AYKSSI 2021 Call for Proposals

Project Title: Assessment of Chinook Salmon Freshwater Production in the Kwethluk River

Investigators:

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Project Period: 05/01/2021 – 06/30/24

AYK SSI Funding: $139,042
Matching Funds: $66,600

Study Location: The Kwethluk River watershed, a lower Kuskokwim River drainage tributary with the Kwethluk River weir site at lat. 60.812225, long. 161.435833.

Abstract: Partitioning mortality between freshwater and marine life stages is a key step towards identifying the life stages that are influential in determining population trends and has been identified as a priority within the AYKSSI Chinook Action Research Plan and the 2021 AYK SSI RFP. The proposed project builds on a 2015 pilot study followed by four years of assessment of the abundance, migration timing, and production of juvenile Chinook salmon in the Kwethluk River, Alaska, conducted from 2015 to 2018. Spawning escapements and subsequent returns are estimated at the adjacent Kwethluk weir with an 18-year time series. Using the same rotary screw trap and mark-recapture techniques employed in the earlier study, we propose a 2-year study (2022 and 2023) to estimate Chinook salmon smolts and pre-smolts emigrating past the Kwethluk River Weir, compared with adult escapement data, to robustly quantify relationships between smolt abundance, total adult returns, and spawning escapements and selected environmental drivers. This project uses a highly cost-effective method and involves strong community engagement and capacity building with the Organized Village of Kwethluk. The resulting time series will provide the only long-term freshwater productivity signal for Chinook salmon in the Kuskokwim River drainage.

AYK SSI PROPOSAL FORMAT

I. INTRODUCTION

Dramatic declines in salmon returns occurred in western Alaskan rivers within the Arctic-Yukon-Kuskokwim (AYK) Region in the late 1990s to early 2000s and again from 2012 to the present, resulting in restrictions to commercial and subsistence fisheries (AYK SSI 2006, AYK SSI 2015; Larson 2020). Poor returns of Chinook salmon (*Oncorhynchus tshawytscha*) resulted in both State and Federal disaster declarations in some years.

Salmon life histories are divided between freshwater and marine survival, and there is increasing evidence that the abundance of juvenile Chinook salmon in the first year of ocean residency is a significant predictor of adult returns (Murphy et al. 2017; JTC 2020), with annual marine mortality tending to be relatively stable. The historical emphasis in salmon research and management has been to link abundance of spawning adults to returns of adult salmon in subsequent years (Ricker 1954; Quinn and Deriso 1999). In some cases, freshwater production has been linked to potential rearing habitat, but this has had mixed results when applied to other systems (Parken et al. 2006; Liller et al. 2018). However, this approach does not adequately consider freshwater survival beyond the potential of an unspecific measure of density dependence at some life stage. Given the implications of early marine abundance on adult returns, much of the observed variability in annual Chinook salmon returns may be related to freshwater survival, in this case referring to survival from adult salmon on the spawning grounds to the smolt stage when salmon emigrate to the marine environment. In a rapidly warming environment, salmon in the marine environment may migrate to more optimal thermal regimes. However, Chinook salmon in their natal freshwater habitats have few options for seeking better environments. Jones et al. (2020) found evidence that water temperature and seasonal stream flow were correlated with interannual variability in Chinook salmon productivity.

Given the importance of freshwater survival, particularly in the absence of early marine information for Kuskokwim River Chinook salmon, it is critical to understand freshwater productivity as a link that fisheries managers can use in anticipating future returns. An understanding of changes to the dynamics of productivity requires an adequate baseline, coupled with monitoring for changes in production and environmental conditions. Good inferences are supported by good data. There are few studies exploring spawner-to-smolt, freshwater productivity in the Kuskokwim River drainage, particularly in recent years of rapid environmental change. The Kwethluk River supports one of the largest average number of spawning Chinook salmon in the Kuskokwim River drainage (Liller and Savereide 2018). The Kwethluk River is also one of the few Kuskokwim River tributaries where salmon escapement is monitored by a weir, promoting effective assessment of spawning salmon passage. The weir site provides a logistical benefit for establishing a smolt trap. Boersma et al. (2019) evaluated smolt passage using a rotary screw trap installed near the weir location during 2015–2018, providing a baseline and valuable logistical information for future studies. Continuation of a smolt passage study on the Kwethluk River will build upon past data to help further understand environmental effects on smolt survival within the river given a continuing changing climate. This project will build on the previous study by monitoring abundance and condition of out-migrating smolt, collecting environmental data such as temperature and water depth, and further exploring relationships between smolt outmigration with previous adult spawner returns and environmental measurements.

