

## **Alaska Sustainable Salmon Fund Statement of Work**

**I. Project Title:** Climate Warming Effects on Chinook Salmon Foraging Conditions and Growth

**II. Project Number:** 52002

**III. Principal Investigator**

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**IV. Project Period:** 3/1/19 - 11/30/21

**V. AKSSF Objective:** 3A-2

**PCSRF Objective:** P&A

**VI. Project Description**

1. Synopsis

Chinook salmon (*Oncorhynchus tshawytscha*) are critical to subsistence in communities along major rivers of the Yukon River drainage in interior Alaska. Climate change is likely to challenge Chinook salmon in this area with increased water temperature and streamflow. Historically, Chinook population productivity has declined in years with sustained high flow during the period when juvenile Chinook are feeding in freshwater, probably due in part to reduced prey consumption and growth. Because the optimal temperature for growth of juvenile Chinook salmon is much lower when they are food-limited than when they are well-fed, determining the likely response to a warming climate requires understanding how conditions for prey consumption vary with streamflow. Therefore, this project will quantify spatiotemporal and flow-related variability in the concentrations of drifting prey and distracting debris in the Chena River basin, one of the major Chinook producers in interior Alaska and the watershed most heavily impacted by human development in the region. Locally-tested foraging and bioenergetics models will connect these measurements to field-validated juvenile growth predictions under current and projected future climatic conditions. These results will inform organizations restoring impacted habitat with finite resources about which areas have the requisite thermal and foraging conditions to support more juvenile Chinook salmon if other habitat qualities such as cover and connectivity are improved.

2. Introduction

The Chena and Salcha River Chinook populations, which produce almost half of total Middle Yukon area Chinook salmon, have been declining since the mid-1990s, and there is concern that conditions during the key freshwater growing period are contributing to this decline. The Chena River is the focus of streambank restoration, culvert replacement, and other restoration efforts; however, significant questions remain around which forms of restoration are likely to have long-term benefits to juvenile Chinook production as water temperature, streamflow, and prey resources respond to changes in climate.

Climate models predict that interior Alaska will experience warmer temperatures and up to a 25% increase in annual precipitation in the next sixty years. Such changes are expected to increase river temperatures, base flows, and the frequency of extreme high-flow events. Recruitment of Chinook salmon in the Chena River is negatively associated with high flows during the freshwater rearing period, likely because poor conditions for growth at above-average flows reduce juvenile body size, leading to lower growth and survival in each year thereafter. In addition to temperature, juvenile Chinook salmon growth depends on prey consumption, which depends on the

concentrations of drifting prey and distracting fine debris that make prey more difficult to detect. Debris items occupy at least 91% of Chena Chinook foraging activity because they outnumber prey by 300-to-1 under baseflow conditions and by an unknown greater amount at high flows. Any flow- or debris-related reduction of prey consumption in a warming climate could be important because bioenergetics modeling shows that fish need more prey to fuel their faster metabolism in warmer water; therefore, prey consumption determines whether growth increases or decreases with rising temperatures. Over two summers, this project will collect the data necessary to model drifting prey and debris concentrations as functions of flow. Previously-validated foraging and bioenergetics models will then predict seasonal Chinook growth under current and projected future temperature and flow conditions, and a combination of existing and new growth data will validate these predictions.

An alliance of stakeholders coordinated by the Tanana Valley Watershed Association has identified natural riparian vegetation, natural streambanks and large wood, fish passage above barriers, conservation of sloughs and wetlands, and invasive species control as critical restoration objectives in the Chena River watershed. These objectives have been targeted by significant but finite restoration funds, and prioritizing projects requires knowing which parts of the basin have the capacity to support more juvenile Chinook salmon if habitat is restored. By sampling drift and modeling growth at sites representative of multiple habitat types in the lower, middle, and upper basin, this project will identify which specific regions within the Chena River basin, and which general types of habitat in similar Yukon basin rivers, are most conducive to growth of juvenile Chinook Salmon now and in the future.

