# OBJECTIVES, ANALYSES, AND BRAINSTORMING FOR UPPER SALMON FISH TRACKING STUDY

Created by Mike Ackerman

November 11, 2018

# OBJECTIVES

1. Using existing rotary screw traps, identify the proportion of juvenile Chinook salmon from each brood year that emigrate as pre-smolts (fall) to overwinter in the mainstem Salmon versus those that emigrate as smolts the following spring and overwinter in natal tributaries.
2. Identify the movement, distribution, and habitat use of overwintering juveniles using both fixed-site and mobile radio telemetry.
3. After identifying the location of individual juveniles, perform fish surveys (e.g., rafting electrofishing) to determine juvenile fish densities and the length frequency distribution of captured individuals. The goal is to determine whether radio tagged individuals are representative of the wintering juvenile population at large.
4. During fish surveys, collect tissue samples from a representative sample of juveniles. Tissue samples will be used for genotyping; multi-locus genotype data will be used to identify the population of origin of individuals using parentage based tagging and genetic stock identification. The goal is to determine whether multiple stocks (populations) throughout the upper Salmon River are using downstream habitats for winter rearing, and whether the distribution of radio-tagged individuals can be considered representative of un-tagged populations.
5. During fish surveys, Passive Integrated Transponder (PIT) tag capture individuals. Detection of PIT tagged individuals at Lower Granite Dam will be used to compare survival of individuals wintering in various reaches of the migration corridor (e.g., natal tributaries, upper mainstem Salmon, lower mainstem Salmon).
6. Install temperature loggers at each of the fixed-site receivers. Temperature data from each of the sites will be used to develop a spatially and temporally continuous temperature model than can be used to describe fish movement and distribution.

# ANALYSES AND BRAINSTORMING

## Using existing rotary screw traps, identify the proportion of juvenile Chinook salmon from each brood year that emigrate as pre-smolts (fall) to overwinter in the mainstem Salmon versus those that emigrate as smolts the following spring and overwinter in natal tributaries.

As stated, this objective is easy. For each Chinook brood year, we simply need to compile emigration abundance estimates at the L3A0 and Pahsimeroi RSTs broken out by trapping seasons (summer = parr, fall = pre-smolt, spring = smolt), and just estimate the proportion of juveniles that emigrate at each life stage, annually. Then simply estimate the proportion emigrants by life-state. It would also be nice and easy to provide adult escapement estimates for each of those brood years, preferably broken out by sex (with males broken out by jacks and adults).

With that said, there’s a low hanging fruit here. In conversations with BOR & OSC, they are interested more in the why and when do juveniles emigrate? We should address two additional questions here:

1. What determines the proportion of juveniles that emigrate as pre-smolts versus smolts?
2. For those that emigrate as pre-smolts, why and when do they emigrate?

### Why and When do pre-smolts emigrate?

There’s a lot of interest in determining both when (daily, weekly) and why pre-smolts emigrate when they do. To answer this, we could first summarize daily emigration counts/abundance for all the years we have reliable data at the L3A0 RST (2013? – present). And for each daily count/abundance we could generate a dataset of covariates that might explain daily counts/abundance. Covariates may include:

* Discharge
* ∆ Discharge
* Adult Escapement
* QRF Capacity
* River Temperature
* ∆ River Temperature
* Moon Phase (not joking)
* Trap RPMs
* A measure of leaf litter?
* Weather
  + Ambient Temperature
  + Precipiation
  + Barometric Pressure
  + Cloud Cover
  + Wind
* Others?

Essentially, can we develop a model that explains the number of Chinook pre-smolt daily counts/abundance during the fall (to end of season) trapping season at the L3A0 trap?

Further, can we develop a model that explains the proportion of emigrants, for each brood year, that emigrate as pre-smolts? This is likely related to some combination of winter capacity (QRF), adult escapement, and hydrograph? One thought that has been brought up multiple times (BOR, OSC) is can we actually reduce the number of pre-smolt emigrants by modifying the fall hydrograph. i.e., we’ve noted that a lot of pre-smolts ‘pulse’ or emigrate when all of the Lemhi water diversions are turned off. Can we actually reduce pre-smolt emigrants (or stress) by reducing the rate that diversions are turned off? Should we ‘smooth’ the rate that we increase discharge in the mainstem? What about actually leaving some diversions on? BOR and OSC are keenly interested in this.