II. PROJECT DESIGN

A. Objectives and Project Design

1. Rational & Project Research Question: *Have changes in the suitability or productivity of freshwater habitat used for spawning, rearing, and migration contributed to declines in AYK Chinook salmon stocks? [AYK SSI Theme 1 – "Drivers of Freshwater Mortality"]*

The freshwater life stage sustains over half of the total egg-to-adult mortality for most salmon populations (Bradford 1995), and juvenile salmon abundance upon marine entry can be a significant indicator of future adult Chinook salmon returns (Murphy et al. 2017; JTC 2020). In-season management of salmon returns is directed at providing: (1) adequate escapement for stock sustainability; (2) subsistence harvests that meet food and cultural needs; and (3) resources for other consumptive and non-consumptive uses. Over 90% of Chinook salmon harvests occur within the boundaries of the Yukon Delta National Wildlife Refuge on the lower river, an area from which salmon must still migrate for weeks to reach the spawning grounds (Clark and Smith 2017). Thus, predictions of future returns are largely tied to preceding adult spawner estimates and can be wildly inaccurate (e.g., forecasts for Kuskokwim River Chinook salmon returns in 2013 and 2020). Understanding how freshwater productivity is driven by environmental variables has the potential to directly inform management decisions in terms of predicting future returns. This project focuses on assessing how productivity and population dynamics are linked to environmental forcing factors that control growth and survival during the freshwater component of the Chinook salmon life cycle. Having a better understanding of freshwater productivity, and how that productivity changes over time, can inform management decisions in terms of pre-season expectations and in-season implementation.

An evaluation of how freshwater environmental condition drive Chinook salmon productivity results in the following primary hypotheses:

H_1: Productivity of Chinook salmon smolt in the Kwethluk River is tied to freshwater environmental conditions, notably water temperature and flow.

H_2: Returns of adult Chinook salmon to the Kwethluk River rely on both smolt abundance and smolt condition.

2. Project Objectives:

Objective 1: *Identify the relationships between smolt abundance and spawning escapements by partitioning freshwater productivity.*

Objective ***2:*** *Identify variables that may relate to changes in environment and/or habitat resulting in changes in mortality. Specifically, informed by prior analysis (Boersma 2019; Jones et al. 2020), we hypothesize that* ***smolt production is regulated by: 1) fall water temperature; 2) precipitation events.***

Our long-term goal is to create a 10–12 year time series that can inform and improve forecasts to enable managers to anticipate and more effectively adapt to changes in productivity well in advance of adult salmon returns (plans are forming to apply for other funding sources to continue the project). This timeline is based on covering a maximum generation of a Chinook salmon life cycle (7 years) while trying to encompass decadal change in environmental conditions.

3. Project Responsiveness to AYK SSI 2021 Research Priorities:

[Clearly identify which of the AYK SSI 2021 Priority Research Theme(s) will be addressed through the project and briefly describe how, through implementation of the project objectives, your understanding of one or more of the priority research themes will be advanced.]

The AYK SSI Priority states (AYK SSI 2015):

- Embryonic, and juvenile stages are all vulnerable to changes in freshwater environmental conditions.
- For example, incubating embryos can be affected by several variables including winter temperatures, oxygen regimes, and flow-related gravel scouring.
- Juvenile salmon, prior to ocean entry, may be limited by food resources that affect growth rates and associated survival during smolting, and by mortality losses to freshwater predators.

Rational: This project contributes to our understanding of freshwater mortality to population dynamics by:

- Assessing the relationship between adult returns and subsequent smolt abundances.
- Assessing the relationship between smolt abundance and subsequent adult returns.
- Partitioning mortality between freshwater and marine life stages is required as a step toward identifying the life stages that are influential in determining population trends.
- Robustly quantifying freshwater productivity may reduce uncertainty in existing production dynamics models and could provide insights into recent declines in productivity.
- Quantifying freshwater productivity is critical for insights into changes driven by climate shifts.

4. Methods:

Methods for implementing Objectives 1 and 2 above are based on those used in AYK SSI 2016 Project "An Assessment of Kwethluk River Chinook Salmon Freshwater Production" (Boersma et al. 2019).

Fish Capture and Handling– Rotary-screw traps and stratified capture – recapture modes are a commonly used method to successfully estimate population size, migration timing, and other characteristics of migrating juvenile salmonids. We will use a rotary-screw trap in the Kwethluk River to capture out-migrating smolts from mid- April (depending on river breakup) through mid-June. Prior work determined that one smolt trap is sufficient to attain the study objectives. During a 2015 pilot study, investigators were able to attain capture efficiencies of 2–6% (Webber et al. 2016). The trap consists of a revolving stainless-steel, 2-mm-mesh cone on aluminum pontoons. The cone entrance diameter is 2.4 m with about half (2.2 m^2) submerged. Stream flow causes the trap cone to rotate and fish passing through the cone will be collected in a live box at the downstream end of the trap. The trap will be located just upstream of the adult fish weir located approximately 45 RKM upstream of the Kwethluk River confluence with the Kuskokwim River (Figure 1).