### 3. Locations

Baseline and high-streamflow sampling sites:

- North Fork, Chena Hot Springs Road @ third bridge: 64.944325, -146.251807
- Middle Mainstem, Chena Hot Springs Road @ first bridge: 64.896203, -146.414780
- Lower Mainstem @ Nordale Road Bridge: 64.846674, -147.409869

Spatial variability sampling sites:

- Lower Mainstem below Mitchell Expressway Bridge: 64.840488, -147.845157
- Lower Mainstem @ Moose Creek Dam: 64.792908, -147.183181
- Cripple Creek @ Old Chena Ridge Road: 64.835727, -147.885458
- Little Chena River @ Chena Hot Springs Road Bridge: 64.885323, -147.249775
- Jenny M. Creek @ Chena Hot Springs Road Bridge: 64.878845, -146.987599
- Flat Creek Slough @ Rosehip Campground: 64.875233, -146.773994

### 4. Related Projects

None

## VII. Objectives

- Quantify foraging conditions (the concentrations of drifting prey and distracting debris) for juvenile Chinook salmon as functions of streamflow in the lower, middle, and upper portions of the Chena River basin
- Measure spatial variation in baseline and moderately high-flow foraging conditions at six additional locations throughout the Chena River basin representative of different types of restoration targets
- Predict Chinook Salmon growth potential in the Chena River basin, at present and under likely climate change scenarios, by integrating collected drift data and existing temperature model products into foraging and bioenergetics models
- Determine which areas within the Chena River basin offer adequate foraging conditions to support more juvenile Chinook salmon if other habitat qualities (e.g., connectivity or woody cover) are restored

### **VIII. Methods**

During two May-August field seasons, a two-person field crew will sample drifting invertebrates and debris, measure fish sizes, and log or collect ancillary measurements such as light intensity, temperature, and turbidity. Statistical models summarizing these data will provide inputs to a series of established, locally-tested foraging and growth models that will then be run to predict growth potential for juvenile Chinook salmon in different parts of the Chena River basin under present conditions and likely climate change scenarios varying flow, storm frequency, and water temperature. Climate change scenarios will be based on preexisting climate model products that estimate future conditions of streamflow and stream temperature.

Sampling trips will target different aspects of spatial, temporal, or flow-driven variability in drifting invertebrate and debris concentrations. Approximately 24 day trips per year will study three sites near Chena Hot Springs Road during high-flow events to quantify drifting invertebrates and debris during the rising, peaking, and falling stages of each event. An estimated seven more trips per year to these sites will quantify summer variation in baseline, low-flow conditions. Three trips per year during low-flow conditions will intensively sample a full 24-hour period at the middle mainstem site to quantify diel variation and determine if other data should be adjusted for diel patterns. Lastly, drift and debris will be sampled at two flow levels at six lower-mainstem and off-channel sites representative of current restoration targets or post-restoration potential.

Several less intensive forms of sampling will provide supplemental data to parameterize or test the models. Temperature and light intensity will be recorded continuously using Hobo Pendant loggers at each site, and turbidity will be measured with each field site visit. A jetboat will be used to access rearing habitat and sample fish lengths and weights at two-week intervals near the Middle Mainstem sampling site, and these data will be used to validate growth models. Fish will be captured using dip nets or minnow traps, anesthetized, and measured for fork length and mass.

Invertebrate drift will be sampled with a device that pumps water from the river and pours it at a precisely measurable rate through nested coarse and fine nets suspended in the air with sealed openings. This method avoids several sources of bias inherent in

standard drift nets. Mesh size will be fine enough (100 microns) to capture the smallest common prey of juvenile Chinook salmon. Samples will be collected from standardized within-pool positions (near the longitudinal center of the pool, in water near the bank characteristic of Chinook foraging velocities). Sampled invertebrates will be preserved in ethanol and sent to a laboratory contracted for identification to family or order and measurement to the nearest 1 mm. Previous experience sampling the Chena River suggests each sample should represent the contents of approximately 10 m<sup>3</sup> of water, containing on average 430 total drifting invertebrates, in order to estimate the abundance of drifting invertebrates in common Chinook prey size classes (2-4 mm) with acceptable precision (CV < 0.3).

