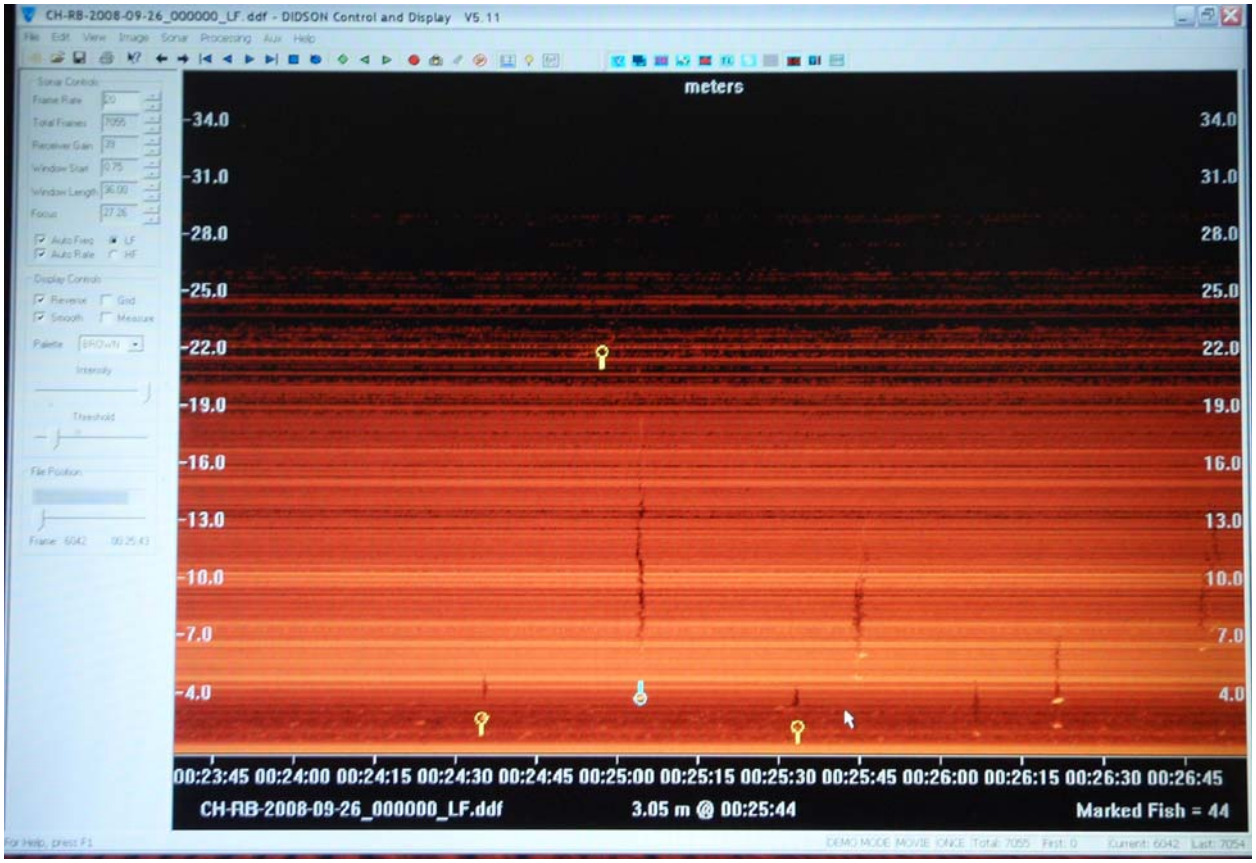
U.S. Fish & Wildlife Service

Comparison of Expanded Partial Hour and Full Hour Sonar Counts of Fall Chum Salmon on The Chandalar River, Alaska.

Alaska Fisheries Data Series Number 2015-2



Fairbanks Fish and Wildlife Field Office
Fairbanks, Alaska
July 2015

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Cover: Fish traces being counted on an echogram with DIDSON software.

