Regional Operational Plan ROP.KBRR.2013.01

Headwater Stream Rearing Habitat-Phase II

by

Coowe Walker

December 2013

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)	
centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm
Weights and measures (English)	
cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd
Time and temperature	
day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s
Physics and chemistry	
all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General	
Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat or long
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics	
all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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HEADWATER STREAM REARING HABITAT-PHASE II

by

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Alaska Department of Fish and Game, Division of Sport Fish, Homer

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Division

December 2013

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This document should be cited as:
Coowe Walker. 2013. Headwater stream rearing habitat-Phase II. Alaska Department of Fish and Game, Division of Sport Fish, Regional Operational Plan ROP.KBRR.2013.01 Homer.

Signature page

Project Title:	Headwater Stream Rearing Habitat-phase II
Project Leader:	Coowe Walker
Division, Region, and Area:	Sportfish, KBRR, Kenai Lowlands
Project Nomenclature:	
Period Covered:	May 15-November 30, 2013
Field Dates:	May 15-August 30, 2013
Plan Type:	Category I

Approval

Title	Name	Signature	Date
Project Lead	Coowe Walker	Coowe Walker	1/8/14
Research Coordinator	Angela Doroff	[signature]	8 Jan 2014

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PURPOSE

Understanding the interconnectedness of the surrounding landscape to headwater streams is critical in order to maintain their productivity. This project builds on previous research. Combining new data and models with the flow-weighted slope model that we have developed and validated, will demonstrate how stream physical habitat, chemistry, macroinvertebrate communities, and individual fish species can be predicted based on remotely sensed digital elevation, land cover, and stream data sets. This is important because the large spatial expanse of the Kenai Lowlands and remoteness of many streams prohibits direct sampling of all, but a few locations. One of the most important aspects of this modeling effort is that the models clearly show the mechanisms (e.g. alder patches, groundwater seeps, slope gradients) are driving wetland and stream productivity. This allows for predictive understanding of how changes to these landscape features will affect adjacent streams. The result will be a spatial data set of headwater rearing habitat areas, including important landscape features that support them, for the Kenai Lowlands region of southcentral Alaska. Specifically, we will model productivity in headwater streams from alder nitrogen sources and wetland DOM sources, and the effects of that productivity on juvenile salmon growth and movement. The models developed through this work will result in spatially explicit understanding of landscape processes that contribute to headwater stream habitat, and will include identification of 'hotspots' for headwater stream productivity. Information from the models will be presented in a user-friendly interface to allow for ease of understanding and use by land owners, land-use decision makers and managers. This project will result in new data sets and models that will be combined with an existing model predicting fish presence in headwater streams of the Kenai Lowlands to create a landscape framework model that identifies 'hotspots' of stream productivity support through alder (N) and dissolved organic matter (DOM).

OBJECTIVES

The objective of this study during 2013 is to:

1. Quantify the relationship between nitrate-N and Dissolved Organic Matter (DOM) subsidies from alder (*Alnus spp.)* and wetlands, respectively, to headwater stream productivity and juvenile salmon survival and growth. Specifically, we will test the following hypotheses:
    a. Stream productivity, measured as gross primary production (GPP), bacterial production potential (BPP), *Calamagrostis* litter breakdown rates, macroinvertebrate densities and biomass, and juvenile salmonid growth and condition will significantly increase in response to experimental dosing when compared to paired control reaches in each of the streams.
    b. Stream productivity in low and high DOM streams will not differ significantly in the absence of experimental n additions (that is, in the upstream sections that are not dosed) because both stream types are limited strongly by nitrate-N. An alternative hypothesis is that even in the absence of experimental N additions, higher DOM streams are more productive because microbes are able to utilize organic sources of nitrogen that are not generally believed to be bioavailable (Lutz et al. 2011). This alternative result would demonstrate the importance of wetlands even in the absence of alder.

METHODS

The study will be carried out in two first-order streams that are as similar as possible in terms of catchment size (Figure 1). One stream, STAR -171, has naturally high dissolved organic carbon (DOC) but low dissolved inorganic nitrogen (DIN); and one stream, ANC-1203, has moderate DIN and low DOC (Walker et al 2012). To achieve our objectives, we will follow protocols established in the formal scientific literature. Data analysis will be conducted at Baylor University, led by project co-principal investigator, Dr. Ryan King; and at the Smithsonian Environmental Research Center, led by project co-principal investigator, Dr. Dennis Whigham. Description of statistical analyses may be found in the full proposal for this project, which was funded in 2011 (Walker et al. 2011).