Debris from drift samples will be dried and weighted after invertebrates are removed. To develop a statistical model for converting these masses into counts of individual debris particles by size class, a computer vision system will be deployed concurrently with approximately 37 drift samples per year, stratified across sites and flow conditions. This system will be an improved version of a device and algorithm previously developed and tested on the Chena River. The hardware consists of a digital camera photographing the water passing through a flow-through chamber at frequent intervals, with lighting, backdrops, and post-processing methods designed to allow isolation and measurement of individual drifting debris particles. Data from this device will be modeled to infer particle counts from the masses collected in all of the other drift samples. Debris concentrations will ultimately inform prey detection and capture probabilities in foraging models.

This project will use a drift foraging model recently developed and tested on Chena River Chinook salmon to predict the effects of measured prey and debris concentrations on the net rate of energy intake of juvenile Chinook salmon. The Fish Bioenergetics 4.0 model will then be used to convert estimates of energy intake into temperature-dependent growth. This project will leverage existing datasets and ongoing research projecting future stream flow and temperature regimes of the Chena River to drive the foraging and bioenergetics models. Once the Fish Bioenergetics model has been run for a series of current and future temperature, streamflow, and storm frequency scenarios, results will be mapped using geospatial software (ArcGIS) and map products will identify which general areas in the Chena River basin offer the greatest potential for Chinook salmon growth. The models will also evaluate whether the six spatial variability sites offer suitable foraging conditions at base flow and moderately high flow.

Model predictions of Chena River Chinook salmon growth as a function of temperature and streamflow will be validated against new length and mass measurements collected at two-week intervals during the 2019 and 2020 field seasons. Additional length and mass validation data will be obtained from past projects of the current investigators and collaborators in 2009 and 2015 and a planned project in 2018. These will be supplemented with small amounts of length-only data from 2008, 2010, and 2014.

## **IX. Benefits**

This project will clarify the intertwined roles of temperature, streamflow, and prey availability in controlling juvenile Chinook salmon growth, habitat needs, and climate

vulnerability. Managers can use such information to prioritize the type and location of restoration actions that will provide refugia from challenging conditions and reinforce strongholds of juvenile Chinook salmon in the Chena River. The spatiotemporal variability in juvenile Chinook salmon foraging conditions is important both for assessing habitat quality and for anticipating consequences of environmental change because prey consumption determines whether growth rates will respond positively or negatively to a warming climate, or to restoration of relatively warm-water habitats. Sampling spatially diverse sites will also help determine whether the relatively warm, developed, lower reaches of the Chena River basin comprise potential high-quality habitat in need of restoration, or whether patterns in foraging conditions limit prey consumption to a degree that makes warmer water less suitable for growth than currently heavily occupied habitats. Given that high freshwater growth rates are beneficial to the long-term survival of Yukon Chinook, and freshwater streamflow is strongly related to population productivity, the information this project provides will help managers optimize restoration of the freshwater environment to conserve future Chinook salmon returns.

**X. Products, Milestones, and Timelines**

- March-April 2019: Build the drift pump and optical debris-counter, test them in unfrozen rivers at SFR headquarters in Washington, and ship them to Fairbanks; hire and train summer field technician in Fairbanks
- May-September 2019: Sample prey and debris drift concentrations and juvenile Chinook salmon lengths and weights
- October 2019-April 2020: Conduct initial data analysis and modeling
- May 2020: Present year one results to the American Fisheries Society (Alaska) meeting in Anchorage
- May-September 2020: Sample prey and debris drift concentrations and juvenile Chinook salmon lengths and weights
- July 2020: Present results to date to the American Fisheries Society annual meeting (Columbus, OH)
- October 2020-October 2021: Finish analyzing data and write project report and publications
- May 2021: Present year two results to the American Fisheries Society (Alaska) meeting in Juneau
- November 30, 2021: Provide final report to AKSSF

**XI. Project Budget**

Summary Budget	Total
100 Personnel	\$180,525
200 Travel	\$7,545
300 Contractual	\$54,405
400 Supplies	\$13,372
500 Equipment	\$0
Subtotal	\$255,847
600 Indirect	\$41,295
<b>Total</b>	<b>\$297,142</b>

