Imaging sonar deployment in the lower Copper River to enhance early season management - 2019

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Executive Summary/Abstract

In order to enumerate up-migrating Copper River Salmon, two Tritech Gemini 720is sonars were deployed May 3 to June 11 2019 in the lower Copper River, at a site by the confluence of the Clear Martin and Copper rivers, approximately 10 river miles north of the open ocean. One sonar was mounted on the east bank of the river, while the second was mounted on a floating platform deployed on the western side of the river. Hourly and daily counts of upriver passage were determined, and the results posted multiple times per day via internet for use by ADF&G managers and the general and fishing public.

A post-deployment analysis of the difference between the Clear Martin sonar and the ADF&G sonar site at Miles Lake showed that the Clear Martin site counted considerably fewer fish than were counted at Miles Lake, as has occurred in previous years. The differences may be due to the nature of how salmon navigate the lower delta (i.e. they may not mostly travel near the bank). Lagged correlations suggest that the salmon took approximately 2 days to transit between the Clear Martin and Miles Lake, which is within the range of swimming speeds by Sockeye salmon observed elsewhere.

Background/Rationale

The Copper River salmon fishery is managed in part with a sonar site operated by the Alaska Department of Fish and Game (ADF&G) at the Million Dollar Bridge/Miles Lake at mile 50 of the Copper River Highway. ADF&G operates multiple sonar systems at the site (one on each bank), and fish are counted by technicians from 10 minute subsets done at multiple frequencies. The sonar systems used by ADF&G are highly specialized imaging multibeam sonars (Soundmetrics Inc. DIDSON and ARIS) that produce a video-like image by scanning at high frequencies. This allows individual fish to be counted as the pass the sonar, which results in very good estimates of escapement.

The ADF&G sonar site is located at the first point above the Copper River delta where the river is confined to a single channel, and is approximately 35 miles from the nearest ocean entry point to the Copper River Delta at Kokenhenik Bar. Direct measurement of the swimming velocity of up-migrating salmon has not been done in the Copper River, but estimates from matching up abundance peaks between the fishery, a site at Flag Point (~15 miles from the ocean) or the clear Martin River (~10 miles from the ocean) and the Miles Lake site suggest that it takes 2 to 5 days for salmon to transit through the delta (Degan et al., 2005). The lag between the time when the fish enter the river (and are no longer available to the fishery) and when they pass the counters at Miles Lake complicates timely management of effort by the fishery, and can lead to escapements in excess of expectations.

The main channel of the Copper River has been transitioning from having the bulk of the flow through the western side of the delta at Flag Point (mile 27 of the Copper River Highway),

towards the east (Brabets and Conaway, 2009). Those changes in flow regime lead to significant damage to a number of the bridges of the Copper River Highway in the early 2000's. After being almost completely undermined by the new main channel, bridge 339 at mile 37 was closed in 2011 and became the new terminus of the Copper River Highway. In the years since the channel has continued to migrate eastward.

