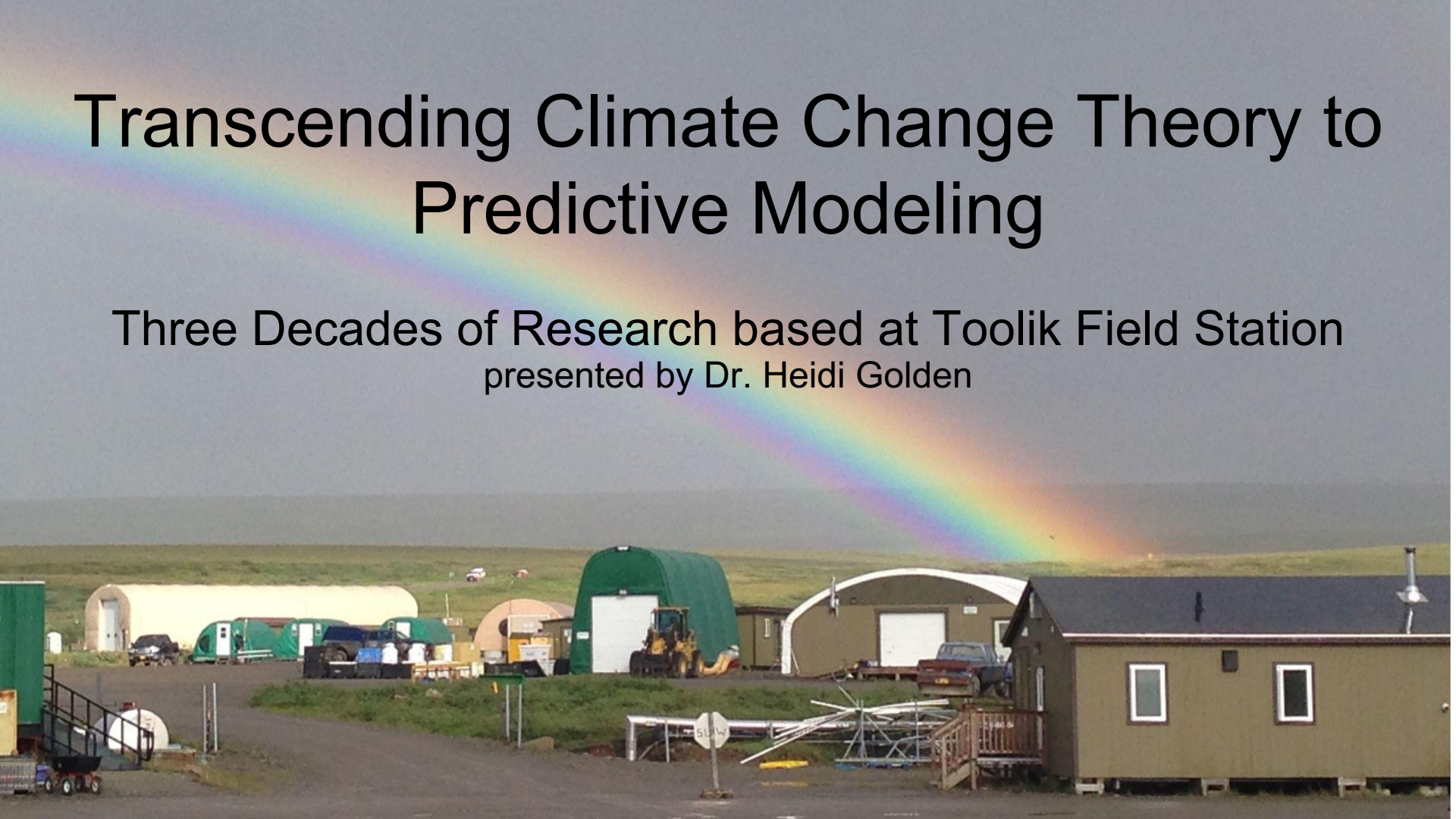
Transcending Climate Change Theory to Predictive Modeling

