Arctic LTER Project

Arctic Streams in a Changing Climate

The Streams Research Group

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University of Vermont

Arctic LTER Mid-Term Review
18 June 2013

The Arctic LTER Streams Team

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- Heidi Golden, University of Connecticut (Ph.D. Student)
- Michael Kendricks, University of Alabama (Ph.D. Student)
- Julia Larouche, University of Vermont, Ph.D. Student
- Sam Parker, University of Vermont (Ph.D. Student)
- Jeff Kampman, Murray State University (M.S. Student)
- Adam Wloskowski, University of Vermont (M.S. Student)
- …and numerous REU, graduate, and co-PI alumni

Streams interpretation of the overall ArcLTER goal

What we hypothesized: "Our overarching hypothesis is that arctic headwater streams are poised to undergo – and may have already begun – a phase of adjustment to climate warming that will substantially alter the hydrologic, nutrient, and sediment regimes in stream ecosystems in ways that will significantly change their biotic structure and ecological functions."

What we proposed:

- Long-term monitoring
- Effects of long-term fertilization
- Hydrologic disruption of stream food webs
- Stream structure and habitat quality in a changing arctic landscape

Mapping ArcLTER Objectives to Streams Research

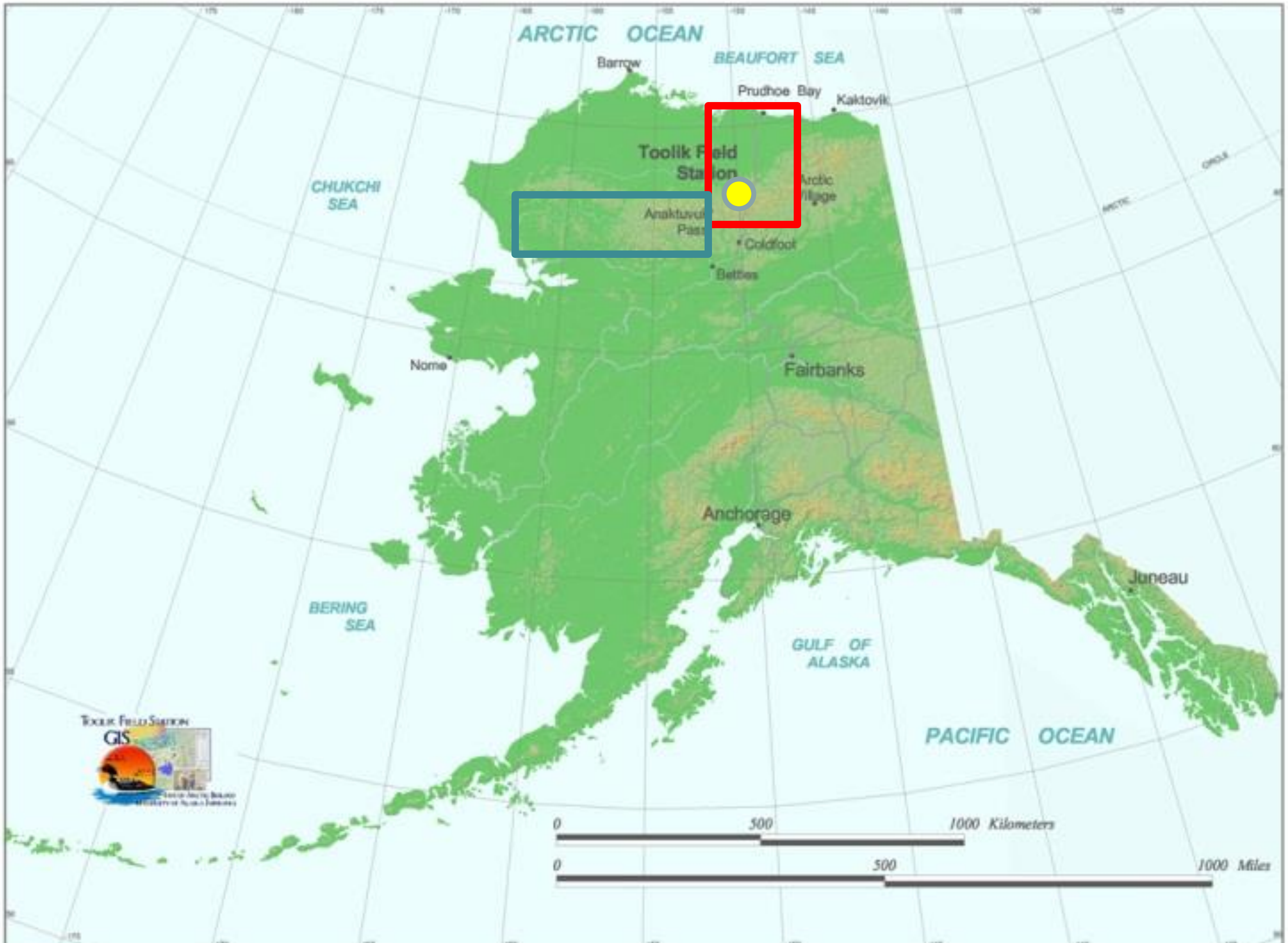
ArcLTER Shared Objectives

1. How does climate control ecosystem states, processes, and linkages?
2. How do disturbances change ecosystem states, processes, and linkages?
3. How do climate and disturbance interact to control biogeochemical cycles and biodiversity at catchment and landscape scales?

Take home messages about the Streams research (This talk)

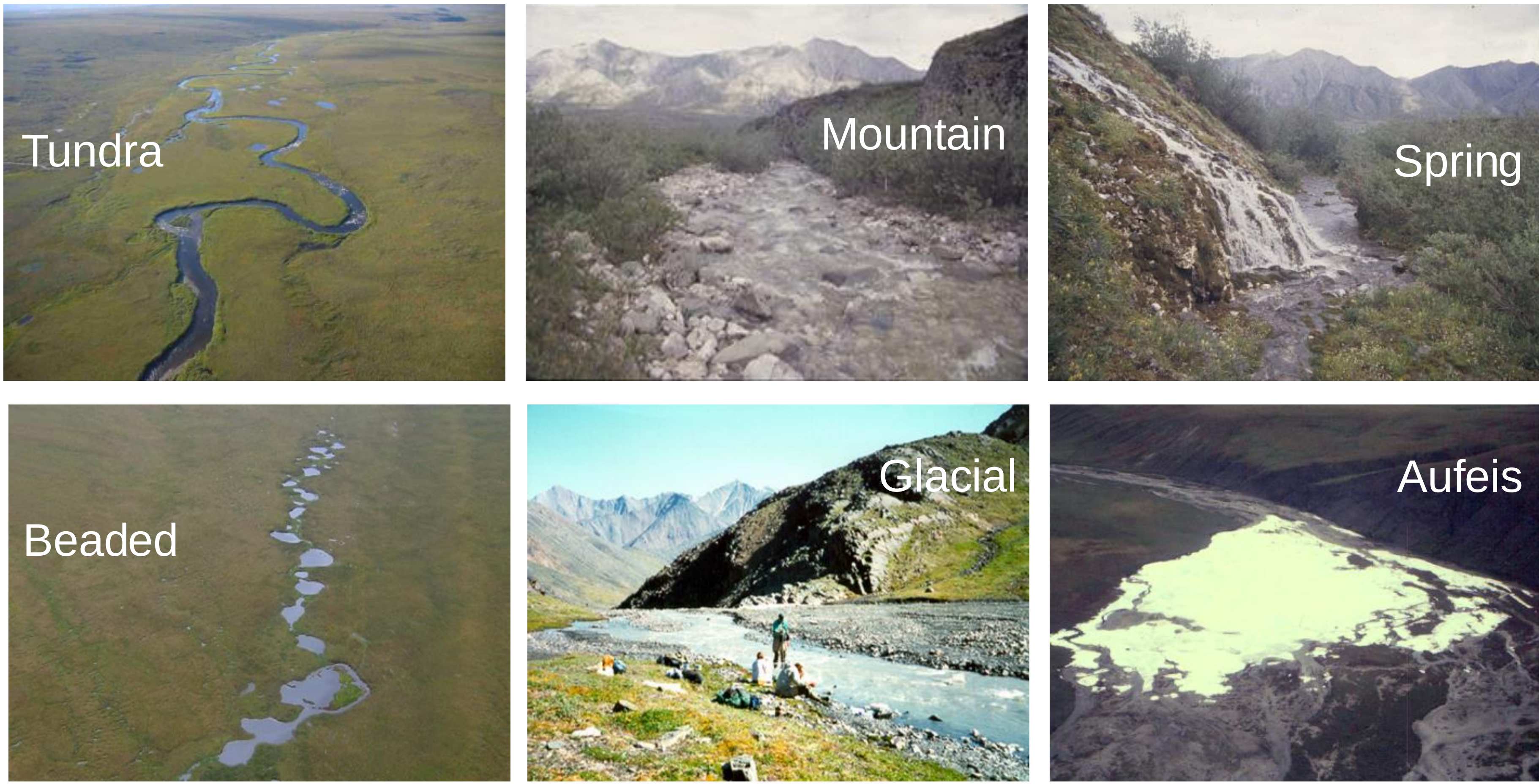
- Foundations
  - The disturbance template
  - Bottom up and top down effects
  - The hyporheic influence
- Current research
  - Arctic stream biogeochemistry in a changing climate
  - Arctic stream ecology in a changing climate
- Synthesis and integration