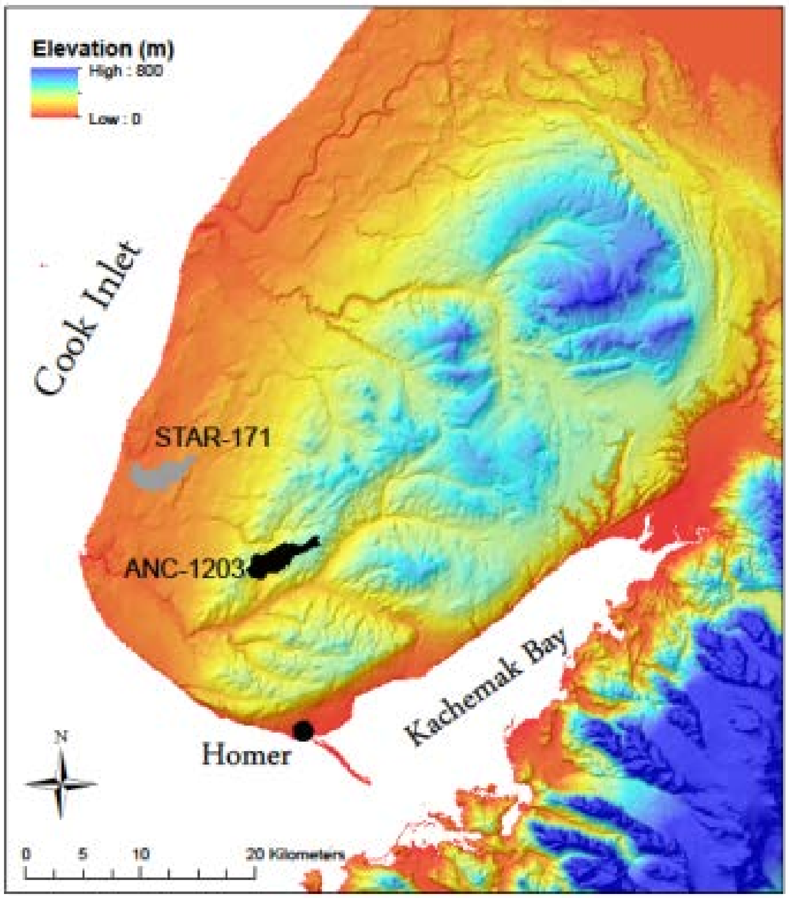

Figure 1.–Regional elevation map of the lower Kenai Peninsula, Alaska, showing the two study watershed locations. ANC-1203 (shown in black) is a watershed with naturally high DIN levels due to alder in the surrounding landscape; STAR-171 (shown in grey) is a watershed with naturally high DOC levels due to abundant wetlands in the watershed.

In STAR-171, the stream with high naturally available DOC, we will experimentally add nitrogen to bring stream N up to similar levels of streams that have naturally occurring DIN inputs from alder. In the stream with naturally occurring DIN levels from alder, we will experimentally add DOC to bring the levels up to levels similar to streams in the area that have naturally occurring dissolved organic matter (DOM) from wetlands (Figure 2).