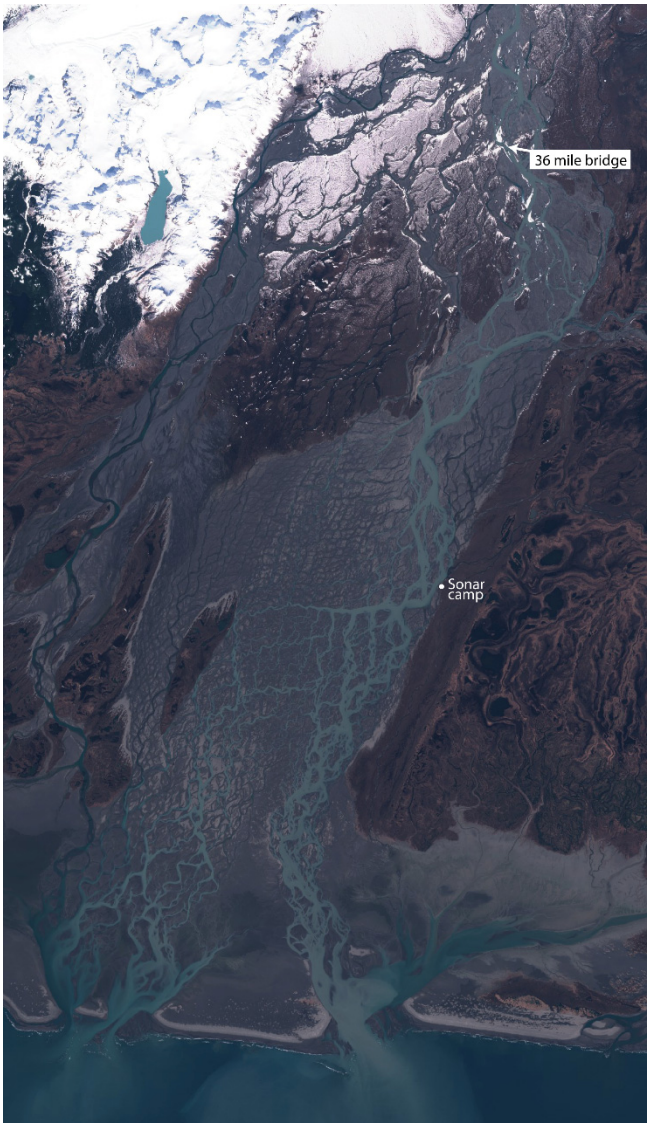

Figure 1: The lower Copper River delta, April 27 2019, imaged with the ESA Sentinel-1 satellite.

Presently, during periods of low discharge, essentially all the water in the river passes through the main channel at bridge 339; as discharge increases and water levels rise, other channels begin to come on-line (Jeff Conaway, USGS Hydrologist, personal communication). Satellite imagery also suggests that during low water, the river is confined to a relatively small number of channels until a point near where the Clear Martin River enters the delta (~10 miles from Kokenhenik Bar), and is heavily braided below that (figure 1). A pilot study done in 2015 for the CR/PWSMA indicated that the channel near the Clear Martin River was the lowest possible point in the Copper River delta where fish might be counted with acoustic methods: a 720 kHz Tritech Gemini 720 imaging sonar deployed at the site in late June observed fish passage in the main channel. In 2016 a pilot deployment was done at the Clear Martin site during the early part of the salmon run (May to mid-June), using a rented DIDSON sonar (the same type used by ADF&G at Miles Lake) on the east bank, and several thousand fish were counted. In 2017 two of the Gemini 720is sonars were deployed at the Clear Martin site from early May to mid-June, with a sonar on each bank. Again several thousand fish were counted, with most observed passing along the eastern bank. In 2018, with support from a grant from the NOAA Saltonstall Kennedy program, two Gemini 720is sonars were purchased and again deployed at the Clear Martin site; those sonars were deployed again in 2019 and this report outlines the results of that deployment.

Narrative of the deployment

Two sonar systems were purchased from Tritech, Inc. in 2018, they were identical Gemini 720is units (http://www.tritech.co.uk/product/gemini-720is-1000m-or-4000m). The 720is sonars operate at 720 kHz, which is similar to the lower frequency employed by the ADF&G DIDSON sonars.

The winter of 2018/2017 was below average in terms of snow accumulation in the lower delta and breakup also came very early. The camp was deployed on May 3rd, and the east bank sonar made operational that day (fig. 3), which was the earliest deployment of sonars so far by this project. River travel conditions were very good, there was very little debris and floating ice, and no ice dams were encountered. The second sonar was mounted on a floating platform developed in 2018 and deployed May 4th.

The east bank sonar was placed at a site adjacent to the sonar camp and immediately below a cutbank, and slightly set back from the main channel (so that the sonar would not be in danger of being hit by floating debris). A 40' long x 20' deep net weir made from seine web (donated by Mike Maxwell at LFS) was set up just downstream of the sonar frame to move up-migrating fish away from the bank so that they might be better ensonified.

