A comparison of expanding ten-minute per hour estimates to full hour counts for salmon passing a weir and sonar.

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Introduction

It is often the practice to count the passage of anadromous fish escaping to a river for 10 minutes of each hour and expand that count by 6 in order to estimate the entire hours passage of fish. This study examines the assumption that counting for 10-minutes of each hour and expanding by 6 can represent a full census, or counting 60 minutes of each hour. The study took place on the Chignik River in Alaska during 2016 to 2018, for several weeks in August and September. During this time period sockeye salmon (*Oncorhynchus nerka*) and coho salmon (*O. kisutch*) are abundant and during odd years so are pink salmon(O. gorbuscha). There may be some less abundant Dolly Varden (*Salvelinus malma*) as well as chum salmon (*O. keta*) & Chinook salmon (*O. tshawytscha*) that are are present but less abundant in the escapement. The relationship was examined by year, species (or total of all speciecs combined), and method of enumeration, namely weir or sonar. For weirs we examined the relationship with sockeye salmon, coho salmon, and the total of all fish, regardless of species and for the sonar the total of all fish.

Methods

Fish escapement in the Chignik River, Alaska was enumerated using a weir and a DIDSON[1] sonar.

The weir is a roughly 100 m pile-driven structure of aluminum panels spaced 25 mm apart that is set up to be fish tight. A channel was provided for fish to pass through the weir. All fish passing through the weir were video recorded for enumeration. A boat gate, open only when necessary, allows for passage of boats and all salmon escaping during boat passage were visually estimated.

Upstream of the weir, two DIDSON sonars were set up on opposing banks of the river. Their range extended almost across the entirety of the river. The width of the river is 70 m at the sonar location. The ranges were non-overlapping and the middle of the river (2-3 m) was not ensonified. During the 2016 season the sonar was X distance up stream of the weir. During 2017 and 2018 the sonar was Y distance upstream of the weir. The sonar images were recorded for post season enumeration of fish passage. Fish species was not determined by the sonar images. Species apportionment for sonar comes from beach seining the river approximately every 4 days (Cite op). Examining the expanded 10-minute estimate to 60-minute count by species for sonar didn't add to an understanding of the relationship we were examining which was whether the expanded 10-minute-per-hour estimate, represents the censused count well. Because of this only the total of all species combined was evaluated for sonar.

For both the weir and the sonar, the 10-minute estimates of the total net gain (upstream escapement minus downstream movement) of upstream fish passage was recorded. This number was multiplied by 6 to estimate passage for the entire hour. For comparison the escapement count for the 60-minute census of net gain of upstream fish passage was recorded to come up with the census count for that hour. This was done post season. The hourly estimates or counts were summed for each day.

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[1]Use of DIDSON name does not imply endorsement.

It should be noted that fish passage for both the weir and sonar primarily occured during daylight hours. So while hour to hour comparisons would not be expected to be as similar due to the timing of fish passage from the weir to the sonar, daily estimates and counts should compare well.

Analysis

A total of 12 census-to-estimate relationships were examined for 2016 -2018. Analysis for the weir data were done for sockeye salmon, coho salmon, and total fish passage. Sonar data were only examined for total fish passage. That makes a total of 4 species or species groupings, each which were examined for the 2014-2016 years for a total of 12 relationships.

A linear regression between the independent variable, 60-minute counts, and the dependent variable, expanded 10-minute estimates, was produced. (Figures 1 & 2)

Since some of the residuals appeared to be not independently and identically distributed (Table 1, Shapiro column, bolded pvalues), we used the non-parametric Wilcoxon rank sum test to examine the relationships first. Because we were testing 12 hypotheses, the Bonferroni correction for an alpha of 0.05 was 0.05/12, approximately 0.004.

Our null hypothesis was that the 60-minute count and the expanded 10-minute estimate of fish passage were equivalent, the alternative was that they were not. In each of the 12 cases we failed to reject the null hypothesis. (Table 1, column Wilcoxon) This gives support to the notion that the 10-minute counts may adequately estimate the 60-minute counts.

For 8 of the 12 cases the data was normally distributed and hypothesis testing on the linear regression was appropriate. (Table 1, column Shapiro). Here the Bonferroni correction was $0.05/8 = 0.00625$. All regressions were statistically significant with p values < 0.001 (Table 1, column Linear Reg). In order to test if estimates and census counts were equivalent our null hypothesis was that the regression's slope was equivalent to 1, our alternative hypothesis was that it was not. In all 8 cases we failed to reject the null hypothesis. (Table 1, column slope_eq1). This also gives support to the notion that expanded 10-minute counts adequately estimate the 60-minute counts.

Conclusion

An expanded 10-minutes per hour count was appropriate for estimating the 60-minute census, and at a fraction of the cost of doing a census.
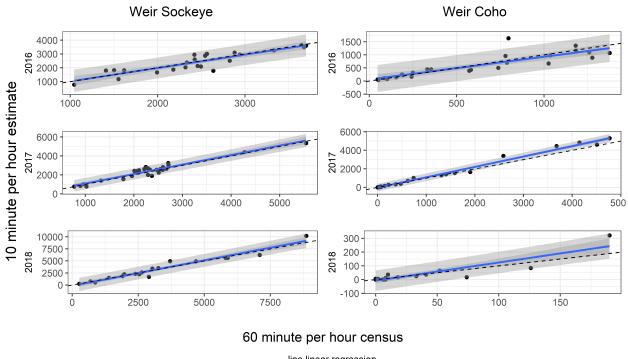
Table 1

Species	Method	Year	Shapiro	Wilcoxon	Linear Reg	Slope = 1	Adj R^2
Coho	Weir	2016	**< 0.001**	0.390	**< 0.001**		
Coho	Weir	2017	**0.004**	0.301	**< 0.001**		
Coho	Weir	2018	**0.002**	0.637	**< 0.001**		
Sockeye	Weir	2016	0.308		**< 0.001**	0.735	0.79
Sockeye	Weir	2017	0.812		**< 0.001**	0.998	0.92
Sockeye	Weir	2018	0.190		**< 0.001**	0.406	0.94
Total	Sonar	2016	0.220		**< 0.001**	0.080	0.70
Total	Sonar	2017	0.802		**< 0.001**	0.007	0.97
Total	Sonar	2018	0.654		**< 0.001**	0.066	0.86
Total	Weir	2016	0.495		**< 0.001**	0.358	0.78
Total	Weir	2017	**0.004**	0.218	**< 0.001**		
Total	Weir	2018	0.267		**< 0.001**	0.383	0.94

Figures

Figure 1

Comparision of 60 min/hr census vs 10 min/hr estimate.

Figure 2

Comparision of 60 min/hr census vs 10 min/hr estimate.