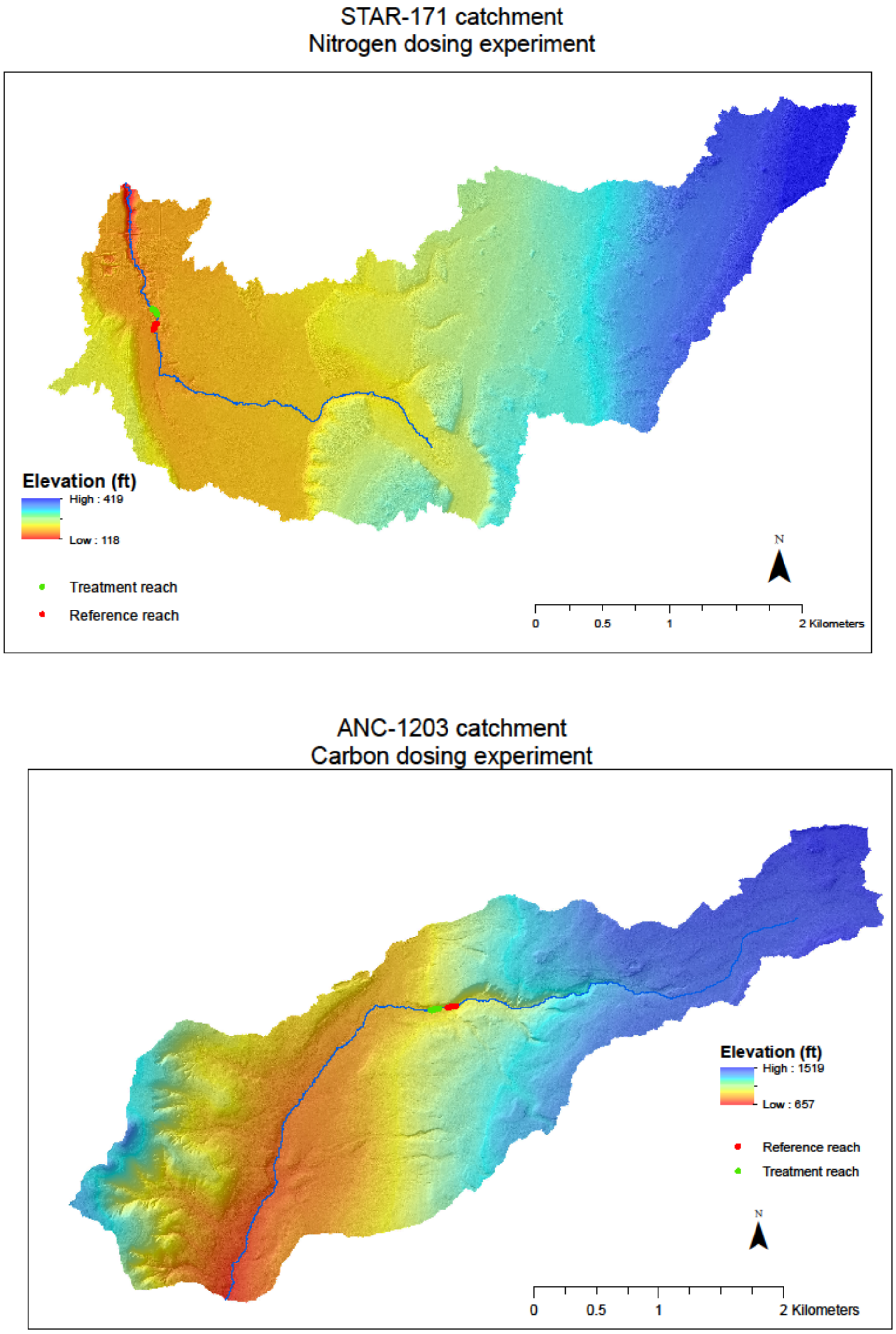

Figure 2.–Catchment scale elevation images of the watersheds for the two study areas; STAR-171 (above) and ANC-1203 (below) based on Lidar data

Within each stream, we will select two 75-m reaches. The upstream reach will serve as an experimental control unit because it will not receive nitrate-N or C additions (Figure 3).

Dosing protocols will follow techniques that are common,. Standardized and tested in scientific research (specifically see Johnson et al. 2012; King and Richardson 2003; Bernhardt and Likens 2002).

