**The BiOp methodology of estimating adulty upstream survival through the CRS**

Initial estimates of adult upstream survival using PIT tags were undertaken by Charlie Paulsen, a statistician who worked as a contractor for BPA in the early 2000’s. I took over the process in the mid-2000’s. The primary means of reporting has been a spreadsheet that calculates and reports adult upstream survival from 2002 to the present. This spreadsheet has been shared with BPA and the COE for their annual reporting requirements and other parties upon request. The Survival estimates have also appeared on NOAA websites mostly as graphs.

The spreadsheet was developed to meet reporting and analysis requirements for the various CRS BiOps and used by other agencies as well in their annual reports. Survival estimates were generated and reported for the Bonneville (BON)to McNary (MCN), McNary to Lower Granite (LGR) and Bonneville to Lower Granite reaches. Two estimates were reported for each ESU, one for fish that migrated in-river as adults and one for fish that were transported as results. No distinctions were made between hatchery and wild fish.

One of the reasons that the survival was not subdivided into smaller reaches in the original reporting format was that not all dams had PIT tag detection in the adult ladders. The spreadsheet includes estimates of per dam survival calculated by taking the nth root ( n= number of dams in the reach) of the larger reach survival. As more PIT tag detectors came on line I calculated shorter reach survivals, though the official reporting remained at the Bon to MCN, MCN to LGR and BON to LGR reach levels. These short reach and project level estimates were used for various ad hoc analyses and to resolve with greater detail, where mortalities were occurring in the CRS. Shorter reach estimates appeared in some of the later CRS BiOps.

**Methodology**

Due to the high detection efficiencies (aprox 97-100%) of PIT tag detectors in adult ladders, a simple binomial method was used to estimate reach survival.

Upstream Dam detections/Downstream detections =survival estimate

Though this estimate is actually Suvival \* Detection efficiency, since the detection efficiency is so close to 1 it was decided this method was sufficient for our purposes. It also had the advantage of being transparent and accessible. These factors are very important when estimates are used for management decisions in a frequently contentious process.

The PIT tag detections at all adult ladders in the CRS for a particular migration year were downloaded from the PTAGIS website and entered into an access database. This data base used queries to filter data, and track detections by PIT tag code at each dam. Thus the numbers of PIT tags at each dam represent a true tracking of individual PIT tags between dams rather than just a general count of PIT tags detected at each dam. The Databases were also used to examine other information including travel time. PIT tag counts for Bonneville, McNary and Lower Granite were then entered into the excel spreadsheet for further analysis.

In the spreadsheet basic reach survival estimates were calculated using the upstream/downstream method described. These reach estimates were corrected for harvest (for each reach) and straying in each reach. Harvest corrections were based on harvest rates reported in the annual Joint Staff Report produced by Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife. Harvest Corrections are calculated separately for the Bon to MCN and MCN to LGR reaches. The harvest correction is calculated as

(Reach survival)/ (1- harvest rate)= Reach survival estimate corrected for harvest

The same harvest rate correction is applied to survival estimates for both transported and in-river fish.

Straying is corrected for by applying a fixed estimate of straying based on those estimated in (ref). The calculation takes the same form as that applied to the harvest correction:

(Reach Survival)/(1- stray rate) = Reach Survival estimate corrected for straying

The same straying rate is applied to transported and in-river fish.

The estimate for the entire CRS reach is calculated as

( LGR tag count/BON tag count)/ (1- BON to MCN harvest rate)\*(1- MCN to LGR harvest Rate)\*(1-stray rate)= BON to LGR survival estimate corrected for harvest and straying.

This methodology is simple and straight forward, but far more information can be derived from the data that is available. Changes to the methodology were avoided to maintain comparability between years (though it would be relatively simple to recalculate all years with any new method) and because reporting requirements remained as the BON to MCN, MCN to LGR and BON to LGR reaches.

**Selection of data to be used in the analysis**

Selection of the tags to be used in analysis and how to assign them to a particular group faced two competing factors, the need to use tags from fish which were representative of the ESU/DPS, and the need to have sufficient tags to make a precise estimate of survival.

Since fish used in adult survival analysis were generally tagged as juveniles for other projects, populations are almost certain to be over-represented or under-represented in the pool of tags available for an ESU or DPS. Thus, there is always some degree of surrogacy in the analysis. In interpreting results it should be remembered that there may be factors that may result in the actual survival of a particular population being significantly different than the survival for the population as a whole.

