Readme

**Scripts**

1. CWT Spawning Data Prep.R – Preparing coded-wire tag recovery data from spawning grounds and hatchery for hatchery-origin cohort reconstruction

2. CWT Harvest Data Prep.R – Preparing coded-wire tag recovery data from ocean and in-river harvest. Calculating the age-aggregated encounter rate.

3. Hatchery Cohort Reconstruction.R – Cohort reconstruction code for hatchery cohorts from CWT data. Calculates hatchery-origin maturation and impact rates.

4. Impact rates shared.R – Calculating impact rates based on encounter rate and average harvestability and release mortality.

5. Hatchery Cohort Reconstruction by sex.R – Sex-specific cohort reconstruction code for hatchery cohorts using impact rates from hatchery cohort reconstruction.

6. Natural Cohort Reconstruction Prep.R – Age specific escapement based on scale data. Kimura Chikuni adjustments

7. Natural Cohort Reconstruction.R - Cohort reconstruction code for natural cohorts. Calculates hatchery-origin maturation and impact rates. Can be done for males only, females only, or both.

8. Comparing Vital Rates.R – code for generating figure 1 and 2

9. SRR.R – spawner reduction rate calculations and visualizations

10. Sensitivity Analysis.R – sensitivity of impact rates, maturation rates, and spawner reduction rates to changes in size at age and release mortality.

**1. CWT Spawning Data Prep.R**

**Data input**

**CWTReleased.csv** – coded wire batch data for winter-run Chinook salmon for brood year from 2000-2017. Obtained from RMIS database.

**CWTRecoveries.csv** – all recoveries of winter-run Chinook salmon for brood year from 1999-2018. Obtained from RMIS database.

**Escapement to Hatchery All.csv** – total number of fish (hatchery and natural-origin) recovered at the hatchery each year. Obtained from SacPas.

**CWT Recoveries SG.csv** –recoveries of winter-run Chinook salmon from spawning ground surveys for brood year from 1998-2017. Missing data in RMIS database filled in by USFWS from Mike O’Farrell.

**SexRatioSG.csv** – Observed sex ratio on the spawning grounds. From Doug Killam.

**Total to Hatchery All.csv –** Hatchery and natural-origin fish taken to the hatchery and used as broodstock

**Data output**

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

**Escapement to Hatchery\_F.csv** – CWT recovered at hatcheries from females and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. Used in *Hatchery Cohort Reconstruction by Sex.R*

**Escapement to Hatchery\_M.csv** – CWT recovered at hatcheries from males and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. Used in *Hatchery Cohort Reconstruction by Sex.R*

**Hatchery Release.csv –** Number of hatchery fish released for every brood year. Created from CWTReleased.csv data. Used to calculate survival before age-2 (not necessary for this analysis) in *Hatchery Cohort Reconstruction.R.*

**Natural Escapement to Hatchery.csv** – Male and female natural-origin fish collected for broodstock at the hatchery. Used in the *Natural Cohort Reconstruction Prep.R*

**CWT to SG.csv** – Age Specific escapement by brood year. Used in the *Sensitivity Analysis.R*

**HatcheryRunSizeCWT.csv –** Total estimate of hatchery fish on the spawning grounds every run year. From *CWT Spawning Data Prep.R*

**CWTBootstraps.Rds –** Age Specific escapement by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *Hatchery Cohort reconstruction. R*

**CWTBootstraps\_F.Rds–** Age and sex-specific escapement by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *Hatchery Cohort reconstruction by sex.R*

**CWTBootstraps\_M.Rds–** Age and sex-specific escapement by brood year. A list with 1000 items, each representing a bootstrapped sample. Used in *Hatchery Cohort reconstruction by sex.R*

**2. CWT Harvest Data Prep.R**

**Data input**

**CWTReleased.csv** – coded wire batch data for winter-run Chinook salmon for brood year from 2000-2017. Obtained from RMIS database.

**CWTRecoveries.csv** – all recoveries of winter-run Chinook salmon for brood year from 1999-2018. Obtained from RMIS database.

**sitearea.modified.csv** – file with the region each sampling site is located within

**Size\_limits.csv** –file with the size limit (inches) associated with each fishery type, location, and time.

**release.mort.rate.csv** – file with the release mortality rate associated with each fishery type, location, and time.

**length.at.age.csv** – length of age of winter-run Chinook salmon in the ocean. From O’Farrell et al. 2012 Appendix A

**years with values.csv –** Supporting file with months and years where fishing occurred. Use as a placeholder (for when there is no fishing data for a cohort in a period where there is fishing.