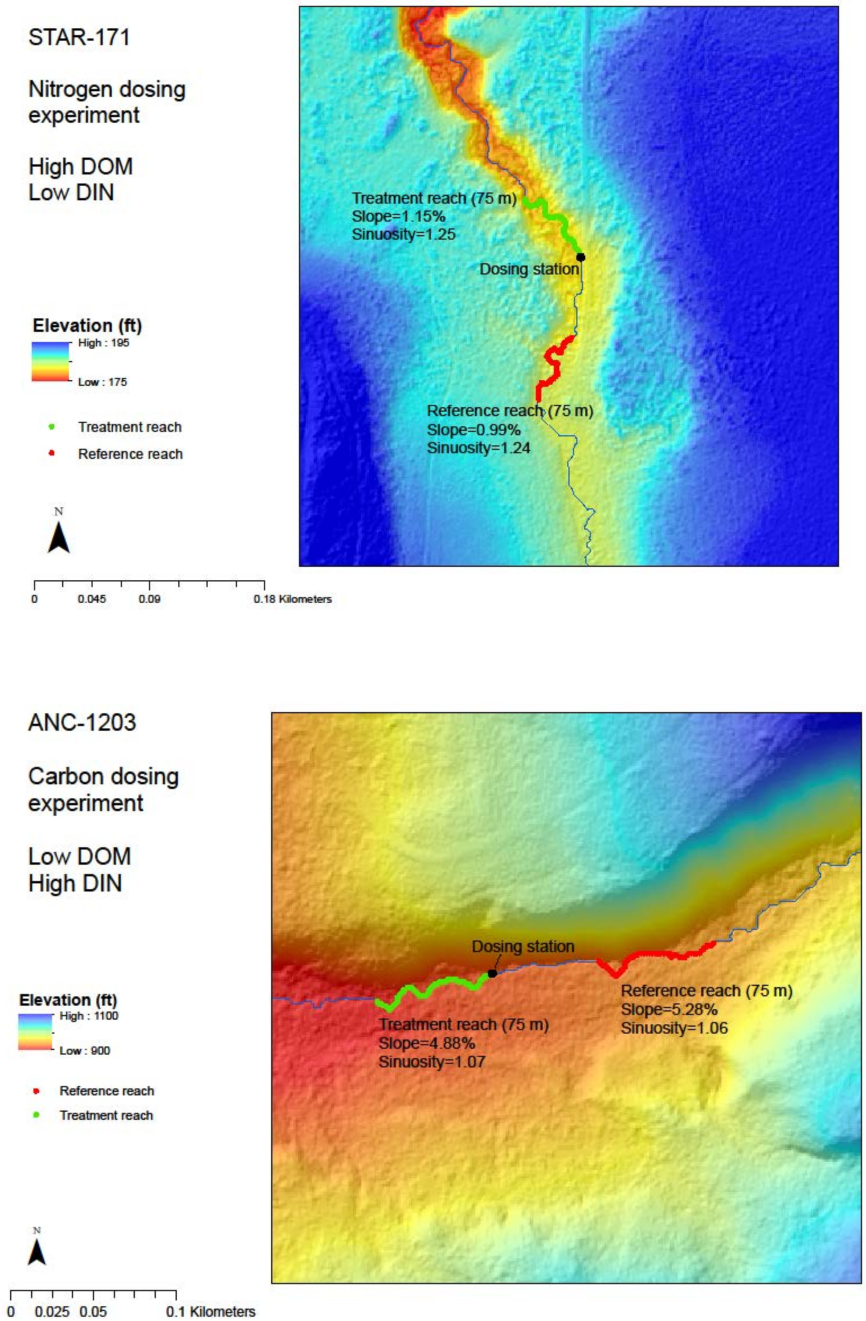

Figure 3.–Dosing reaches for the two study watersheds; nitrogen dosing at STAR-171 (above); and carbon dosing at ANC-1203 (below).

Briefly, the lower reach (treatment) of STAR-171 will be dosed continuously using a concentrated stock solution of either NaNO3, a commonly used nitrate salt that contains no other elements likely to be limiting to stream productivity or harmful to biota (Webster and Valett 2006). The treatment reach of ANC-1203 will be dosed with a concentrated stock solution of potassium-acetate (CH_3COOK), with sodium-bromide (NaBr) used as a tracer. Dosing will be accomplished using a solar-powered peristaltic pump calibrated to deliver a constant volume of stock solution from a 50-L carboy to the stream at the upstream end of the 50-m to 100-m reach. The rate of dosing will be calibrated to achieve a minimum stream concentration of 300 µg/L NO_3-N at STAR-171, during baseflow conditions, which is equivalent to those observed in streams situated in catchments with 5-10% alder cover, (roughly the average for Kenai Lowland headwater streams) (Shaftel et al 2013). At ANC-1203, we will aim to achieve 15mg/L DOC minimum stream concentration during baseflow conditions, which is similar to levels observed in catchments with abundant wetlands in the Kenai Lowlands.