Survival estimates for all 7 ESU/DPS that passed through the CRS were calculated for each year. In the case of Upper Columbia ESU/DPS survivals were only calculated for the BON-MCN reach.

Only adults which were PIT tagged as juveniles, and thus had a known origin, were used for analysis. Fish were assigned to ESU based on the geographical location of their release point. Large numbers of adults are tagged annually at the Bonneville Adult Fish facility and sometimes other research projects. However, without knowing their true origin, the assumption that they will continue to end of the reach is violated because their natal stream may lie within the reach. Snake River ESU/DPS populations originating below LGR were excluded from analysis of survival for SR ESU/DPS to avoid issues with turnoff. Unlisted Chinook and Steelhead originating from the Clearwater Basin were included in survival estimates for SR ESU/DPS because their run timing was similar.

The Mid-Columbia Steelhead DPS was more problematic because its populations are distributed along the BON to MCN reach and so have differing levels of exposure to the effects of the CRS. The estimate for Mid-Columbia Steelhead was based on the BON to MCN reach survival for Yakima and Walla Walla steelhead populations. This was chosen because it represents a “worst case” scenario, which is preferred when estimating negative effects on listed species under the ESA. A more accurate method would be to calculate the survivals of each population based on the reach survival of the reaches they actually traversed and then weighting the survivals by the the proportion of the total DPS each population represents and then combining them to make a survival estimate for the entire DPS. However, there was insufficient data available to take this approach. Not every population had enough PIT tagged fish for a survival estimate of sufficient precision, until relatively recently not all dams were equipped with PIT tag detections so not all reaches could be separated, and difficulties with finding the population proportions within the DPS for each year. Essentially the Yakima and Walla Walla populations were surrogates for the rest of the populations in the DPS, and had the longest exposure to the CRS so would suffer the maximum effect. The actual difference in survivals between these populations and the downstream populations was probably small. The major mortality factor on these populations is harvest, most of which occurs in the Bonneville and Dalles Pools.

For species other than Steelhead, all detections within the calendar year of interest were used. For Chinook ESU which are separated by run (SR Spring/Summer chinook, etc.) only tags that included that information were assigned to that ESU and used in the analysis. Thus the analyses may have included fish identified as Spring/Summer Chinook which were detected at BON in September, or Fall Chinook detected at BON in May.

All of the listed Steelhead which traverse the CRS are “Summer steelhead”, that is they arrive at BON mostly from June to September, but do not spawn until March-June of the following year. Thus it is possible for detections of a Steelhead in the CRS to span two calendar years. In the case of Upper Columbia this was not a problem as they tend to pass through the BON-MCN reach relatively quickly. In Contrast, a significant (10-20%) proportion of Snake River Steelhead may arrive in Summer, but remain in the BON-MCN reach until the following spring when they rapidly move upstream. This has been known from fish counts from a number of years, with a springtime pulse of steelhead passage observed at dams where there are only Summer Steelhead present. PIT tag detections confirm this behavior. Thus, for SR Steelhead DPS the survival for a return year is calculated from June 1 to May 30 of a particular year. This cutoff date was based on examining patterns of fish passage and the information that some high elevation populations of SR steelhead spawn in June, so fish moving as late as May can still arrive in time for spawning. In assigning survival to a particular year the convention of Spawn year-1 was used. That is the fish passes Bonneville in July 2009 and is expected to spawn in April 2010, so it is assigned to the 2009 year class. Harvest estimates for the year the fish entered the CRS (2009 in the example above) are used for the entire year class when making survival corrections for harvest. Most harvest is likely to occur during the main migration period, but fish remaining is the CRS through the winter and early spring are subject to additional harvest exposure. The true harvest rate the entire ESU is exposed to would be very difficult to calculate, so the harvest rate for the year the steelhead pass BON is used. This is likely to be a slight underestimate of total harvest for this ESU, which should be remembered in interpreting survival estimates corrected for harvest.