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Comparison of expanded partial hour and full hour sonar counts of Fall Chum Salmon on the Chandalar River, Alaska.

Jeffery L. Melegari

Abstract

Three years of sonar count data (2011-2013) were evaluated to assess the error rates from expanding 30-minute per hour sample counts verses the actual counts collected with DIDSON during the Chandalar River Fall Chum Salmon *Oncorhynchus keta* enumeration project. Hourly error rates were unbiased. Nearly all the total daily (left bank + right bank) error rates were within ±10% of the full counts (100 % for 2011 and 2012 and 95% for 2013). Total estimates of fish passage for all years were ±0.5% or less of the actual counts. Confidence intervals calculated for the subsample estimates of the total season passage were narrow, and captured the total seasonal passages from the actual counts for all three years.

Introduction

Accurate escapement data is integral to salmon management, and a variety of methods have been employed to determine escapements (Cousins et al., 1982; Johnson et al., 2007). These methods range from indirect methods such as redd counts, to more direct fish passage counts using towers, hydroacoustics, or weirs. Direct passage count methods possess the potential for the greatest accuracy, especially when enumerating 24 hours per day throughout an entire run (Parsons and Skalski, 2010). However, it is not always possible or feasible to count 24 hours per day. Even when it is possible to count 24 hours per day, once an enumeration method has been validated it can be beneficial to seek efficiencies to sampling design. When complete counts are not logistically or economically feasible, systematic sampling is commonly used with counting towers or hydroacoustics to provide estimates of salmonid escapements (Johnson et al 2007; Reynolds et al 2007).

The United States Fish and Wildlife Service, Fairbanks Fish and Wildlife Field Office, has used hydroacoustics to enumerate Fall Chum Salmon *Oncorhynchus keta* returning to the Chandalar River in interior Alaska since 1994. From 1994 through 2013 the Chandalar project conducted complete 24-hour daily counts to determine seasonal fish passage. However, declining budgets have led to the need to reduce costs. Adopting a systematic sampling regime would reduce the time needed to analyze the sonar data in the field, which would allow reduction of the field crew size and related cost savings. Before committing to a systematic sampling regime, we evaluated the error rates of expanded counts derived from sampling the first 30 minutes of each hour. The objective of this analysis was to evaluate error rates of the proposed sampling, by comparing passage estimates calculated from the samples to actual 24 hour counts acquired during the 2011–2013 seasons.

Study Area

The Chandalar River is a fifth-order tributary of the Yukon River and drains the southern slopes of the Brooks Range. The Chandalar River sonar study area is located at 66° 42.01′ N and 146° 02.63′ W, approximately 21.5 river kilometers from its confluence with the Yukon River. Detailed descriptions of the study area can be found in Daum et al. (1992) and Melegari (2014).

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Methods

Data collected during normal operations of the Chandalar River Fall Chum Salmon enumeration project from 2011 to 2013 were used for this analysis. Nothing unusual or atypical occurred during these three years that would suggest the data from any of the years were unsuitable for this analysis. All data were collected using Sound Metrics DIDSON systems and were manually counted using the DIDSON control and display software, version 5.25 (Sound Metrics Corp. 2010). A long range DIDSON was used on the left bank and a standard range DIDSON was used on the right bank. The sonar systems were operated 24 hours per day, except during intermittent periods for maintenance, repairs, aim adjustments, or relocating the DIDSON as water levels changed. The DIDSON data were saved to files at 30 minute intervals. Data files were examined in the echogram view and when potential targets were encountered they were further evaluated by reviewing that section of data in the normal image view to verify that the targets were fish and to determine the direction of travel. Count data from these files were then exported to ASCII files, which were compiled and summarized using a Microsoft Excel Visual Basic for Applications macro developed by the author. Further details of the Chandalar River enumeration project's normal operations can be found in Melegari (2012; 2013; 2014)

To ensure the observed error was due to subsampling and not some other factor, days without full 24 hour counts on both banks were discarded from the analysis. For days with full 24 hour counts on both banks, the first 30-minute file of each hour was used as a 30-minute subsample. Hourly fish passage was estimated for each bank from the 30-minute subsample counts using:

$$\hat{E}_h = 2 \bullet C_h. \qquad (1)$$

Where $\hat{E}_h$ = estimated hourly upriver count for hour h, and C_h = upriver count during the first 30 minutes of hour h.

