Sockeye escapement estimation and ASL sampling for the Nuyakuk River, 2023

BBSRI

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1. Executive Summary

The Bristol Bay Science and Research Institute (BBSRI) operated an adult salmon counting tower on each bank of the Nuyakuk River, Alaska in 2023. Data collected were used to estimate the age-specific adult sockeye salmon (Oncorhynchus nerka) escapement in the Nuyakuk River. Towers were located at the same locations in the lower Nuyakuk River as has been used historically by BBSRI and the Alaska Department of Fish and Game (ADF&G). These data were collected to reinitiate sockeye counts and conduct ASL sampling (age, sex, length) that will be used to update the historical brood table for this stock, assess the quality of Nushagak River sockeye escapement estimates, and support the broader assessment of aquatic resources with respect to the proposed Nuyakuk Hydroelectric Project (FERC No. P14783, Nushagak Cooperative (2023)).

Sockeye counts and ASL sampling followed protocols used by ADF&G (Brazil and Salomone, 2016) and ensured consistency with the historical data (annual counts of sockeye were counted from 1956 – 1988 and 1995 – 2002). In brief, staff counted salmon for 10 minutes of each hour from a tower on each riverbank; hourly passage was estimated by expanding the 10-minute counts six-fold and then summed for a total daily count. ASL samples were collected from sockeye captured with a purse seine. Beyond those fish, a number of sockeye were radio-tagged to support the Nushagak Cooperative's migration and passage assessment for the Project Area.

Counts began on 27 June at 16:00 hrs and continued through 25 July at 23:59 hrs for a total of 29 days (Table 1). Of the 1,360 counting events, 82 (6%) of which had to be estimated due to poor visibility (rain or wind) or wildlife interference (bears in water or close to tower). The hours with a missed count were interpolated according to the standard method (for every hour missed, two hours prior and after were averaged). The operational termination date is determined as three days of counts that are less than 1% of the cumulative escapement, however the escapement was exceptionally high this year and resulted in needing less than 22,000 counted. We operated beyond the standard count objective for an additional five days to ensure the tail of the migration was included in the sample period. Daily escapement peaked on June 29 with 250,686 sockeye (Figure 1). Total escapement of sockeye to the Nuyakuk River was 2,303,748 for the counting period.

ASL samples totaled 543 and an additional 77 sockeye were radio-tagged. Digital data for this study was provided to the Nushagak Cooperative and Alaska Department of Fish and Game after final QAQC, analysis and reporting were complete.

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5. Introduction

This report details the operations, methods, analyses and results of the 2023 salmon counting tower activity on the Nuyakuk River, Alaska.

1. Tower Operations on the Nuyakuk River

Historical estimates of escapement to the Nuyakuk River using counting towers were first conducted in 1956 (ADF&G 2022). The counting program continued for 33 consecutive years through 1988 and then was not conducted for 6 years during the period 1989-1994. Counting was reinitiated in 1995 and continued for 12 consecutive years through 2006 and then was not conducted for 16 years during the period 2007-2022. In 2023, BBSRI reinitiated counting to collaborate on data collection efforts of the Nushagak Cooperative (NC) to conduct a feasibility assessment for a proposed hydroelectric facility on the Nuyakuk River.

BBSRI developed a Land Use Agreement with Koliganek Natives LTD (KNL) to conduct salmon counting activities in 2023 and 2024 at the historical location used by ADF&G and BBSRI. KNL agreed to allow use of their land and all structures on both sides of the river at the historical counting tower site (N 59° 52.914', W 157° 33.593'), refurbishment of the existing structures, build 3 wall-tent platforms, store equipment on the site that is not feasible to fly in and out annually, and all activity associated with salmon counting towers. BBSRI agreed to pay a land lease of $2,000 for each year of the land use agreement and to follow all requirements and stipulations of the land use agreement (memo to Jerry Liboff, KNL, from Jordan Head, 5/18/23).

2. Rationale for the Study

The Nushagak Cooperative has proposed a hydroelectric facility on the Nuyakuk River and engaged in a feasibility assessment through the license process of the Federal Energy Regulatory Commission (FERC). The Nuyakuk River is one of largest producers of sockeye salmon in the Nushagak River basin and is a pristine home of many fish and wildlife species. Therefore, the health of the Nuyakuk as an ecosystem is of paramount importance to local communities and Bristol Bay as a whole.

BBSRI is a regional non-profit fisheries research organization with the mission of conducting applied research and monitoring to improve the well-being of residents of the Bristol Bay area. In this regard, the development of a hydro facility on the Nuyakuk could have a substantial impact on fisheries resources, and therefore BBSRI entered the public process as a stakeholder on the Aquatic Resources Working Group (ARWG) within the FERC license process. The ARWG is an important mechanism for BBSRI and other organizations to provide comments and recommendations on the fisheries studies made in the Cooperatives' Revised Study Plan (RSP) to assess potential impacts.

BBSRI neither endorses nor opposes the proposed Project. Our role is to be an objective

voice of science-based input on everything fish and aquatics, and the associated evaluation of the potential risk of harm or benefit to those resources by the construction and operation of a hydro facility. It is our goal to assist in the design of rigorous studies and the interpretation of data so that the public and stakeholders can be aware of the risks when deciding whether the proposed Project is appropriate for their community.

One of BBSRI's study recommendations was to restart counting sockeye on the Nuyakuk using visual observation of fish passing towers on the riverbank. The counting tower approach is one method to fulfill the need for a visual survey method as per the Cooperatives' "upstream adult migration" study (section 4.1.1.7.2 of the RSP). In an official comment, BBSRI declared that "Annual spawning abundance during the Study Plan period will be essential to the Nuyakuk brood table and the LCM and that this data need is not explicitly stated in the RSP" (Appendix 1). Further, the memo clarified the rationale as to why this information was important to examine Project effects. Later, a feasibility assessment in 2022 determined that there were potential locations to operate fishing counting towers near the Project Area. However, through the ARWG, BBSRI proposed that NC move the counting tower location from that identified in the feasibility assessments to the historical site in the lower Nuyakuk used by ADF&G (and BBSRI) in prior years to provide consistency and the continuation of the historical data set where the site was proven and chosen based on site characteristics for the purpose of producing reliable and representative counts of sockeye.

