfished3Lower: lower bound of 95% confidence interval of Sept 1 abundance

Unfished3Mean: mean Sept 1 abundance

Unfished3Upper: upper bound of 95% confidence interval of Sept 1 abundance

**Unfished3 Natural.csv –** mean natural-origin age3+ ocean abundance on September 1 if the stock was never fished and the 95% confidence intervals. From *7. Natural Cohort Reconstruction.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Unfished3Lower: lower bound of 95% confidence interval of Sept 1 abundance

Unfished3Mean: mean Sept 1 abundance

Unfished3Upper: upper bound of 95% confidence interval of Sept 1 abundance

**Nofishing3 CWT.csv –** mean hatchery-origin age3+ ocean abundance on September 1 if the stock was not fished in the current run year and the 95% confidence intervals. From *5. CWT Cohort Reconstruction.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Nofishing3Lower: lower bound of 95% confidence interval of Sept 1 abundance

Nofishing3Mean: mean Sept 1 abundance

Nofishing3Upper: upper bound of 95% confidence interval of Sept 1 abundance

**Nofishing3 Natural.csv –** mean natural-origin age3+ ocean abundance on September 1 if the stock was not fished in the current run year and the 95% confidence intervals. From *7. Natural Cohort Reconstruction.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Nofishing3Lower: lower bound of 95% confidence interval of Sept 1 abundance

Nofishing3Mean: mean Sept 1 abundance

Nofishing3Upper: upper bound of 95% confidence interval of Sept 1 abundance

**Sept1 CWT.csv –** mean hatchery-origin age3+ ocean abundance on September 1 in the current run year and the 95% confidence intervals. From *5. CWT Cohort Reconstruction.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Sept1Lower: lower bound of 95% confidence interval of Sept 1 abundance Sept1Mean: mean Sept 1 abundance

Sept1Upper: upper bound of 95% confidence interval of Sept 1 abundance

**Sept1 Natural.csv –** mean natural-origin age3+ ocean abundance on September 1 in the current run year and the 95% confidence intervals. From *7. Natural Cohort Reconstruction.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Sept1Lower: lower bound of 95% confidence interval of Sept 1 abundance Sept1Mean: mean Sept 1 abundance

Sept1Upper: upper bound of 95% confidence interval of Sept 1 abundance

**SRR.csv –** Spawner reduction rate (including both hatchery and natural-origin fish) by fisheries in cumulative years by run year and the 95% confidence intervals. From *8. Combined Cohort Reconstruction.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

SRRLower: lower bound of 95% confidence interval of the spawner reduction rate

SRRMean: mean spawner reduction rate

SRRUpper: upper bound of 95% confidence interval of the spawner reduction rate

**SRRy.csv –** Spawner reduction rate (including both hatchery and natural-origin fish) by fisheries in the management year of the run year and the 95% confidence intervals. From *8. Combined Cohort Reconstruction.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

SRRyLower: lower bound of 95% confidence interval of the spawner reduction rate

SRRyMean: mean spawner reduction rate by fisheries in the management year of the run year

SRRyUpper: upper bound of 95% confidence interval of the spawner reduction rate

**SRRy CWT.csv –** hatchery-origin spawner reduction rate by fisheries in the management year of the run year and the 95% confidence intervals. From 5*. CWT Cohort Reconstruction.R.*

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

SRRyLower: lower bound of 95% confidence interval of the spawner reduction rate

SRRyMean: mean spawner reduction rate by fisheries in the management year of the run year

SRRyUpper: upper bound of 95% confidence interval of the spawner reduction rate

**Impact Uncertainty CWT.csv –** age-specific impact rates for all hatchery-origin fish and their 95% confidence intervals. From 5*. CWT Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

ImpLower: lower bound of 95% confidence interval of age-specific impact rate

ImpMean: mean age-specific impact rate

ImpUpper: upper bound of 95% confidence interval of age-specific impact rate.

Age: age for which impact is reported calculated by run year minus brood year

**Impact CWT Bootstrap.Rds –** Ocean fishery impact (n) by brood year and month. Unrecovered tags in harvested fish were resampled 1000 times to generate 1000 estimates of fishery impact (including drop-off mortality and release mortality). From *4. CWT Harvest Data Prep.R*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Remaining column variables: Month and age of ocean fishery encounters

**Impact Natural Bootstrap.Rds –** Estimated age-specific impact (N) of natural origin fish (using hatchery-origin impact rates) by brood year. From in *7. Natural Cohort Reconstruction*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Imp2: Age-2 impact

Imp3: Age-3 impact

Imp4: Age-4 impact

**Harvest Bootstrap.Rds –** Ocean fishery harvest (n) by brood year and month. Unrecovered tags in harvested fish were resampled 1000 times to generate 1000 estimates of fishery harvest (excludes drop-off mortality and release mortality). From *4. CWT Harvest Data Prep.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Remaining column variables: Month and age of ocean fishery encounters