Three Decades of Research based at Toolik Field Station

presented by Dr. Heidi Golden



Toolik Field Station: Then and Now

1991

2019

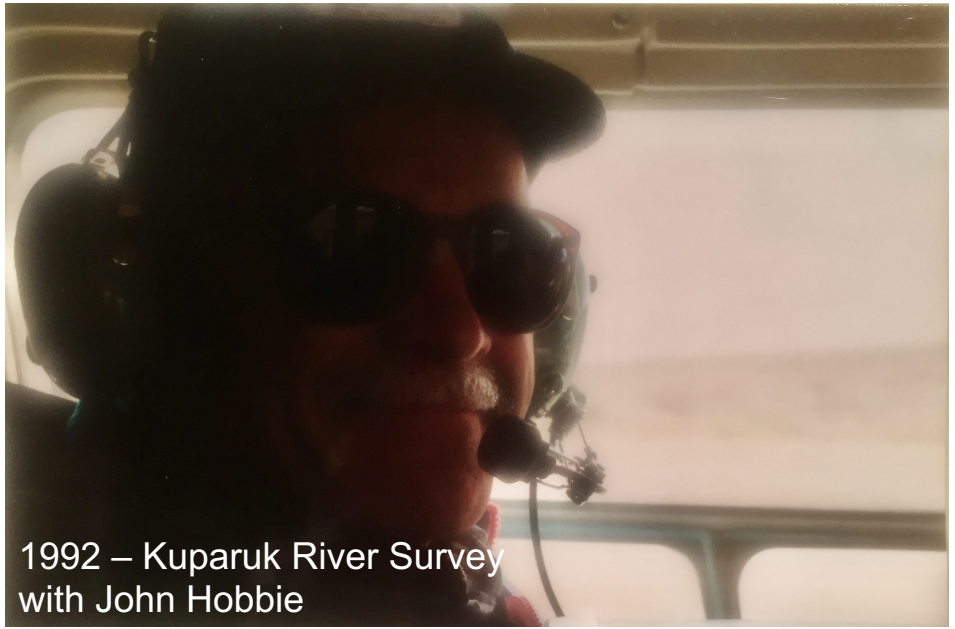
Some things have changed

4th of July

1990's

2015

Some things remain unchanged

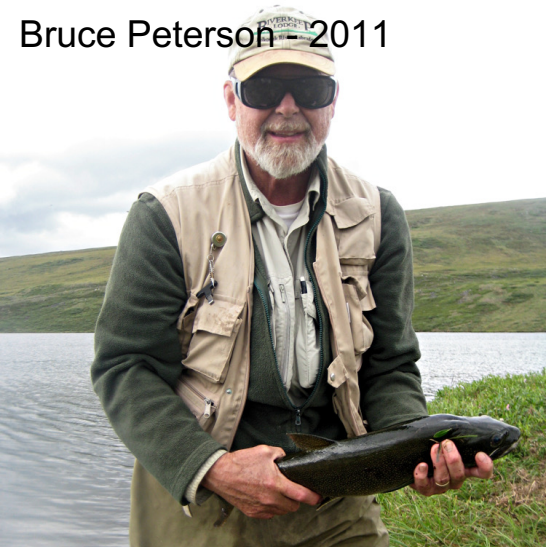


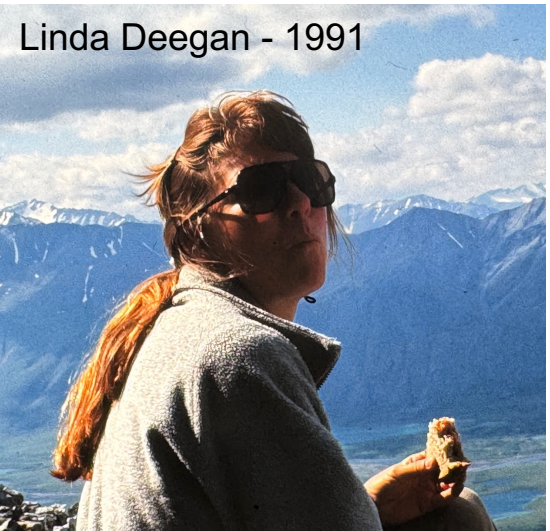
Culture of Collaboration

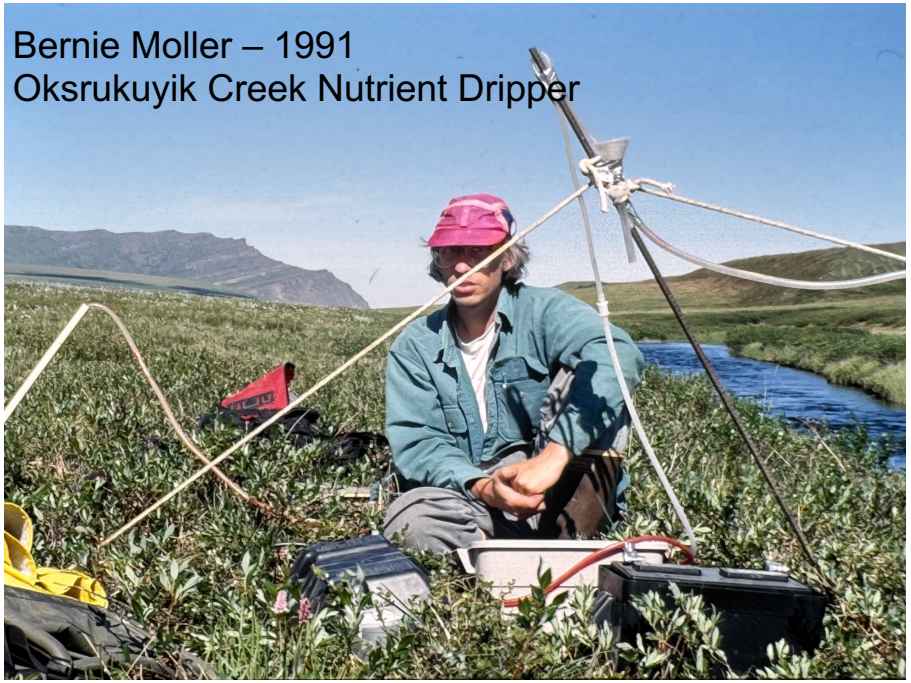
Collaborations
Gaining Skills
Broader Understanding
Life-long relationships

Arctic LTER
Stream Trophic Interactions

1990s


Bruce Peterson – 2011

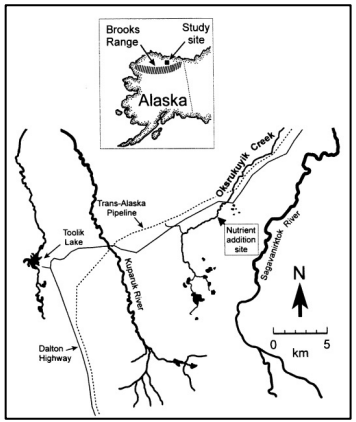

Linda Deegan - 1991

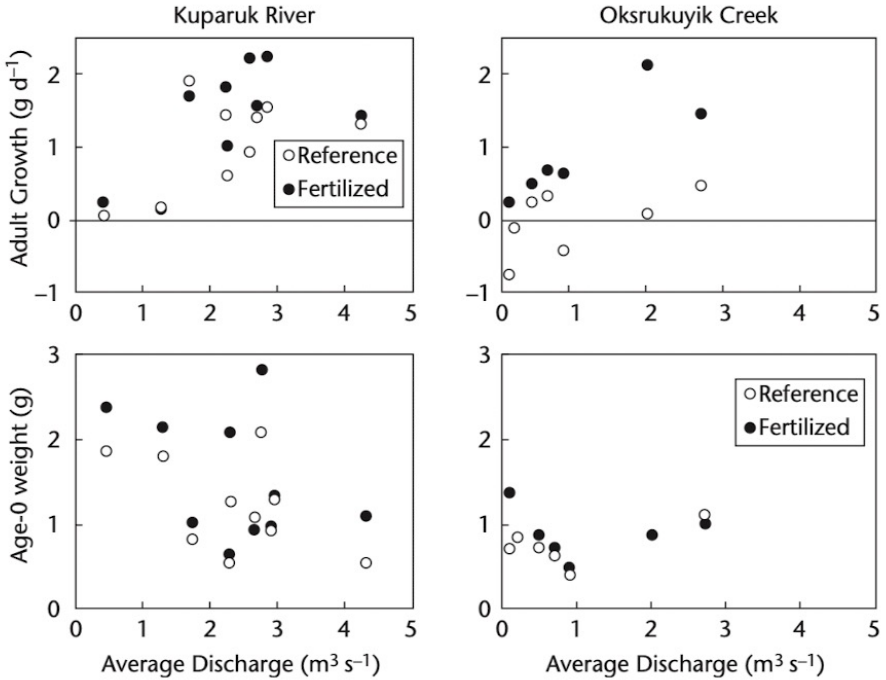

Bernie Moller – 1991
Oksrukuyik Creek Nutrient Dripper


Arctic Grayling

Memory… a 1990's NSF Site Review
NSF Program Officer, "How do you get all this stuff out here to the rivers?"
Bruce Peterson, "We hire strong women."

Life Stage Variation in Growth





Nutrients stimulated production at all trophic levels.
Moss dampens bottom-up trophic cascades.

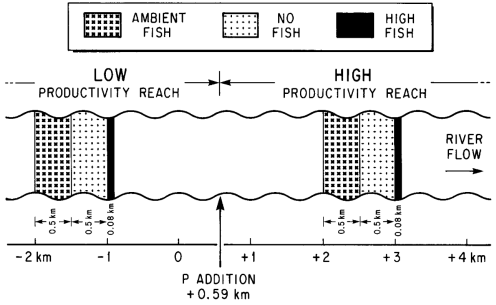
Fish growth is resource limited
Strongly influenced by River Discharge and Temperature.