The west bank sonar was initially deployed across the river from the camp in a second channel the opened up in 2018 or 2019, in a downward-looking configuration, in approximately 10 feet water depth. Salmon passage in the second channel was consistently low at that site, and on May 20th the floating platform was relocated to the main channel at a site immediately across from the sonar camp. The sonars and camp were removed on June 11th.

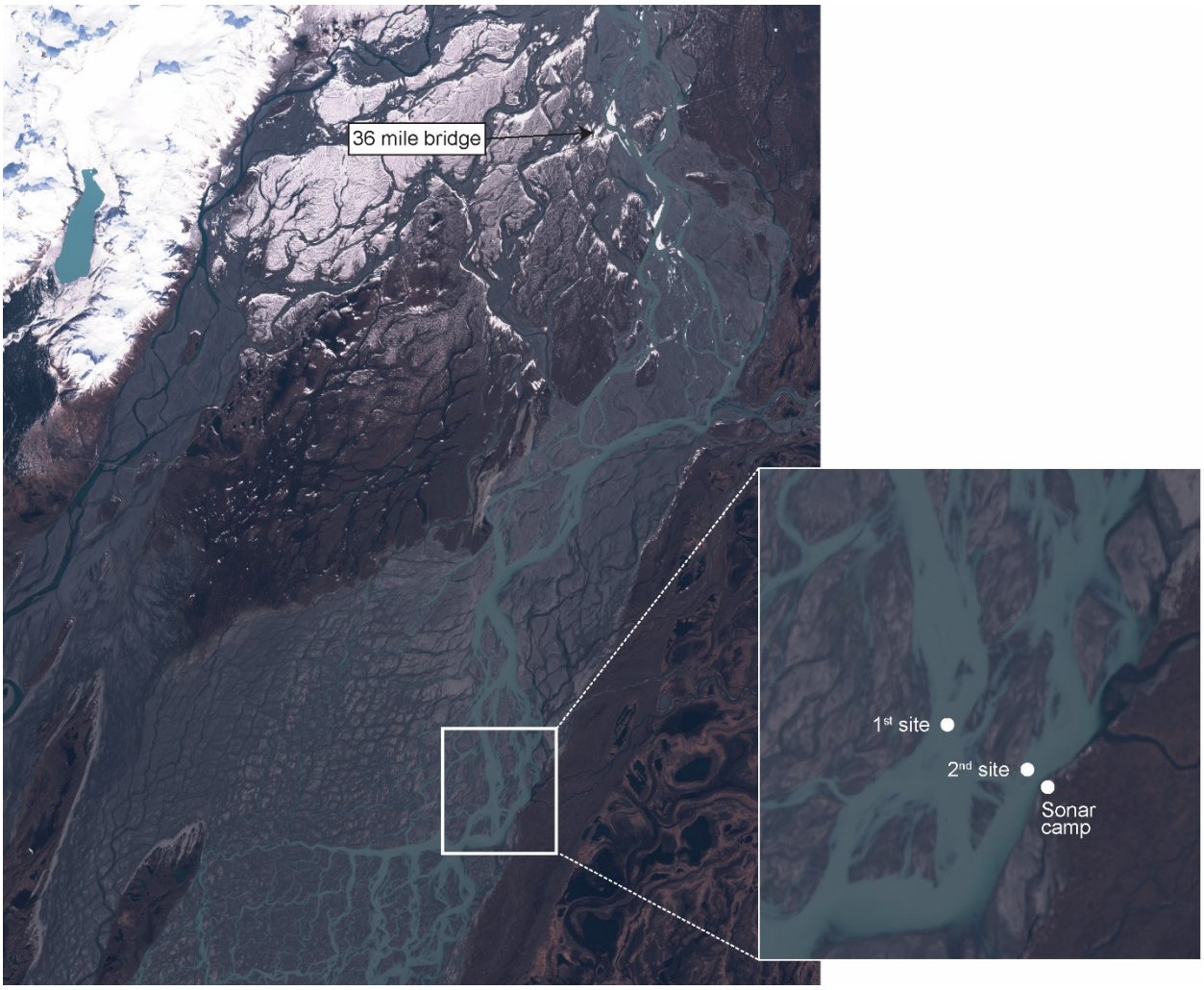

Figure 2: Deployment locations in the lower delta, including the first and second sites where the floating sonar platform was deployed.