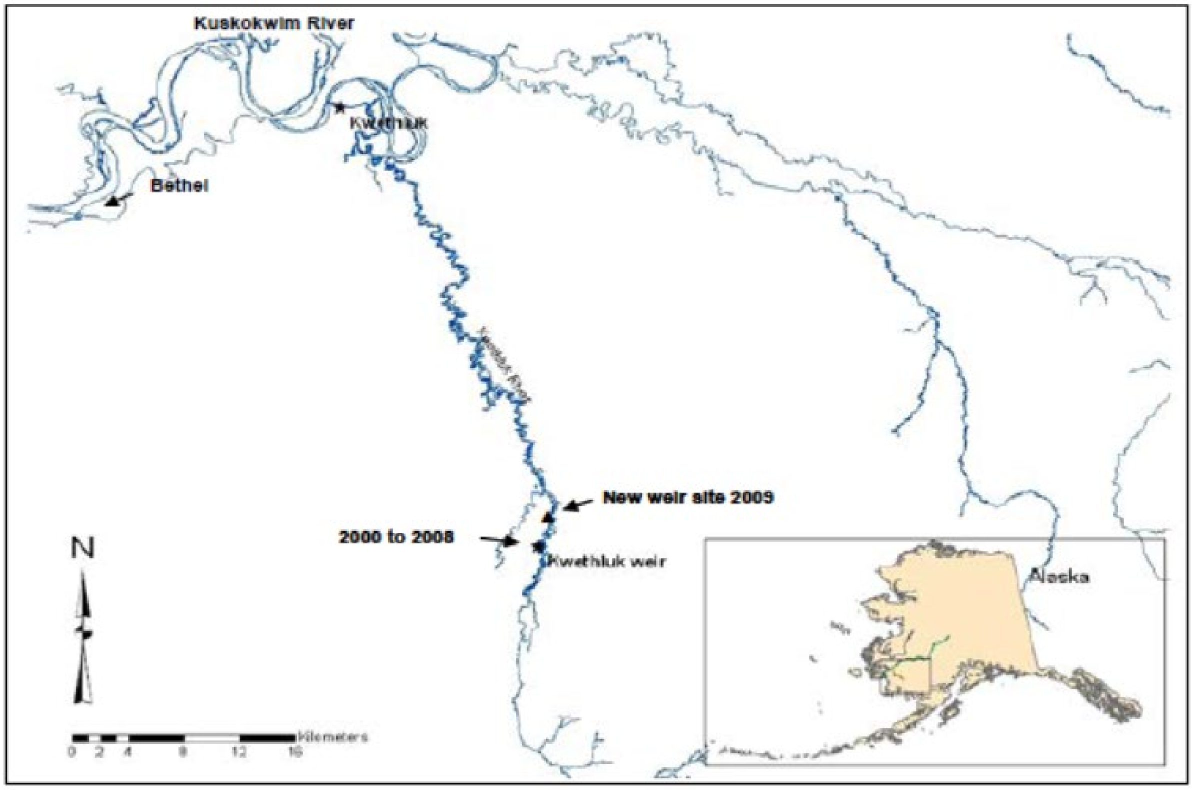

Figure 1: *Location of Kwethluk River Weir; rotary screw trap site installation site is just upriver from the new weir 2009-present.*

This allows for use of current infrastructure to launch the project at ice out and reduce costs significantly. Water velocities at this site are adequate to turn the screw trap to maximize capture. The location is near the transition from a braided actively meandering river channel with high habitat complexity to a lower gradient meandering channel with sinuosity changing from 1.4 above to 2.4. With the sinuosity change, velocity decreases and interstitial spaces are filled with fines. The trap will be secured to pulleys on the installed cabling system that stretches across the river at 6 m height to allow rapid adjustments to position the trap in the thalwag with changing water flows to maximize capture efficiency. The trap will be checked at least twice daily between 0700 and 2200 hours. Our experience of outmigration timing during the 2015 pilot study was similar to Burril et al. (2010) on the Kwethluk River with the majority of Chinook salmon smolt outmigration occurring during May and June, similar to other western Alaskan populations (Roth et al. 1983; Murphy et al. 2009). During the 2015 pilot study, only 5% of the pre-smolt captures occurred from June 1 to September 24. Therefore, we will operate the trap to monitor fish migration mid-April to mid-June and environmental data will be collected throughout the year utilizing data loggers.

All fish captured at the rotary-screw trap will be identified to species and smolt stage and examined for marks. Because not all fish captured at the rotary-screw trap will be true smolts, we will classify all captured fish as either smolt, parr, or transitional based on the presence or absence of parr marks and skin coloration as per Ewing et al. (1984) and Viola and Shuck (1995). Fish that are silver in coloration and have very faint or non-existent parr marks will be classified as smolts, fish that are dark in coloration and have very distinct parr marks will be classified as parr, and fish with characteristics of both smolt and parr (silver in coloration with distinct parr marks) will be classified as transitional.

Another distinguishing characteristic of smolts versus parr or pre-smolts is darkening of fin tips (Thedinga et al. 1994) or fin margin blackening (Wedemeyer et al. 1980).

Objective 1. Identify the relationships between smolt abundance and spawning escapements potentially partitioning density dependence between freshwater and marine life cycles.

Task 1. Estimate number of Chinook salmon smolts emigrating from the Kwethluk River through time such that estimates are within 25% of the true value 90% of the time.