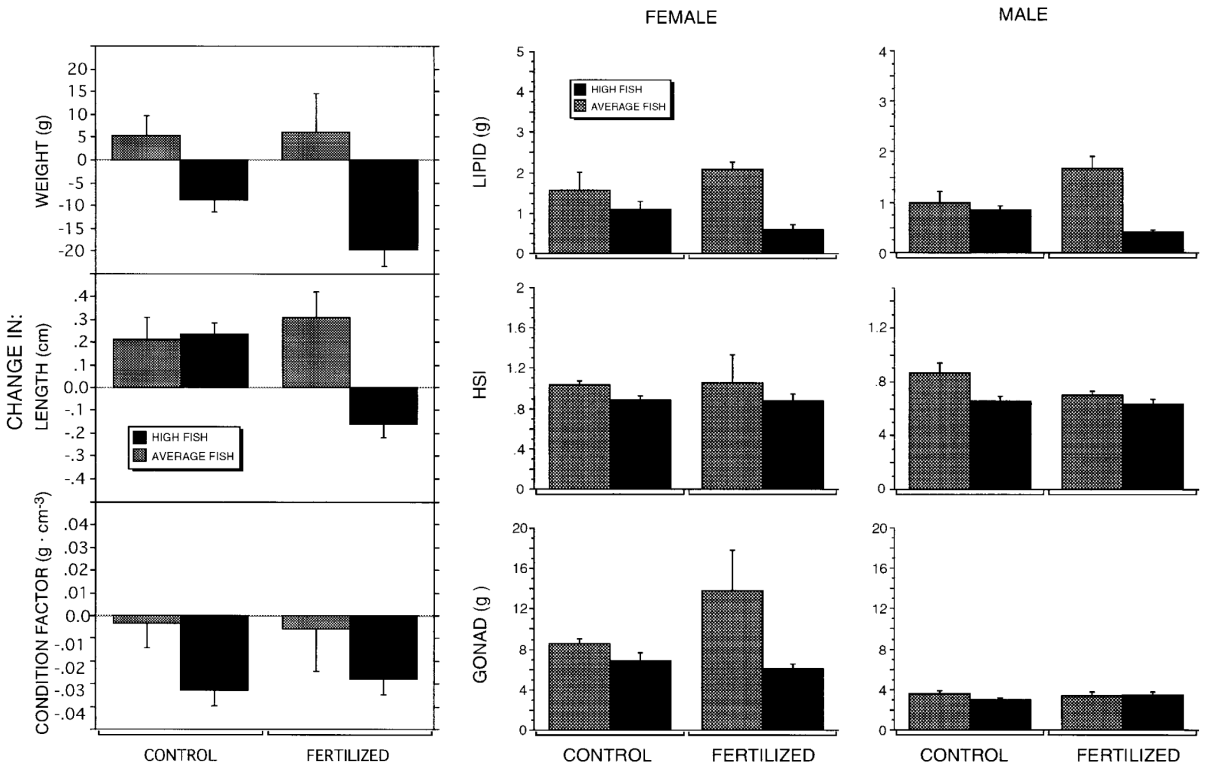
High discharge favors adult growth, low discharge/high temperature favors Age-0 growth.

Evolution of a life history well suited to Arctic environmental variability.

Deegan et al. 1999

Density Dependence, Growth, and Vital Rates

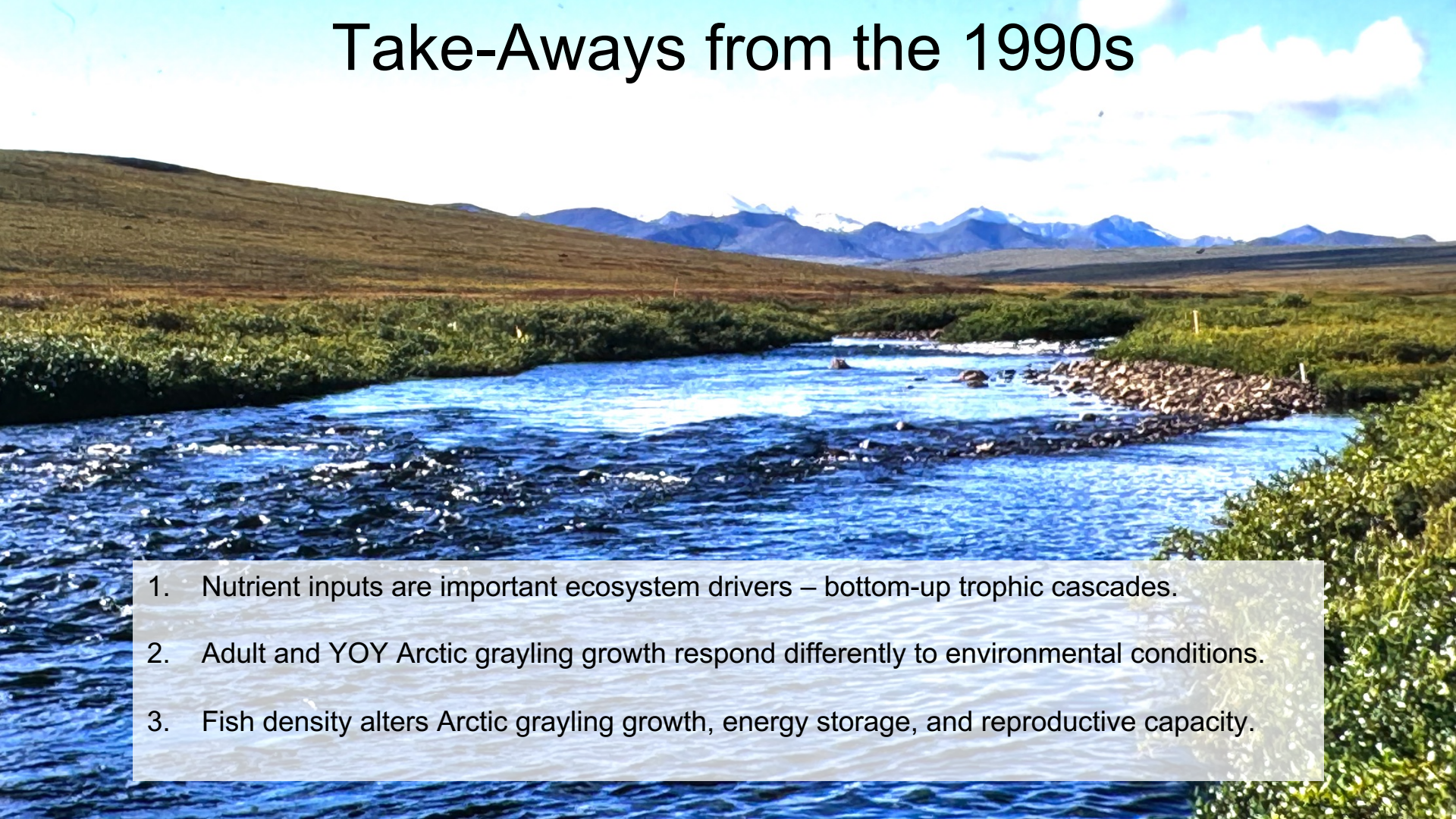




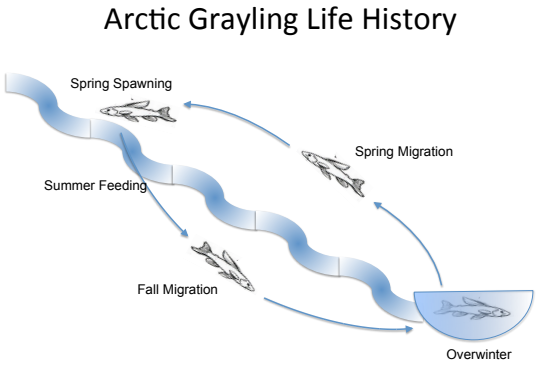
High Fish Density >> Reduced Growth, Energy Storage, Reproductive Capacity

