Alaska Sustainable Salmon Fund
August 2015 Completion Report

Title:	Headwater Stream Rearing Habitat – Phase 2
Number:	44709
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Preliminary Synopsis:
This project will create a spatially explicit predictive model for identifying areas of significant influence to juvenile salmon in headwater streams, specifically in the Kenai Lowlands region of Alaska. This new tool will build on recently developed models and understanding by incorporating several new sources of information including: (1) the combined role of wetlands and alder in driving headwater stream productivity; (2) the effects of headwater stream productivity on juvenile salmonid growth and survival; and (3) preliminary investigations of juvenile fish movement in headwater stream systems. This information will be presented in a GIS format that identifies basic landscape features that drive stream productivity and the effects on juvenile salmonids. Understanding how surrounding landscapes are integrated into nutrient and hydrologic loads to streams and how these basic inputs affect fish productivity will provide a framework for conserving important headwater stream rearing habitat for juvenile salmonids. This project continues work begun in AKSSF project 44507.

Final Synopsis:
This project has resulted in new understanding of how peatlands, riparian wetlands, and alder patches in the watersheds of headwater streams influence the productivity of juvenile salmon rearing in the Kenai Lowlands region of Alaska. Study results suggest that carbon from peatlands is an important energy pathway in salmon-rearing headwater streams, and that ecological "hotspots" may occur where catchment cover of wetlands and alder (a nitrogen-fixing shrub) are both relatively high. In such places, carbon and nitrogen inputs may synergistically enhance stream productivity. This project also clearly demonstrates the important coupling of riparian wetland vegetation to streams and confirms that juvenile salmonids travel between different headwater habitat types during their freshwater residence. Together, the results of this project provide compelling new data for the conservation of a diversity of headwater stream habitats, and especially including conservation of the surrounding landscape elements that are linked to stream productivity.

Project Activities and Results:
Objective: Quantify the relationship between nitrate-N and DOM subsidies from alder and wetlands, respectively, to headwater stream productivity and juvenile salmon survival and growth

Project investigators conducted two field experiments to test hypotheses about how landscape elements in headwater stream catchments influence riparian wetlands and stream productivity. We used a fertilization study to test the hypothesis that dissolved nitrogen (DIN) from alders in headwater stream catchments influences the productivity of riparian wetlands, and a whole-stream enrichment experiment to test the hypothesis that even low levels of dissolved organic carbon (DOC) from peatlands could significantly influence stream metabolism and juvenile salmon production in headwater streams where dissolved nutrients are relatively high but DOC is

relatively low.

To examine the effects of alder cover on headwater stream riparian vegetation, we compared two sites, one with high amounts of alder cover in the watershed, and another without significant alder cover. In each site, we fertilized riparian vegetation plots with nitrogen (N), and looked at the response by measuring vegetation biomass above ground (leaves and shoots) and below ground (roots). If a greater response to the N was detected in the sites without alder, that would support our hypothesis that riparian vegetation productivity is limited by the amount of alders (and N) in the catchment. We also measured continuous water levels in the adjacent headwater streams. Our results show that during the growing season the stream water level is almost always lower than the wetland (i.e., very little contact between the two). Flooding is mostly in the late autumn and a few times in the summers with heavy rains. Where alder is present in the headwater stream catchment, this periodic connection is sufficient to elevate N levels in the riparian wetlands resulting in higher biomass and more leaf litter hanging over the stream, which in turn provides more palatable substrates for stream invertebrates to digest, leading to higher abundances of available prey (macroinvertebrates) for juvenile salmonids. This work highlights the dynamic connection between the stream and riparian wetland.

To examine the effects of peatlands on headwater stream carbon levels, we conducted a whole-stream enrichment study by dosing a headwater stream that is naturally low in carbon, but relatively high in N due to alder cover in the catchment, with a small amount of DOC, simulating the effects of available carbon from peatlands. Our results showed that even low-level dissolved organic carbon additions resulted in rapid and substantial ecosystem responses, including increased bacterial biomass and a dramatic increase in macroinvertebrate and juvenile salmonid densities over a very short time (62 days).

The implications of this study are important because they suggest that DOC, which in this region is derived almost exclusively from peatlands, is an important energy pathway in salmon-rearing headwater streams. It also illustrates the potential for ecological "hotspots" where catchment wetland and alder cover are both relatively high. In such places, dissolved organic carbon (from peatlands) and dissolved organic nitrogen (from alders) may syngergistically enhance production in headwater streams of the Kenai Lowlands region.

