Project Title: Longitudinal distribution patterns and habitat associations of juvenile coho salmon *Oncorhynchus kisutch* in tributaries of the Little Susitna River, Alaska.

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Overarching Goal: Determine juvenile coho salmon distributional limits and habitat use characteristics in high gradient tributaries of the Little Susitna River.

Goals:

1. Determine and characterize the upstream limits of juvenile coho salmon by age and size class in high gradient headwater tributaries of the Little Susitna River (2010-11).
    a. Objective 1. Sample 3 high gradient, headwater tributaries of the river in a continuous manner to the upstream extent of juvenile salmon distribution.
    b. Objective 2. Use length-frequency analysis and scale/otolith analysis to determine the age of captured individuals and describe the distribution within the tributary systems by age class.

2. Characterize available habitat in headwater tributaries (including thermal profiles by elevation) and relate to distribution patterns of juvenile coho salmon by age and size class (2010-11).
    a. Objective 1. Develop thermal regime profiles of 3 high gradient tributaries by deploying temperature loggers over a range of elevations within each system.
    b. Objective 2. Develop models of stream temperature characteristics (mean summer temperatures, maximum summer temperatures, maximum winter temperature and minimum winter temperature) by elevation and watershed size.
    c. Objective 3. Use a continuous, streamwide approach to collect habitat information at 200 m reach lengths. Habitat characteristics include: pool frequency, wood debris counts, maximum and average pool depths, riparian composition, presence of undercut banks, gradient, and dominant substrate. Further, elevation measures will be taken to supplement and validate information gathered remotely.
    d. Objective 4. Use regression techniques to develop models predicting the presence and absence of juvenile coho salmon by age class in stream reaches based on a subset of habitat variables collected. If coho are continuously present along the occupied stream reach, I will: 1) identify barriers to the upstream extent (i.e., distance from mainstem river, gradient, elevation, or thermal properties of the site).
    e. Objective 5. Model CPUE (number of fish captured per reach sampled) of juvenile coho salmon based on habitat characteristics of the reach to identify important areas of high juvenile productivity and corresponding habitat features.

3. Determine short-term temporal changes in distribution of coho salmon juveniles in headwater streams between July and September of 2010 and 2011.

    a. Objective 1. Engage in repeat sampling for all study streams – continuous if time allows; however, if time does not allow, sample the former upstream extent of coho salmon distributions to determine if that changes over the growing season (July – September).

4. Validate single-pass electrofishing techniques as a surrogate of fish abundance in headwater systems of the Little Susitna drainage (2011 if objectives 1-3 are met).
    a. Objective 1. Using closed-population mark-recapture techniques, measure the abundance of juvenile coho salmon in easily accessible 200 m reaches of tributaries.
    b. Objective 2. Measure habitat features of 200 m reaches that may affect sampling efficiency (e.g., pool depth, woody debris, undercut banks).
    c. Objective 3. Develop logistic regression models of single-pass sampling efficiency based on habitat features. Validation models will be used to correct CPUE data for each tributary to better reflect actual fish abundances.
    d. Objective 4. Using corrected abundance data, repeat Objective 5 of Goal 2.

To achieve these objectives, we will thoroughly sample selected headwater tributaries in the Little Susitna drainage using a continuous, repeat sampling technique to determine spatial patterns in fish distribution, as described by Bateman et al. (2005). The lower effort associated with this technique allows an increase in sampling extent to the watershed level (Bateman et al. 2005; Gresswell et al. 2006; Torgersen et al. 2006; Torgersen et al. 2007), but reduces the precision and accuracy of abundance estimates (Rosenberger and Dunham 2005). Therefore, my primary objectives concentrate on identifying the distributional patterns of coho salmon age classes, rather than relative abundance over the sampling area. In conjunction with fish sampling, I will conduct a streamwide assessment of habitat, including variables known to be important for juvenile salmon and sampling efficiency of salmonids. In particular, we will focus on temperature, pool frequency, wood debris, stream size, gradient, elevation, and distance from mainstem river habitat. The final objective will focus on validation of the model following Rosenberger and Dunham (2005) in the second year of the project.