This project funds the following entities:

- South Fork Research, Inc. (SFR): \$238,763
- UAF: \$58,379

**SFR Budget**

<b>SFR Budget</b>	<b>Total</b>
100 Personnel	\$147,364
200 Travel	\$4,709
300 Contractual	\$52,685
400 Supplies	\$12,299
500 Equipment	\$0
Subtotal	\$217,057
600 Indirect	\$21,706
<b>Total</b>	<b>\$238,763</b>

**SFR Budget Narrative:**

**Line 100: Personnel (\$147,364)**

- Carol Volk, Senior Research Ecologist, will oversee SFR project administration, coordinate with the Alaska Department of Fish and Game (ADF&G) and University of Alaska Fairbanks (UAF), and assist in reporting and manuscript writing: 2 months @ \$9,035/month = \$18,070.
- Jason Neuswanger, Senior Fisheries Ecologist, will develop sampling plans and detritus counter equipment, coordinate and participate in field work, perform data analyses, and participate in report and manuscript writing: 11.25 months @ \$8,500/month = \$95,625.
- A field sampling technician (TBD) will be responsible for field collection of drift samples and fish capture and measurements during the summer seasons; between field sampling trips, the technician will perform data entry and process and ship drift samples: 1,566 hours @ \$21.50/hour = \$33,669.

**Line 200: Travel (\$4,709)**

Jason Neuswanger, Senior Fisheries Ecologist, will travel to the Tolt, Skykomish, or Snoqualmie River watersheds in Washington to develop and test debris counter and drift set up prior to the 2019 field season (March-April 2019):

- Personal vehicle mileage: 60 miles/trip @ 0.565/mile x 6 trips = \$204

Jason Neuswanger, Senior Fisheries Ecologist, will travel to the Chena River for one month in 2019 and 2020 to oversee field sampling set up and train technicians for summer sampling (April 30-May 31, 2019, and June 1-July 1, 2020):

- Airfare: 2 tickets Seattle to Fairbanks @ \$450/ticket = \$900
- Lodging: 9 nights for pre- and post-field sampling @ \$150/night = \$1,350

Jason Neuswanger will travel to Anchorage to present project results at the American Fisheries Society (AFS) meeting in spring 2020 (dates TBD):

- Airfare Seattle to Anchorage: \$400

- Lodging: 4 nights @ \$150/night = \$600
- Meals per diem: 4 days @ \$75/day = \$300

Carol Volk will travel to Columbus, OH, to present project results at the National AFS annual meeting in the summer 2020 (August 30-September 3):

- Airfare Seattle to Columbus: \$400
- Lodging: 3 nights @ \$125/night = \$375
- Meals per diem: 3 days @ \$60/day = \$180

Line 300: Contractual (\$52,685)

- AFS Alaska Registration: \$200
- AFS Annual Meeting registration: \$200
- Drift sample processing (macroinvertebrate and detritus fractions): 308 samples @ \$166.20/sample = \$51,190
- Annual shipping of drift samples to contracted macroinvertebrate lab for processing: 2 shipments @ \$350/shipment = \$700
- Shipping of field supplies from Seattle to Fairbanks prior to the 2019 field season: \$395

Line 400: Supplies (\$12,299)