As noted before, since tags are highly unlikely to be distributed evenly across an ESU., there is always some degree of surrogacy in estimates. In the case of SR Sockeye, unlisted Upper Columbia Sockeye have been used for surrogates in a number of years (noted on spreadsheet). If less than 40 PIT tags are detected at Bonneville for a particular ESU/DPS the precision of the survival estimate will be unacceptably low. Before 2009 Unlisted Upper Columbia Sockeye (originating from Wenatchee, and Okanagan lakes) were used to provide and estimate of survival for SR Sockeye. In 2018-2020 UC Sockeye and SR Sockeye were combined to provide a survival estimate because of low SR Sockeye returns related to difficulties with hatcheries in Idaho. These surrogate estimates only provide an estimate for the BON to MCN reach. Since UC Sockeye have earlier run timing, a significant number pass through the CRS before the Summer Chinook harvest openings, so UC sockeye tend to have higher survival rates through the BON to MCN reach. So, using them a surrogate for SR Sockeye will likely result in over estimates of reach survival.

At any level of analysis lower than ESU/DPS surrogates will almost certainly have to be used to provide survival estimates with acceptable levels of precision. As long as Assumptions that the fish will behave in a similar manner to the target population, and they are present in the reaches of interest during the same time as the group of interest it should provide an acceptable methodology. Using the same species, but from a different ESU is a good approach to meet these assumptions. However, the individual experiences of a particular subgroup may have an effect as well. Fish which were captured and tagged at the Bonneville Fish facility show a higher survival through the BON to MCN reach than those tagged a juveniles (and not captured at the facility) passing through the reach. There could be some sort of sampling bias in effect related to the selection parameters for tagging fish at the facility, but there is also the possibility that the experience of being captured, handled and tagged makes the fish more wary and thus likely to be captured by a gill net. In either case, use of BONAFF fish in a survival estimate would l inflate the survival estimate of fish passing through the BON to MCN reach.

**Filtering/Screening Data**

After collecting the initial tag data and assigning it to an ESU/DPS, further filtering is required. Typical estimates of adult survival do not include jacks (1 year in Ocean) or precocial fish (return upstream in same year that they migrate downstream. This is primarily and issue for Chinook. Both Jacks and Precocial fish have significantly different survival rates through the CRS than older fish (>2 ocean years). In the case of jacks, they generally have a higher rate of of survival especially through the BON to MCN reach. This is probably due to the size selectivity of gillnet harvest. Precocial fish have generally have much lower survival rates than older fish. The decision of what ages of fish to include in the analysis is based on the reporting requirements and maintaining consistency for between year comparisons. Due to the size selectivity of gill net harvest which is the primary means of harvest in the BON to MCN reach (Zone 6) there also appear to be differences in survival between year classes of older fish as well, though if one assumes that tags are proportionately divided among the year class the pooled survival will proved an accurate estimate.

One of the hazards of the data mining approach we use for adult survival estimates is the potential that the fish may have been tagged by a study that affects their BON to MCN survival in some way that makes them not representative of the population. Unless I know this is true of a particular group of fish, either through previous analyses or something that can be determined from the metadata included in PTAGIS, I generally assume that the negative effects of most studies will have resulted in the death of the fish in 2-4 years in the ocean. Given the high mortality experienced in the ocean, (95-99.5%) this seems like a reasonable assumption, but there is always the chance of some bias. The risk of bias from this source is also related to the total number of tags in the analysis, and should be more seriously considered (and is more easy to identify) when a relatively small number of tags is available for the analysis

In the methodology I have used to do the actual analysis of survival, employing access databases, duplicate detections of tags can be very problematic. Bonneville detections present a problem from the beginning because of its fish ladder layout. There are 4 separate observation sites in PTAGIS For the fish ladders, and their arrangement means that fish may be detected at 1-2 sites, even if they pass the ladder in one trip. For survival analysis the most important information is that they were detected at least once at the observation site, so a query or filter that selects only the first or last observation is sufficient. Other Dams in the BON to MCN reach have two ladders which are listed as separate observation sites by PTAGIS, once again employing a query or filter strategy that choses only the first or last observation for the entire dam will be sufficient for survival analysis. However, the cause of multiple observations at Dams other than Bonneville is likely to be due to fallback and reacension of the fish ladder.