Justification

The ability to predict fish distributions and understand habitat factors that limit persistence is important for informed fisheries management and in turn conservation of fish species. Habitat models are useful for assessment of habitat suitability and estimation of habitat loss due to disturbance (Orth and Maughn 1982; Moyle and Baltz 1985; McClendon and Rabeni 1987; Orth 1987) and can indicate which habitat configurations are most limiting or productive for a species at selected scales. As our understanding of habitat associations advances, so does the effectiveness and scientific basis of management decisions. For example, the health of a population limited by the availability of woody debris could be enhanced by the addition of wood to stream reaches and the restoration of riparian communities throughout the watershed. Models that predict the presence or absence of a species at reach and watershed spatial scales over year or decade time periods are typically of most interest to managers because manipulations at these scales, such as stream bank stabilization or stream corridor restoration, are generally the most logistically and socially feasible and these scales are most relevant to fish populations (Fausch et al. 2002).

In this document, I propose a two-year study within the Little Susitna River system of southcentral Alaska. The overarching goal of the proposed project is to attain a greater understanding of what habitat conditions affect and limit the distribution of juvenile coho salmon *Oncorhynchus kisutch* in high gradient headwaters of this watershed. My primary objective is to determine longitudinal distribution of juvenile coho salmon by age and size class within this system and associate spatial patterns in juvenile fish distributions with habitat features, including thermal characteristics, gradient, and instream habitat characteristics. This will be accomplished using a multiple logistic regression statistical model of fish-habitat associations, distributions, and abundances for juvenile *O. kisutch*. Spatially explicit habitat data will be analyzed using Geographic Information Systems (GIS).

Work in 2010 will focus on assessing habitat conditions and identifying upper distributional limitations of juvenile coho within high gradient headwater streams. Sampling of stream habitat units to investigate distribution patterns will occur in July, August, and September. Baseline monitoring of spatial and temporal thermal patterns within headwater streams of the Little Susitna River will be established in June and continue throughout the duration of the study. Work in 2011 will focus primarily on validating the multiple logistic habitat model and producing abundance estimates of juvenile coho salmon by cohort within high gradient tributaries of the Little Susitna River drainage if objectives 1-3 are met.

Background

The Little Susitna watershed drains over 160 km^2 within the Cook Inlet region of southcentral Alaska and originates at the Mint Glacier on Montana Peak in the Talkeetna Mountains north of Palmer, Alaska. The river flows southwest for approximately 177 km, discharging into upper Cook Inlet approximately 21 km west of Anchorage and 11 km east of the mouth of the Susitna River. The Little Susitna River supports runs of Chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, sockeye salmon *O. nerka,* pink salmon *O. gorbuscha*, and chum salmon *O. keta* (Ivey et al. 2009). Small tributaries within the upper Little Susitna drainage are high gradient (channel slope >2%), single order systems known to contain juvenile salmon (Johnson and Weiss 2007; Curran and Rice 2009; Davis and Davis 2009); however, the extent to which these tributaries are used over this life stage is unknown.

Management Context:
The Little Susitna River coho salmon sport fish harvest is the second largest freshwater fishery for coho salmon in Alaska (second to the Kenai; Ivey et al. 2009). Typically, managers rely on run enumeration and population modeling to manage fisheries of this kind; however, retention of key spawning and rearing habitats are critical components of any effective management plan. Understanding how these habitats function spatially and temporally across the landscape

and how they respond to anthropomorphic disturbances is vital for the long-term stewardship of productive and diverse salmonid populations within the Matanuska-Susitna Valley.

The Matanuska-Susitna region of Alaska is affected by ongoing development near the city of Anchorage and nearby towns of Wasilla and Palmer; however, it has the potential to be an example to other urban locations in the United States on how to continue human development while maintaining aquatic habitat integrity and environmental sustainability. However, without a better understanding of the ecology of surrounding systems and the nature of human impacts, this goal is unattainable. In addition, managers require research to inform and prioritize ongoing restoration, preservation, and development activities.

The upper Little Susitna drainage is a relatively intact system with a variety of Pacific salmon runs; however, increased development and urbanization in the area, an established and expanding road system, and increased recreational and commercial fishing pressure on salmon stocks in the region are threats that require management consideration. Data on salmon stocks in the area are limited; we lack a full understanding of adult salmon spawning habitat distribution, juvenile rearing habitat, and what habitat factors limit the distribution and production of Pacific salmon in the region.