Methods

Both of the sonars transmit data via an Ethernet connection, and data logging was done through a small standalone network set up in the main tent of the camp. Data from the west bank sonar was streamed to the camp via a wireless data link. Data logging and processing was done by two dedicated computers (one per sonar), and fish counting was done with a third laptop also connected to the network. Network address translation and data transmission was done through a Sierra Wireless RV50 cellular modem connected to the Copper Valley Wireless cellular network. An active diversity directional antenna was pointed at the cellular repeater on Wolverine ridge. Connection quality was generally very good, in the -60 to -70 dB range (-50 dB is an excellent "5 bar" connection, and a very poor connection is in the -100 to -110 dB range), and data transmission speeds were acceptable.

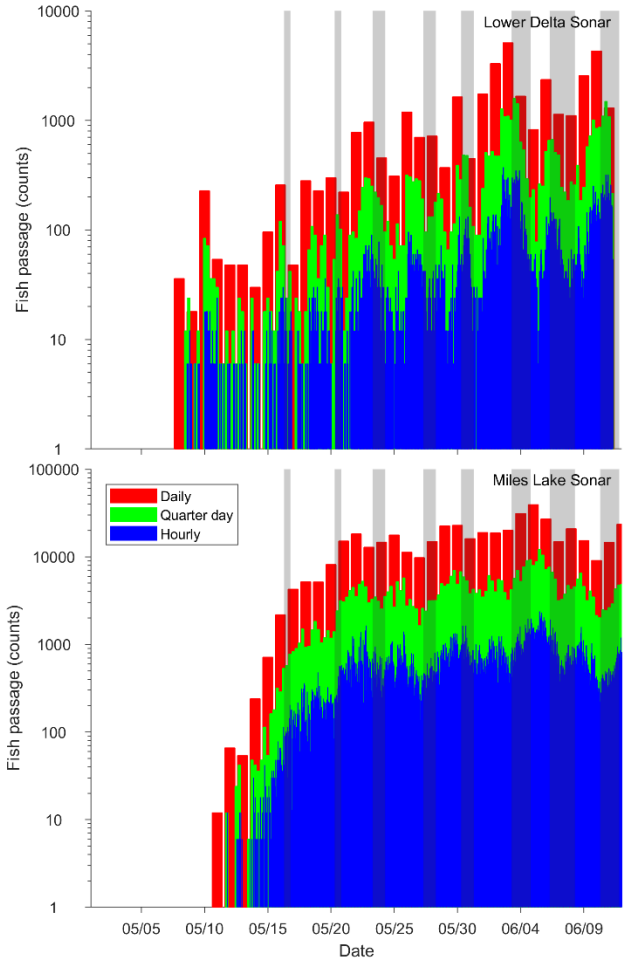

Figure 3: Counts of fish passage made at the Clear Martin sonar site (this project, top panel) and the ADF&G sonar site at Miles Lake (bottom panel). Hourly counts (blue bars) were binned into 6 hour (quarter-day, green) and 24 hour (daily, red) bins for further analysis. Fishing periods are denoted by the grey boxes.

The Gemini software does not have a provision for automated recording, so routines were developed in the AutoIT scripting language to start and stop recording by the sonars and the processing of the data collected. The east bank sonar was set to record the first 10 minutes out of every hour and the floating platform sonar was set to record for 10 minutes starting at 15 minutes after the hour.