There will be very limited spatial effects of the dosing beyond the study reaches; and within the study reaches, the dosing should only stimulate productivity of microbes and algae, resulting in higher numbers of invertebrates for dollies and cohos to consume. In other words, this is an environmentally realistic experiment, which will not result in unusual growth of algae or bacteria, but rather that the effects will be subtle, if detected.

The stock solution will be held within a carboy dosing tank, and will be set up at least 2 meters from the stream, enclosed within a 600 liter stock tank as secondary containment, and with cinderblocks placed around the carboy for stabilization. The containment tank will be covered with a lid and locked. A secured PVC pipe will house the tubing from the pump to the stream (Figure 4). Stock solutions and pumps will be checked and calibrated at least every other day for the duration of the study.

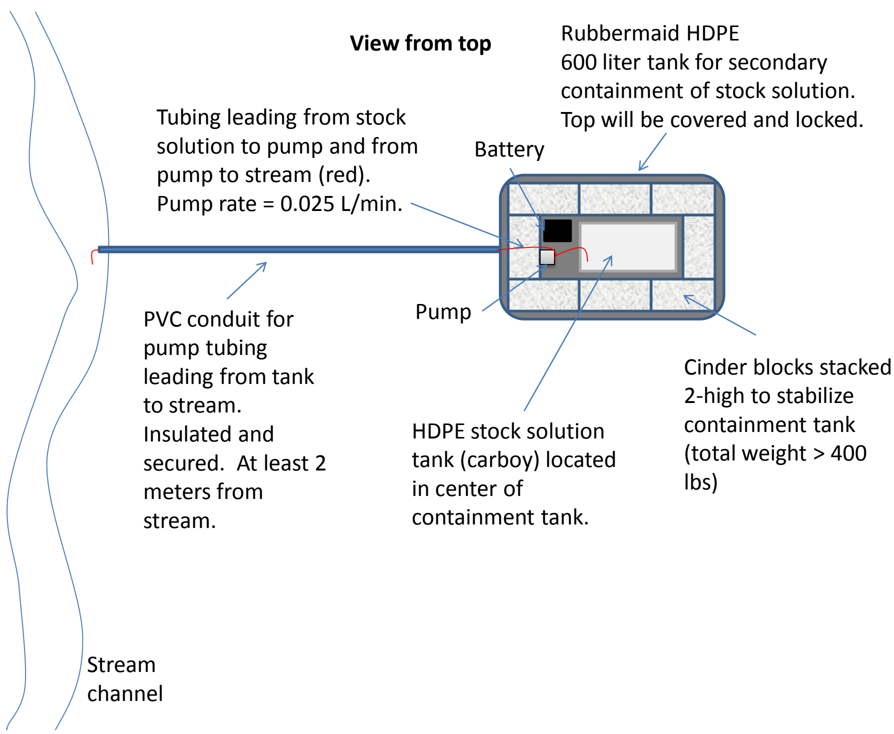

Figure 4.–Schematic showing dosing tank set-up.

Measures of stream productivity will be estimated during the dosing experiment as follows, using methods described in Scott et al. (2008) and references therein (and see Figure 5). Algal and bacterial (periphyton) productivity, biomass accumulation, and nutritional quality (nutrient ratios) . Periphyton variables will be measured prior to dosing and after 2, 4, 8, and ~12 weeks of dosing. Briefly, we will use dual-labeled radiobioassays to estimate algal (primary) and bacterial (secondary) productivity on rocks collected systematically from each reach. Biomass and nutritional quality will be estimated by removing periphyton from rocks and estimating ash-free dry mass (AFDM), chlorophyll a, and carbon, nitrogen, and phosphorus concentrations.

Litter breakdown rates and little quality over the 3-month dosing period will be estimated using methods described in Shaftel et al. (2011). Our previous work suggests that litter of *Calamagrostis canadensis* is the most important basal resource in these headwater streams, thus its breakdown rate (assimilation by invertebrates) is a direct measure of stream productivity and ecosystem functioning. We will also collect subsamples of material from litter bags to measure bacterial productivity on the decomposing litter using methods described in #1 above.