BBSRI and the NC agreed to collaborate on the implementation of the Nuyakuk fish counting towers at the historical site and was intended to benefit each other by collecting additional valuable data and alleviating some financial burden through cost-sharing. BBSRI was interested in operating the towers to expand data collection with a higher level of effort to support regional fisheries objectives while maintaining NC's commitments. This included counting 24 hrs, 7 days/wk to achieve a data set that would better support the impact assessment by improving LCM population abundance analyses, characterization of run timing, and eDST fishery value assessments.

BBSRI funded the predominant share of the study costs to manage and staff the study, procure equipment and supplies, build and demobilize the towers and camp, maintain the raw and summarized data, and conduct the data analyses. Nushagak Cooperative contributed to the cost of conducting the study and added the tower operations and BBSRI to their Aquatic Resource and Fish Habitat permits as issued by ADF&G.

3. Data Collection for Sockeye – escapement counts, scales for age, and radio-tagging

Operational methods and sampling protocols for the towers were based on Brazil and Salomone (2016).

The objectives of the activity include:

1. Count the number of adult sockeye that pass the left and right bank towers to

estimate the escapement to within +/- 5% of the actual number 95% of the time;

2. Estimate the sex composition of the escapement to within +/- 10% of the actual composition 95% of the time;
3. Estimate the mean length, by age, of the escapement to within +/-10% of the actual length 95% of the time;
4. Estimate the proportion of each dominant age class to within 5% of the actual proportion 90% of the time.

Independent from those primary objectives, the towers operation also supported a radio-telemetry study being conducted by NC. Tower staff applied tags to sockeye captured for ASL sampling. The intent of tagging in the lower river was to provide radio-tagged fish to pass through the proposed Nuyakuk Hydro Project Area and contribute to the estimation of passage metrics. Applying a portion of the total number of tags available at the tower location, rather than tagging only near Nuyakuk Falls, provided several benefits to the study including effective distribution of tags over the run, additional recovery time from tagging to promote natural upstream migration behavior prior to entering the study area, quantifying the upstream migration rate, and potentially detecting sockeye migrating up tributaries to spawn.

4. Crew Training

There are many forms of training conducted to promote safety and quality data collection. These are the prime topic areas.

General Safety and PPE protocols – Crew are expected to arrive for field work with First Aid and CPR training. Site and operational awareness, slips/trips/falls, sharp objects, use of construction tools, head/eyes/hands/feet protection, use of waders and belt, camp maintenance and food handling, InReach and satellite phone use.

Boat operation and maintenance – lines and knots, fuel and supplies, engine parts and operation, hazards on the water.

Fish Counting protocols – principles of fisheries management, salmon life cycle, counting towers, sonar, aerial surveys, harvest, and count rotation schedule.

ASL Age/Sex/Length protocols - PowerPoint, discussion and practice. Purpose and use of data; sampling effort, fish handling, species and sex identification; measuring length; scale collection, quality, mounting, and preservation; FDMS (Fish Data Management System) data entry; scale age determination and notation.

Shotgun protocols – Four principles of gun safety and other handling guidelines, reasons for why use of a gun did not work, bear and moose anatomy, Remington 870 mechanics and parts, loading and unloading, failures of the gun and user, carry, hand grip and body position, ammunition, gun care and maintenance, sighting and live fire, storage.

6. Methods

5. Study Area and Study Timing

Study Area

The Nuyakuk River flows out of Tikchik Lake and is a tributary to the Nushagak River. Points of interest include the Nuyakuk Falls, approximately 5 miles downstream of Tikchik Lake, and the Nuyakuk confluence with the Nushagak, approximately 9 miles upstream of Koliganek, AK. The counting towers are nearby to the towers camp (59.882504°N, -157.560878°S) which is located approximately 31 miles downstream of Nuyakuk Falls and 11 miles upstream of the confluence with the Nushagak.

Dates of Operation

The towers are typically operated from late June through late July. Staff arrived at the camp on 21 June to begin the building of new structures and the refurbishment of historical structures. New construction included three tent platforms and an outhouse. Staff began demobilizing camp operations on 25 July which included storing some materials (towers, lumber) on-site for the winter, and transporting other materials (camp equipment and supplies) by boat down to Koliganek.

6. Sockeye counts protocol

To accomplish the objectives of the study generally requires:

1. Identification of an effective location to count upstream migrating salmon. The locations of prior years' towers were found and assessed for quality of observation ability. The tower site on the left bank was identical to that used previously, and that on the right bank was moved downstream ~30 yrds from prior years;
2. Building of aluminum scaffold towers on each of the left and right banks of the river, and the implementation of site-specific features that aid in effective counting. A full complement of scaffolding was built at each tower site;
3. Conducting visual counts of sockeye using a three-person crew that rotate over three 8-hour shifts in a day (12am – 8am, 8am – 4pm, 4pm – 12am). For each hour of the day, a single 10-minute count is conducted on each bank. A count on the first bank begins approximately at the top of the hour and followed by a count on the other bank. Each value is recorded along with any supporting observations. Paired trials of two observers counting the same fish at the same tower for a 10 min session are typically conducted at the top of the hour at shift change;
4. Expanding each 10 min session count to an hourly estimate by multiplying it by 6 and summing the hourly estimate for each hour of the day to calculate a daily estimate.

7. ASL Sampling Protocol

Fish Capture

Fish were captured using a "trip-seine" arrangement (Figure 3) that uses a fixed mooring buoy as an anchor point part way out into the channel. The net traps near-bank migrants by having a closed upstream end where the net is tied to the bank, and an open downstream end where the net float's part way out into the channel and parallel to the bank. The net is activated by releasing the net from the buoy upstream and pursing the downstream end of the net to the riverbank. Both ends of the net can be pulled together to make the bag smaller.