Fish passage counts were done on the third laptop using the high resolution videos produced by the Gemini software from the raw files. Counts from each 10 minute period were converted to hourly counts by multiplying the number of counts in the subset by the fraction of each hour that was recorded (i.e. 6). Hourly counts were posted several times per day, and each day's hourly counts summed up to produce a daily count. Spreadsheets with the hourly and daily counts were posted to the PWSSC lower Copper Sonar website (http://pwssc.org/2019-lower-copper-sonar/) directly by the technicians as the counts were finished. In general the overnight counts were

done as soon as possible each morning, and the counts done once or twice during the day as the files accumulated.

The western bank deployment was done from a "mini-barge" that was fabricated specifically for this project. The barge was designed by a marine architect (Dan Lofstrom at Steady Flux, Inc.) and fabricated locally by Ryan Webber of Northshore welding. The barge is 6 feet long by 2 ¾ feet wide, with generous freeboard for carrying a large battery payload. A directional wireless antenna mounted on the barge pointed at the sonar camp was used to transmit data and control the sonar electronics. The sonar was mounted on a Pelco pan/tilt head so that it could be remotely aimed from the camp, and ethernet actuated relays were used to keep unnecessary electronics powered off when not in use to preserve battery life. An ethernet-enabled voltmeter was also installed to monitor the batteries. Solar panels were added in 2019, which were enough to keep the batteries charged during the entire deployment.

2018 Copper River stage height

The state of the river during the deployment may be inferred by examining the hydrograph of discharge (figure 4). Discharge data from the USGS station at the Million Dollar Bridge were taken from the NWIS water data website (discharge is derived from stage height observations, and are thus a proxy for water height). The data record at that site is patchy, but includes several years of observations from 1989 to present. To put the 2019 river height (the red line in figure 4) in context, an average daily discharge was calculated (the black line in figure 4).

Water levels were mostly below average during the early part of the deployment, with one short (~1 week) event of higher than average levels (fig. 4). Water levels were above average during the second half of the deployment.

Comparison between the Clear Martin site and the ADF&G Miles Lake site

Hourly counts of fish passage at the Miles Lake site were made available by Shane Shepherd at the ADF&G Miles Lake weir (figure 3, bottom panel). Hourly counts from the North and South bank sonars were summed, and then binned into both quarter-day (i.e. 6 hour) counts, and daily (24 hour) counts. The choice of bin size is somewhat arbitrary, the quarter-day counts appear to preserve most of the "pulses" of fish moving through, while removing some of the high frequency variability of the hourly counts. The lower delta counts do seem to respond quite quickly to fishing periods, with consistent declines in fish passage concomitant with fishing periods (fig. 3).