**Data output**

**River Harvest.csv –** Age-3 and Age-4 in-river harvest by brood year. Used in Hatchery Cohort Reconstruction.R

**River Harvest\_M.csv –** Male age-3 and Age-4 in-river harvest by brood year, split by sexes based on observed sex ratio in CWTs

**River Harvest\_F.csv –** Female age-3 and Age-4 in-river harvest by brood year, split by sexes based on observed sex ratio in CWTs

**Catch Bootstrap.Rds** – Ocean fishery encounters (n) by brood year and month. Unrecovered tags in harvested fish was resampled 1000 to generate 1000 estimates of harvest, which was then divided by the proportion that was of legal size to estimate number encountered.. Used in *Hatchery Cohort Reconstruction.R*

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

**Catch Representation.Rds** – The proportion of harvest for each fishery type and region for every month of fishing. 1000 resampled values. Used later in this script when calculating the average harvestability and release mortality based on spatial and fishery type distribution.

**Avg Harvestability.Rds** – the proportion that cohort was harvestable during a given month, based on the spatial distribution of catches in the ocean at the time (across cohorts). Used in *Impact rates shared.R* and *Natural Cohort Reconstruction.R*

**Avg ReleaseMort.Rds** – the proportion that cohort was release mortalities during a given month, based on the spatial distribution of catches in the ocean at the time (across cohorts) that affected the release mortality rate. Used in *Impact rates shared.R* and *Natural Cohort Reconstruction.R*

**3. Hatchery Cohort Reconstruction.R**

**Data input**

**CWTBootstraps.Rds –** Age Specific escapement by brood year. A list with 1000 items, each representing a bootstrapped sample. Created in *CWT Spawning Data Prep.R*

**Escapement to Hatchery.csv** – CWT recovered at hatcheries and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. Created in *CWT Spawning Data Prep.R*

**River Harvest.csv –** Age-3 and Age-4 in-river harvest by brood year. Created in *CWT Harvest Data Prep.R.*

**Hatchery Release.csv –** Number of hatchery fish released for every brood year. Created from CWTReleased.csv data. Used to calculate survival before age-2 (not necessary for this analysis).

**Catch Bootstrap.Rds** – Ocean fishery encounters (n) by brood year and month. Unrecovered tags in harvested fish was resampled 1000 to generate 1000 estimates of harvest, which was then divided by the proportion that was of legal size to estimate number encountered. From *CWT Harvest Data Prep.R.*

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

**Data output**

**CWT Cohort Reconstruction.Rds –** Hatchery cohort reconstruction full results, bootstraps.

**Maturation\_Uncertainty\_CWT.csv –** Age 2, 3, and 4 maturation rates and their 95% confidence intervals.

**Impact\_Uncertainty\_CWT.csv –** Age 3 and 4 ocean fishery impact and their 95% confidence intervals.

**4. Impact rates shared.R**

**Data input**

**CWT Cohort Reconstruction.Rds –** Hatchery cohort reconstruction full results, bootstraps. From *Hatchery Cohort Reconstruction.R*

**Avg Harvestability.Rds** – the proportion that cohort was harvestable during a given month, based on the spatial distribution of catches in the ocean at the time (across cohorts). From *CWT Harvest Data Prep.R*

**Avg ReleaseMort.Rds** – the proportion that cohort was release mortalities during a given month, based on the spatial distribution of catches in the ocean at the time (across cohorts) that affected the release mortality rate. From *CWT Harvest Data Prep.R*

**Data output:**

**Impacted\_hatchery\_shared.csv** – Age 3 and Age 4 impact rates with 95% CI based on age aggregated data.

**Impacted\_hatchery\_notshared.csv** – Age 3 and Age 4 impact rates with 95% CI based on age aggregated data. Is equivalent toMaturation\_Uncertainty\_CWT.csv.