Data Sample size and Collection

The target sample size to achieve statistical rigor is 500 fish per time stratum and there is typically two or three stratum for a season, depending on run timing (Brazil and Salomone 2016). Therefore, a minimal sample size of 1,000 to 1,500 fish is desired. Age (A), sex (S) and length (L) information is collected from sockeye captured at the bank of the camp site. Age is determined from collected scales, sex by visual examination, and length (nose-fork) by measuring to the nearest mm on a sampling board outfitted with a meter tape or stick (Figure 4). Data was entered into the FDMS application.

8. Age Composition Estimates

Scales collected from sockeye and ASL data collected in the field and summarized in FDMS export files were provided to ADF&G Commercial Fish Division scale lab for aging. Data records were returned from the lab with the freshwater and marine ages indicated. Age composition for all the aged samples was calculated along with the mean length by age. Further, historical data on age composition for available years for the Nuyakuk River and the Nushagak District harvest was also provided by ADF&G (2023a).

In Bristol Bay, there are four major age classes of adult sockeye salmon where fish have one or two winters in freshwater and 2 or 3 winters at sea. Because a fish spends its first winter as an egg in the gravel it does not have a scale, to determine the total age of a fish, 1 must be added to the number of annuli (winters) shown on the scale. Salmon ages are recorded in European notation (Koo 1955 and Mosher 1969 as cited in Brazil and Salomone 2016) that includes the number of years spent in fresh water after emergence from the gravel, a period, followed by the number of years spent in the ocean. The total age of the fish is the sum of the number of years spent in fresh water and the number of years in the ocean plus one to account for time spent in the gravel as an embryo.

9. Radio-tagging

BBSRI's supported radio-telemetry operations being conducted by NC for an adult salmon passage study. The intent of the operation at the tower location was to provide radio-tagged fish to pass through the proposed Nuyakuk Hydro Project Area and contribute to the

estimation of passage metrics. Fish that were tagged at this location had the benefit of adequate time to recover and demonstrate natural upstream migration behavior. The NC team provided tags, needles, a fixed station, and valuable training and support to achieve the objectives of our role. Tagging method is provided in Nushagak Cooperative (2023).

The basic goal of the BBSRI operation was to release 100 sockeye and Chinook with radio tags. We attempted this by capturing migrants using the trip seine operated to conduct ASL sampling of the overall run. Tagging effort was intended to occur about every other day to spread tags out over the run. However, a substantial proportion of the anticipated run arrived early, so we deployed a larger number of tags on six days between 7 July – 21 July. This allowed some spread over the population and the respective hydrologic conditions.

The near-bank location of the trip seine was not effective at capturing Chinook - not one was caught. Nushagak sonar counts were historically low, so we may have had less opportunity, but it is also possible that Chinook were migrating further away from the bank, or both. It was not physically possible or safe to operate the trip seine further out in the channel at the prolonged high flows.

BBSRI provided NC with tagging data and included for each individual fish the date, tag code, length, sex, time of last tag release, and any pertinent comments. The NC team downloaded the upstream telemetry station, and we checked the station occasionally to see that it was intact, charging, and scanning. BBSRI did not analyze the telemetry data.

Target fish for tagging were identified as “healthy migrants” as described below, and crew were trained based the premise that the entire process of catching fish, tagging them, and then releasing them is a stressful event for the fish and can result in their death. Husbandry (the trapping and holding conditions you create for the fish), handling (where you put your hands on the fish), the duration of time to complete tag attachment, and how/where you release the fish will cumulatively determine which fish live to migrate, and those that don’t. The tagged fish are meant to represent the overall population and become a critical source of data for understanding their behavior, and in this case, how they pass the Nuyakuk falls.

When NOT to tag a fish:

- Clear injury like a seal bite, missing fins, missing eye;
- Old as indicated by looking very mature, moribund, spawned out;
- Trapped for a “long” period, usually due to being hooked up by jaw or maxillary bone, or rolled in the bag of the seine;
- Mishandled, dropped, or held one hand by its caudal peduncle.

When TO tag a fish:

- Fish randomly captured from the seine bag. No targeting / selecting fish for big/small, bright/dark, males/females;

- The number of fish in the bag is between 5 and 15, depending on size of the bag and the duration of time to tag all the fish in that catch;
- The target number of fish is achieved with a large catch by partitioning the net (e.g., half length) and letting the rest of the catch go, or dip-netting several fish from the seine bag in a single dip;
- Net-marked fish that do not show injury other than scale loss and a little fungus;
- Fish with fungus was okay (e.g., a little fungus around the head due to net marks is acceptable) EXCEPT if it had heavy, broad coverage fungus and stinks as if it is nearing death (moribund);

Guidelines for having fish survive the catch and tag process include:

- This is a two-person task - develop a system of working together that efficiently and safely results in minimal time with each fish. This in NOT ASL sampling – comparatively, these fish are to be processed with much greater care;
- Whenever possible, purse the seine. Bring both ends nearly together to create an effective catch volume;
- Recommended handwear are the black nitrile gloves. You can use cotton gloves inside the nitrile if that is more comfortable;
- Always hold a fish with two hands in the way we demonstrated to you for transfers between the net, trough, and river;
- Ensure the tagging tote and trough have enough fresh water to cover the fish gills. If not done already, drill holes in the tote to provide some water exchange but completely refresh the water as necessary.

7. Results

10. Dates and Effort of the Counting Operation

Counting of sockeye began on 27 June at 1600 hrs and ended on 25 July at 2359 hrs for a total of 29 calendar days (Table 1). Over the season, 41 hourly counts could not be conducted due to weather conditions and are represented in the data as interpolated estimates. Fifteen days had counts conducted for every hour of the day.