Objective: Examine patterns of juvenile movement within and between headwater streams

To examine movement of juvenile salmonids within and between different types of headwater stream habitats identified in the predictive Flow-Weighted-Slope (FWS) model that we developed previously, we marked 998 fish with individual identifying tags (PIT tags) and installed a series of five PIT tag reading antennas that enabled us to track movements over a 1.5 year period. The results confirmed our hypothesis, based on our previous sampling, that large pre-smolt coho salmon are moving upstream to overwinter in the low gradient, deeper, and slower headwaters. By combining the scale of movement with the FWS model, we are able to identify tracts of landscape that contain the suite of headwater stream habitats used by juvenile coho salmon for freshwater rearing, an important consideration for management and conservation of salmon populations.

Objective: Use the information obtained in Objectives 1-2 in combination with existing data and models to develop a publically available GIS based tool that identifies important landscape connections to headwater streams

We will add the GIS data identifying important landscape connections to headwater streams to the existing predictive model for stream juvenile salmonid presence and abundance that was delivered to the Kenai Peninsula Borough in 2012. However, that model has not been made available to the public on the KPB website as of this report. We are communicating with the Borough to provide assistance in order to facilitate posting of the model. We plan to augment that model with the new information on linkages between landscape components (alders, peatlands, and riparian wetlands) and stream productivity, based on the results from this project. Alternatively, we may post the GIS tool on the University of Alaska Center for Conservation Science website, where it will be available to all interested parties.

Product Dissemination:

This project has been disseminated to a variety of audiences in different venues:

Public Presentations

- Special Seminar Islands and Ocean Center, Homer, 2013
- Kachemak Bay Science Conference, 2013 and 2015
- Kachemak Bay 'Ignite' sessions, Homer, AK, 2014
- Kachemak Bay Research Reserve Community Council, 2013
- Tools for Managing Salmon Symposium, Anchorage, AK, 2013

Scientific Meetings

- Society of Wetland Scientists meeting, Duluth, MN, June 2013
- Joint Aquatic Sciences Meeting, Portland, OR, 2014 (4 presentations)
- American Fisheries Society, Alaska Chapter meetings, Kodiak, AK, 2014
- Conference on Biological Stoichiometry, Ontario, Canada, 2015

Invited Presentations to Stakeholder Groups

- Alaska Department of Fish and Game Leadership meeting, Anchorage, AK, 2013
- Alaska Department of Fish and Game Kachemak Bay Advisory Committee, Homer, AK, 2013
- Ninilchik Tribal Council, Ninilchik, AK, 2013
- Alaska Board of Foresters meeting, Kenai, AK, August, 2013
- Kenai Peninsula Borough Task Force on Riparian Buffers, Soldotna, AK, 2013
- Kenai Peninsula Fish Habitat Partnership meeting, Homer, AK, 2013
- North Pacific Fisheries Association Board of Directors meeting, Homer, AK, 2015
- Cook Inlet Aquaculture Association Board of Directors meeting, Soldotna, AK, 2015

Reports and Other Products:
Electronic copies of the publications listed below have been submitted on the home page for this project on the Alaska Sustainable Salmon Fund project website.

Robbins, CJ; King, RS; Yeager, AD; Walker, CM; Back, JA; Whigham, DF. 2014. *Low-level addition of dissolved organic carbon increases nitrogen uptake and bacterial biomass production in an Alaskan headwater stream.* Poster presentation at the Joint Aquatic Sciences Meeting, Portland, OR.

King, RS; Walker, CM; Yeager, AD; Robbins, CJ; Cook, SC; Doyle, RD; Maurer, J; Whigham, DF. 2015. *From microbes to salmonids: Dramatic ecosystem response to low-level dissolved organic carbon additions in an Alaskan headwater stream.* Poster presentation at the Conference on Biological Stochiometry, Ontario, Canada, 2015.

Cook, SC; King, RS; Robbins, CJ; Yeager, AD; Walker, CM; Whigham, DF. 2014. *Macroinvertebrate abundance dramatically increases in response to low-level dissolved organic carbon additions in an Alaskan headwater stream.* Poster presentation at the Joint Aquatic Sciences Meeting, Portland, OR.