Emigrating smolt will be captured with the rotary screw trap. All fish captured at the rotary-screw trap will be identified to date and time captured, species and smolt stage, and examined for marks. The trap does not cover the entire river. Assuming a capture efficiency of 5% (Table 1), the sample goal will be to mark a minimum of 130 Chinook salmon smolt each day for a total of 910 fish/weekly strata. To reduce stress while handling, these fish will be anesthetized using a buffered tricaine methanesulfonate (MS-222) solution at a concentration of 40 mg/L (Schoettger and Julin 1967) with a target induction time of one to three minutes (CBFWA 1999), measured for length (fork length, nearest mm) and weight (nearest (0.1 g), marked according to Table 2 using surgical scissors cleaned with alcohol, and placed in a live well and allowed to recover. Fish will be marked with period-specific top and bottom lobe caudal fin clips. To facilitate identification of marked fish during recapture events, fin-clipped will also be immersed in a Bismarck brown dye solution before being released back into the river upstream of the trap. All marked fish (Tables 2 and 3) will be released at least 450 m above the trap to allow marked fish to mix with unmarked fish (Seelbach et al. 1985; Thedinga et al. 1994). This distance was used during 2015 and allowed the river thalwag to change river banks twice before reaching the screw trap ensuring mixing of marked fish. Releases will occur near dusk or by 2200 hours as we expect the majority of smolt to migrate at night similar to the 2015 pilot study and other studies (Roper and Scarnecchia 1996; Eskelin 2004; Volkhardt et al. 2007; Burril et al. 2010; Anderson and Stillwater Sciences 2011). We will note any mortality prior to release of the marked fish. Lengths and weights of all recaptured fish will be measured to investigate size selectivity of the trap and calculate condition. Fish condition will be calculated as Fulton's condition factor (K; Nash et al. 2006).

Table 1. Necessary numbers of fish to be marked for relative errors (5-50%), alpha =0.05 and 0.10, and trapping efficiencies of 0.5, 1.0, and 5.0%. All fish will be released after handling. Sample sizes are based on an assumed 5% capture efficiency and a relative error of 20%. (Table modified from Carlson et al. 1998).

Relative	Trap Efficiency 0.5%		Trap Efficiency 1%		Trap Efficiency 5%	
Error (%)	α=0.05	α=0.1	α=0.05	α=0.1	α=0.05	α=0.10
5	320,500	217,829	160,250	108,914	32,050	21,783
10	80,401	54,792	40,201	27,396	8,040	5,479
15	35,963	24,582	17,982	12,291	3,596	2,458
20	20,405	14,006	10,203	7,003	2,041	1,401
25	13,205	9,111	6,603	4,556	1,321	911
35	6,940	4,852	3,470	2,426	694	485
45	4,363	3,100	2,181	1,550	436	310
50	3,613	2,590	1,807	1,295	361	259

Table 2. Summary of proposed handling disposition (marks and measurements), sample sizes, and purpose. All fish will be released after handling.

Handling Disposition	Sample Size	Purpose
Partial fin clip	1,200/weekly strata (about 6,000)	Trap efficiency
Measured & released	300/weekly strata (about 2,400)	Length composition, condition
Scale sample	77/weekly strata (about 600)	Age composition

Table 3. Marks by weekly stratum for Chinook salmon smolts used to estimate trap efficiency.

Strata	Mark
1, 3, 5, 7,	Partial caudal fin clip, top lobe
2, 4, 6, 8,	Partial caudal fin clip, bottom lobe

We will use environmental measurements including stage height, air and water temperature, and general observations of water clarity, and trap revolutions-per-minute to investigate correlations with trap efficiency.

We will explore the limited evidence that the freshwater life history of AYK Chinook salmon juveniles are utilizing a variety of rearing and migration strategies manifesting as a redistribution to other suitable habitats (Bradford et al 2008). Because we are monitoring the emigration in the upper portions of the watershed, we are poised to observe this type of plasticity as age 0 fish migrate to possible downstream suitable rearing habitats. We would expect that this redistribution would scale to the parental spawning densities and may potentially offset the density effects to the population productivity.

Task 2. To compare variations in adult productivity with pre-smolt and smolt production.

The life stage specific productivity (pre-smolt, smolt, and adults per female spawner) estimate will be calculated as:

$$\text{productivity} = \left(\frac{\text{estimated pre}-\text{smolt,smolt or adult return abundance}}{\text{female spawners}}\right)$$

We will use estimates of female spawning escapement collected by OSM project 20-308 "Kwethluk River Salmon Run Timing and Abundance" to derive the estimates of females to smolt production. Productivity estimates will apply female adult escapements from the smolt brood year.

Objective 2. ***Quantify variables related to environment and or habitat changes that may affect mortality.***

Task 1—Estimate the age and size composition of Chinook salmon smolts in the Kwethluk River such that simultaneous 90% confidence intervals have a maximum width of 0.20.

This objective will be accomplished using scale samples collected from a sub-sample of marked fish, up to 11 Chinook salmon smolt each day (Table 2).This sample size goal was established such that simultaneous 90% confidence interval estimates of the age composition for each species in each week will have a maximum width of 0.20 based on two age categories (Bromaghin 1993), and allows for an estimated 15% unreadable scales. Scale "smears" will be collected from the preferred area (Jearld 1983), but from the right side of the fish to minimize problems when scales are removed from the left side of returning adults. Scales will be placed in individual coin envelopes and labeled with capture date, crew, capture method, location, species, length, and smolt stage. Scales will be aged following the standards and guidelines of Mosher (1968, 1969), and juvenile ages will be reported based on the number of winters the fish spent in fresh water followed by a plus sign (e.g., age 1+). All other non-marked and non-target fish captured in the smolt trap will be identified to species and smolt stage, counted, placed in a live well and allowed to recover, and released once fish have recovered from handling. We will note any mortality prior to release.