Deegan et al. 1997

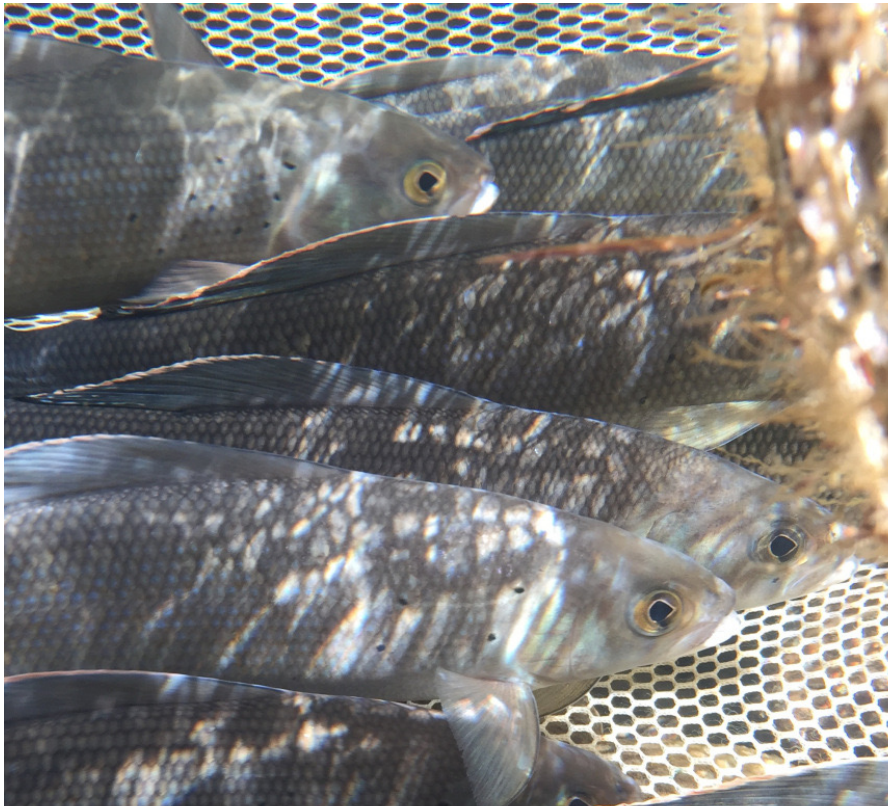
Take-Aways from the 1990s



1. Nutrient inputs are important ecosystem drivers – bottom-up trophic cascades.
2. Adult and YOY Arctic grayling growth respond differently to environmental conditions.
3. Fish density alters Arctic grayling growth, energy storage, and reproductive capacity.

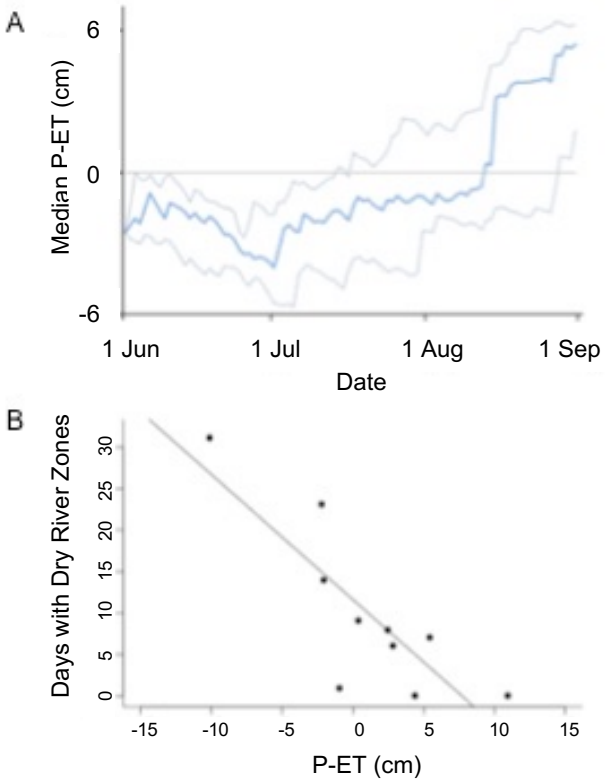


Fast Forward to 2006



Memory: Catching fish with Justin Johnson

Changing Aquatic Connectivity



Kane et al. 2004; Hinzman et al. 2005

Decreased P - ET >> Increased River Drying

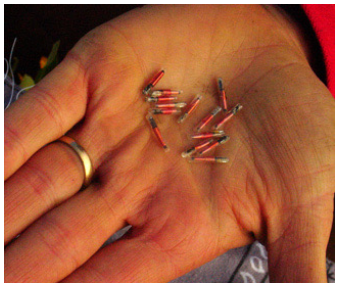
FishScape 2009 - 2017

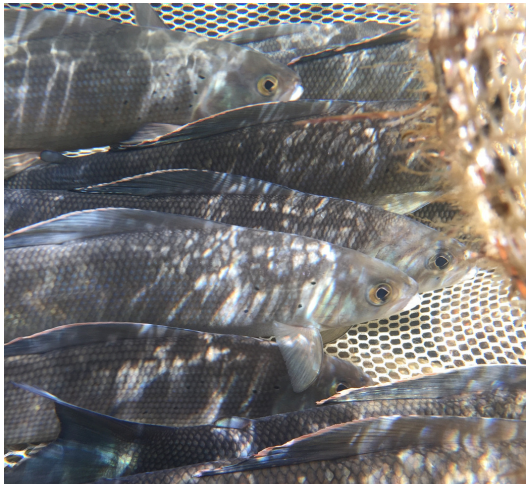
Monitoring Fish Movement
Aquatic Connectivity
Stream-Lake Trophic Subsidy
Landscape Population Genetic Structure
Local Trait Adaptation (Evolution)