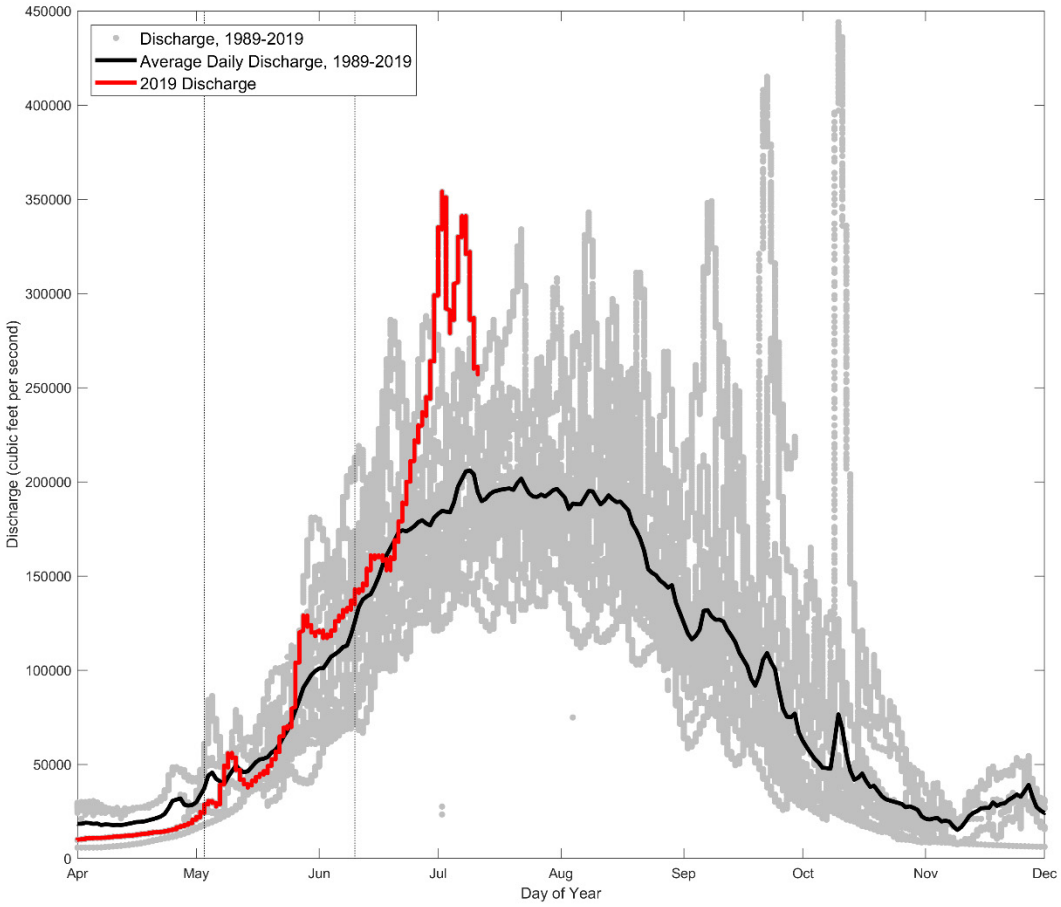

Figure 4: Discharge hydrograph at USGS station 15214000 (Million Dollar Bridge) during 2019. Grey dots are all observations (i.e. made between 1988 and present), and the red line indicates observations made in 2019. "Average" discharge is indicted as a daily average (black line) fit through the entire dataset. The dashed vertical lines indicate when the sonars were deployed and demobilized.

The Miles Lake site showed a steady ramping up of fish passage into late May, with counts more or less steady after that. The Miles Lake sonars counted approximately an order of magnitude more fish than the Clear Martin sonars.

There is a lag time between when fish were counted at the Clear Martin site and when they pass the sonars at Miles Lake. If one assumes that the fish travel at a roughly constant rate, then there may be some coherence between the two sites that will be indicated by the correlational lags between the two sites. The counts made at the Clear Martin site may be correlated against counts made at Miles Lake at some point in the future – this is termed a lag (e.g. counts made at the Clear Martin site at time 0 can be correlated against counts made at Miles Lake 1, 2 or 3 days later, and so forth). For each correlation, a Pearson's correlation coefficient was determined, and the statistical significance of each correlation tested using a Student's t distribution for a

transformation of the correlation. The probability value of the test indicates the probability that a correlation was detected when none exists. Correlations with probabilities < 5% are presented as statistically significant (i.e. there was a 1 in 20 probability that the correlation occurred by chance alone)

The lagged correlations showed the best correspondence between the Clear Martin and Miles Lake sonars between 1 and 3 days, with the best correlations in at approximately 2 days (fig. 6). If one assumes that up-migrating salmon use the main channel of the river, the distance between the Clear Martin site and Miles lake is approximately 25 miles. A transit time of two days between the Clear Martin site and Miles like implies an average velocity of 0.15 m/s (slightly more than a third of a mile per hour), which is toward the lower end of swimming speeds observed in sockeye salmon migrating up the Fraser River, where speeds have been observed to vary between 0.14 and 3 m/s (Hinch and Rand 1998; Hanson et al 2008).