Restoration and conservation efforts are presently underway in the upper Little Susitna drainage; in particular, managers are replacing culverts to increase the stream length and area available to juvenile salmon. However, it is difficult to assess the effectiveness of these restoration activities without a better understanding of the quality and potential of habitats upstream of culvert replacements. Prioritization of which culverts to replace is based solely on the length of habitat upstream of the culvert that would then be available to colonizing species of salmon. Additional consideration of differential capacity of upstream habitats to bear and support salmon populations is not taking place due to lack of information and research in the area. Potential differences among upstream habitats in productivity and thermal characteristics could affect the potential of these areas for producing juvenile salmon.

Finally, increased human development and urbanization around the cities of Anchorage and Wasilla have impacted stream biotic integrity and will do so in the upper Little Susitna region, where this work is proposed. However the extent and severity of impact will vary based on habitat quality; this information is needed to predict the impacts of ongoing and planned suburban expansion in the region. Given the variety and importance of management concerns in this region, work on habitat requirements and preferences of juvenile coho salmon is both important and timely. Prior work on coho salmon and related species have emphasized a variety of potential habitat features that may be important for juvenile salmon; in the following sections, we review and highlight some of these features.

Important habitat features for juvenile salmon in headwater streams:
A wide variety of habitat features have been identified as important for rearing and growing salmonids in headwater streams (Fausch et al. 1988). These include features related to salmonid bioenergetics such as macroinvertebrate productivity (Richardson 1993), water

velocities (Bisson et al. 1988), and thermal regimes (Welsh et al. 2001). Other important features for the long-term survival of fish species include measures of habitat complexity such as the presence of wood debris (Fausch and Northcote 1992; Crispin et al. 1993), habitat surface area (Burns 1971), and pool frequency (Dolloff 1986). I am choosing to emphasize habitat characteristics that can be quickly assessed at spatial scales most relevant to managers and most likely to be important to juvenile fish in a high gradient, headwater system. Consideration will also be given to landscape processes, such as distance from potential winter refugia (i.e., mainstem Little Susitna River).

Procedures

Overview:

Three headwater tributaries of the Little Susitna River will be surveyed for juvenile coho salmon distributions, habitat variables, and thermal regimes during July, August, and September in 2010 (N = 3 streams) and 2011 (N = 3 streams). Tributary habitat surveys will begin at the confluence with the Little Susitna River and extend upstream in a contiguous manner. Electrofishing will be used to sample juvenile coho salmon within high gradient tributaries of the Little Susitna River during July, August, and September. Age-class designations will be determined from length-frequency distributions verified by scale and otolith readings. Longitudinal distribution will be documented using a combination of contiguous stream sampling, ground-based habitat surveys and Geographic Information Systems (GIS). Temperature data loggers will be distributed throughout the length of channel at locations where thermal changes are likely (e.g., tributary confluences) or at a minimum of every 400 m.

Habitat Sampling:

Each tributary will be assigned a unique identifier (1-3). Tributary size will be determined by measuring stream discharge once monthly during baseflow conditions using the standardized USGS cross-sectional protocol. A tape will be extended across the stream, and depth and velocity measurements will be taken at 0.5 m intervals along the stream. For each 0.5 m section, we will calculate the discharge for each cell (n) as Qn = wnDnVn, where wn is the width of the cell (m); Dn, the depth of the cell at the midpoint (m); and Vn, mean velocity of the cell at the midpoint (m/s). Discharge (Q) for the transect will then be calculated as:

$$Q = \sum Qn = w1D1V1 + w2D2V + \ldots\ldots + wnDnVn$$

A two to three-person crew will conduct contiguous surveys for the tributaries proceeding in an upstream fashion. Habitat characteristics within individual tributaries will be assessed in a streamwide manner, using the Basinwide Visual Estimation Technique (BVET) as a guide (Dolloff et al. 1993; Hankin and Reeves 1988). The length of stream sampled will be parsed into 200 m lengths. For each 200 m reach, we will collect the following habitat data:

1) Average pool depth
2) Maximum pool depth
3) Pool Frequency
4) Average stream width at pools
5) Riparian composition

6) Number of wood pieces
7) Presence or absence of undercut banks
8) Stream slope
9) Dominant substrate
10) Water temperature, oxygen content, pH, and conductivity

Starting distance and elevation at the beginning of each 200 m reach will be recorded; reaches will be approximately 200 m in length because they will be delineated at habitat unit breaks (i.e., transition between pool, riffle, or glide). Handheld laser rangefinder devices will be used to measure exact lengths of all sampled reaches. Additionally, a GPS waypoint (WP) will be taken and recorded at the beginning of each reach. This GPS coordinate will be marked with flagging to aid in later delineation of reaches during fish sampling.