Woodwell Climate Research Center

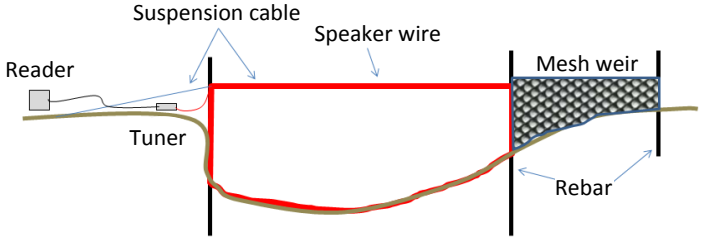
University of Connecticut 1881

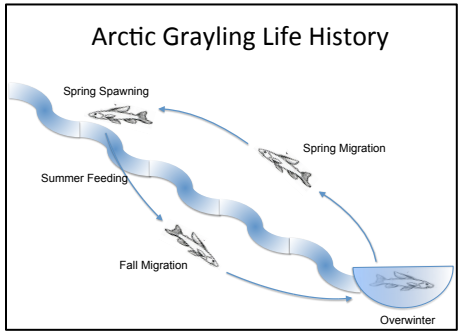
Monitoring Fish Movement Patterns



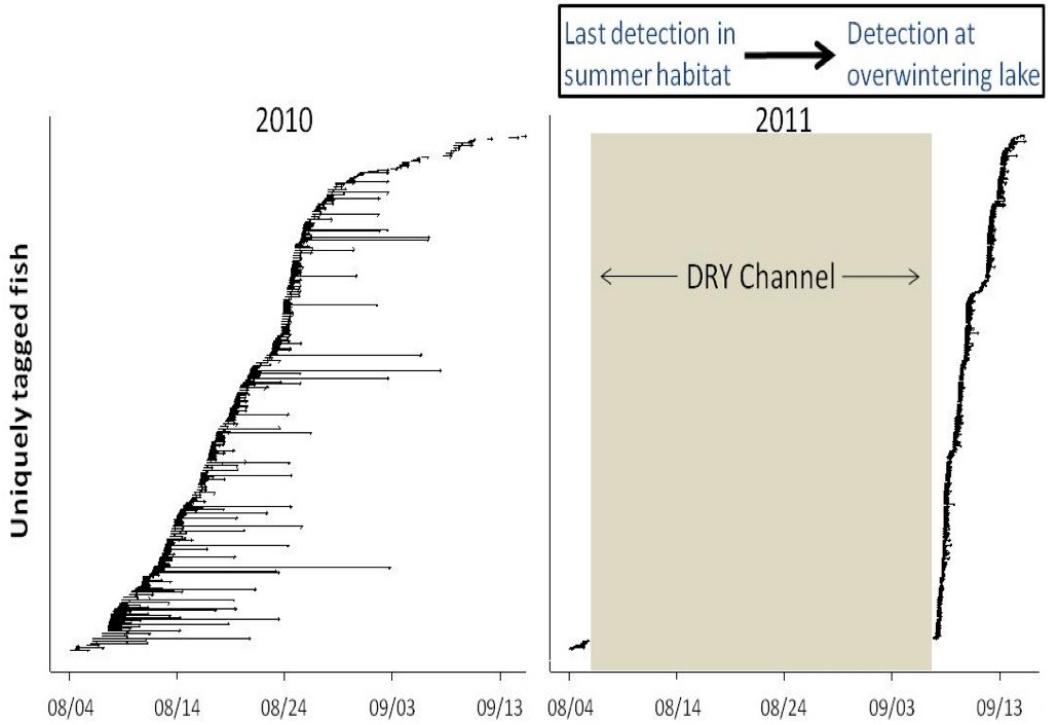


PIT-Tag Antennas





River Drying Alters Fall Migration



Unobstructed

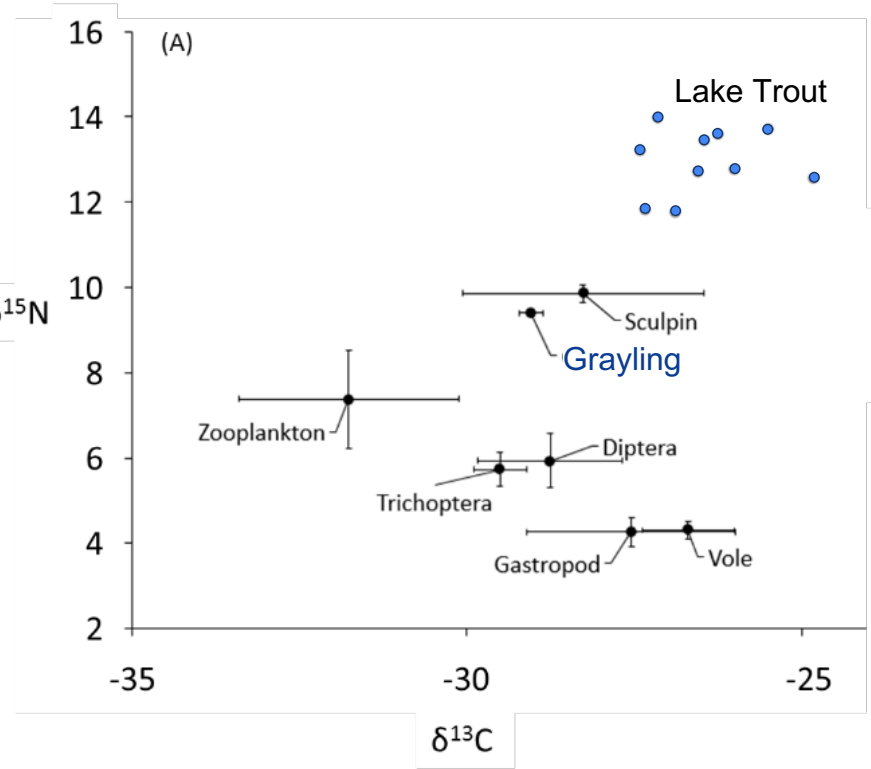
Obstructed

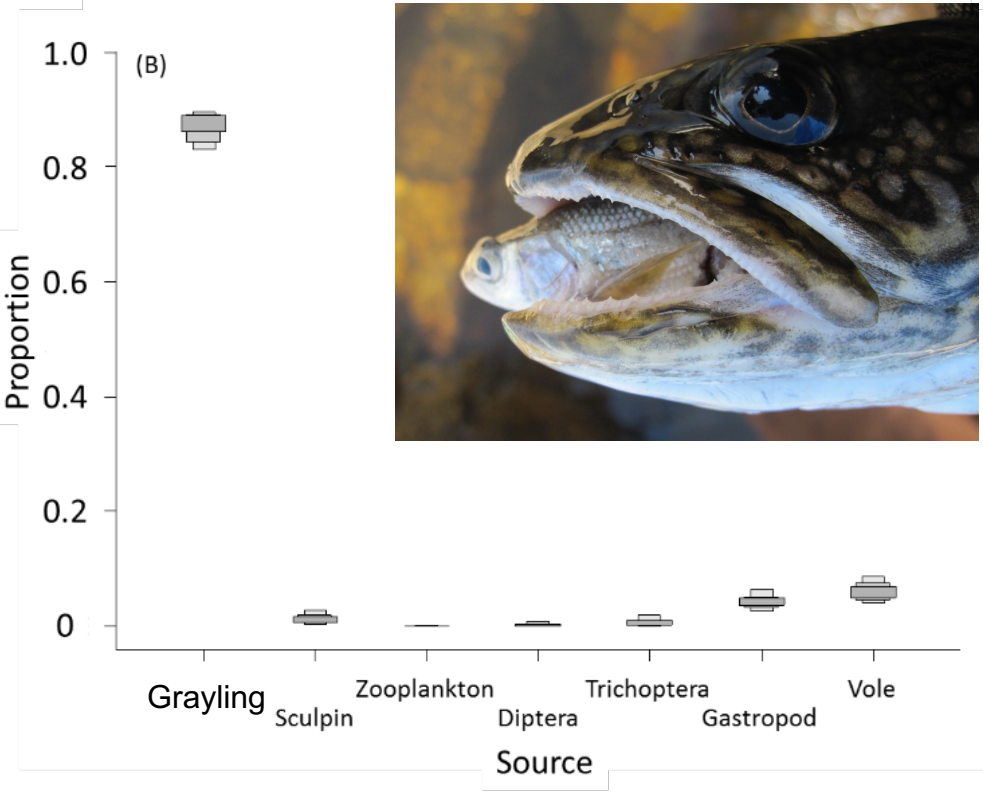
Lost ~ 30 grams

Population Vital Rates

Overwinter survival?
Next season's year class strength?