**Harvest Natural Bootstrap.Rds –** Estimated age-specific harvest (N), which excludes non-landed mortalities, of natural origin fish (using hatchery-origin impact rates) by brood year. Used in *9. Comparison with SI.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Har2: Age-2 harvest

Har3: Age-3 harvest

Har4: Age-4 harvest

## Data output

**Abundances.csv –** Metrics of abundance from the cohort reconstruction and the Sacramento Index and their differences

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Sept1: Estimated ocean age 3+ ocean abundance on September 1 based on the cohort reconstruction

Nofishing: Estimated potential abundance in the absence of fishing in the current management year based on the cohort reconstruction

Unfished: Estimated potential abundance in the absence of the cumulative effects of fishing based on the cohort reconstruction

PostSI: The post season estimate of the Sacramento Index, “the SI is the sum of (1) SRFC ocean fishery harvest south of Cape Falcon between September 1 and August 31, (2) SRFC impacts from non-retention ocean fisheries when they occur, (3) the recreational harvest of SRFC in the Sacramento River Basin, and (4) the SRFC spawner escapement.

SIvsSept1: Proportional increase in estimate of Sept 1 ocean age 3+ abundance through cohort reconstruction versus SI (proxy for Sept 1 ocean age 3+ abundance). Equals (Sept 1 – SI) / SI.

SIvsPE: Proportional decrease in estimate of potential escapement absent fishing in the current management year through cohort reconstruction versus SI (proxy for potential escapement). Equals (Potential escapement – SI) / SI

**Fig4.png –** Spawner reduction rate (SRRy) and exploitation rate derived from the SI every run year. For SRRy, points indicate the mean while error bars indicate the 95% credible intervals from resampling. Only point estimates were reported for the SI-derived exploitation rate. Only impacts of ocean fishing during the current management year are considered, and harvest north of Cape Falcon is excluded.

**Exploitation.csv –** Metrics of fishing impact on the spawning population from the cohort reconstruction and the Sacramento Index.

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

SRRy: mean spawner reduction rate by fisheries in the management year of the run year

SRR: mean spawner reduction rate

ExploitR: “Total ocean harvest, non-retention ocean fishery mortalities, and river harvest of SRFC as a percentage of the SI.” – PFMC 2024

**Fig2.png –** Age-specific ocean impact rates every harvest year. Points indicate the mean while error bars indicate the 95% credible intervals from resampling.

**Harvest.csv –** Metrics of fishing impact and harvest from the cohort reconstruction and the Sacramento Index metric of harvest.

Variable descriptions

run\_year: the year of the fisheries (the year after September 1 abundance)

Harvest: estimated of harvested (landed) fish through cohort reconstruction

Impact: estimate of fishing impact (harvested fish and non-landed mortality) through cohort reconstruction.

OceanHarvest: ocean harvest reported in Table II-1 of the Pacific Fishery Management Council 2024 Preseason Report 1. “The sum of (1) SRFC ocean fishery harvest south of Cape Falcon between September 1 and August 31 and (2) SRFC impacts from non-retention ocean fisheries when they occur.” – PFMC 2024

HarvestvsSI: Proportional change in estimate of harvest in the current management year through cohort reconstruction versus PFMC’s estimate of harvest. Equals (CR Harvest – SI Harvest) / SI Harvest

ImpactvsSI: Proportional change in estimate of impact in the current management year through cohort reconstruction versus PFMC’s estimate of harvest. Equals (CR Impact – SI Harvest) / SI Harvest

# 10. Maturation and productivity results.R

## Data input

**Maturation Uncertainty CWT.csv –** Age 2, 3, and 4 maturation rates for all hatchery-origin fish and their 95% confidence intervals and standard deviation across bootstrapped iterations. From *5. CWT Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural.csv –** Age 2, 3, and 4 maturation rates for all natural-origin fish and their 95% confidence intervals and standard deviation across bootstrapped iterations. From *7. Natural Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty CWT CNFH.csv –** Age 2, 3, and 4 maturation rates for Coleman National Fish Hatchery and their 95% confidence intervals and standard deviation across bootstrapped iterations. From *5. CWT Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty CWT FRH.csv –** Age 2, 3, and 4 maturation rates for Feather River Hatchery and their 95% confidence intervals and standard deviation across bootstrapped iterations. From *5. CWT Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty CWT NFH.csv –** Age 2, 3, and 4 maturation rates for Nimbus Fish Hatchery and their 95% confidence intervals and standard deviation across bootstrapped iterations. From *5. CWT Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural Sac.csv –** Age 2, 3, and 4 maturation rates for natural-origin fish returning to the Sacramento River and their 95% confidence intervals and standard deviation across bootstrapped iterations. From *7. Natural Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural Feather.csv –** Age 2, 3, and 4 maturation rates for natural-origin fish returning to the Feather River and Feather River Hatchery and their 95% confidence intervals and standard deviation across bootstrapped iterations. From *7. Natural Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural American.csv –** Age 2, 3, and 4 maturation rates for natural-origin fish returning to the American River and Nimbus Fish Hatchery and their 95% confidence intervals and standard deviation across bootstrapped iterations. From *7. Natural Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural Battle.csv –** Age 2, 3, and 4 maturation rates for natural-origin fish returning to Battle Creek and Coleman National Fish Hatchery and their 95% confidence intervals and standard deviation across bootstrapped iterations. From *7. Natural Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural Clear.csv –** Age 2, 3, and 4 maturation rates for natural-origin fish returning to Clear Creek and their 95% confidence intervals and standard deviation across bootstrapped iterations. From *7. Natural Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural Yuba.csv –** Age 2, 3, and 4 maturation rates for natural-origin fish returning to the Yuba River and their 95% confidence intervals and standard deviation across bootstrapped iterations. From *7. Natural Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**Maturation Uncertainty Natural Other.csv –** Age 2, 3, and 4 maturation rates for natural-origin fish returning to Cottonwood Creek, Cow Creek, Mill Creek, Deer Creek, and Butte Creek and their 95% confidence intervals and standard deviation across bootstrapped iterations. From *7. Natural Cohort Reconstruction.R.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

