**Dungeness SONAR analysis**

**Background**

*Objective*

Estimate adult steelhead abundance with precision based on counts of fish passage at a SONAR unit deployed in the Dungeness River.

*Data*

The data consist of upstream and downstream counts of steelhead-sized fish moving past the SONAR sites in 30 minute blocks. The SONAR was intended to be operational 24 hours a day,7 days a week but the imagery review was sub-sampled with 30 minutes of every hour sampled. There were also unplanned outages due to equipment failure, high flows or other issues. Lastly, bull trout with some overlap in body size with steelhead were also present in the river, and a netting effort provided species composition data to allocate fish counts to steelhead vs. bull trout. The SONAR imagery provides an estimated body size for counted fish and we also have body size data for fish captured during the species composition work.

Thus there are three sources of uncertainty in the data

1. Expanding 30 minute imagery observations into 60 minute estimates
2. Accounting for outages (periods without any imagery observations)
3. Exclusion of bull trout from imagery estimates based on species composition data

**Step 1 - Expansion of 30 minute observations**

To provide data for expanding 30 minute counts to 60 minutes, a subset of days throughout the season were reviewed for the full 60 minutes.

Develop a regression relationship between 30 minute counts and 60 minute counts. Each replicate is a 60 minute time block, with the 30 minute count predicting the 60 minute count. Force regression through the origin.

For each 30 minute observation, estimate 60 minute count. Use error or variance of regression relationship to estimate variance of each 60 minute prediction. Sum variance across all estimated 60 minute time blocks in season.

We know how to build the regression and make a prediction, but could use help with the variance estimation component.

**Step 2 - Accounting for outages**

The approach for estimating SONAR outages would be to use average passage rates (fish per day or fish per hour) from adjacent period before and after the outage. There is some discretion or judgment needed to identify the appropriate period (duration) before and after the outage for calculating average catch rates.

Where is the catch rate in unobserved time period *i,* is the catch rate in the adjacent time period and is the duration (number of hours or days) of the outage.

The variance during each outage would be

This captures the variance derived from using average catch rates. To avoid the additional variance associated with step 1 above, use the 30 minute direct observations to calculate rather than the expanded 60 minute estimated catch.

Variances from steps 1 and 2 are additive. Both are similar in concept in that they estimate abundance and variance during gaps in the continuous monitoring.

**Step 3 - Exclusion of bull trout**

Organize abundance and variance derived in steps 1 and 2 into strata, where each strata is a period of SONAR data associated with a species composition sampling event, typically a few weeks. Sum abundance and variance for within each strata.

For each strata, estimate steelhead abundance as:

Where is the abundance in strata *s,* is the estimated catch in strata *s* from step 1 and 2, and is the proportion of steelhead-sized fish that are steelhead in the species composition data.

The variance of is

Where *n* is the number of samples used to establish the proportion.

For each strata, the total variance will be

We can restrict the exclusion of bull trout to fish ≤ 67 cm because 67 cm is the upper end of the bull trout size distribution. In other words, we can safely assume fish observed on the SONAR ≥ 68 cm are steelhead.