Macroinvertebrates from rock baskets will be retained in a 350 um mesh sieve, enumerated, and identified to genus following King et al. (2012). We will sample macroinvertebrates at weeks 4, 8 and 12 using replicate rock baskets deployed prior to dosing. Rock baskets are commonly used in experiments with repeated observations because other sampling methods are too disruptive to habitat in the stream. Rock baskets provide a standard surface area and volume of habitat while reducing disruption to the reach because they are easy to remove. Biomass will be estimated using length-mass regression equations (Benke et al. 1999).

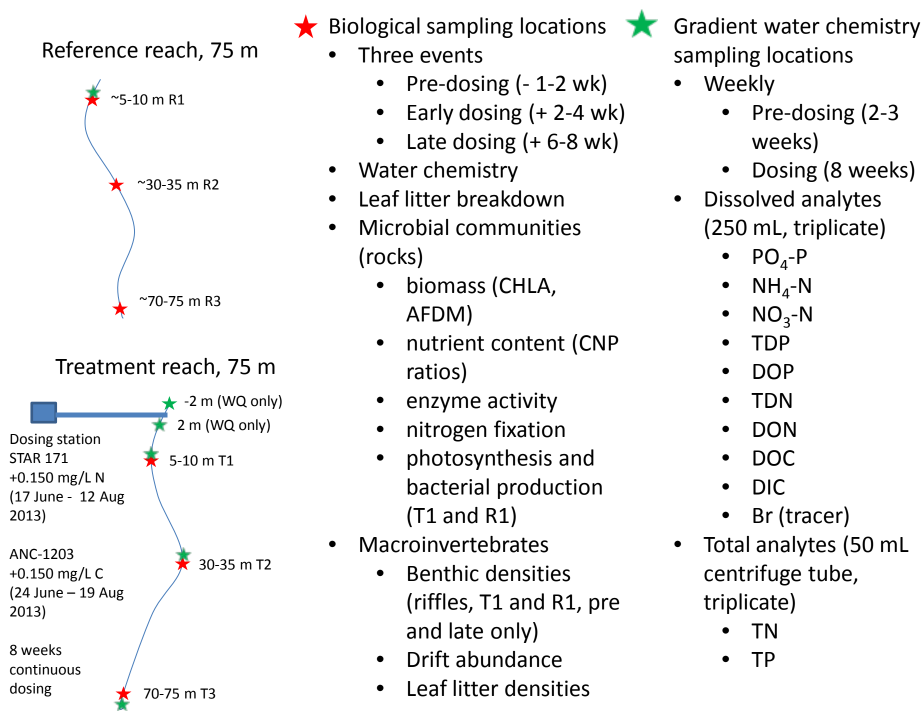

Figure 5.–Schematic showing approximate locations and timing for leaf litter breakdown, microbial communities and macroinvertebrates sampling (red stars); and for weekly water chemistry sampling (green stars).

Juvenile salmonids will be assessed prior to and after the dosing experiment (Figure 6) following standard protocols as described in King et al. 2012. At the beginning of the experiment, prior to dosing, we will use three-pass electrofishing to capture all juvenile salmonids within the study reaches. We will record length and mass of all recaptured fish. Individuals less than 55mm will be tagged with elastomer tags, color coded by reach. Individuals ≥ 55mm in length will be marked with passive integrated transponder (PIT) tags, an electronic marking system that allows each fish to be assigned a unique identification code (Roussel et al. 2000). For PIT tagged fish we will use a handheld (wand) PIT tag reader to identify tagged fish within the study reaches without actively sampling. At the end of the experiment, we will use similar procedures to capture, measure and weigh juvenile salmonids within each reach.