- External hard drive for data storage (WD MyPassport 4TB): 3 hard drives @ \$94/drive = \$282
- Photo chamber blacking for debris counter (Vantablack-coated aluminum plate): \$4,970
- Photo chamber glass for debris counter: 5 sheets @ \$100/sheet = \$500
- Photo chamber structure parts (e.g., braces, hinges, framing structure): \$500
- Photo chamber lights: 20 lights @ \$22.50/light = \$450
- Marine battery for photo chamber lights: \$300
- Sony Alpha A7R II camera body for debris counter: \$1,998
- Sony FE 90mm f/2.8 Macro G OSS camera lens for debris counter: \$899
- SanDisk Extreme Pro 256 GB camera memory cards: 2 cards @ \$130/card = \$260
- Camera DC power adapter: \$50
- Drift sample storage containers (large Whirl-Pak bags, 500 count): \$105
- Fish bait storage containers: (small Whirl-Pak bags, 500 count): \$66
- Small field sampling processing items (e.g., funnels, buckets, flashlight, tubs): \$100
- Rite in the Rain 200 sheet datasheets: \$33
- 24 gal Rubbermaid Action Packer totes: 2 totes @ \$35/tote = \$70
- Orvis Silver Sonic Chest waders for field technician: \$225
- Orvis Encounter wading boots for field technician: \$98
- Betadine for sanitation: \$18
- Hobo Pendant model ua-002-64 temperature loggers for field sites: 9 data loggers @ \$64/data logger = \$576
- Honda WX15 motor for drift pump: \$499

- Hoses, brackets, and building materials for drift pump: \$300

Line 600: Indirect (\$21,706)

SFR will use the de minimis indirect rate of 10% (as described in 2 CFR 200) which excludes, among other items, subaward amounts over \$25,000, capital expenditures, and equipment.

### UAF Budget

UAF Budget	Total
100 Personnel	\$33,161
200 Travel	\$2,836
300 Contractual	\$1,720
400 Supplies	\$1,073
500 Equipment	\$0
Subtotal	\$38,790
600 Indirect	\$19,589
Total	\$58,379

UAF Budget Narrative:

Line 100: Personnel (\$33,161)

Erik Schoen, Research Professional 5, will develop sampling plans, participate in field work, coordinate with SFS and ADF&G, perform data analyses, and participate in report and manuscript writing:

- 0.75 months @ \$10,782/month = \$8,087
- 1.5 months @ \$11,052/month = \$16,578 (rate of pay effective 7/1/19)
- 0.75 months @ \$11,328/month = \$8,496 (rate of pay effective 7/1/20)

Line 200: Travel (\$2,836)

Mark Wipfli, Professor, and Erik Schoen, Research Professional 5, will travel to Juneau for the 2021 Alaska AFS meeting (dates TBD):

- Airfare: 2 tickets Fairbanks to Juneau @ \$466/ticket = \$932
- Lodging: 4 nights @ \$150/night x 2 people = \$1,200
- Meals per diem: 4 days @ \$88/day x 2 people = \$704

Line 300: Contractual (\$1,720)

- AFS Registration 2021: 2 registrations @ \$200/registration = \$400
- Satellite phone minutes through UAF phones: 300 minutes @ \$1/minute = \$300
- Journal page charges for manuscript publishing: \$1,000
- Laser printing of project field datasheets from OfficeMax: \$20

Line 400: Supplies (\$1,073)

- Ethanol for macroinvertebrate preservation: 15 gallons @ \$15/gallon = \$225
- Gas for field work: 100 gallons @ \$3.50/gallon = \$350
- Fish anesthesia (Aqui-S): \$198

- Small field and laboratory processing supplies (e.g. squirt bottles, sieves): \$300

Line 600: Indirect (\$19,589)

UAF’s federally negotiated indirect cost rate through June 30, 2018, is 50.5% excluding, among other expenses, subawards over \$25,000, equipment, and tuition remission.

**XII. Match Budget**

<b>ADF&amp;G SF Match Budget</b>	<b>Total</b>
100 Personnel	\$40,000
200 Travel	\$0
300 Contractual	\$64,000
400 Supplies	\$0
500 Equipment	\$0
<b>Total</b>	<b>\$104,000</b>

ADF&G SF Match Budget Narrative:

Line 100: Personnel (\$40,000)

A Fishery Biologist II (TBD) will participate in field work and assist in data analyses: 2 months/year @ \$10,000/month (including overtime) x 2 years = \$40,000.

Line 300: Contractual (\$64,000)

- 2017 Ford F250 truck (in-kind use): 5 months/year @ \$3,400/month x 2 years = \$34,000
- 18’ boat with 90 hp jet engine (in-kind use): 5 months/year @ \$3,000/month x 2 years = \$30,000