## Identify the movement, distribution, and habitat use of overwintering juveniles using both fixed-site and mobile radio telemetry.

For movement, perhaps the first thing to do is summarize the number of tags/fish observed passing each site, the detection probability of each site, and the estimated number of fish passing each site. Also, for each reach estimate the reach-specific and cumulative transition probabilities. Finally, after spring emigration, PIT observations in the hydrosystem could be added to the capture histories to add a reach-specific transition probability for bottom-of-study (e.g., Twin Bridges) to LGR. Probably no need to estimate reach-specific below there for this study.

But also, we want to monitor movement rates (spatially and temporally) and how they change throughout the season. For example, do fish move faster early in the season (Oct, Nov) to find suitable winter rearing locations? Do fish slow down during mid-winter when they find a suitable location, i.e., does movement slow significantly or stop at some point? What initiates this? Temperature, ice formation, daylight hours? Finally, does movement begin again sometime in spring and what initiates that?

Using the above information, can we identify a critical period of winter rearing where movement is minimal? And how do fish distribute during those critical periods? For movement and distribution, we need to capture both the spatial and temporal components. When and where do fish distribute in the mainstem Salmon during critical winter months.

We can use weekly fixed-site data to identify reaches where we think Chinook pre-smolt density is highest. Using that information, we should hone in on fish and maximize observations using mobile telemetry (raft, hike, drive). For mobile, we just need a timestamp, tag code, and approximate lat/long. Locations likely don’t need to be overly accurate (i.e., within 100 meters) because we are more interested in macro-habitat than micro-habitat.

This information can likely be gleamed using individual capture histories and/or maps & visualizations that show fish distribution through the monitoring season. One idea is a map, similar to our R Shiny application, that shows estimated fish densities (or just fish per reach) on a weekly time step. When are fish moving downstream and when do they slow?

A combination of the above can be used to identify critical winter habitats in the mainstem Salmon R.

Regarding habitat, it is yet to be determined what habitat data will be collected. We have a phone call scheduled for Dec 5, 2018 @ 2:00 pm Mountain to discuss that with BOR, OSC, and WDFW. At least in the Salmon River, we will be more interested in macro-habitat use. E.g., what reaches of the Salmon River have the highest relative densities of juvenile Chinook and why? This could be some combination of paired drone imagery and ADCP profiling.

## After identifying the location of individual juveniles, perform fish surveys (e.g., rafting electrofishing) to determine juvenile fish densities and the length frequency distribution of captured individuals. The goal is to determine whether radio tagged individuals are representative of the wintering juvenile population at large.

Using telemetry data, identify reaches with increased densities (or relative densities) of overwintering Chinook pre-smolts. In those areas, using raft e-fishing to capture Chinook juveniles and collect FL data from every fish captured. Length frequency distributions from mainstem captures can then be compared to the length frequency distributions of Chinook fall emigrants at the L3A0 and Pahsimeroi RSTs. Here we can test for statistical differences in length frequency distributions. We might expect that mainstem captures are actually smaller than L3A0 and Pahsimeroi pre-smolts because we know that Lemhi and Pahsimeroi fish are larger at age than other populations in the upper Salmon. Showing differences would be evidence that we are also encountering pre-smolts from elsewhere (e.g., upper Salmon, Valley Creek, Yankee Fork, East Fork, North Fork, Panther). Additionally, a genetic sample will be taken from each juvenile Chinook encountered (see below). Ideally, it would be nice to assign a lat/long (at least approximate) to all Chinook captured.

Here, I’m thinking we target high density areas to maximize captures. However, we’d also be interested in estimating densities (or relative densities) by reach. This objective and the below objective should be collaborative with IDFG (Jordan Messner). See their recent presentation. Jordan has been estimating CPUE, by species, for reaches in the mainstem Salmon River during Sep – Oct, and starting in fall 2018 is collecting genetic samples from Chinook salmon. Jordan has offered to share their data and genetic samples. Does it makes sense for us to also build a raft e-fisher suitable for mainstem sampling? We could 1) assist with fall sampling (Sep – ice formation) and 2) possible provide spring sampling (after ice-up to before high flow). Spring sampling would allow us to compare distribution and relative densities between fall and spring and provide additional information on movement. Spring sampling would also bolster sample sizes to achieve this objective.