**5. Hatchery Cohort Reconstruction by sex.R**

**Data input**

**CWTBootstraps\_F.Rds–** Age and sex-specific escapement by brood year. A list with 1000 items, each representing a bootstrapped sample. From *CWT Spawning Data Prep.R*

**CWTBootstraps\_M.Rds–** Age and sex-specific escapement by brood year. A list with 1000 items, each representing a bootstrapped sample. From *CWT Spawning Data Prep.R*

**Escapement to Hatchery\_F.csv** – CWT recovered at hatcheries from females and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. From *CWT Spawning Data Prep.R*

**Escapement to Hatchery\_M.csv** – CWT recovered at hatcheries from males and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. From *CWT Spawning Data Prep.R*

**River Harvest\_M.csv –** Male age-3 and Age-4 in-river harvest by brood year, split by sexes based on observed sex ratio in CWTs. From *CWT Harvest Data Prep.R*

**River Harvest\_F.csv –** Female age-3 and Age-4 in-river harvest by brood year, split by sexes based on observed sex ratio in CWTs. From *CWT Harvest Data Prep.R*

**Hatchery Release.csv –** Number of hatchery fish released for every brood year. Created from CWTReleased.csv data. Used to calculate survival before age-2 (not necessary for this analysis).

**Data output**

**CWT Cohort Reconstruction\_Females.Rds -** Hatchery cohort reconstruction full results, bootstrapped. For females.

**CWT Cohort Reconstruction\_Males.Rds -** Hatchery cohort reconstruction full results, bootstrapped. For males.

**Maturation\_Uncertainty\_CWT\_Sex.csv –** Age 2, 3, and 4 maturation rates and their 95% confidence intervals, by sex.

**6. Natural Cohort Reconstruction Prep.R**

**Data input**

**Scale Readage.csv –** scale aging by CDFW for winter-run from 2005-2018 for natural and hatchery-origin fish.

**Escapement Numbers.csv –** total estimate of spawners on spawning ground each year. Estimated number of females. Reported ratio of females.

**Natural Escapement to Hatchery.csv** – Male and female natural-origin fish collected for broodstock at the hatchery. From *CWT Spawning Data Prep.R*

**HatcheryRunSizeCWT.csv –** Total estimate of hatchery fish on the spawning grounds every run year. From *CWT Spawning Data Prep.R*

**Data output:**

**Spawners Unadjusted.Rds –** total run size proportion by age proportions from scale data. No aging corrections made. For *Natural Cohort Reconstruction.R*

**Female Spawners Unadjusted.Rds–** total female run size proportion by age proportions from female scale data. No aging corrections made. For *Natural Cohort Reconstruction.R*

**Male Spawners Unadjusted.Rds–** total male run size proportion by age proportions from male scale data. No aging corrections made. For *Natural Cohort Reconstruction.R*

**Spawners Unadjusted.Rds –** total run size proportion by age proportions from scale data with Kimura Chikuni adjustments. For *Natural Cohort Reconstruction.R*

**Female Spawners Unadjusted.Rds –** total female run size proportion by age proportions from female scale data with Kimura Chikuni adjustments. For *Natural Cohort Reconstruction.R*

**Male Spawners Unadjusted.Rds –** total male run size proportion by age proportions from male scale data with Kimura Chikuni adjustments. For *Natural Cohort Reconstruction.R*

**7. Natural Cohort Reconstruction.R**

**Data input**

**CWT Cohort Reconstruction.Rds –** Hatchery cohort reconstruction full results, bootstraps. From *Hatchery Cohort Reconstruction.R*

**Avg Harvestability.Rds** – the proportion that cohort was harvestable during a given month, based on the spatial distribution of catches in the ocean at the time (across cohorts). From *CWT Harvest Data Prep.R*

**Avg ReleaseMort.Rds** – the proportion that cohort was release mortalities during a given month, based on the spatial distribution of catches in the ocean at the time (across cohorts) that affected the release mortality rate. From *CWT Harvest Data Prep.R*

**Escapement Numbers.csv –** total estimate of spawners on spawning ground each year. Estimated number of females. Reported ratio of females.

**Female Spawners Unadjusted.Rds –** total female run size proportion by age proportions from female scale data with Kimura Chikuni adjustments. From *Natural Cohort Reconstruction Prep.R.*

**Male Spawners Unadjusted.Rds –** total male run size proportion by age proportions from male scale data with Kimura Chikuni adjustments. *Natural Cohort Reconstruction Prep.R.*

**Data output**

**Natural Cohort Reconstruction.Rds–** Natural cohort reconstruction full results, bootstrapped.

**Natural Cohort Reconstruction\_Male.Rds–** Natural cohort reconstruction full results for males, bootstrapped.

**Natural Cohort Reconstruction\_Female.Rds–** Natural cohort reconstruction full results for females, bootstrapped.

**Maturation\_Uncertainty\_Natural.csv** **–** Age 2, 3, and 4 natural-origin maturation rates and their 95% confidence intervals.

