Chinook FRAM Base Period Documentation:

Evaluation of Base Period Exploitation Rates

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November 2016 Draft

# Background

Base period exploitation rates (BPERs) are the core component of a FRAM base period dataset. As part of the QA/QC process for the new Chinook FRAM base period dataset, we reviewed the BPERs produced by the calibration program and identified any values that were potentially unrealistic and in need of adjustment.

# Review Methodology and identification of Problematic BPERs

Base period exploitation rates were retrieved from the Calibration Support database subsequent to running the Chinook FRAM base period calibration program. Values were sorted in order of magnitude from high to low. Additionally, FRAMBuilder output was used to determine the number of CWT recoveries used to determine the BPER for each stock-age-fishery-time step and the number of escapement recoveries for each stock-age.

Candidates for adjustment were identified if they met the following criteria:

1. BPER > 0.10
2. Total number of escapement recoveries for the stock-age < 20

After review, there were 20 records that met the above criteria (Table 1).

# BPER Adjustment for Age 5 in PRE-Terminal Fisheries

Of the 20 records identified in Table 2, 12 are for Age 5 fish in pre-terminal fisheries, indicating that there may be a reoccurring issue where BPERs are being over estimated for some stocks in fishery/time steps with low sample sizes of recoveries. To address this issue we propose adjusting these age 5 BPERs based on the relationship between age 4 and age 5 BPERs.

The initial dataset used to generate the age 4 to age 5 BPER relationship included all age 4 and age 5 BPERs for stocks where there were greater than 100 age 5 escapement recoveries (Table 2). We set this sample size threshold based on the assumption that BPERs are more likely to be accurate for stock-ages with higher numbers of escapement recoveries. The dataset was then filtered to instances where both the age 4 and age 5 BPER was greater than zero for any given stock-fishery-time step. Records from time step 4 were also removed, as these are derived from recoveries and BPERs from time step 1. Due to violated assumptions using untransformed data, a regression analysis was performed using log-transformed age 4 BPER as the predictor variable and log-transformed age 5 BPER as the response variable. The resulting regression was highly significant (p < 0.001) with an R2 of 0.82 and slope equal to 0.927 (Figure 1).

Figure 2 presents untransformed age 4 BPERs vs untransformed age 5 BPERs. The twelve records in Table 2 that represented age 5 fish in pre-terminal fisheries are identified by data points with red boarders. Of these twelve, the one data point that is positioned beneath the regression line is for Hood Canal Fall Yearling Chinook caught in the Area 12 Sport fishery. Given that the age 5 BPER here has a corresponding age 4 BPER of similar magnitude and that this is essentially a local stock in the fishery, we might expect a higher BPER and recommend leaving this value unadjusted. For the remaining 11 records, we recommend adjusting the age 5 BPER downward to the value predicted by the above linear regression model and the age 4 BPER for that stock-age-fishery-time step (Table 3).

The BPER for a stock-age-fishery-time step can be adjusted through an iterative process of manipulating the corresponding ‘Catch’ value in the ‘CWTAll’ table of the Calibration Support database. Base period exploitation rates are calculated using the following formula:

$$BPER\_{s,a,f,t}=\frac{ExpCatch\_{s,a,f,t}}{Cohort\_{s,a,t}×LegalProp\_{s,a,f,t}}$$

Where $ExpCatch\_{s,a,f,t}$ is the catch input times an escapement expansion factor and a fishery expansion factor, $Cohort\_{s,a,t}$ is the cohort size resulting from the cohort reconstruction within the calibration, and $LegalProp\_{s,a,f,t}$ is the proportion of the cohort that is vulnerable to the fishery based on stock specific growth functions and fishery size limits.

This process is iterative due to the fact that cohort size is a function of catch (among other variables), thus, manipulating the catch input will also affect the cohort size. The first step is to adjust the ‘Catch’ values in the ‘CWTAll’ table of the Calibration Support database by an adjustment factor equal to the ratio of the adjusted age 5 BPER to the original BPER (Table 3). The calibration program is then run with the updated inputs and the resulting BPERs are retrieved and compared to the target BPER. This process is repeated, continuing to adjust the catch inputs based on the ratio of the target BPER to the BPER resulting from the last calibration run until the BPERs converge with the targets. Once this was completed, the resulting age 4 and age 5 BPERs were retrieved from the Calibration Support database and plotted against each other in a scatter plot similar to Figure 2, showing the updated records positioned on the regression line (Figure 3).