In terms of making survival estimates, fallbacks are mostly significant in how they can potentially cause error (typically double counting a fish). Using a methodology that matches tags across dams rather than a simple count of tags detected at the dam can help avoid this. Some species, such as sockeye, tend to have high fallback rates and may reascend the ladder multiple times. This can lead to very confusing results if a simple tally of detections is used. Fish falling back over dams is a matter of concern for fish managers (though it is typically only weakly related to a particular dams operations) and there are various strategies that can be used as part of the survival analysis to identify fallbacks, delay time, etc.. These are beyond the intended scope of this paper so I will not discuss them further here. I typically use an “interrogation summary’ query to extract data from PTAGIS for analysis, it includes one result per PIT tag for each observation site with a first and last observation (summarizes observations from multiple antennas) date and time. If you wish to try to determine a more detailed picture of the fish’s behavior within the ladder you can use an “interrogation detail” query which will report every observation at every antenna within an observation site. This may result in a very large amount of data though, because some sites have multiple and antennas, as well as fish being detected multiple times at the same antenna.

**Workflow**

My workflow has changed over the years, generally in the direction of becoming more efficient.

1. Download Data from PTAGIS database. Use an” Interogation Summary query” for all 8 adult ladders in the CRS for the calendar year of a particular migration season for the Species of interest. Ensure that the attributes of the query include information that will allow you to parse the data into ESU/DPS and perform needed filtration of data. Though much filtering may be done in the PTAGIS database, that may also result in needing to do further queries and downloads in the future.
   1. The default query includes most of the information you will need. Adding “migration year” and “first (observation)year” will allow easier filtering of minijacks (ocean 0) and Jacks (Ocean 1). The Ice Harbor observation site combines Juvenile bypass and fish ladder observations so it will require this information to sort adults from juveniles. “Release site subbasin” may also be useful information to add.
   2. If you know you will not be calculating survival for Jacks or Mini-Jacks you can filt
   3. It is good practice to use uniform queries for each year. Standard queries may be saved in PTAGIS, only the “first observation year” parameter then needs to be changed for each new download. This saves time and helps ensure the same group of fish is used for analyses each year.
   4. Results from Ice Harbor can be problematic as the PTAGIS site includes both upstream (presumably adult) and downstream (presumably juveniles) detections. By applying a filter to the “first year” column the juvenile detections from Ice Harbor, as well as minijacks can be removed. Use a conditional filter: “first year greater than migration year”. The queries used in the access database also will filter out Ice Harbor Juvenile and minijack detections, but by doing it before download you are putting less unused information in the access database.
   5. Steelhead, whose migration spans a calendar year require an entry of Jan 1, 2020x in the “first observation Date” attribute, and an entry of May 31, “202X+1 in the last observation date attribute”. The migration year is assigned to 202X (year they passed Bonneville)
2. Download files. I typically download files in .csv format and open them in EXCEL to check for any obvious problems. If any post-processing of data needs to be done, excel is often far better for this than the Access database where the rest of the processing will occur
3. Load the downloaded data into the access database. Unless it is a new database you will be appending the data to a central observations table. This is another reason for using uniform queries, you can only append data to a table if there is a perfect match of metadata.
4. The basic Access database for survival estimation includes 3 main tables
   1. Observations:PIT tag Observation data for all 8 dams of the CRS (probably multiple years) downloaded from PTAGIS
   2. ESU/DPS-release site crosstalk table: lists the ESU/DPS for each release site 9exact name matchj) in PTAGIS. This is used to assign fish to a particular ESU/DPS for analysis
   3. Transportation: This file contains of each PIT tag by migration year and if the fish migrated in-river or was transported to the estuary. Currently I use files provided by DART. These files, and any I have produced myself are actually inferences that a fish was transported rather than a direct detection of fish being loaded into a barge. The basic algorithim for identifying a transported fish includes: detection in a bypass system of a collector dam (LGR, LSGS, LMN) on a date within the specified transportation window, the final detection antenna (requires “interrogation detail” query of PTAGIS) of the fish in the bypass system that does not lead to a return to the river, and that the day was not a day when fish collected for transport were released to the river for some reason (typically listed on fish passage center website).
5. Query structures: Originally, I downloaded detections for each dam separately and kept them in separate tables. I later changed to a mass download of data from all dams in the CRS and kept it in one central data table. This greatly reduced the amount of work to download and handle the data. So in my current methodology a query is used to establish a list of fish observed at Bonneville for a particular year, this query also crosslinks to the transportation table (via PIT tag code) and the ESU table (via release site) and adds the transportation status and ESU information to each record. The first year value provides the information to group observations by migration year, except for steelhead whose returns span more than one calendar year which will be discussed later. Ocean age is also calculated at this step by including a field First year- Migration year. Depending on what sort of analysis is desired various ages can be excluded. Jacks (ocean 1) are typically excluded from most conversion analyses so a value of >1 one may be entered in the criteria field of the ocean age. It is also possible to not put in a criteria which will provide conversion estimates by ocean age (if you filtered mini-jacks-Ocean 0 before downloading you will not get any results for them).