Crews will measure and record dissolved oxygen content, pH, and conductivity using a handheld YSI meter once within each 200 m reach; sampled in the river thalweg just below the habitat ‘breaks’ that define each reach. Crews will proceed upstream in a zig-zag pattern, taking frequent depth measurements in pools (5-10 points per pool) from which average and maximum depth will be estimated. Pools are identified as hydrologic units with a concave stream bottom within the river thalweg, a smooth water surface, and slower water velocities compared to the remainder of the stream reach (Frissell et al. 1986; Hawkins et al. 1993) and, occupy over half of the stream channel. If the channel splits into two channels, each pool will be assessed and enumerated separately. For each pool, width will be visually estimated. Precise, baseline measurements (channel width) for pools will occur systematically for one out of every ten units for a sampling fraction of 10 percent.

Further, the presence and number of woody debris will be measured for each 200 m reach. Wetted bankfull width will be recorded at multiple locations along the habitat unit parallel to the stream thalweg using a range finder or depth measuring staff and the average distance recorded. Estimated maximum depth of each habitat unit will be measured as an average of 10 to 20 points taken while proceeding upstream and across the channel in a zig-zag pattern. Woody debris within each habitat-unit will be counted and assigned to classes measured along a 5-category scale following Flebbe (1999) (**1**: 10-50 cm diameter, 1-5 m length; **2**: >50 cm diameter, 1-5 m length; **3**: 10-50 cm diameter, >5 m length; **4**: > 50 cm diameter, > 5 m length; and **5**: rootwads). Actual measurements will be recorded in one out of every ten or twenty habitat units for a sampling fraction of 10% or 5%, depending on local conditions (i.e., 1 in 10 or 20, given frequency of pools).

Certain reaches may contrast hydrologically with the remainder of the high gradient streams due to beaver activity (e.g., beaver ponds) and / or low gradient stretches (wet meadows). The length of these areas, their dimensions, and, when possible, depth characteristics will be measured carefully. Where possible, the same data for those reaches (width, depth, wood debris, etc.) will be collected as with other parts of the stream system; however, some reach features such as pool frequencies will be impossible to collect. These reaches may need to be excluded from later analyses or incorporated in a different manner; therefore, their characteristics will be assessed thoroughly and carefully to allow for maximum flexibility.

Thermal Regimes:
Stream temperatures will be monitored in each headwater tributary beginning June 2010 through September 2011, using temperature data loggers (UTBI-001 HOBO TidbiT v2 Temp Loggers, ONSET, Pocaset, MA). Prior to deployment all data loggers will be calibrated and checked for accuracy using the ice water bath method and checked against a NIST (National Institute of Standards and Technology) thermometer. Stream temperatures will be collected over the study duration which will capture maximum temperatures during summer growing periods. Twenty temperature loggers will be distributed and deployed throughout each headwater tributary (*N=3*) with particular attention to localized and small-scale variability in temperatures occurring in lateral, horizontal, or vertical directions (Dunham et al. 2005). Additional loggers will be placed in areas where sudden changes in thermal regime may occur (e.g., downstream from beaver dams, wet meadows, or tributary confluences). Loggers will be anchored in location using sandbags filled with substrate materials present at locations of deployment. Deployment sites will be marked on the ground for future identification using a combination of (1) flagging placed in a conspicuous location labeled with; logger ID, GPS coordinates, approximate distance, compass bearing, and angle to data logger using an oil-based paint marker and; (2) double sided aluminum tags identifying the logger ID, GPS coordinates, approximate distance, compass bearing, and angle to data logger. Photo documentation of upstream and downstream habitats will be recorded to accompany detailed field notes of data logger deployment sites.