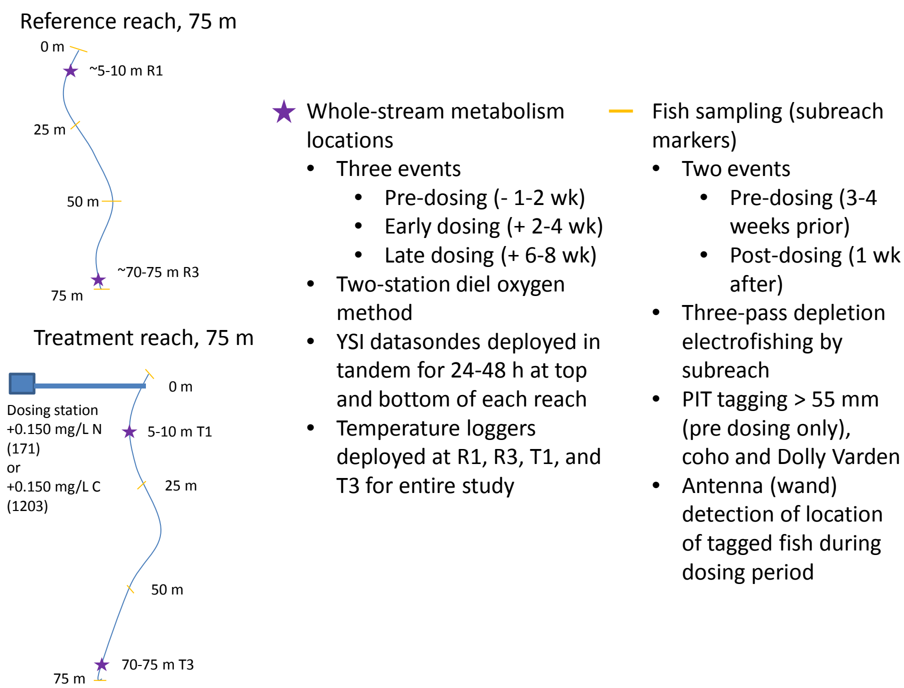

Figure 6.–Schematic showing approximate locations for fish sampling in study stream reaches (yellow bars), and whole-stream metabolism (oxygen consumption) locations (purple stars). Fish will be sampled prior to dosing and after the end of the dosing experiment. Stream metabolism will be assessed three times; prior to dosing, early during the dosing experiment and late during the dosing experiment.

SCHEDULE AND DELIVERABLES

Field activities will be initiated on, or around, May 15 2013 and conclude on, or around, August 15 2013.

Data editing and analysis activities will be initiated in September 2013. Final error correction, reduction, and analysis of the data will be completed by April 30 2014. Initial development of the headwater stream GIS framework for landscape conservation will be drafted by September 30 2014. Workshops with Kenai Lowland decision maker groups to present and get feedback for the GIS framework will be conducted in April and May 2014. Between August and November 2014, the GIS framework will be modified based on user-group comments; data analysis will continue, public outreach and professional meeting presentations will be held, and the final report and manuscripts will be prepared. The final report to the funder, AKSSF, is due by November 30 2014.

Data	Activity
Feb-Apr 2013	Permitting, purchasing, travel and accommodation plans, data sheet preparation, field gear check
May-Aug 2013	Initiate and complete field work
Sep –Oct 2013	Data entry, sample packaging and delivery
Oct 2013	FRP permit report
Nov 2013	AKSSF semi-annual report due
Jan-Aug 2014	Data analysis, model development
Apr 2014	AKSSF semi-annual report due
Sep-Oct 2014	Final Report and manuscript preparation
Nov 15 2014	Final Report internal review
Nov 30, 2014	Final Report submitted to AKSSF

RESPONSIBILITIES

Position	Name/Affiliation	Responsibilities
Project Biologist II	Coowe Walker, KBRR	Supervise project, assist in field sampling as needed, report preparati
Project Technician III	Jasmine Maurer, KBRR	Crew leader, organize daily activities, assist in field and laboratory work as needed. Provide sampling summaries to project PI's on a weekly basis.
Project co-PI	Dr. Dennis Whigham, Smithsonian Environment Research Center	Lead sampling design and analyses of riparian vegetation data
Project co-PI	Dr. Ryan King, Baylor University	Lead sampling design and analyses of stream nutrient, invertebrate and fish data
Project graduate student	Alyse Yeager, Baylor University, supervised by Ryan King	Assist with field sampling and analysis of stream nutrient and primary productivity
Project graduate student	Caleb Robbins, Baylor University, supervised by Ryan King	Assist with field sampling and analysis of stream invertebrate and fish productivity

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