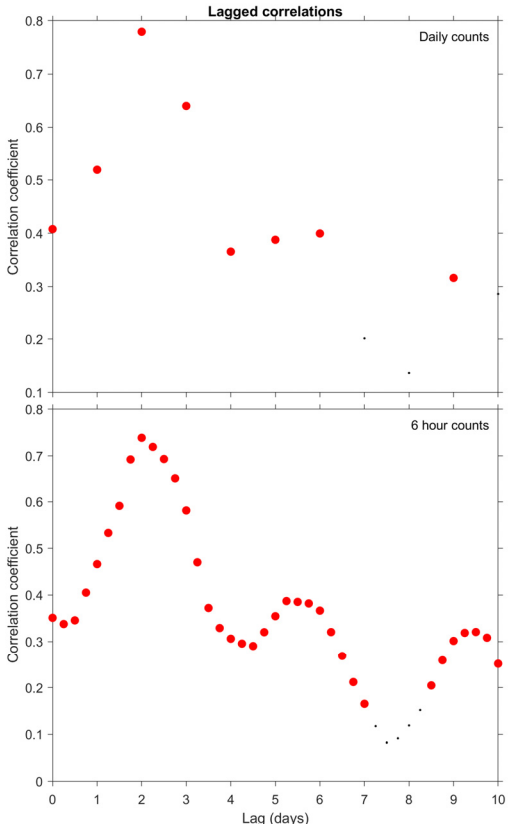

Figure 5: Lagged correlations between daily (top panel) and 6 hour (bottom panel) counts at the lower delta and Miles Lake sonars. Red dots indicate correlations that were signifiant with $p<0.05$.

The lower delta sonar project has now run for four years which presents a long enough time series that an interannual comparison of counts at the lower delta and Miles Lake sites may be made. In order to compare the two, daily counts at the lower delta site were compared to those made at Miles Lake with a two day lag (the approximate time it takes salmon to swim between the two sites) from 2016 to 2019 (fig. 6). Comparing the counts this way shows that there is something of a linear relationship between the two in log-log space, but that there is considerable variability, and that counts at the lower delta site are approximately an order of magnitude less than those made at Miles Lake.