# Tables

**Table 1.** Base period exploitation rates that are candidates for adjustment based on identified criteria. TermFlag indicates the terminal status of a fishery (0 = pre-terminal, 1 = terminl), nTags indicates the number of CWT recoveries for each stock-age-fishery-time step, and EscRecs indicates the total number of CWTs recovered in escapement for the stock-age.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| StkID | Stock | Age | FishID | Fishery | TermFlag | TimeStep | BPER | nTags | EscRecs |
| 1 | NkSm FF | 5 | 40 | Tr 7BCDNet | 1 | 3 | 0.6495 | 3 | 4 |
| 10 | Tula FF | 3 | 51 | NT TulaNet | 1 | 3 | 0.4715 | 67 | 18 |
| 10 | Tula FF | 5 | 51 | NT TulaNet | 1 | 3 | 0.4146 | 3 | 0 |
| 10 | Tula FF | 2 | 40 | Tr 7BCDNet | 1 | 3 | 0.3995 | 1 | 9 |
| 22 | BPHTule | 5 | 10 | WCVI Troll | 0 | 2 | 0.3896 | 1 | 0 |
| 10 | Tula FF | 5 | 13 | N GS Sport | 0 | 2 | 0.3887 | 1 | 0 |
| 2 | NFNK Sp | 5 | 1 | SEAK Troll | 0 | 1 | 0.3583 | 6 | 10 |
| 3 | SFNK Sp | 5 | 1 | SEAK Troll | 0 | 1 | 0.3583 | 6 | 10 |
| 19 | OR Tule | 5 | 1 | SEAK Troll | 0 | 3 | 0.3343 | 1 | 0 |
| 17 | HdCl FY | 5 | 10 | WCVI Troll | 0 | 2 | 0.2940 | 1 | 9 |
| 10 | Tula FF | 5 | 15 | BC JDF Spt | 0 | 2 | 0.2610 | 1 | 0 |
| 10 | Tula FF | 3 | 52 | Tr TulaNet | 1 | 3 | 0.2360 | 0\* | 18 |
| 17 | HdCl FY | 5 | 42 | Ar 5 Sport | 0 | 3 | 0.2301 | 1 | 9 |
| 10 | Tula FF | 5 | 52 | Tr TulaNet | 1 | 3 | 0.2081 | 0\* | 0 |
| 9 | Stil FF | 5 | 15 | BC JDF Spt | 0 | 1 | 0.1829 | 1 | 18 |
| 18 | SJDF FF | 5 | 15 | BC JDF Spt | 0 | 1 | 0.1749 | 0\*\* | 0 |
| 10 | Tula FF | 5 | 36 | Ar 7 Sport | 0 | 1 | 0.1735 | 1 | 0 |
| 17 | HdCl FY | 5 | 64 | A 12 Sport | 0 | 1 | 0.1624 | 1 | 9 |
| 10 | Tula FF | 2 | 51 | NT TulaNet | 1 | 3 | 0.1582 | 6 | 9 |
| 1 | NkSm FF | 5 | 39 | NT 7BCDNet | 1 | 3 | 0.1479 | 3 | 4 |