Fish Sampling:
Sampling using a backpack electrofisher (LR-24 electrofisher or equivalent, Smith Root, Vancouver, WA) will proceed upstream in a continuous manner sampling all accessible channel areas and cover (Reynolds 1996; Dunham et al. 2009). Crews will adjust voltage, pulse, and frequency to maximize capture probability without causing injury to fish. Efforts will be made to account for electrofishing size selectivity sampling bias without causing detrimental effects to the fish. Operation of electrofishing equipment in salmonid waters will be performed according to guidelines established by federal agencies (NMFS 2000). Dissolved oxygen, temperature, and conductivity readings will be taken periodically throughout the day. These features are known to affect sampling efficiency of the backpack electrofisher and will provide limits to fish sampling (low oxygen or high temperatures will make fish more vulnerable to incidental mortality) and may be useful later on for fish abundance calibration purposes (Rosenberger and Dunham 2005).

Presence/absence sampling for juvenile coho salmon will occur in a continuous upstream manner throughout each headwater tributary. The entire stream course will be divided into sampling units of approximately 200 m in length. Units will begin at the confluence with the Little Susitna River. Sampling unit length and distance from confluence will be measured on the ground with handheld laser rangefinders. Each new sampling unit will correspond with a habitat “break” or transition between a pool, riffle, or glide. The upstream limit to sampling will be determined in the following manner: if two consecutive sample reaches (200 m) result in zero catch of coho salmon, then sampling will cease. If an incidental observation indicates fish presence, but the fish is not directly captured, sampling will continue. Finally, if an obvious barrier to fish movement is observed (e.g., a direct drop of 3 m or more within a restricted stream channel), if accessible, one additional sample of zero catch upstream of that barrier will be considered sufficient evidence for determination of the upstream limit of juvenile coho salmon.

Stream reaches will be delineated on the ground for future sampling using one or more of the following methods (1) Flagging placed above or adjacent to the stream course. Sampling crews will use oil-based paint markers and label the flagging located at the start of each unit with the distance from confluence, date, and initials of each crewmember or (2) Double faced aluminum tags affixed in a conspicuous location. All tags will be labeled with information identifying the start of each habitat unit, appropriately labeled with; distance from confluence, date sampled, GPS coordinates and sampling crew Initials.

Age-Size Class Determination:
For length-frequency analyses, fork lengths of all coho sampled will be measured to the nearest millimeter. Lengths will be recorded with a fish measuring device fashioned from a 30 cm piece of PVC pipe cut length-wise and fitted with a measuring tape. If necessary, all fish collected for sampling will be anesthetized in tricaine methane sulphonate (MS-222, 15-25mg/L) to reduce stress during handling (Summerfelt and Smith 1990). One crew member will measure fish to the nearest mm and a second will record data. After measuring, anesthetized fish will be allowed to recover in a separate live well prior to release. If three crewmembers are present, the third crewmember will monitor the recovery process and maintain fresh oxygenated water within holding buckets. All fish will be released and distributed evenly within the habitat-unit of initial sampling. Care will be taken to release fish well downstream of the subsequent area to be sampled.

Age-class designations will be determined from length-frequency distributions and verified by scale / otolith readings (Dolloff 1986). During each sampling period from each stream reach, scale samples from thirty individuals representative of each 10 mm size class (40-50, 50-60, 60-70, 70-80, 80-90 mm) will be collected from the left side of the fish as described by Johnson et al. (1986). Scale samples will be collected using a dull scalpel and placed on a small sheet of paper stored in a scale envelope. The accuracy of ageing using scales will be verified through comparison with otoliths. Twenty otolith samples over a size range of juvenile fish will be collected throughout the summer sampling period. Standards and guidelines of Mosher (1968) will be used in aging scales. Salmon ages will be reported according to the European method described by Jerald (1983). Incidental mortalities will be preserved in a 10% buffered formalin (Kelsch and Shields 1996) or 95% ethanol solution (Secor et al. 1992) and used for otolith age verification of scale readings. Vials will be labeled using alcohol resistant lab markers and properly labeled with habitat unit id, date of capture, and sampling crew initials.

Data Analysis

I describe my analytical approach below, organized by my study goals, and, when relevant, objectives.

1. Characterize available habitat in headwater tributaries (including thermal profiles by elevation) and relate to distribution patterns of juvenile coho salmon by age and size class (2010-11).
    a. Objective 2. Develop models of stream temperature characteristics (mean summer temperatures, maximum summer temperatures, minimum winter temperature and maximum winter temperature) by elevation and watershed size.