11. Counts of Sockeye

Expanded hourly counts of sockeye was a total estimate of 2,303,748 (Table 1). Excluding the first partial day, daily estimates ranged from approximately 4,100 to 250,700. Daily counts increased rapidly on the third day of counting to a peak on 29 June (Figure 5). Prior to initiating standard counts, no sockeye were observed by staff while constructing the

camp over a 5 day period, and indicates that we likely observed and counted the beginning of the migration. Daily counts declined precipitously to 6 July and then gradually tapered till the end of the season, except for a two-day spike observed on 15-16 July. Hourly counts were highest for the period of 11 am to midnight and counts on the Left and Right bank tracked each other in a similar pattern (Figure 6). The total count on the Left (1,149,456 - 49.9%) and Right (1,154,292 - 50.1%) banks were very close, so there was no apparent preference of bank orientation for upstream migration.

12. Age, Sex and Length of Sockeye

Catch sampling using seining was conducted on 15 days over the monitoring period and captured 612 sockeye (Table 2). Of these, 535 were sampled for ASL.

In total, 446 had paired age (years), sex determination (M,F) and length (mm) (Table 3). Sockeye were overwhelmingly freshwater age 1 (97%) and included marine ages from 1 to 4. Age 1.3 fish represented 83% of the samples followed by 1.2 fish at 7%.

Of 542 sockeye with a sex determination, the composition was 53% female and 47% male (Table 3).

The average length of all sockeye measured for length was 546 mm, and so was the length of all aged sockeye (Table 3). Males averaged 563 mm and females 531 mm using all lengths. All lengths by sex were also very close in length to those that were aged. Age 1.4 sockeye had the longest length of the represented age classes (580 mm), followed by those that were age 1.3 (561 mm).

13. Radio-tagging of Sockeye

Of 612 sockeye captured, 77 were radio-tagged and released (Table 2). These fish were generally not sampled for scales and sex determination to shorten the handling time. Field data for date and tag code was provided to Nushagak Cooperative for use in their assessment of Nuyakuk falls passage times.

8. Discussion

14. Counts of Sockeye at Nuyakuk River

Historical estimates of escapement to the Nuyakuk River using counting towers (ADF&G, 2023b) was first conducted in 1956 (Figure 7). The counting program continued for 33 consecutive years through 1988 and then was not conducted for 6 years during the period 1989-1994. Counting was reinitiated in 1995 and continued for 12 consecutive years through 2006 and then was not conducted for 16 years during the period 2007-2022. In 2023, BBSRI reinitiated counting to collaborate on data collection efforts of the Nushagak Cooperative's to conduct a feasibility assessment for a proposed hydroelectric facility on the Nuyakuk River.

The interrupted time series of escapement estimates, and the effect of fisheries confounds an assessment of production, but we can make some basic observations regarding the available information (Figure 7). During the first period of continuous operations, there appears to be a shift toward higher escapement by a factor of 2.9 from 1975-1988 (period 1b, avg = 474K excluding the 1980 fishery strike) compared to the earlier part of that series from 1956-1974 (period 1a, avg = 122K). After the first data gap (period 2), average escapement was approximately 68% lower (period 3, avg = 152K) than period 1b and appears to mark a shift toward lower production to a similar level to period 1a (but still 25% higher). Another data gap (period 4) is ended by counts being reinitiated in 2023 which documented the second largest escapement to the Nuyakuk since monitoring began. Further, 2023 (period 5) was also a record escapement when excluding 1980 when there was a fishery strike (no commercial fishing).

The daily number of sockeye migrating past the counting towers illustrated a pattern marked by an abrupt start and a rapid increase to a peak within two days. An almost equally rapid decline in numbers occurred within the next 7 days immediately following the peak (Table 1, Figure 5). We observed 11% of the run on the single peak day, 40% over the first four days, and 60% of the run in the first 7 days. This pattern may be an indication of the Nuyakuk population staging at/near the mouth of the river.

15. Age, Sex and Length of Sockeye

Historical estimates of age composition for the Nuyakuk River include 23 years of data and indicate representation of 12 different age classes. For the seventh time in the record, age 1.3 was greater than 80%. Two age classes have always contributed less than 1% and five have a cumulative contribution less than 1% (Table 4). Unusually high age representation in the less common classes substantially skews the long-term averages. Like 2023, age 1.3 (65%) and 1.2 (23%) dominate the historical average. For 2023, some age class representations stand out compared to prior years: freshwater age 0 sockeye were noticeably absent (only observed two other years), age 1.1 had its highest contribution ever, and age 1.2 was lower but typical of years when age 1.3 comprised greater than 80%.

The target sample size of 1000-1500 to achieve statistical rigor for ASL metrics was not achieved (total 535 resulted in 446 with an age, sex and length). Further, temporal sampling over the run was not systematic enough to allow partitioning the data into strata. Therefore, the collected data was treated as a single time stratum (rather than having two or three) and provided less information to characterize the population over the run. However, we did observe that counts on the Left and Right bank tracked each other with similar numbers and pattern, so we think that capturing fish only on the left bank an adequate sampling protocol.

16. Recommendations

Operations at the Nuyakuk towers had not been conducted for 16 years when BBSRI reinitiated counts in 2023, so the study was essentially starting from scratch. In that regard, we

can make some recommendations on how to improve operations for 2024.

- Maintain a dynamic study Operational Plan to allow inseason additions and revisions.
- Designate an individual as crew lead to allow effective decision making, singular communications with the Study Lead, and implementation of safety protocols;
- Conduct additional on-site training of crew on ASL sampling procedures, seining operations, boat/motor operation;
- Install riffle dampeners upstream of the counting area to lessen water surface agitation and improve visual observation ability;
- Plan for and implement a more structured ASL sampling effort to achieve target goals;
- Improve data and file management protocols to ensure all collected data is written in a notebook, digitally copied, and appropriately identified;
- Conduct regular paired observer counts to allow an assessment of variation between observers (none were conducted);
- Collect and post regular photos of field operations;
- Conduct a more thorough post-season maintenance of equipment and supplies. Determine a means of drying out all gear to allow reuse and fewer problems at the start of subsequent seasons;