\* Uses non-treaty Tulalip net as surrogate fishery

\*\* Uses Stillaguamish recoveries as surrogate stock

**Table 2.** Number of CWT recoveries by age for each stock. Highlighted stocks are those that had > 100 age 5 escapement recoveries and were used to generate the age 4 to age 5 base period exploitation rate relationship.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **StockID** | **Stock** | **Age 2** | **Age 3** | **Age 4** | **Age 5** |
| **1** | NkSm FF | 101 | 990 | 395 | 4 |
| **2** | NFNK Sp | 38 | 469 | 249 | 10 |
| **3** | SFNK Sp | 38 | 469 | 249 | 10 |
| **4** | Skag FF | 89 | 376 | 376 | 39 |
| **5** | SkagFYr | 89 | 376 | 376 | 39 |
| **6** | SkagSpY | 350 | 1018 | 3140 | 437 |
| **7** | Snoh FF | 28 | 250 | 872 | 89 |
| **8** | SnohFYr | 76 | 245 | 745 | 100 |
| **9** | Stil FF | 127 | 378 | 615 | 18 |
| **10** | Tula FF | 9 | 18 | 59 | 0 |
| **11** | MidPSFF | 797 | 3367 | 3218 | 90 |
| **12** | UWAc FF |  | 185 | 418 | 51 |
| **13** | SPSd FF | 1036 | 1453 | 884 | 22 |
| **14** | SPS Fyr | 223 | 185 | 418 | 51 |
| **15** | WhiteSp | 332 | 896 | 1116 | 74 |
| **16** | HdCl FF | 1044 | 1949 | 1336 | 51 |
| **17** | HdCl FY | 1373 | 121 | 111 | 9 |
| **18** | SJDF FF | 0 | 0 | 0 | 0 |
| **19** | OR Tule | 107 | 933 | 216 | 0 |
| **20** | WA Tule | 327 | 986 | 1092 | 163 |
| **21** | LCRWild | 6 | 15 | 100 | 115 |
| **22** | BPHTule | 734 | 1721 | 263 | 0 |
| **23** | UpCR Su | 40 | 561 | 2738 | 2117 |
| **24** | UpCR Br | 318 | 1173 | 1001 | 138 |
| **25** | Cowl Sp | 1015 | 1653 | 622 | 18 |
| **26** | Will Sp | 1169 | 8013 | 2566 | 25 |
| **27** | Snake F | 1179 | 2543 | 2375 | 228 |
| **28** | OR No F | 99 | 851 | 901 | 303 |
| **29** | WCVI Tl | 61 | 145 | 289 | 81 |
| **30** | FrasRLt | 80 | 172 | 134 | 9 |
| **31** | FrasREr | 28 | 94 | 211 | 30 |
| **32** | LwGeo S | 217 | 269 | 188 | 29 |
| **33** | WhtSpYr | 337 | 385 | 542 | 48 |
| **34** | LColNat | 425 | 1823 | 1280 | 163 |
| **35** | CentVal | 6594 | 8949 | 725 | 0 |
| **36** | WA NCst |   | 132 | 293 | 161 |
| **37** | Willapa | 54 | 645 | 1065 | 317 |
| **38** | Hoko Rv | 112 | 411 | 374 | 118 |
| **39** | MidORCst | 384 | 911 | 1514 | 326 |

**Table 3.** Adjusted age 5 BPERs and resulting catch input adjustment factors for the pre-terminal age 5 BPERs identified for adjustment in Table 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Stock** | **Fishery** | **TStep** | **Age 4 BPER** | **log(Age 4)** | **log(Age 5)** | **Adjusted Age 5 BPER** | **Original Age 5 BPER** | **Adjustment Factor** |
| **2** | **1** | 1 | 0.0285 | -1.5455 | -1.4333 | 0.0369 | 0.3583 | 0.10 |
| **3** | **1** | 1 | 0.0285 | -1.5455 | -1.4333 | 0.0369 | 0.3583 | 0.10 |
| **9** | **15** | 1 | 0.0332 | -1.4786 | -1.3712 | 0.0425 | 0.1829 | 0.23 |
| **10** | **13** | 2 | 0.0124 | -1.9068 | -1.7683 | 0.0170 | 0.3887 | 0.04 |
| **10** | **15** | 2 | 0.0142 | -1.8480 | -1.7138 | 0.0193 | 0.2610 | 0.07 |
| **10** | **36** | 1 | 0.0728 | -1.1381 | -1.0554 | 0.0880 | 0.1735 | 0.51 |
| **17** | **10** | 2 | 0.0587 | -1.2317 | -1.1422 | 0.0721 | 0.2940 | 0.25 |
| **17** | **42** | 3 | 0.0115 | -1.9410 | -1.8001 | 0.0158 | 0.2301 | 0.07 |
| **17** | **64** | 1 | 0.1631 | NA | NA | NA | 0.1624 | NA |
| **18** | **15** | 1 | 0.0323 | -1.4903 | -1.3821 | 0.0415 | 0.1749 | 0.24 |
| **19** | **1** | 3 | 0.0000 | NA | NA | 0.0000 | 0.3343 | 0.00 |
| **22** | **10** | 2 | 0.0420 | -1.3765 | -1.2766 | 0.0529 | 0.3896 | 0.14 |