Stream-Lake Trophic Subsidy

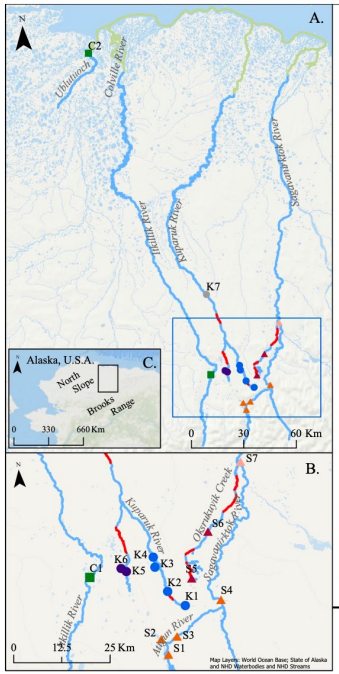


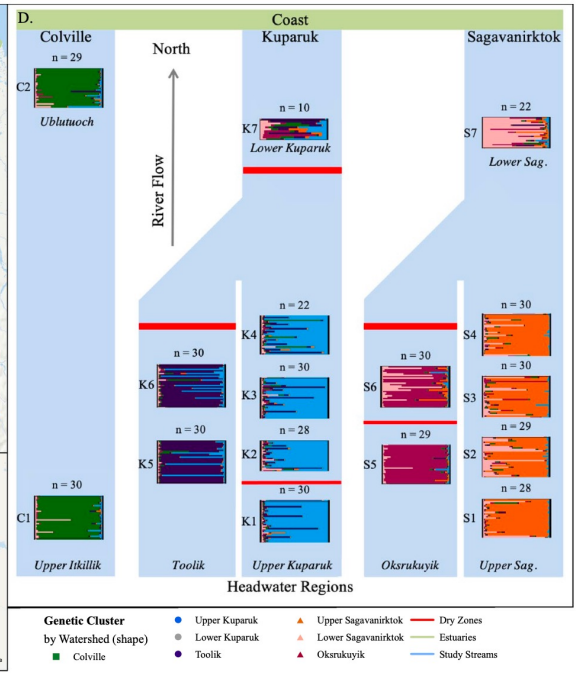


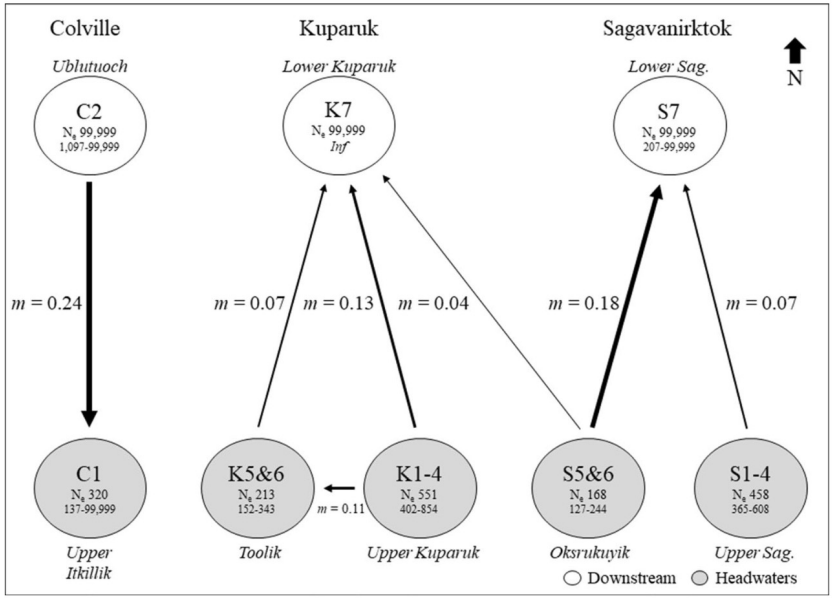
Arctic Grayling Transport Nutrients from Stream to Lake Communities

Deegan et al. (unpub)

Landscape Population Genetic Structure



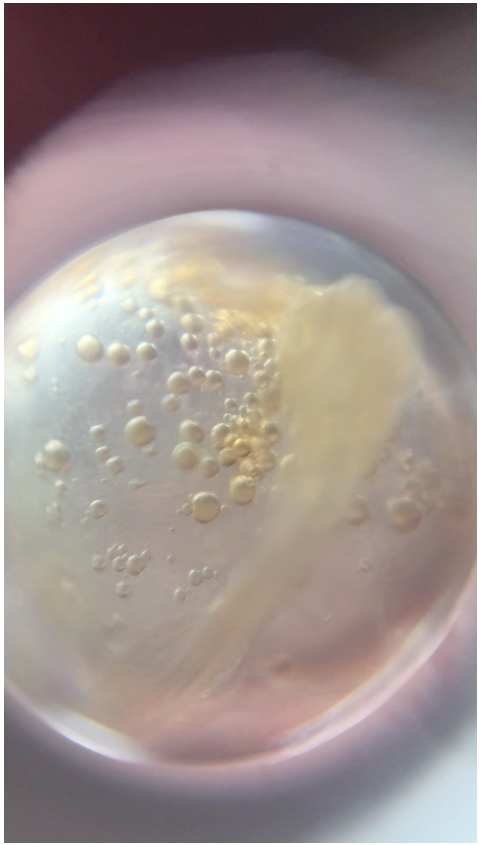


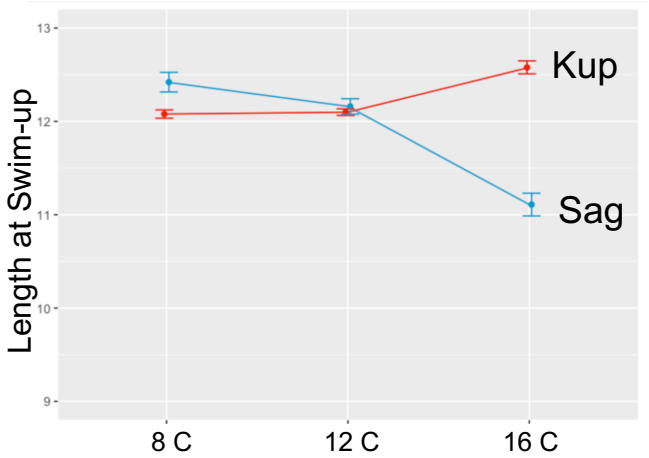


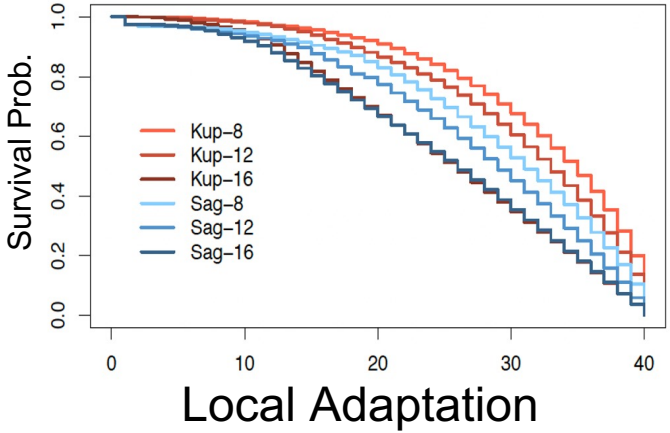
Small semi-isolated headwater populations
Downstream biased gene flow
Large genetically diverse coastal population