Smolt mean lengths will be compared between years to determine if size at smolting is stable. Length and condition factor will be compared between years to determine if they are stable or vary with smolt production. Smaller average lengths have been linked with more abundant outmigrations, and a correlation with age at maturity of returning adults (Tattam et al. 2015). Average sizes of YOY will be compared from each quartile of the rotary screw trap operations and plotted using box plots.

Task 2. Collect environmental measurements including annual daily water temperatures and stage heights to correlate with smolt outmigration and growth.

Geist et al. (2006) reported that 535 ATU (average temperature units) are required for Chinook salmon eggs to hatch under natural thermal regimes, and another 409 ATU to reach emergence (total average 944; range 868-1,001). Empirical modeling of rotary screw-trap data in the Tuolumne River suggested that degree-days were the best predictor of outmigration, and the maximum date occurred at 1,562 ATU (Jager and Sale 2006). We will evaluate this relationship using a stepwise AIC model selection procedure to identify the important variables that explain smolt outmigration timing, including: degree days during egg development and emergence, and degree days during YOY overwintering. Condition factors of smolt will be compared with smolt numbers, temperatures, etc.

Each day, water stage will be recorded using a pressure transducer logger anchored on the bottom at a fixed position near the weir. Relative stage height will be calculated as the average daily measurement divided by the sum of the annual values. Water temperature will be recorded every hour year-round (Mauger et al. 2015) using a Tidbit data logger anchored on the bottom at fixed positions approximately 1–2 m in depth. The water stage loggers will be positioned in an appropriate position near the weir site as soon as possible after ice out. The temperature loggers will be placed in the spawning grounds prior to the return of adult salmon. Loggers will be accessed and data downloaded in spring and fall, unless a severe environmental event such as a flood occurs and it is necessary to verify that a logger is still in position (when it is safe for the crew to evaluate).

Data Analysis – Accumulated temperature units (ATUs; °C) will be calculated from the mean annual spawning dates (Harper et al. 2018) until the spring of the first year of life as the sum of average daily temperatures. Temperature effects on condition and productivity will be estimated as a series of linear regressions to annual maximum fall (period from spawning to freeze up) ATUs, productivity ($\ln(R_y/S_y)$, where R_y is total smolt outmigrating in year y and S_y is total returns across years from the smolt outmigration in year *y*), spawning abundances (*S*), and median condition (*K*).

Task 3. Monitor the inter-annual transition of pre-smolt to spawner abundance identifying the relative importance of the pre-smolt movement to future adult returns.

The proposal requests funding for two years of field work in order to provide a baseline for comparing adult returns in years 2024–2027.

Data Analysis – Our analytical approach largely follows that of Boersma et al. (2019). The abundance of migrating juvenile Chinook salmon will be estimated in a Bayesian framework using a closed population estimator (Bird et al. 2014), modified to incorporate a log-normal distribution of migration timing (Adkinson and Su 2001). This approach more readily allows for abundance estimation during times when direct observations are not possible (e.g., during early spring when ice prevent installation of the smolt trap). Daily mark and recapture data will be combined into 7-day strata during which recapture probabilities are assumed to be similar. If recapture information is not available for a given time strata (e.g., due to trap problems), the closest available time step will be used as a proxy. The temporally stratified recapture data will be arranged as an m-array format (Kéry and Schaub 2012).

Calculating abundance estimates from the stratified capture histories (y) first requires an estimation of the detection rate p. Because the population is treated as closed, a fish's vulnerability to capture (a) at time t was fixed at 1.0. Capture histories will be modeled as multinomial random variables with the recapture parameter π_t = Pr$(y_t = 1|a_t, p_t)$ where $p_t = a_t p_t$ and the total number of releases is mt. Because fish cannot be recaptured prior to their release, and fish can only be recaptured only once within the strata in which were marked, values above and below the main m-array diagonal will be set to zero. The posterior distribution for the recapture history will be

$$y_t \sim Multinomial(p_t, m_t). \quad (1)$$

The true, but unknown, population size N_t at time t was modeled as a negative binomial random variable, conditioned on p_t and the number of unmarked individuals n_t captured at each time t. The posterior distribution, truncated at the observed catch for the true population size, is

$$N_t \sim Negative\ Binomial(p_t, n_t)T(n_t, \leq \infty). \quad (2)$$

Total estimated annual juvenile abundance (N) is the sum of the annual stratified (N_t) estimates:

$$N = \sum_t N_t. \quad (3)$$

Ice conditions during early spring prevents direct observation of migrating smolt. However, by assuming a long-normal distribution of migration timing we will us p_t from the closest available time strata as a proxy as a proxy to estimate n_t for the missing observation(s). The number of unmarked individuals captured at each time step will be modeled as a random variable from a Poisson distribution of lambda > 0 (λ_t)

$$n_t \sim Poisson(\lambda_t) \quad (4)$$

$$\lambda_t = h\left(\frac{(ln(t) - ln(\mu))}{w^2}\right) \quad (5)$$

where h is the maximum stratified catch, μ is the strata of peak catch, and w^2 is the variance for migration timing.