Where we've worked



Toolik Field Station GIS Map Archive

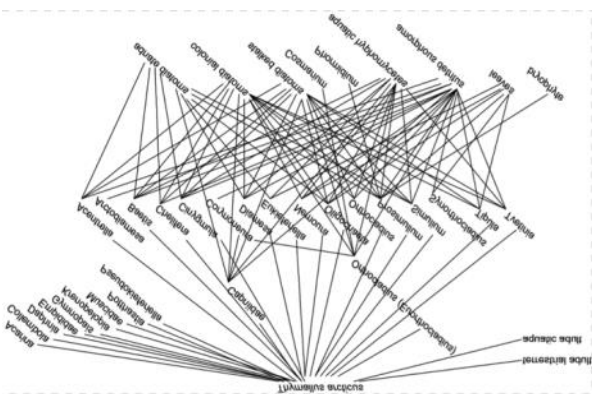
Foundation:
Arctic Stream Types



Bowden et al. (2013) ArcLTER Synthesis

Characteristics of Arctic Streams

- High inter- and intra-annual variability in discharge
- In general, oligotrophic and unproductive, but…
- Specific stream types do differ
- Fewer food web components, but…
- Reasonably complicated food web interactions



Kuparuk River, Parker (2008)

Thymallus arcticus , M. Kendricks

Take Home Message:
A Habitat Template for North Slope Streams

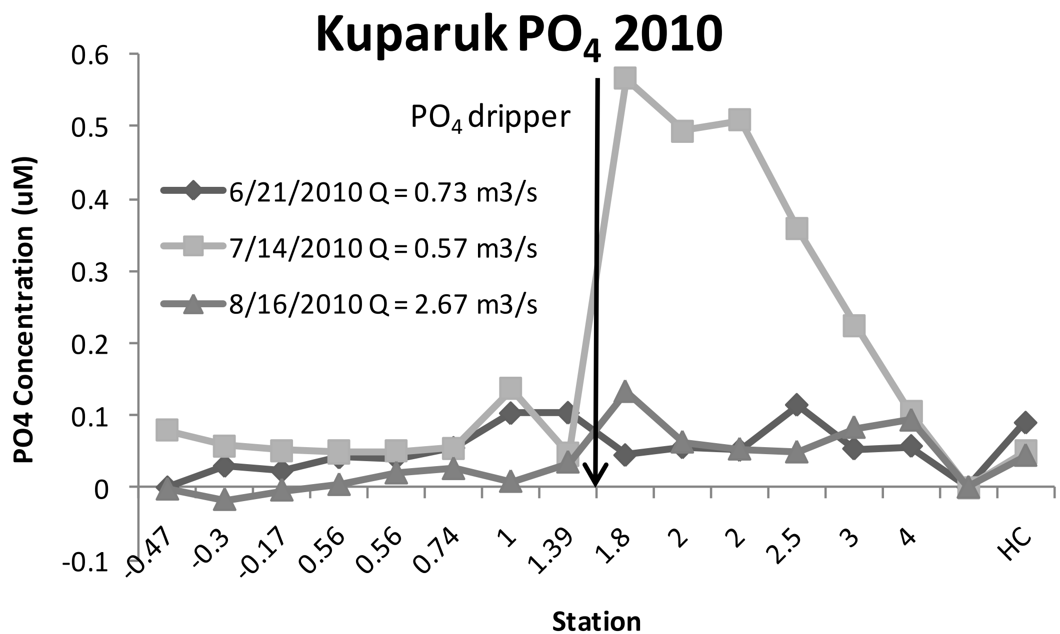
- Major driver: substrate disturbance from variable discharge events
- Major driver: freezing conditions (tipping point for freezing during winter)
- Minor driver: oligotrophic conditions

Discharge and freezing are "climate-susceptible" drivers

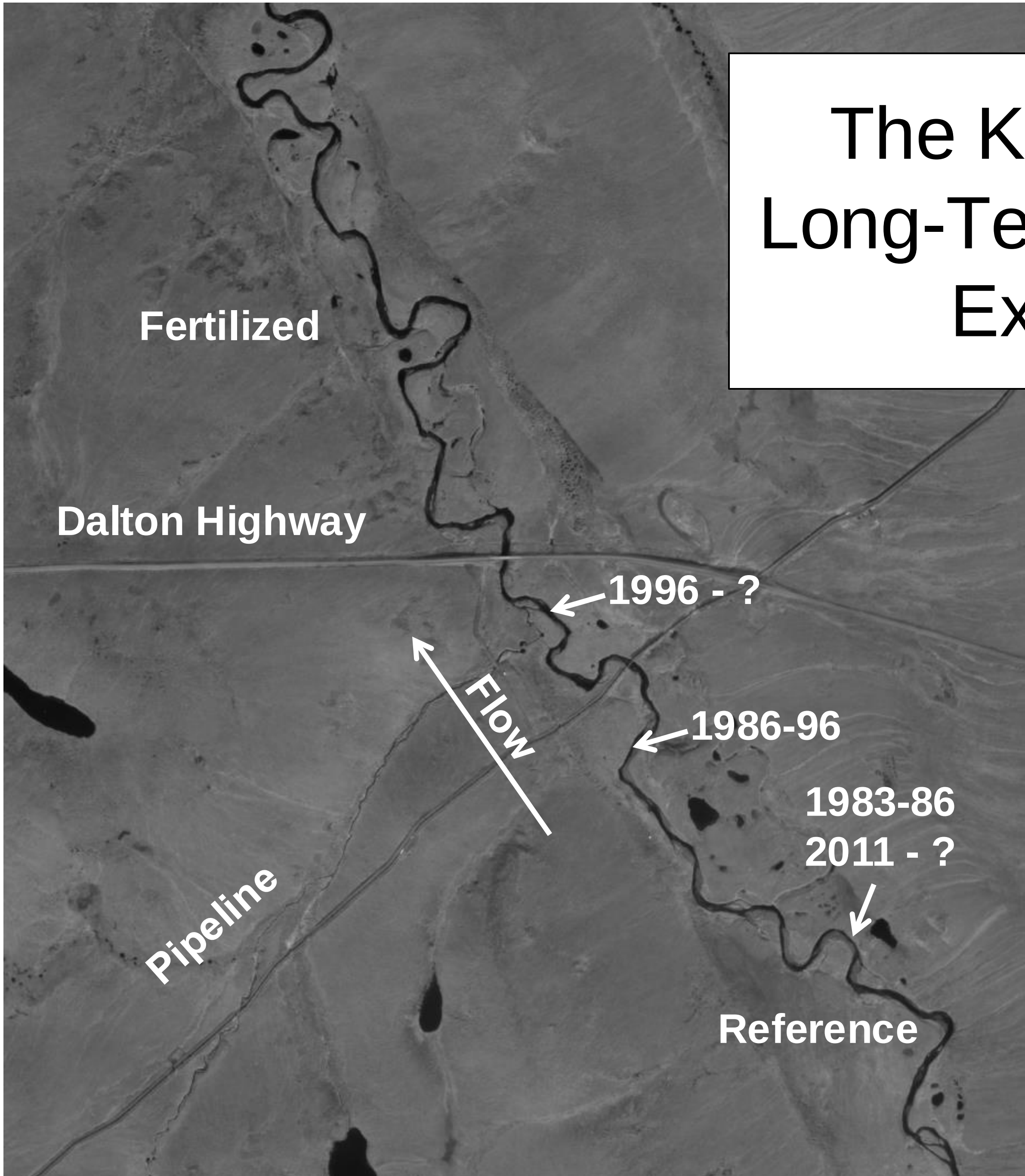
Parker and Huryn (2011)