A difficulty posesd by Bonneville is that the fish ladders actually comprise 4 PTAGIS sites and typically fish passing the ladder will be detected at more than one site. To solve this issue the query is a summation grouped by PIT tag Number, excluding site identifiers, and with observation times/dates selected as first. This should result in only one record per PIT tag in the list created by this query.

Lists are created for other dams and sites included in the analysis by more queries. One for each dam/site. These are simpler typically only including the PIT tag and the observation time. Since Lower Columbia Dams have 2 fish ladders, listed as different sites there is a risk of duplication of a PIT tag in the list due to fallback and re-ascension of the other ladder. For this reason, the queries are also summations, grouping by PIT tag and with a qualifier of first on the observation time/date.

The survival estimate is generated by a trace query. The BON query, which provides the base list for a year, is linked to all the dam/site queries included in the analysis. There is a prompt to enter the desired migration year at the start of the query (provides information to the first year selection criteria in the BON query). The tables are linked by PIT tag codes. The relationship of the links are a result for everything in the BON and only the results from the other queries that match the BON query. The structure of the query includes the PIT tag code from the Bon query and the first observation. I typically used first observation as the value produced by the queries from each of the other tables. It really doesn’t matter what value from the table is used from the tables as this is just really a query to establish presence or absence. Any result produced by a link between the BON list and observation of the matching PIT tag at the particular dam can be used. Using first observation facilitates modification of the query to produce travel time estimates.

The structure of the the query is the PIT tag from the BON list, and observations (or no observation) for the PIT tag up the CRS in geographical order. For estimation of survival in this list the most important information from each detection site is detection/ no detection. So you have a for each fish that shows if it was detected or not at each dam as you move upstream in the CRS.

One of the issues that occasionally arises with these databases are duplicate records. They can occur for many reasons, errors in query structure, fallback, etc. Using summation queries that group according to PIT tag and use a qualifier such as minimum or maximum to reduce multiple observations for a particular site to a single value. Anything that is different between two observations, and is not resolved by a summation operation like selecting the minimum or maximum value available will produce another line for a particular pit tag Since we are producing an observation/no observation matrix, multiple lines for a single PIT tag are the largest likely source of error.

To summarize the data, and help eliminate duplicate lines, a secondary trace query is used. This query is a summary query, grouping by the PIT tag, and using a “count” qualifier for each observation site. With no duplicate lines in the original matrix, the value for each observation site should be 1 or 0. If there were multiple lines in the first trace query for the same PIT tag, the value will be greater than one. Since we are mainly interested in a binomial output (observation/no observation) if the actual values present are greater than one it does not really matter. As long as there is only one line for each PIT tag it will produce valid results. The problem arises when we want to go from individual results to summarize observations for each dam. If each value is equal to 1 then we can simply add all of them together for each dam (column) to give the total observations for each dam. If some are greater than one to summarize them another step is needed to reduce all values so they are not greater than 1.

Results of the secondary trace should be checked to verify that there are no values greater than 1. This can be done fairly simply with a sort operation (largest to smallest) for each dam (column). If none are found another summary query is applied to the secondary trace query that sums the total observations by dam. This provides the raw data for the simple binary (upstream/downstream) calculation of survival for each reach. Another summary query can be used to calculate the actual survivals. However, since the reporting format for the BiOp is a standard spreadsheet, generally the numbers are entered into the spreadsheet for the actual survival calculation. It is very simple to copy/paste the results of any Access query into an excel spreadsheet. Since excel has more capacities for data manipulation and analysis I typically paste results of the summary queries into an excel spreadsheet for further analysis.