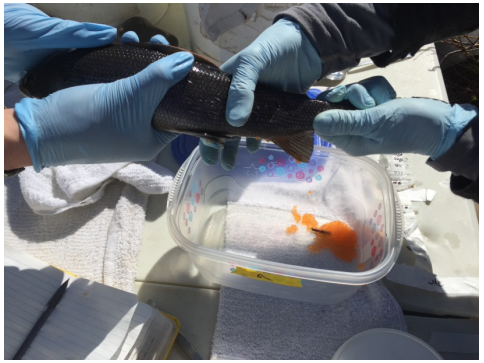
Golden et al. 2021

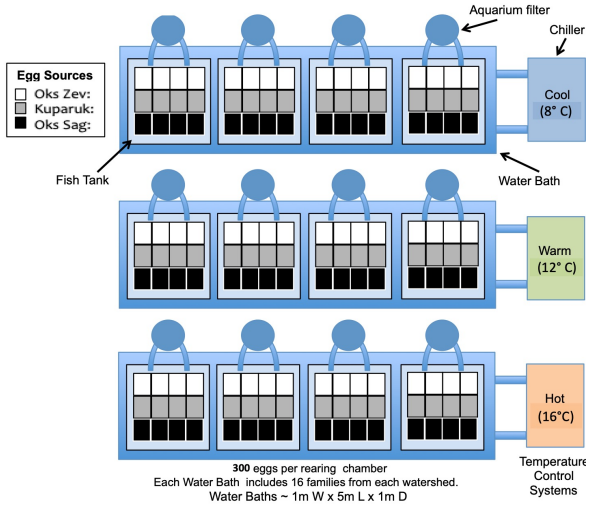
Linking Genetics to Early Life History Traits











Conceptual Model

1. Bottom-up trophic cascades.
2. Responses to environmental conditions.
3. Changes in vital rates.
4. Changes to movement and dispersal
5. Impacts on vital rates
6. Trait evolution
7. Changes to trophic subsidies

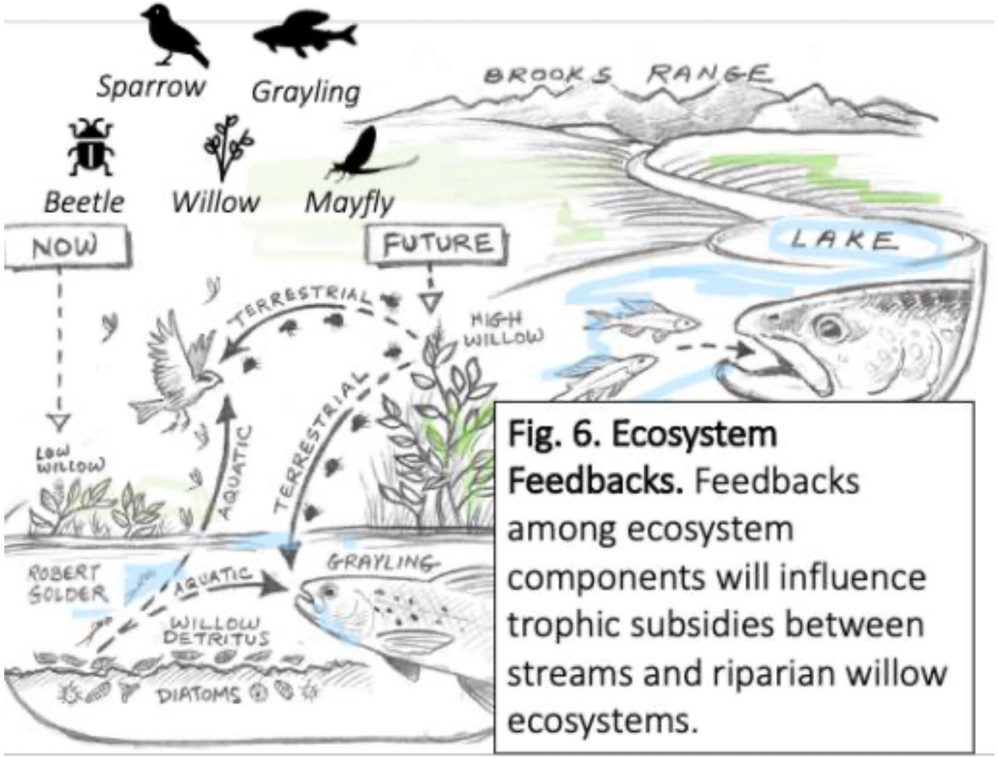


Fig. 6. Ecosystem Feedbacks. Feedbacks among ecosystem components will influence trophic subsidies between streams and riparian willow ecosystems.

Artwork: Robert Golder

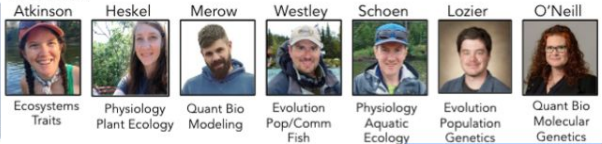
Predictive Models of cross-ecosystem function that include species trait evolution