9. Acknowledgments

The BBSRI tower crew included Colby Buell, Addison Green, and Evan Link. Cover photo by Colby. Tim Sands (ADF&G), Phill Stacey (ADF&G), Stacy Vega (ADF&G), Chris Napoli (BBEDC), Tony Zoch (BBEDC), and Michael Link (BBEDC) provided operational support. ADF&G provided two skiffs, aged the scale samples, and logistical/equipment support. Audrey Thompson and MaryLouise Keefe of Kleinschmidt coordinated field operations with our team and provided technical support for the radio-telemetry component of the operation. Chuck Sauvageau of McMillen coordinated with BBSRI to be included on Aquatic Resource and Fish Habitat permits for Nushagak Cooperative as issued by ADF&G, provided logistical support, and coordinated air charters and re-supply's with us. Gabe Davis of Sunday Air taxi provided transport to/from the tower site over the operating period. Fritz and Cindy Johnson rented us very comfortable accommodations in Dillingham. Kris at Lifeline Logistics hauled building supplies, gear and fuel upriver to the tower site from Dillingham by barge and landing craft. Koliganek Natives LTD permitted land access at the towers site. Jerry Liboff rented us storage space in Koliganek, and residents of the village assisted with equipment transport. Dennis Williams of Antler Aviation provided air charters from DLG to KGK. Will Chaney and Jordan Head coordinated the study and was jointly funded by the Nushagak Cooperative and BBSRI.

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11. Tables

Table 1. Daily and cumulative sockeye estimates, Nuyakuk River Towers, 2023.

Date	Daily Sockeye	Cumulative Sockeye
27-Jun	1,836	1,836
28-Jun	128,928	130,764
29-Jun	250,686	381,450
30-Jun	229,320	610,770
1-Jul	204,996	815,766
2-Jul	222,492	1,038,258
3-Jul	166,362	1,204,620
4-Jul	173,040	1,377,660
5-Jul	136,536	1,514,196
6-Jul	76,266	1,590,462
7-Jul	63,234	1,653,696
8-Jul	59,976	1,713,672
9-Jul	58,254	1,771,926
10-Jul	60,294	1,832,220
11-Jul	47,388	1,879,608
12-Jul	66,108	1,945,716
13-Jul	24,966	1,970,682
14-Jul	24,534	1,995,216
15-Jul	78,042	2,073,258
16-Jul	89,898	2,163,156
17-Jul	40,938	2,204,094
18-Jul	21,156	2,225,250
19-Jul	22,644	2,247,894
20-Jul	20,514	2,268,408
21-Jul	10,374	2,278,782
22-Jul	8,412	2,287,194
23-Jul	7,614	2,294,808
24-Jul	4,860	2,299,668
25-Jul	4,080	2,303,748

Table 2. Dates for ASL catch sampling of sockeye at the Nuyakuk River towers site, 2023. Additional sockeye were sampled and radio-tagged.

	Sampled	Sampled and radio-tagged	Total
6/28	18		18
6/29	1	7	8
7/1	48		48
7/3	48		48
7/4	96		96
7/6	94		94
7/7		5	5
7/9		8	8
7/10	17	20	37
7/11	95		95
7/12		4	4
7/15	118		118
7/16		27	27
7/20		2	2
7/21		4	4
Totals	535	77	612

Table 3. Mean length and age composition for sockeye captured at the Nuyakuk River Tower site, 2023. Includes sockeye with a paired age (fresh.marine), length (mm) and sex (M or F). Separately are those with only a paired length and sex. Age designations determined by ADF&G (2023a).

Age (freshwater.marine)	1.1	1.2	1.3	1.4	2.2	2.3	ALL aged	ALL lengths
Male mean length (mm)	324	434	585	606	-	582	561	563
Male No. of samples	15	10	180	8	-	6	219	257
Female mean length (mm)	328	479	538	551	530	536	531	531
Female No. of samples	2	20	188	7	1	9	227	285
Total mean length (mm)	324	464	561	580	530	554	546	546
Total No. of samples	17	30	368	15	1	15	446	542
Age Composition	4%	7%	83%	3%	0%	3%		

Table 4. Age composition of Nuyakuk River sockeye, by escapement year. Years 1979 - 1988, 1995 – 2006, and 2023. Age designations determined by ADF&G (2023a).

	# 0.1	%	# 0.2	%	# 0.3	%	# 0.4	%	# 1.1	%	# 1.2	%	# 1.3	%	# 1.4	%	# 2.1	%	# 2.2	%	# 2.3	%	# 2.4	%	Total # Aged
Year																									
1979									3	0%	447	65%	232	34%					6	1%	1	0%			689
1980					1	0%					88	10%	792	87%					32	4%					913
1981					3	0%					112	12%	711	74%	1	0%			30	3%	109	11%			966
1982	1	0%							2	0%	62	8%	643	78%	9	1%	9	1%	5	1%	88	11%	1	0%	820
1983			6	1%	27	3%	7	1%			358	39%	488	53%	18	2%			8	1%	8	1%			920
1984											224	16%	1161	81%	2	0%			20	1%	20	1%			1427
1985			37	2%	40	3%					336	22%	632	42%	15	1%			424	28%	17	1%	2	0%	1503
1986			11	1%	37	4%	1	0%			99	10%	727	70%	3	0%			5	0%	151	15%			1034
1987					7	6%	2	2%			41	36%	54	48%	4	4%			1	1%	4	4%			113
1988			39	4%	24	2%	15	1%			110	10%	888	80%	14	1%			5	0%	13	1%			1108
1995			23	5%	12	3%	11	2%			191	40%	221	46%	6	1%			6	1%	7	1%			477
1996			93	17%	31	6%			3	1%	101	18%	321	58%	2	0%			3	1%	1	0%			555
1997					7	1%					84	16%	394	76%	27	5%			3	1%	2	0%			517
1998					11	5%					18	8%	182	84%	3	1%			1	0%	1	0%			216
1999			2	1%	8	4%					44	20%	152	68%	11	5%			2	1%	6	3%			225
2000					1	0%			1	0%	331	74%	108	24%	1	0%			3	1%	2	0%			447
2001			1	0%	26	6%	1	0%			15	3%	402	87%	7	2%			1	0%	8	2%			461
2002			14	3%	15	3%					139	26%	320	59%	41	8%			9	2%					538
2003			6	1%	5	1%					61	10%	546	86%	6	1%			1	0%	7	1%			632
2004			2	1%	3	2%					48	24%	138	70%	3	2%					2	1%			196
2005			9	1%	32	4%			2	0%	363	43%	387	46%	6	1%			35	4%	10	1%			844
2006			6	1%	6	1%					292	32%	586	63%	8	1%	1	0%	19	2%	5	1%			923
2023									**17**	**4%**	**30**	**7%**	**368**	**83%**	**15**	**3%**			**1**	**0%**	**15**	**3%**			**446**
Grand Total	1	**0%**	249	**2%**	296	**2%**	37	**0%**	28	**0%**	3594	**23%**	10453	**65%**	202	**1%**	10	**0%**	620	**4%**	477	**3%**	3	**0%**	15970