Mat2Lower: lower bound of 95% confidence interval of age-2 maturation rate

Mat2Mean: mean age-2 maturation rate

Mat2Upper: upper bound of 95% confidence interval of age-2 maturation rate

Mat3Lower: lower bound of 95% confidence interval of age-3 maturation rate

Mat3Mean: mean age-3 maturation rate

Mat3Upper: upper bound of 95% confidence interval of age-3 maturation rate

Mat4Lower: lower bound of 95% confidence interval of age-4 maturation rate

Mat4Mean: mean age-4 maturation rate

Mat4Upper: upper bound of 95% confidence interval of age-4 maturation rate

SDMat2: standard deviation of age-2 maturation rates across iterations.

SDMat3: standard deviation of age-3 maturation rates across iterations.

SDMat4: standard deviation of age-4 maturation rates across iterations.

**SIdata.csv –** Information on the Sacramento Index reported in Table II-1 of the Pacific Fishery Management Council 2024 Preseason Report 1.

Variable descriptions

Year: the year of the fisheries

Jacks: Estimated escapement of age-2 spawners

PostSI: The post season estimate of the Sacramento Index, “the SI is the sum of (1) SRFC ocean fishery harvest south of Cape Falcon between September 1 and August 31, (2) SRFC impacts from non-retention ocean fisheries when they occur, (3) the recreational harvest of SRFC in the Sacramento River Basin, and (4) the SRFC spawner escapement.

OceanHarvest: The sum of troll and recreation harvest and non-retention fisheries (e.g. coho-only fisheries, non-retention GSI sampling) mortality.” – PFMC 2024

ExploitR: “Total ocean harvest, non-retention ocean fishery mortalities, and river harvest of SRFC as a percentage of the SI.” – PFMC 2024

**Productivity.csv –** mean productivity (age-2 fish produced per adult spawner) and the 95% confidence intervals. From *7. Natural Cohort Reconstruction.*

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to outmigration).

ProdLower: lower bound of 95% confidence interval of productivity

ProdMean: mean productivity

ProdUpper: upper bound of 95% confidence interval of productivity

Age2Lower: lower bound of 95% confidence interval of age-2 recruits

Age2Mean: mean age-2 recruits

Age2Upper: upper bound of 95% confidence interval of age-2 recruits

ParentLower: lower bound of 95% confidence interval of run abundance

ParentMean: mean run abundance

ParentUpper: upper bound of 95% confidence interval of run abundance

**OutmigrationSurvival.csv –** mean hatchery-origin survival from release to age-2 and the 95% confidence intervals.

Variable descriptions

brood\_year: the year in which eggs were laid (the fall prior to release).

OutSLower: lower bound of 95% confidence interval of the outmigration and early ocean survival

OutSMean: mean outmigration and early ocean survival

OutSUpper: upper bound of 95% confidence interval of the outmigration and early ocean survival

## Data output

**Fig3.png** – Maturation rate at age two (top) and age three (bottom) for Sacramento River Fall Chinook salmon from hatcheries and natural production. Points indicate the mean while error bars indicate the 95% credible intervals from resampling.

**FigA1.png –** Age-2 maturation rates for Sacramento River Fall Chinook salmon from hatcheries (top) and natural production (bottom). Points indicate the mean while error bars indicate the 95% credible intervals from resampling.

**FigA2.png –** Age-3 maturation rates for Sacramento River Fall Chinook salmon from hatcheries (top) and natural production (bottom). Points indicate the mean while error bars indicate the 95% credible intervals from resampling.

**Fig 1.png –** Year-1 survival (i.e., from release to age-2) of hatchery cohorts (gold) and productivity (age-2 recruits per spawner) of natural-origin broods (blue).