Juvenile productivity will be defined as the total abundance of migrating juveniles from a brood year divided by the number of spawning adults that were counted in the Kwethluk River to produce that brood. To estimate freshwater production that properly propagates the uncertainty in the number of migrating juvenile Chinook salmon that were produced from spawning adults, we divided the previously estimated posterior distribution of migrating juvenile Chinook salmon by the estimated posterior log-normal distribution of spawning adults as estimated as passing the weir.

Assumptions: The core assumptions associated with our closed mark-recapture study include (Boersma et al. 2019): 1) the population is closed to deaths; 2) all fish have the same probability of capture; 3) each time step has a constant capture probability; 4) marks are not lost between release and recovery; 5) all marks are reported; 6) all marked fish released are either recaptured or pass by the downstream capture site; and 7) all fish are properly identified to species. For assumption 1, we will minimize mortality from handling and marking and document but exclude observed mortalities from the data. A previous study found that the selected release site ensures that most recaptures will occur within the day of marking, making death from other causes unlikely (Boersma et al. 2019). For assumption 2 regarding probability of capture, we will compare the lengths of marked and recaptured fish using a Kolmogorov-Smirnov two-sample test comparing the largest unsigned difference (D) to the critical value (Sokal and Rohlf 1981). Having the release site located several river bends and approximately 450 m upstream of the trap will maximize mixing of marked fish with the population prior to recapture. For assumption 3, we will maintain constant release times and adequate recovery times, flow rates were similar within strata, and that trap operation was as consistent as possible and only moved as necessary and prior to the beginning of a new strata. For assumption 4, the partial caudal fin-clips will be clearly visible and not regenerate in the short time between release and recovery. For assumption 5 a standardized procedure will be adopted to ensure all captured fish are examined for marks and all marks are reported. For assumption 6, we will only mark fish that are over 55 mm long and expected to be age one or older. Previous studies have found that most Chinook salmon in the Kwethluk River spend one year in freshwater (Webber et al. 2016) before migrating seaward, so marked fish are expected to be on their seaward migration and pass the trap shortly after their release (Roper and Scarnecchia 1999). To meet assumption 7 we confirmed species identification using local expertise and standardized identification guides.

5. Results / Deliverable products:

Results will be published in annual progress reports and a final project report. In addition, presentations based on data acquired as part of this study will be prepared for regional Kuskokwim River Salmon Working Group, and national scientific meetings, including the AYK Salmon Symposium. The project team also anticipates publication of one or more manuscripts in a peer-reviewed journal. PowerPoint presentations involving the project findings will be made available. Spreadsheets of daily captures, environmental measurements, and egg-to-smolt estimates will be produced.

April 1 - June 2022: Standardized sampling season and procedures implemented
Fine-tuning of protocols to maximize capture efficiency completed and equipment maintenance done throughout season.

July 30: First semiannual report for January - July 30 period completed.

January 30: Second semiannual report for August – January period completed.

April 1 - June 2023: Standardized sampling season and procedures implemented.
Fine tuning of protocols and equipment done throughout season. Hypothesis testing done.

July 30: Third semiannual report for January - July 30 period completed.

January 30: Fourth semiannual report for August – January period completed.

October –Dec 2023: Final report written

April - June 2024: Standardized sampling season and procedures implemented. Fine-tuning of protocols to maximize capture efficiency completed and equipment done throughout season. Hypothesis testing done. Final Report completed July 1, 2024.

6. Milestones / Project Timeline:

Objective 1. Task 1. Estimate numbers of Chinook salmon smolts emigrating from the Kwethluk River through time such that estimates are within 25% of the true value 90% of the time. To be met by September 30, 2022 and 2023.

Objective 1. Task 2. Compare variations in adult spawners with smolt production to explore if density dependent effects are present in freshwater environments. To be met by June 30, 2022.

Objective 2. Task 1. Estimate the age and size composition of Chinook salmon smolts in the Kwethluk River such that simultaneous 90% confidence intervals have a maximum width of 0.20. To be met by September 30, 2022 and 2023.

Task 2. Collect environmental measurements including annual daily water temperatures and stage heights to correlate with smolt outmigration and growth. Collection of environmental factors to be met by September 30, 2022 and 2023.

Task 3. Monitor the inter-annual movement of pre-smolt to spawner abundance identifying the relative importance of the pre-smolt movement to future adult returns.

Annual pre-smolt movement to be met by Sept 30, 2022 and 2023.