12. Figures

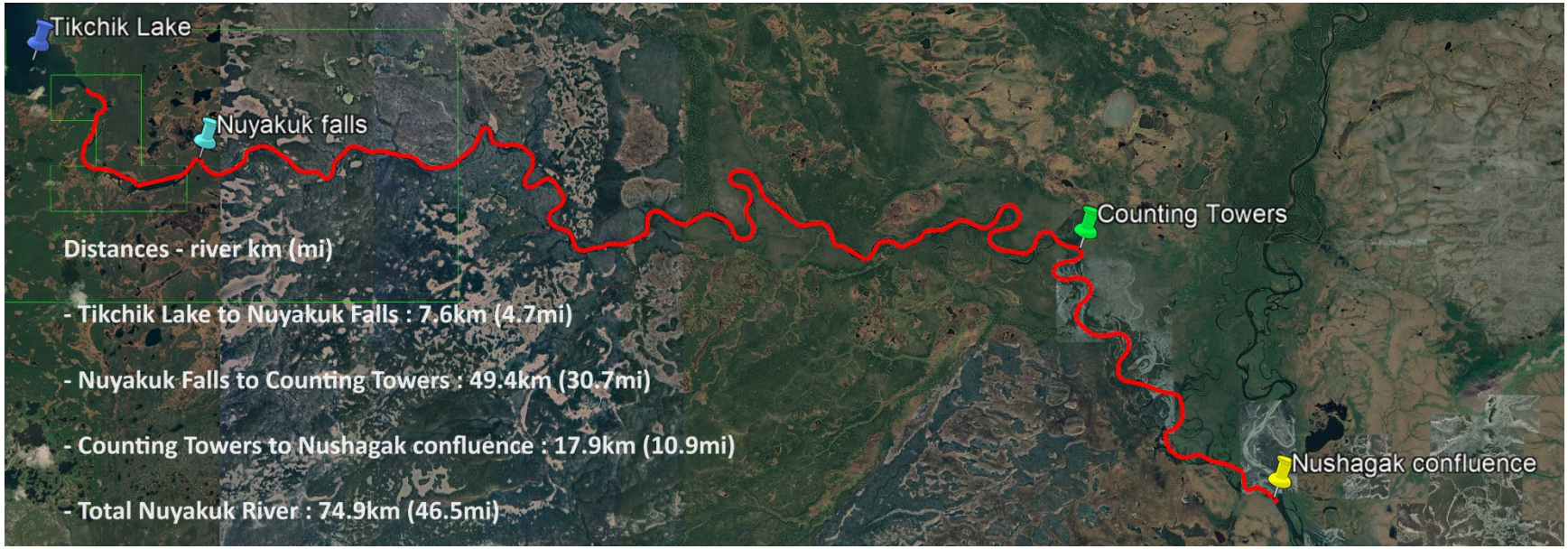

Figure 1. Satellite image of the Nuyakuk River with Points of Interest.

Figure 2. Satellite image of the counting tower locations on the Nuyakuk River.

Figure 3. Trip-seine fishing location on the left bank at Nuyakuk Towers camp.

Figure 4. ASL sampling of sockeye captured with trip-seine.