Hourly passage estimates from both banks were summed to get an estimate of total hourly upstream fish passage. These total hourly estimates were summed to obtain daily estimates of upstream fish passage. Estimates were compared to corresponding actual counts.

Error rates (%) for hourly and daily estimates were calculated using:

$$((\hat{E}_t - A_t)/A_t)\bullet 100 \qquad (2)$$

Where $\hat{E}_t$ = estimated upriver count for time t (in hours or days), and A_t = actual upriver count during time t. Means of hourly error rates were evaluated for each bank individually, whereas daily error rates were evaluated as the sum of left bank and right bank, using a one-sample t-test (two tailed, α=0.05, $H_{0:}$ sample mean = 0) to check for bias.

The total seasonal passage estimates from the samples was obtained by summing the daily estimates. Variance ($\hat{V}$) of the seasonal estimates was calculated using the V5 sample variance estimator suggested by Reynolds et al. (2007):

$$\hat{V} = (1-f)(1/n)\sum_{j=5}^{n} c_j^2 \,/(3.5(n-4)) \tag{3}$$

Where f is the proportion of possible observations that were actually observed, and $c_j = y_j/2 - y_{j-1} + y_{j-2} - y_{j-3} + y_{j-4}/2$, and y_j is the *j*th observation of a systematic sample of *n* observations.

Confidence intervals (95%) for total seasonal estimates were calculated using the normal interval estimator also recommended by Reynolds et al (2007):

$$95\%CI = \hat{Y} \pm 1.96\sqrt{\hat{V}(\hat{Y})} \tag{4}$$

Where $\hat{Y}$ = seasonal passage estimate and $\hat{V}$ = variance of the seasonal passage estimate.

Results and Discussion

After removing days with less than full 24-hour counts on both banks, 37 days of data were used for analysis from 2011, 41 days from 2012, and 40 days from 2013. Mean hourly error rates were not significantly different than zero on either bank or both banks combined for any of the three years (Table 1), indicating that the estimates were not biased. Additionally, hours that had higher error rates were typically hours with very low fish passage (Figure 1). These fish tend to migrate in pairs or small groups that may not be evenly distributed through time, hence estimates from sample counts during hours when only a few groups pass are more likely to deviate from the actual full hourly count. Since the actual numbers of fish passing during these hours with the higher error rates is small relative to the total passage, the overall impact on the final estimate is trivial.

Table 1. — *P* values from one-sample t-tests (two tailed, α 0.05, $H_{0:}$ sample mean = 0) of hourly error rates.

Year	Left bank	Right bank	Combined
2011	t = 0.93 P = 0.35	t = 0.49 P = 0.62	t = 0.87 P = 0.38
2012	t = -1.24 P = 0.22	t = -0.63 P = 0.53	t = -0.91 P = 0.37
2013	t = -0.33 P = 0.74	t = 1.80 P = 0.07	t = 1.62 P = 0.10