If there are duplicate lines with the same PIT tag code produced by the first trace query, I will generally try to identify the source of the duplication as it can also be a sign of some error in the database. If you are confident that there are no sources of duplication other than multiple observations of a fish at one site (no multiplying through some database operation), then the detection/no detection information included in the analysis is still valid. Queries can be designed in Access to reduce the results to 1 or 0. Simpler workarounds include cutting and pasting of the results of the second query into an excel spreadsheet and using sort and editing procedures to manually change all the non-zero observations into values equal to 1. It is then very simple to produce the total numbers of observations per dam, and calculate the reach survival.

As noted before the issue most likely to produce errors in survival estimates is multiple lines with the same PIT tag code. Access includes a detect duplicates query, this can be used to detect duplicates in any table or the results of queries. Data tables may have duplicates because of updates that overlap the current data in the query in time. Checking for duplicates after updates is a good practice to avoid this error. Using this function to check summary queries that still include PIT tag codes is a good practice to detect and correct this potential error. Exc includes a eliminate duplicates function that can be used to detect errors after data is transferred. I suggest copying the total list of PIT tags and then applying the detect errors to that list. Excel will report if any errors were detected.

The end product of the Access process is a number of observations for each dam in the CRS for a particular migration year. For Snake River ESU/DPS (except Sockeye) separate results are provided for fish that migrated in-river or were transported as smolts.

Other Uses:

The matrix of Pit tag codes, 1’s and 0’s produced by the trace summary are the input data for Cormac Jolly Seber survival analysis. Additional work is likely required to match the input format required by a particular software package such as SURPH. Travel time is also extremely easily calculated using the same structure as the trace query but including observation times rather than just detection/no detection. Basic fallback detection is also possible, the most obvious example being observations of the same fish ascending two different ladders at the same dam (only applicable in the lower Columbia). If the difference between the

First and last observations at a site is greater than 24 hours it is also a strong indication that the fish may have fallen back and then re-ascended the same ladder. This is a basic methodology and will fail to detect fish that rapidly re-ascend the ladder, or misinterpret fish that “camp out”, remaining in the ladder for more than the usual passage time and then resume climbing the ladder and leave. The number of antennas and their arrangement should also be considered in using the methods described to detect fallback.

Stage 2: EXCEL Spreadsheet

The second stage of the analysis is the EXCEL adult survival spreadsheet. It is a legacy product dating back to the early 2000’s and is designed to provide outputs used in CRS BiOps. There are tabs for each ESU. For fish subject to Juvenile transportation, separate calculation fields are included for fish that migrated in-river or were transported as smolts.

The uncorrected conversion rate is estimated in the calculation fields by entering the number of PIT tagged fish detected in a particular year at Bonneville, McNary, and Lower Granite into the row corresponding to that year. Conversion rates for the Bonneville to McNary, McNary to Lower Granite, and Bonneville to Lower Granite are calculated in the next section for Snake River ESU/DPS. For Middle and Upper Columbia ESU/DPS only the Bonneville to McNary reach is calculated for reporting purposes. The McNary to Rock Island reaches may also be calculated for Upper Columbia ESU/DPS though they are not a reporting reach for CRS BiOps.

Corrections for harvest in the BON to MCN reach ( Zone 6), harvest above McNary, and straying are applied to the uncorrected conversion rates. Estimated harvest rates are derived from values reported in the Annual Harvest results reported by the Columbia River Compact. Straying rates are from a review of straying rates by XXX(date).

The calculations used are:

The corrected conversion rates for each reach are reported in the next section. The calculation sections still include fields to the right of the corrected conversion rate that are no longer used. The nth root of the survival is calculated for an estimate of survival per dam. This is because when this spreadsheet was built here were far fewer PIT tag detectors in adult ladders, so a direct measurement of survival for each reach and dam was not possible. With the installation of PIT tag detection in the fish ladders at John Day dam in 2018 it is now possible to estimate adult reach survivals for each reach of the CRS.

Other issues/notes.

The numbers of PIT tagged Snake River Sockeye returns to Bonneville in many years has been less than 40 fish (minimum number recommended NWFSC for survival estimates). In those years, PIT tagged Upper Columbia Sockeye (unlisted populations originating from the Okanagan and Wenatchee) were used to estimate Bonneville to McNary survival for Snake River sockeye.

Conversion estimates (Bonneville to McNary) for Middle Columbia Steelhead were estimated based on conversion rates of the Yakima and Walla Walla populations of that DPS. This represents a “worse case scenario” as other populations in this DPS pass fewer dams and have less exposure to zone 6 fisheries so they likely have higher conversion rates.