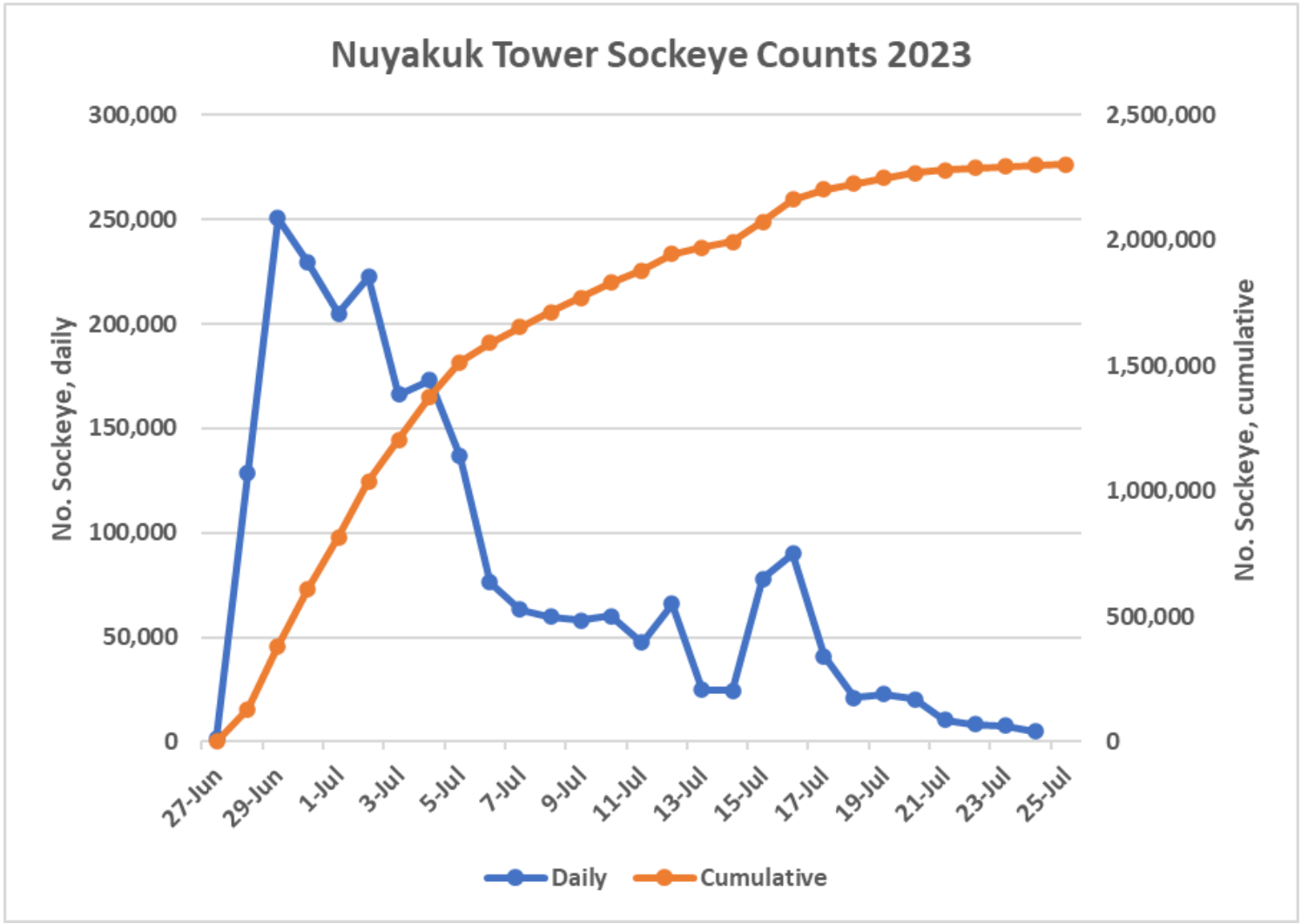

Figure 5. Daily and cumulative sockeye escapement estimates, Nuyakuk River, 2023.

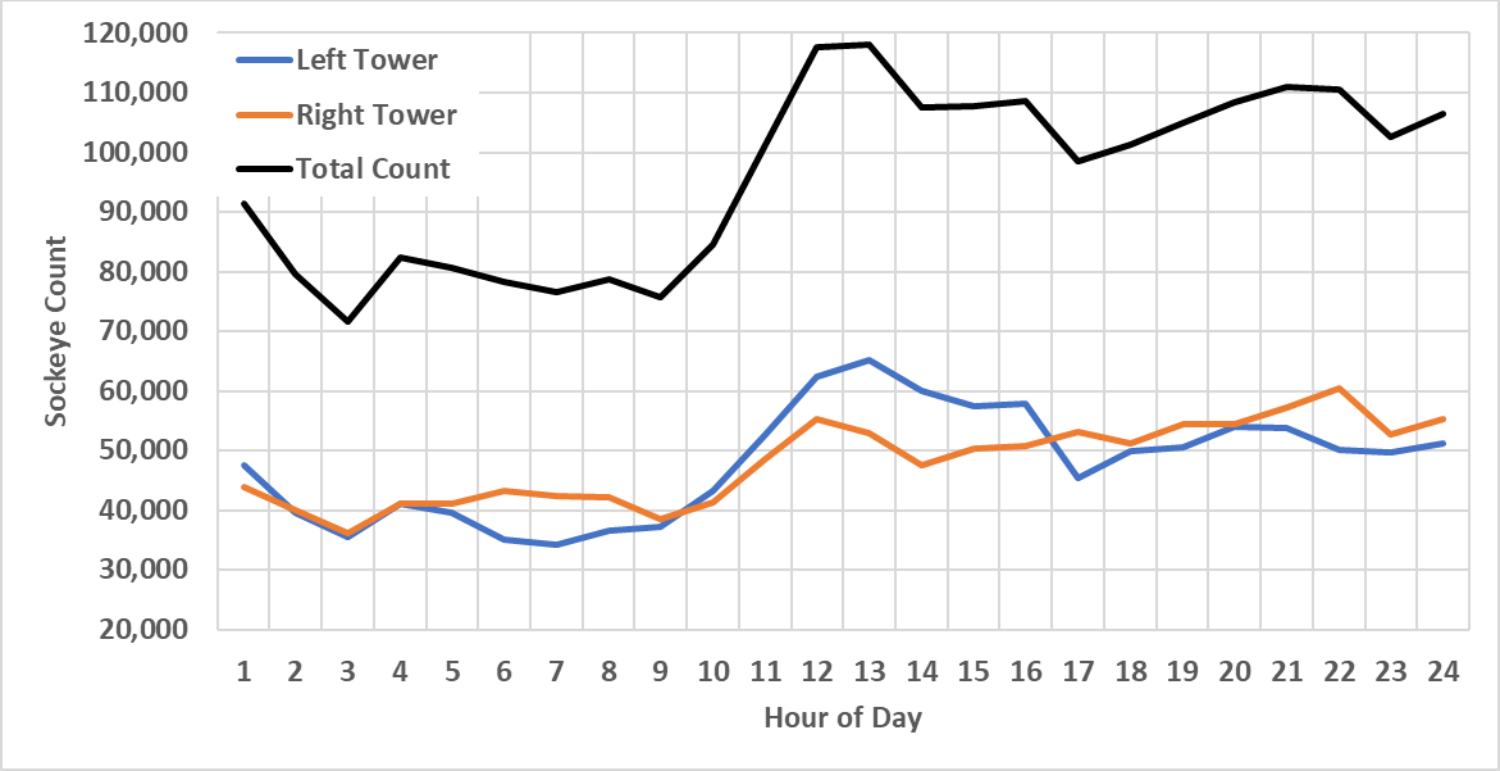

Figure 6. Hourly passage of sockeye escapement at Nuyakuk River, 2023.