**Table 4.** Iterative catch inputs adjustments and resulting BPERs

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **Original** | **ITERATION 1** | **ITERATION 2** | **ITERATION 3** | **ITERATION 4** | **ITERATION 5** |  | **ITERATION 3** |
| **Stock** | **Fishery** | **TStep** | **Catch** | **AdjCatch** | **BPER** | **AdjCatch** | **BPER** | **AdjCatch** | **BPER** | **AdjCatch** | **BPER** | **AdjCatch** | **BPER** |
| **2** | **1** | 1 | 45.63 | 4.70 | 0.0542 | 3.19 | 0.0375 | 3.14 | 0.0369 | 3.14 | 0.0369 | 3.14 | 0.0369 |
| **3** | **1** | 1 | 45.63 | 4.70 | 0.0542 | 3.19 | 0.0375 | 3.14 | 0.0369 | 3.14 | 0.0369 | 3.14 | 0.0369 |
| **9** | **15** | 1 | 17.79 | 4.14 | 0.0503 | 3.50 | 0.0429 | 3.47 | 0.0426 | 3.47 | 0.0425 | 3.47 | 0.0425 |
| **10** | **13** | 2 | 4.07 | 0.18 | 0.0530 | 0.06 | 0.0186 | 0.05 | 0.0171 | 0.05 | 0.0171 | 0.05 | 0.0170 |
| **10** | **15** | 2 | 4.85 | 0.36 | 0.0592 | 0.12 | 0.0211 | 0.11 | 0.0194 | 0.11 | 0.0193 | 0.11 | 0.0193 |
| **10** | **36** | 1 | 3.44 | 1.75 | 0.2264 | 0.68 | 0.1101 | 0.54 | 0.0904 | 0.53 | 0.0882 | 0.53 | 0.0880 |
| **17** | **10** | 2 | 7.32 | 1.79 | 0.1150 | 1.12 | 0.0757 | 1.07 | 0.0723 | 1.07 | 0.0721 | 1.07 | 0.0721 |
| **17** | **42** | 3 | 4.87 | 0.34 | 0.0205 | 0.26 | 0.0159 | 0.26 | 0.0158 | 0.26 | 0.0158 | 0.26 | 0.0158 |
| **17** | **64** | 1 | 3.81 | No Adjustment | No Adjustment | No Adjustment | No Adjustment | No Adjustment |
| **18** | **15** | 1 | 17.79 | 4.22 | 0.0486 | 3.60 | 0.0418 | 3.57 | 0.0415 | 3.57 | 0.0415 | 3.57 | 0.0415 |
| **19** | **1** | 3 | 8.01 | 0.00 | 0.0000 | 0.00 | 0.0000 | 0.00 | 0.0000 | 0.00 | 0.0000 | 0.00 | 0.0000 |
| **22** | **10** | 2 | 8.50 | 1.15 | 0.0805 | 0.76 | 0.0544 | 0.74 | 0.0530 | 0.74 | 0.0529 | 0.74 | 0.0529 |

# Figures

**Figure 1.** Scatter plot of log transformed Age 4 BPERs vs. Age 5 BPERs for stocks with greater than 100 escapement recoveries.

**Figure 2.** Scatter plot of untransformed age 4 vs age 5 BPERs. Black data points represent stocks with > 100 age 5 escapement recoveries (used in the regression from Figure 1), blue data points represent stocks with < 100 age 5 escapement recoveries, and blue data points with red boarders represent the records identified for potential adjustment in Table 1.

**Figure 3.** Scatter plot of untransformed age 4 vs age 5 BPERs after adjustment to problematic age 5 BPERs in pre-terminal fisheries. Black data points represent stocks with > 100 age 5 escapement recoveries (used in the regression from Figure 1), blue data points represent stocks with < 100 age 5 escapement recoveries, and blue data points with red boarders represent the adjusted records from Table 4.

**For full data workup see accompanying excel file “Age 5 BPER Adjustment.xlsx”**