Foundation:
Nutrients are not *un*important

Simple Phosphorus "Dripper" Experiment



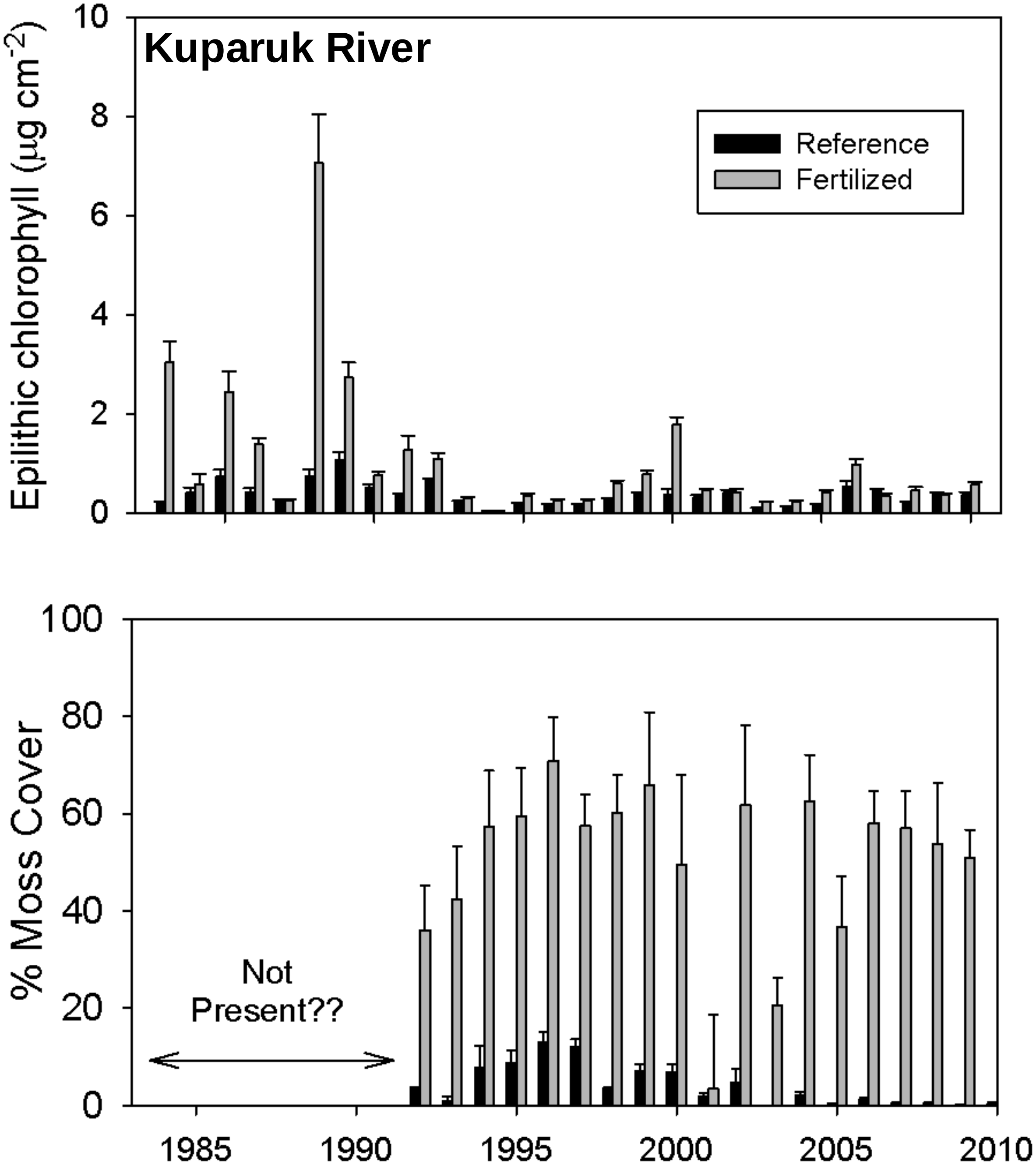
The Kuparuk River Long-Term Fertilization Experiment