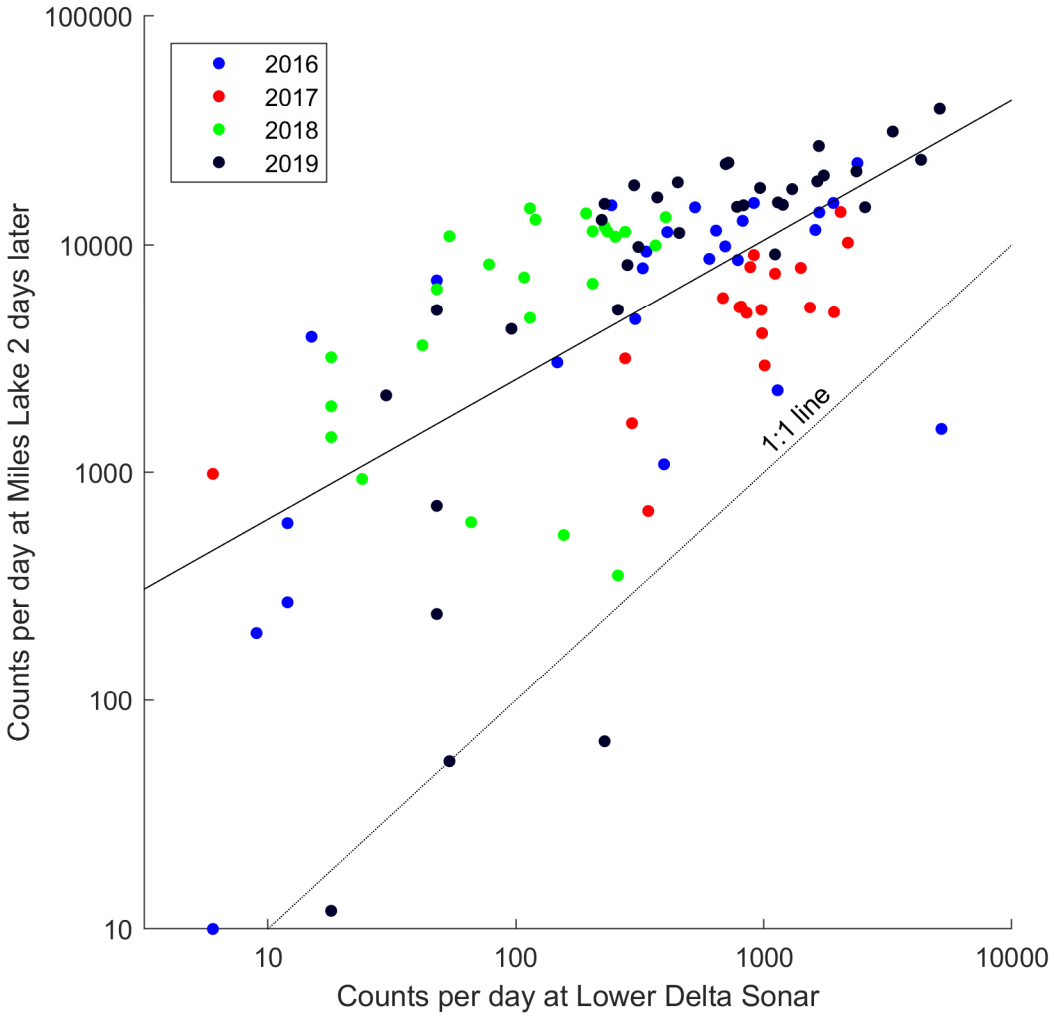

Figure 4: Comparison of counts made at the lower delta site and counts made at Miles Lake two days later, 2016-2019. The dashed line indicates the 1:1 line, and the solid line is a linear regression between the two.

Lessons learned and recommendations

The 2016 - 2019 Clear Martin sonar deployments have counted significantly fewer fish overall than the Miles Lake sonar site. Stage heights in 2016 were above average (perhaps giving up-migrating fish more channel options), and only a single sonar was deployed on the eastern bank, which it was thought might have resulted in the relative undercounting. The 2017 deployment featured a second sonar on the west bank for more complete coverage and low water levels, and fish were indeed counted by both sonars, but were still considerably less than the Miles Lake counts. The western bank at the Clear Martin site was quite shallow near-shore, and was overrun

as water levels rose; counts on that side were generally much smaller than those on the eastern bank.

In 2018 a floating platform was fabricated for the western side, and deployed further away from the bank. It did count passing fish, but again counts were highest on the eastern bank, which suggests that up-migrating salmon are not completely evenly distributed. As well, after several years of not passing Copper River water during the early season, the river channel at Flag Point (27 mile of the Copper River highway) was also clearly passing Copper River water, which may have given upriver migrating salmon a completely different option for migration. With the small number of commercial openings in 2018, it is hard to say whether or not that was the case.

The 2019 deployment investigated the possibility that fish might be travelling through a second channel that has opened up in the lower delta, but did not observe a large number of fish passing and the sonar was repositioned. Low numbers of foraging seals in that channel also suggest few fish were passing through. Future deployments should focus on the western side of the main channel.

It is possible that fish transiting the lower delta do not travel along the banks as they do at Miles Lake, the gradient of the slope in the delta is much lower, as are current velocities. Observations of foraging seals at the site suggest that fish are passing throughout the channel in the lower delta. A rough calculation of the proportion of the channel ensonified by the sonars is approximately $1/10^{th}$ of the river, so that fish being evenly distributed across the river could explain the discrepancy. As long as the differences between counts made at the two sites remain somewhat consistent, they will be of use to managers in gauging early season fish passage.

References

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