## During fish surveys, collect tissue samples from a representative sample of juveniles. Tissue samples will be used for genotyping; multi-locus genotype data will be used to identify the population of origin of individuals using parentage based tagging and genetic stock identification. The goal is to determine whether multiple stocks (populations) throughout the upper Salmon River are using downstream habitats for winter rearing, and whether the distribution of radio-tagged individuals can be considered representative of un-tagged populations.

Very closely related to the above objective. A genetic sample is taken from each juvenile Chinook salmon captured in the mainstem Salmon River. Samples will be genotyped at the IDFG Eagle Fish Genetics Lab. I can then perform genetic stock ID to estimate the population (tributary) of origin of each individual.

Because of genetic similarities among Chinook populations in the upper Salmon, I expect a large proportion of individuals (maybe ½) will be difficult to assign to a population of origin. However, the other ½ may be assigned to a population or tributary. Clustering analyses (e.g., STRUCTURE) could also be used to parse Lemhi and Pahsimeroi Chinook from other fish). Here, it would be useful to collect and include a small sample (30-50) of genetic samples, annually, from the Lemhi (RST would work fine) to include as known origin fish in analyses.

## During fish surveys, Passive Integrated Transponder (PIT) tag capture individuals. Detection of PIT tagged individuals at Lower Granite Dam will be used to compare survival of individuals wintering in various reaches of the migration corridor (e.g., natal tributaries, upper mainstem Salmon, lower mainstem Salmon).

Related to two above objectives. PIT tag each juvenile Chinook captured in the mainstem. This information may be used to address two questions:

1. What is the survival to LGR of pre-smolts captured in the mainstem versus pre-smolts captured at L3A0 and/or Pahsimeroi RSTs? This information could potentially be used to address tag burden issues, i.e., mortality of fish PIT tagged vs. fish PIT & radio tagged.
2. Also, would provide additional information to compare survival of pre-smolts rearing in the mainstem Salmon River (DSR from Copeland et al.) to smolts than remain in the tributaries (NRR).

Additional PIT tags in mainstem rearing fish would allow a variety of survival comparisons; however, likely not sufficient sample sizes to compare reach-specific survivals.

## Install temperature loggers at each of the fixed-site receivers. Temperature data from each of the sites will be used to develop a spatially and temporally continuous temperature model than can be used to describe fish movement and distribution.

Temperature will likely be an important factor in Chinook winter movements. Literature suggests that salmonid fish movement slows, or in some cases ceases, at ≤ 4℃. And that movement may be triggered by rapid changes in temperature. In fall 2018, we installed TibBits at each of the fixed site telemetry receivers and also one at the Lemhi RST. The hope is that we can create a spatially and temporally continuous temperature model for the lower Lemhi, lower Pahsimeroi, and mainstem Salmon for the study area. The temperature model could be used to explain overwinter Chinook movement and distribution. Might be worth discussing with Kevin and/or collaborators whether data we are currently collecting will be sufficient to build such a model? Or do we need to deploy additional TidBits? Or less?

Can we envision ways to correlate fish movement rates and distribution with such a model? What would that framework look like?

# CONCLUSIONS

In the end, I would like to provide BOR and OSC with a single final report (in addition to normal annual reports) after the 5-year study that summarizes findings from the above objectives. I’d also hope to publish one or more peer-reviewed manuscripts.

The final report would summarize:

* What proportion of Chinook salmon leave the Lemhi and Pahsimeroi (others?) as pre-smolts rather than rearing in the natal tributaries?
* What determines the abundance or proportion of Chinook that leave as pre-smolts versus smolts?
* For those that leave as pre-smolts, what determines why and when they leave?
* For those that rear in the mainstem Salmon River, describe their movement and distribution during winter months.
* Are wintering mainstem Chinook just from the Lemhi and Pahsimeroi or elsewhere?
* Compare survival of the various strategies? What strategies provide the greatest fitness or survival?
* Other?

The above list is not comprehensive or final. We should hash this out better at a later date.