1983 to present

Our 30th year coming up!

The benefits of LTER monitoring

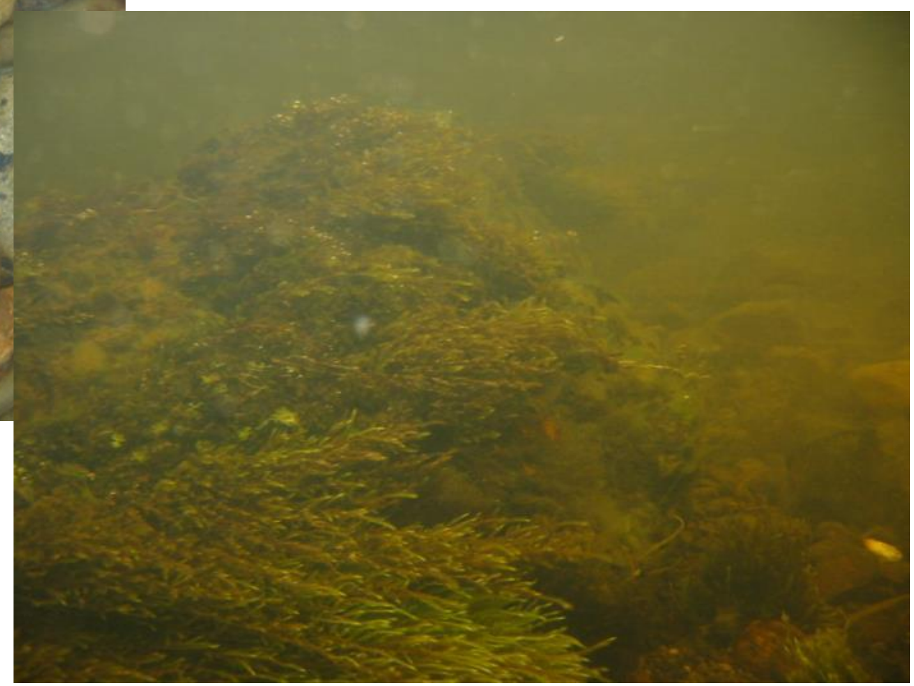


Updated from Slavik et al. (2004)