**Maturation\_Uncertainty\_Natural\_Male.csv** **–** Age 2, 3, and 4 male natural-origin maturation rates and their 95% confidence intervals.

**Maturation\_Uncertainty\_Natural\_Female.csv** **–** Age 2, 3, and 4 female natural-origin maturation rates and their 95% confidence intervals.

**Impact\_Uncertainty\_Natural.csv** **–** Age 3 and 4 ocean fishery impact (N and rate) and their 95% confidence intervals.

**Impact\_ Uncertainty\_Natural \_Male.csv** **–** Male Age 3 and 4 ocean fishery impact (N and rate) and their 95% confidence intervals.

**Impact\_ Uncertainty\_Natural \_Female.csv** **–** Female Age 3 and 4 ocean fishery impact (N and rate) and their 95% confidence intervals.

**8. Comparing Vital Rates.R**

**Data input**

**Maturation\_Uncertainty\_CWT.csv –** Age 2, 3, and 4 maturation rates and their 95% confidence intervals.

**Maturation\_Uncertainty\_Natural.csv** **–** Age 2, 3, and 4 natural-origin maturation rates and their 95% confidence intervals.

**Maturation\_Uncertainty\_CWT\_Sex.csv –** Age 2, 3, and 4 maturation rates and their 95% confidence intervals, by sex.

**Maturation\_Uncertainty\_Natural\_Male.csv** **–** Age 2, 3, and 4 male natural-origin maturation rates and their 95% confidence intervals.

**Maturation\_Uncertainty\_Natural\_Female.csv** **–** Age 2, 3, and 4 female natural-origin maturation rates and their 95% confidence intervals.

**Impacted\_hatchery\_shared.csv** – Age 3 and Age 4 impact rates with 95% CI based on age aggregated data.

**Impacted\_hatchery\_notshared.csv** – Age 3 and Age 4 impact rates with 95% CI based on age aggregated data. Is equivalent toMaturation\_Uncertainty\_CWT.csv.

**9. SRR.R**

**Data input**

**CWT Cohort Reconstruction.Rds –** Hatchery cohort reconstruction full results, bootstraps.

**CWT Cohort Reconstruction\_Females.Rds -** Hatchery cohort reconstruction full results, bootstrapped. For females.

**CWT Cohort Reconstruction\_Males.Rds -** Hatchery cohort reconstruction full results, bootstrapped. For males.

**Natural Cohort Reconstruction.Rds–** Natural cohort reconstruction full results, bootstrapped.

**Natural Cohort Reconstruction\_Male.Rds–** Natural cohort reconstruction full results for males, bootstrapped.

**Natural Cohort Reconstruction\_Female.Rds–** Natural cohort reconstruction full results for females, bootstrapped.

**10. Sensitivity Analysis.R**

**Data input**

**CWTReleased.csv** – coded wire batch data for winter-run Chinook salmon for brood year from 2000-2017. Obtained from RMIS database.

**CWTRecoveries.csv** – all recoveries of winter-run Chinook salmon for brood year from 1999-2018. Obtained from RMIS database.

**sitearea.modified.csv** – file with the region each sampling site is located within

**Size\_limits.csv** –file with the size limit (inches) associated with each fishery type, location, and time.

**release.mort.rate.csv** – file with the release mortality rate associated with each fishery type, location, and time.

**length.at.age.csv** – length of age of winter-run Chinook salmon in the ocean. From O’Farrell et al. 2012 Appendix A

**CWT to SG.csv** – Age Specific escapement by brood year. Created in *CWT Spawning Data Prep.R*

**Escapement to Hatchery.csv** – CWT recovered at hatcheries and expanded. Grouped by brood year so each line is the age distribution each brood comes back as. Created in *CWT Spawning Data Prep.R*

**River Harvest.csv –** Age-3 and Age-4 in-river harvest by brood year. Created in *CWT Harvest Data Prep.R.*