TASKS [Example only; insert tasks & details appropriate to your project.]	**2021** **[No fieldwork due to COVID]**	**2022**		**2023**		**2024**
Start-up phase		April - May				
Data Collection		April - June		April - June		
Data Entry & Analysis		April - September		April - December		
Grant Reporting / Report Writing		Jan (FSR, Progress Report)	Jul (FSR, Progress Report)	Jan (FSR, Progress Report)	Jul (FSR, Progress Report)	Jan (FSR, Progress Report) Prepare final report- Jan - July

7. Performance Ability and Administrative Expertise:

Investigators on this project have extensive experience with the design and implementation of field projects, the analyses and write-up of project results, and budget administration. Similarly, all investigators are experienced with the logistics and adaptability required for implementing field operations in remote areas.

Principal Investigator: Spencer Rearden, U.S. Fish and Wildlife Service

Spencer Rearden is the Supervisory Biologist for the Yukon Delta National Wildlife Refuge. Mr. Rearden earned his B.S. degree in fisheries and wildlife and then his M.S. degree in wildlife science all from Oregon State University. Mr. Rearden either authored or co-authored two professional publications. He has worked as a fisheries technician for four seasons and then a fisheries biologist for one season with the Alaska Department of Fish and Game within the Kuskokwim River area operating fish weirs and the Bethel Test Fish. With his fisheries work, Mr. Rearden has worked on cooperative projects that have included partners with the Village of Kwethluk, Association of Village Council Presidents, Kuskokwim Native Association, and Quinhagak Native Association. After three years of biological work in private industry conducting fish and wildlife surveys, Mr. Rearden worked for the US Fish and Wildlife service as a biologist and assistant manager for the last ten years. Through his upbringing in Bethel and work with the US Fish and Wildlife Service, Mr. Rearden has become familiar with the local people, biological data needs, and how to implement cooperative projects in Western Alaska.

Co-Principal Investigator: Kevin Whitworth, Kuskokwim River Intertribal Fish Commission

Kevin Whitworth is based in McGrath, Alaska, as a fisheries biologist with the Kuskokwim River Inter-Tribal Fish Commission. Mr. Whitworth has a B.S. in wildlife biology from University of Alaska Fairbanks with over 20 years of experience in natural resources and fisheries and served as a principle and co-principle investigator on a multitude of fisheries projects, including previous work with the Takotna River weir.

Co-Principal Investigator, William Bechtol, Ph.D., Bechtol Research

Dr. William Bechtol worked for 25 years with the Alaska Department of Fish and Game, including 9 years as a project biologist for salmon productivity studies to explore both freshwater and marine productivity, and 16 years in both management and research of shellfish and groundfish resources of Southcentral Alaska. After retiring from ADF&G, Dr. Bechtol obtained his Ph.D. with a focus on population dynamics, then continued as a fisheries consultant working collaboratively with a broad range of organizations including the Bering Sea Fishermen's Association, Kuskokwim River Inter-Tribal Fish Commission, Joint Technical Committee of the Yukon River Panel, Association of Village Council Presidents, Tanana Chiefs Conference, Yukon River Drainage Fisheries Association, Alaska Crab Coalition, Alaska Bering Sea Crabbers, U.S. Fish and Wildlife Service, and the North Pacific Fisheries Management Council (NPFMC). Throughout his career, Dr. Bechtol had extensive experience with project design, implementation, analyses, and report writing for a variety of projects across Alaska, serving as author or co-author for over 125 publications, including 21 peer-reviewed publications. Dr. Bechtol remains involved with inseason, community-based monitoring of salmon harvests during the Chinook salmon return to the Kuskokwim River, and also serves on the Bering Sea Crab Plan Team for the NPFMC providing technical analyses of stock assessments and recommending overfishing levels.

Gary Decossas, Fisheries Biologist, Yukon Delta National Wildlife Refuge

Mr. Decossas earned a M.S. Degree in Applied Statistics from Louisiana State University and has been involved with Kuskokwim River fisheries for the last 5 years. Mr. Decossas has either authored or co-authored eight publications, three of which included Kuskokwim River fisheries. With Mr. Decossas's familiarity with Kuskowkim Fisheries, he can help with field data collection and provide insight to help with analyses and build upon project needs.

8. Coordination and Collaboration with Other Efforts:

This project will be in collaboration with the Kwethluk River Weir project operated by the Kenai U.S. Fish and Wildlife Field Office. This project will rely on the camp infrastructure including boats, motors, camp facilities, and crewmembers associated with the weir during the period of July 1–September 10. Some of the same personnel that work on this project early may be employed at the weir during the remainder of the year. Yukon Delta National Wildlife Refuge aircraft will be used to determine the time to deploy crews to the site to take advantage of ice out conditions. The Kwethluk River Weir project, funded by the federal Office of Subsistence Management, will collect data concerning sex and size distribution of the Chinook salmon escapement past the Kwethluk Weir. These escapement data will be used to derive estimates of total eggs for determining spawner or egg to smolt production.