EVOME

Evolving Meta-Ecosystems Institute

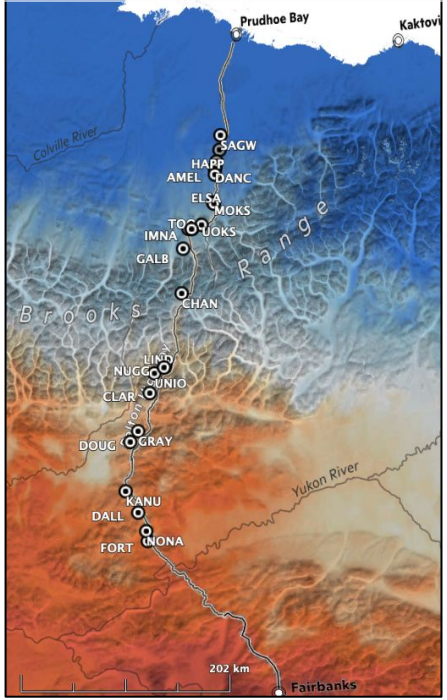
Executive Committee

Science Team



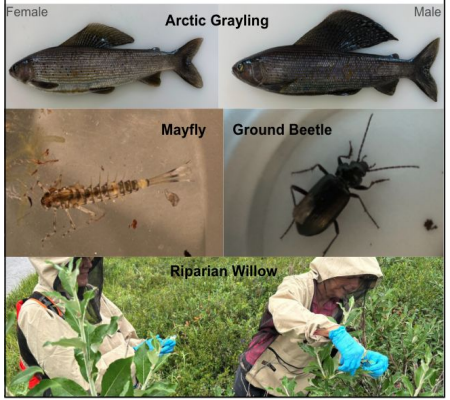
Advisory Board

EVOME Sites: Latitudinal/Thermal Gradient



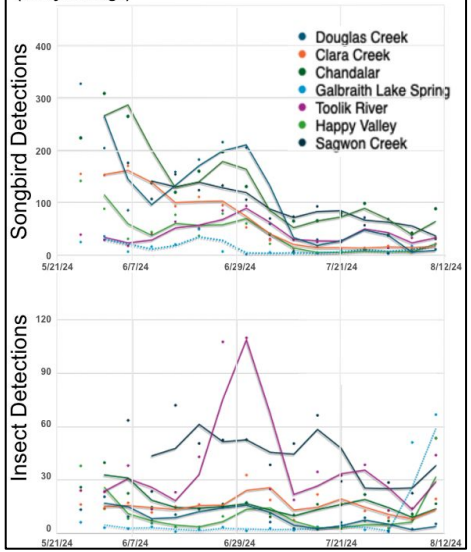
First Annual EVOME All-Team Meeting

Reference Genome Sequencing

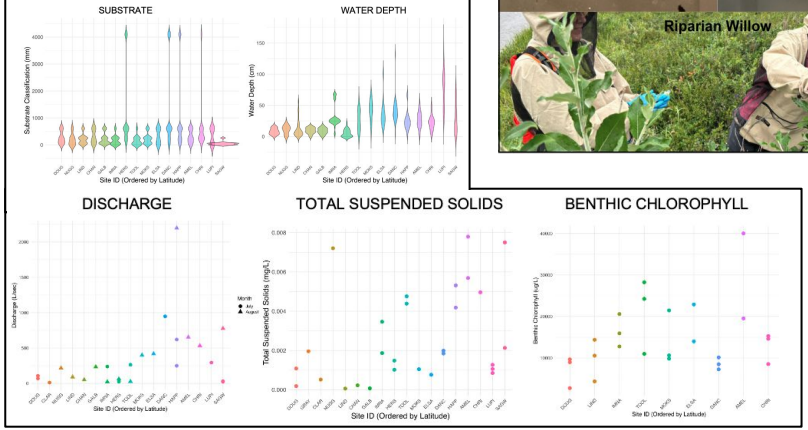


Songbirds and Insects Phenology

(5-day average)



Stream-Riparian Site Characteristics



NSF

Woodwell Climate Research Center

University of Connecticut 1881

UAF University of Alaska Fairbanks

Columbia University

Alabama Crimson Tide

Macalester College Est 1874

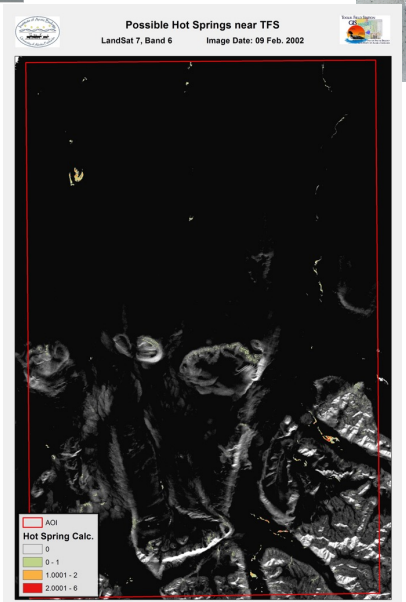
A key mystery in your field that we have solved?

We found multiple populations of Arctic grayling on the North Slope, with the lowest genetic diversity and greatest genetic distance among populations in the headwaters and with downstream dispersal to a large coastal population.

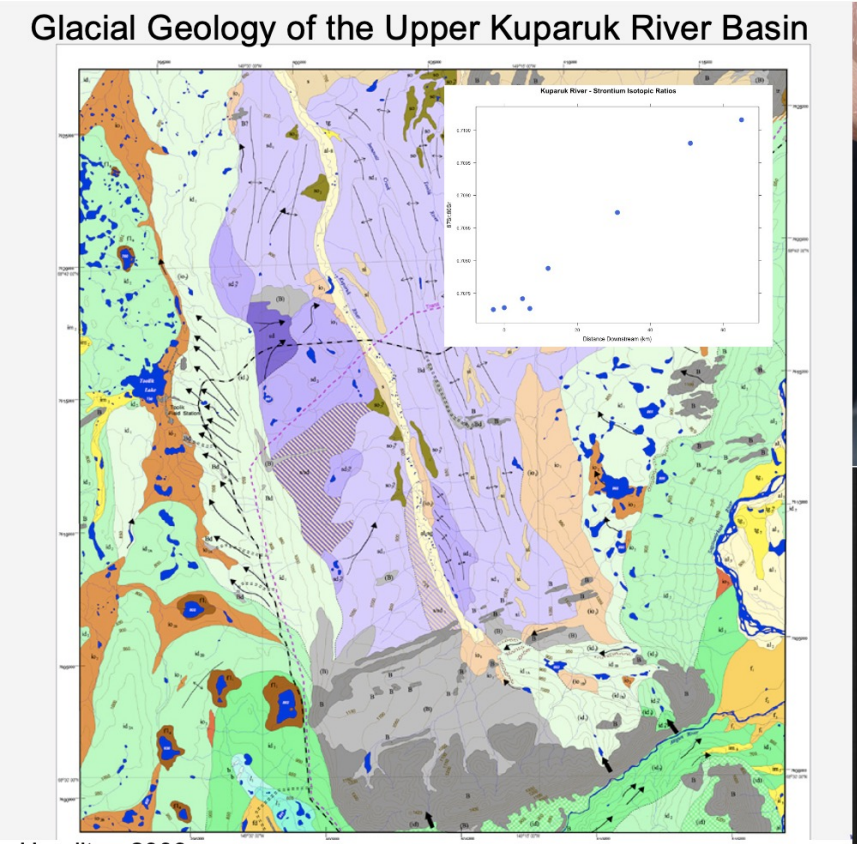
This is significant because unidirectional dispersal of unique genotypes might provide a downstream genetic reservoir for selection to act upon in the future, such as under climate change conditions.

However, small population size and low genetic diversity in headwater populations leave them susceptible to local population extinction.

An “Ah Ha” moment while at Toolik.


Possible Hot Springs near TFS
LandSat 7, Band 6
Image Date: 09 Feb. 2002
AOI
Hot Spring Calc.
0
0 - 1
1.0001 - 2
2.0001 - 6

Otolith Microchemistry ^{87}Sr :^{86}Sr



Hamilton 2003

What mysteries remain?

How will Climate Change influence susceptibility of Arctic fish to disease and parasites?

Images from 2022 ArcLTER Kuparuk River Arctic Grayling Survey

We return to GCL Aug - Sept 2025 to reassess this population.