Temperature data archiving will be done within a Microsoft Access relational database system. Summaries of mean and maximum temperatures will include; daily average on the hottest day (MDAT), overall summer maximum (MDMT), maximum weekly average maximum temperature (MWMT), maximum value of average weekly temperature (MWAT) and the overall average summer temperature (AWAT). I will use linear regression techniques to model stream temperature; the dependent variable will depend on model performance and covariance of the multiple measures described above. Independent variables of the global model will be watershed size, stream elevation, and gradient. Other factors known to affect stream temperature will not be included in the global model because they either do not vary among the study streams (e.g., aspect) or are unknown (e.g., groundwater input). Candidate models will be likely subsets of the global model. I will use the information-theoretic approach for final model selection and inference (Burnham and Anderson 2002).

    b. Objective 3. Use a continuous, streamwide approach to collect habitat information for 200 m reach lengths, including pool frequency, wood debris counts, maximum and average pool depths, riparian composition, presence of undercut banks, gradient, and dominant substrate. Further, elevation measures will be taken to supplement and validate information gathered remotely.
    c. Objective 4. Model the presence and absence of juvenile coho salmon by age class in stream reaches based on a subset of habitat variables collected. If coho are continuously present along the occupied stream reach, I will: 1) identify barriers to the upstream extent (i.e., distance from mainstem river, gradient, elevation, or thermal properties of the site).

Presence/absence of juvenile coho will be displayed along headwater tributaries by age and size class using GIS ARCMap spatial analysis software. Characteristics of those upstream distribution limits will be described for each stream (e.g., slope, elevation, stream width, presence/absence of a barrier, and thermal properties) and for each age class and compared among the stream systems to look for a common feature that determines the limit to fish distribution in the Little Susitna system. I anticipate that upstream distribution limits will be consistent among streams, allowing us to use GIS analysis to map Little Susitna headwater habitats as ‘potential juvenile-salmon bearing streams’ based on my analysis. If coho salmon are not contiguously present in all reaches downstream of their upstream distributional limit, the probability of presence for each age and size class will be modeled based on habitat characteristics using logistic regression. The global model will be a combination of habitat features that meet logistic regression assumptions (normality, lack of covariance); candidate models will be likely subsets of the global models. As described above, I will use the information-theoretic approach for final model selection and inference. Further, the thermal characteristics of streams will also be compared to known tolerances and optimal growth conditions for juvenile coho salmon.

    d. Objective 5. Model CPUE (number of fish captured per reach sampled) of juvenile coho salmon based on habitat characteristics of the reach to identify important areas of high juvenile productivity and corresponding habitat features.

CPUE will be modeled against reach habitat features using Negative Binomial Regression, a useful modeling technique for overdispersed dependent variables, such as count data. Model selection and inference will take place as described above. This model will be used to develop hypotheses regarding what habitat features are most important for juvenile coho salmon productivity (by age class) in headwaters of the Little Susitna River.

2. Determine short-term temporal changes in distribution of coho salmon juveniles in headwater streams over the summer growing season (2010-11).
    a. Objective 1. Engage in repeat sampling for all study streams – continuous if time allows; however, if time does not allow, sample the former upstream extent of coho salmon distributions to determine if that changes over the growing season (July – September).

I will determine if the distributional limit of age classes of coho salmon remained consistent during early, mid, and late summer sampling through direct comparisons of the data sets through time. Modeling described above can take place using a repeat measure approach if the temporal data are available for the entire system. This will take into account autocorrelation due to consecutive sampling periods.

3. Validate single-pass catch as a surrogate of fish abundance in headwater systems of the Little Susitna drainage (2011 if objectives 1-3 are met).
    a. Objective 1. Using closed-population mark-recapture techniques, measure the abundance of juvenile coho salmon in easily accessible 200 m reaches of tributaries of the Little Susitna River.
    b. Objective 2. Measure habitat features of those sites that may affect sampling efficiency.
    c. Objective 3. Develop logistic regression models of 1-pass sampling efficiency based on habitat features. These validation models can be used to correct fish catch data for each stream system to better reflect actual fish abundances.
    d. Objective 4. Using corrected abundance data, repeat Objective 5 of Goal 2.