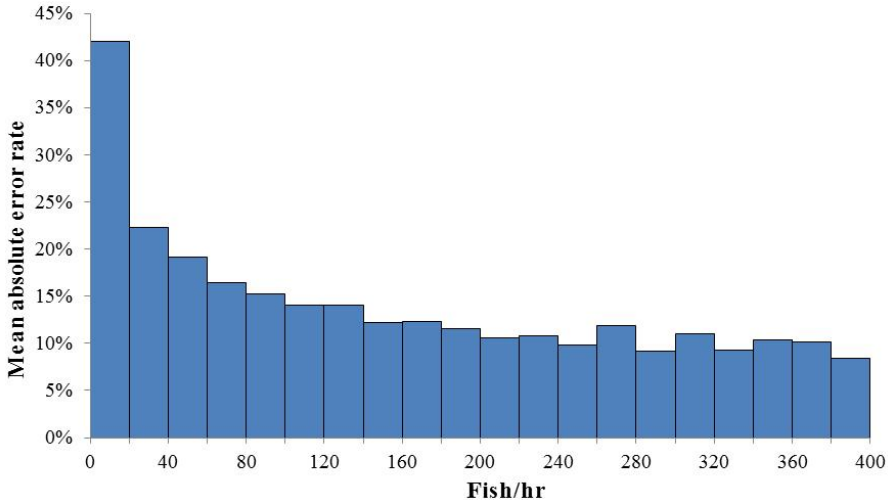

Figure 1. — Mean absolute error rate of hourly estimates from both banks individually on fish passage rates.

Error rates of daily estimates, as expected, were smaller than hourly error rates. Mean error rates of the total (left bank + right bank) daily estimates were 0.5% for 2011, -0.6% for 2012, and 0.8% for 2013. Mean total daily error rates were not significantly differently than zero for any of the three years (t = 1.20 P = 0.24 for 2011, t = -1.35 P = 0.18 for 2012, and t = 1.11 P = 0.27 for 2013). During 2011 and 2012 all of the daily estimates were within ±10% of the actual daily counts, and in 2013 38 of 40 daily estimates (95%) were within ±10% of the actual counts (Table 2). The two days in 2013 that were not within ±10% occurred early in the season, when the daily counts were low (Aug 8, actual daily count of 140, error rate 10.5%; and Aug 15, actual daily count of 151, error rate12.3%). Accuracy and precision of daily counts from the Chandalar sonar project is a management concern because the counts are used to support in-season management decisions. The error rates observed here indicate that we were able to estimate daily passage to within 10% of the actual value at least 95% of the time, which is acceptable for in-season management purposes (Fred Bue, USFWS, personal communication).

Table 2. — Descriptive statistics for percent error of the total (left bank + right bank) daily estimates, and the percent of daily estimates within 5% and 10% of actual daily counts.

Year	Mean	SD	Min	Max	Percent of estimates within 5% of actual counts	Percent of estimates within 10% of actual counts
2011	0.5%	2.5%	-3.1%	9.0%	89.2%	100%
2012	-0.6%	2.9%	-6.2%	5.6%	92.7%	100%
2013	0.8%	4.5%	-6.7%	12.3%	75.0%	95.0%

Estimates of total fish passage for all years were within ±0.5% of the actual counts for the days included in the analysis (Table 3). Confidence intervals calculated for the subsample estimates encompassed the total passage values from the actual counts for all three years.

Table 3 — Actual counts, total estimated counts (from 30 minute sample counts), percent error, variance, and confidence intervals of Fall Chum Salmon seasonal passage on the Chandalar River, Alaska, 2011–2013. Data only includes days with full 24 hour counts.

Year	Actual count	Estimate from sample counts	% Error	Variance	95% CI	
					Lower limit	Upper limit
2011	216,874	217,337	0.2	1.97	216,053	218,621
2012	160,938	160,212	-0.5	1.49	159,251	161,173
2013	195,344	196,341	0.5	3.43	194,732	197,950

Conclusions

The Chandalar River Sonar Project provides daily and seasonal passage estimates for one of the largest Fall Chum Salmon populations in the Yukon River drainage. Managers use these data to both formulate and evaluate management decisions, thus accurate estimates are necessary. Assuming the error rates observed during these three years are representative, this subsampling protocol will produce estimates of daily and seasonal fish passage that are both accurate and precise, and of ample quality to guide in season management.

Acknowledgements

Special appreciation is extended Randy Brown, Aaron Martin, and Jeremy Mears for assistance with analysis and/or report review; and to all the field technicians who helped collect the data over these three years.

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