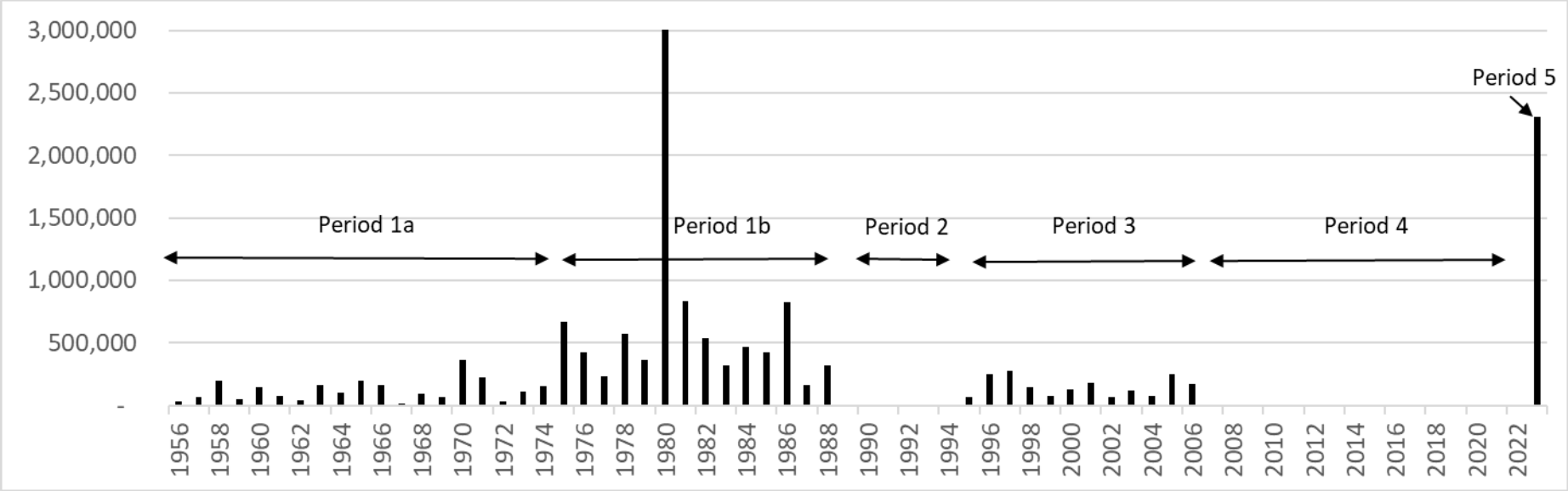

Figure 7. Sockeye Escapement estimates for Nuyakuk River, all years (1956 - 1988, 1995 - 2006, and 2023; ADF&G 2023b). Highest escapements in 1980 (3,027,000) and 2023 (2,304,000).

13. Appendices

Appendix 1. Memorandum from BBSRI to Nushagak Cooperative, August 12, 2022.

Bristol Bay
Science and Research Institute

MEMORANDUM

Date: August 12, 2022

To: Nushagak Cooperative

From: Bryan Nass, Fisheries Ecologist and Michael Link, Executive Director

Re: Comment on Life Cycle Model study in RSP

Brood Tables and the Need for Current Sockeye Escapement Enumeration using a Counting Tower

The study plan to develop a Life Cycle Model (LCM) is proposed to evaluate the potential impacts of the proposed Project on sockeye and Chinook salmon population dynamics. The model is intended to be developed as a stage-structured population dynamics model to represent juvenile and adult life stages. The full life cycle from adult to juvenile to returning adult will be modeled using stage transition equations that will incorporate several environmental and Project Operation scenarios. Ultimately, its utility lies in generating metrics that are indicators of the state of, and long-term sustainability of the salmon populations over the Project lifetime. This includes assessing the effects of changes to upstream and downstream passage success and survival, and changes in fish habitat in the Project Area on the numbers of spawners and juveniles.

To accomplish the goals, objectives, and intent of the LCM study, it will be necessary to develop brood tables for historical and recent production regimes. A brood table provides age specific estimates of total return (catch + escapement) by spawning year. Further, it provides the data necessary to generate a stock production curve that characterizes the relationship between year-specific spawning abundance and the subsequent age-specific returns. In short, this analysis would represent the natural population dynamics of Nuyakuk sockeye and chinook and would be the basis for applying the effects of Project and climate scenarios. A brood table requires recent catch and escapement data to provide meaningful productivity relationship. ADF&G and others have operated a counting tower on the Nuyakuk River from the 1950s until the early 1980s, and then again briefly in the mid-1990s and mid-2000s. These results for sockeye provide a healthy start to a Nuyakuk brood table but need to be augmented with

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Michael Link, Executive Director, Anchorage, 907-440-5766, Michael@BBSRI.org

recent productivity data. Annual spawning abundance during the Study Plan period will be essential to the Nuyakuk brood table and the LCM and *this data need is not explicitly stated in the RSP*. Note that the counting tower will likely be useful only for sockeye and options for collecting data for chinook will need to be explored.

Some of the information required to develop a brood table can be obtained through existing data sources (e.g., annual ADFG reports of catch and escapement for Bristol Bay). However, Nuyakuk escapement data is lacking from the last 2-3 decades and therefore new data collection will be required (e.g., salmon count towers and net capture operations to obtain age composition). This is why the methods feasibility assessment at the proposed site in mid-late August of 2022 will include identification of a potential counting tower and netting site within 2km of the falls.

Escapement estimates from a Nuyakuk counting tower would provide useful information in two ways. First, a tower will provide the first direct estimates of daily and annual Nuyakuk sockeye salmon abundance in almost 20 years and after a substantial increase in the Nushagak sockeye returns in the last decade. Daily estimates provide current and valuable run timing and behavior information; the annual estimates are essential for the development of a brood table for the Nuyakuk stock. Second, new counting tower data will provide an opportunity to use widely accepted run reconstruction methods to estimate (reconstruct) annual Nuyakuk escapement for the years when there has not been any enumeration. Contemporary Nuyakuk escapement and drainage-wide Nushagak River escapement estimates (Portage sonar site) can be combined with genetics-based stock-specific catch estimates in the commercial fishery to validate run reconstruction results from recent years when no counting tower has operated. The reconstruction will provide sufficient data for a meaningful brood table and an LCM to examine Project effects.

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