B. Capacity Building

The Kuskokwim River Inter-Tribal Fish Commission and Yukon-Delta NWR are deeply committed to building and strengthening the capacity of Kwethluk tribal members to conduct fisheries research and monitoring. This freshwater productivity project promotes capacity building through the KRITFC and FWS partnering directly with Organized Village of Kwethluk (OVK) to be involved in and contribute to this project. Building our exiting partnership with OVK for expanded involvement in operation of the Kwethluk weir project, we have met with the OVK to discuss the project (Dec. 11, 2020), share our proposal and confirm the role of OVK in recruiting and hiring technicians to implement this project. This partnership also benefits from the contribution of community members deep local ecological knowledge of their watershed to logistics and advice regarding field operations. We are also actively working on ways to integrate Kwethluk residents with fisheries/natural resource interest, experience and training into project leadership and management roles as well as exploring additional creative approaches to community engagement, employment and training opportunities in salmon research and monitoring.

C. Matching Funds / Partner Contributions

This project will benefit from leveraging extensive personnel time, equipment and logistics from the KRITFC and Yukon-Delta NWR. Principle Investigator Rearden (USFWS) will contribute at no cost to this proposed AYK SSI project 120 hours of project oversight, management, field work, and logistics time. CO-PI Whitworth (KRITFC) will contribute at no cost to this proposed AYK SSI project 120 hours of project oversight, management, field work, and logistics time. Yukon-Delta NWR fish biologist Decossas will contribute at no cost to this proposed AYK SSI project 120 hours of project technician training, field work, and logistics time.

The USFWS will contribute at no cost to this proposed AYK SSI project camp facilities at the Kwethluk Weir to be used as the platform for this project, including crew tents and platforms, tent gear, boat dock and fish weir, boardwalk, cooking equipment, heaters, solar panels, communications equipment.

The USFWS will contribute use of the rotary screw trap.

USFWS Office of Subsistence management has provided funding for the operation of fish weir to determine Chinook salmon escapement and size and age of female salmon at no cost to this proposed project.

Additional equipment and training and logistics contributions: 2 boats for use with the project $24,000; bunkhouse and vehicle use in Bethel @ 110/day for lodging X 60 days (crew, and supervisor) =$6,600 and $60/day for vehicle use X 20 days =1,200; training for crew in bear and firearms safety 50 hrs at 60/hr= $3,000. Total matching funds = $66,600.

III. BUDGET

Project Costs

100 - Personnel (including Fringe Benefits):

- **Three Technicians** pay scale equivalent to GS-5 Bio-technician responsible for assisting the PIs with installation/take out, day to day sampling and operations, and data collection May–June. Project costs include overtime for weekend work May–June.

200 - Travel:

- Co-PI dates of travel between April and June in 2022 and 2023 with per diem. Two RT airfare McGrath to Bethel in 2022, repeat 2023. One RT airfare Homer to Bethel in 2022, repeat 2023. Co-PI travel is for outreach to village, site visit to rotary screw trap and sampling site with crew. Onsite training of personnel in sample collection, marking techniques, trap operations, data analysis. Co-PI and technician per diem total of 12 days in Bethel = $600 per year. Food to be provided the remainder under supplies.

300 - Contractual:

- Helicopter flight for crew to site using Bell B-206BIII helicopter. Approximately 12 hrs of flight @ 1,200/hr = $14,400 per year.
- Co-PI time to analyze data 25 hrs @ 125 per hrs = $3,125 per year.
- Co-PI time to assist in writing report 30 hrs @ $125/hr = $3,750.

400 - Supplies:

- Cables and rope for anchoring rotary screw trap, duckbill anchors for securing cables to land, cable clamps, pulley's, cable winches, signage for safety, $1,000 per year.
- Food calculated at $26 per crew day for 70 days for 3 people = 5,460 per year.
- Sampling equipment = small smolt nets, Bismarck brown, fin clip scissors, write in the rain paper, clip boards, battery for lighting for evening sampling = $1,500 per year.
- Fuel 200 gallons @ 6.95 per gallon = FY 22 $1,400, FY 23 $1,400.
- Propane for cooking 20 lb. tank @ 75.00 x 2 per year, Field laptop. $800.00.
- Pressure transducers for measuring daily water height on an annual basis. $300.00 ea x 2.
- Temperature TIDBITS for measuring in gravel water temperature in spawning locations. $135 X 4 = $540.

500 - Equipment:

- All capital equipment provided by the USFWS including the rotary screw trap, camp infrastructure, tents, and tools, boats, etc.

600 - Indirect Costs:

- Zero indirect costs will be charged.
-

Matching Funds:

Principle Investigator 120 hours of time for additional project oversight, Spencer Rearden PI. Kevin Whitworth Co-PI for 120 additional hours of consultation time. Camp Facilities at the Kwethluk Weir to be used as the platform for this project: includes crew tents and platforms, tent gear, boat dock and fish weir, boardwalk, cooking equipment, heaters, solar panels, communications equipment. Rotary screw trap and freight to site. Operation of fish weir to determine Chinook salmon escapement and size and age of female salmon: Personnel costs =$33,000.

Miscellaneous: 2 boats for use with the project $24,000; bunkhouse and vehicle use in Bethel @ 110/day for lodging X 60 days (crew, and supervisor) =$6,600 and $60/day for vehicle use X 20 days =1,200; training for crew in bear and firearms safety 50 hrs at 60/hr= $3,000. Total matching funds = $66,600.

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