Logistic regression models of sampling efficiency will be chosen based on an information theoretic approach as described above. CPUE may be used as an index of abundance if I have the opportunity to validate this approach in later sampling seasons. If CPUE is deemed an acceptable proxy of fish abundance, habitat associations will be modeled using a mixed model approach, with stream origin as the random variable, and habitat characteristics as fixed variables. Habitat units sampled within each stream reach will be mapped and linked to a database of habitat variables including habitat unit type, length, wetted bank width, minimum and maximum stream depth, surface area, large woody debris content by size class, stream elevation, order, and gradient. For both logistic and mixed models, a model selection and inference approach (Burnham and Anderson 2002) will be used to select the most likely model.

Study Implications

Headwater streams often go unrecognized as important peripheral habitats for salmon populations. However, they are refugia in the event of a disturbance in the mainstem river, represent of an important life history component of the larger population, and may be most reflective of the dynamics of the larger population of coho in the region (Isaak et al. 2003). The dependence of headwater streams on hillslope processes for ecosystem function make them particularly vulnerable to human-related impacts.

Through this work, I will be able to identify the area of the Little Susitna region most suitable for juvenile coho salmon. This will allow for more strategic and informed management of these populations. For example, the replacement of culverts will take place in those systems with the largest area that is used by older, upstream-moving age classes of juvenile salmon, which is unknown at this time. Further, priority can be given to those streams that have features that are known to increase local productivity of juveniles. Finally, my validation project will give local managers information on my sampling efficiency of juvenile coho salmon, which will inform how much effort is required for reliable assessment of salmon distributions in the area. Further, catch data from similar habitats can be calibrated to reflect juvenile salmon abundance, which will dramatically increase our information on those populations. Finally, an understanding of the fundamental niche of juvenile coho salmon by age class will allow us to identify important risks that are limiting the distribution of this species within this watershed and similar habitats elsewhere. This work will give rise to hypotheses regarding mechanisms that regulate the distribution and productivity of juvenile coho salmon populations in the region.

Schedule (Subject to change)

Activity	Time Frame
Habitat typing- preliminary site inspection-field gear prep	May 10 – May 16, 2010
USFWS annual training & field camp preparation	May 17 – May 29, 2010
Habitat sampling & data loggers deployed	June 1 - July 1, 2010
Stream 1	June 1 - June 14
Stream 2	June 16 - June 29
Stream 3	Timeline pending progress on streams 1 &2.
Fish Sampling	July 5 - September 28, 2010
Stream 1	July 5 - July 17
Stream 2	July 19 - July 31
Stream 3	Timeline pending progress on streams 1 &2.
Stream 1	Aug 2 - Aug 14
Stream 2	Aug 16 - Aug 28
Stream 3	Timeline pending progress on streams 1 &2.
Stream 1	Sept 1 - Sept 14
Stream 2	Sept 16 - Sept 29
Stream 3	Timeline pending progress on streams 1 &2.
GIS distribution data analysis Juvenile coho presence by age and size class	October – December, 2010
Scale aging & otolith validation	October – December, 2010

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LONGITUDINAL DISTRIBUTION PATTERNS AND HABITAT ASSOCIATIONS OF JUVENILE COHO SALMON *ONCORHYNCHUS KISUTCH* IN TRIBUTARIES OF THE LITTLE SUSITNA RIVER, ALASKA

A

THESIS

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ABSTRACT

Understanding how high-gradient headwater streams function as rearing habitats for juvenile coho salmon *Oncorhynchus kisutch* is essential for effective population management and conservation. To inform habitat restoration activities within the Matanuska-Susitna Valley, Alaska, I determined upstream distribution limits, validated abundance estimates, and fish habitat relationships in two high-gradient headwater streams of the Little Susitna River in 2010-11. Using a low-effort, spatially continuous sampling approach and linear mixed-effects models, I related local- and landscape-scale habitat associations to abundance estimates. Age-0 coho salmon composed approximately 98% of all fish sampled and inhabited the entire stream length to their upstream limits. Age-1+ fish resided in 64% and 44% of the stream length for the two sampled streams. The mean upstream elevation limit for age-0 fish in these streams was 278m and 267m. For age-1+ fish, the upstream elevation limit in the two streams was 275m and 238m. Percent slope at the distribution limit of age-0 fish was consistent across streams at 5%, whereas percent slope for age-1+ fish correspond to 4% and 6%. Elevation and percent slope consistently described upstream distribution limits among age classes. Therefore, we must consider these landscape features when prioritizing restoration projects in headwater streams.