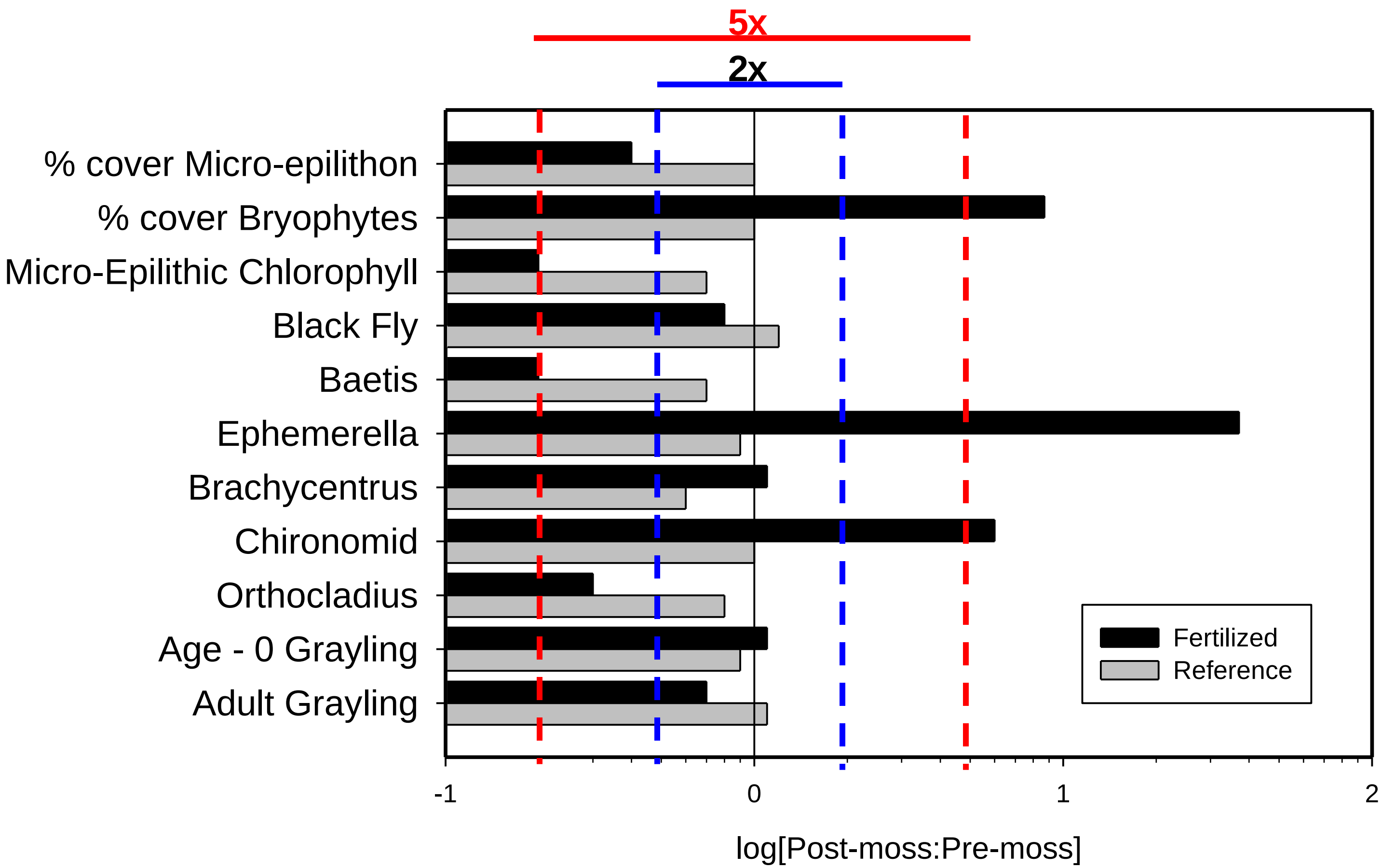
Long-term low-level fertilization with P has significantly altered the Kuparuk ecosystem

Reference reach substrate

Fertilized reach substrate



Summary of Bryophyte Effects on Stream Ecosystems

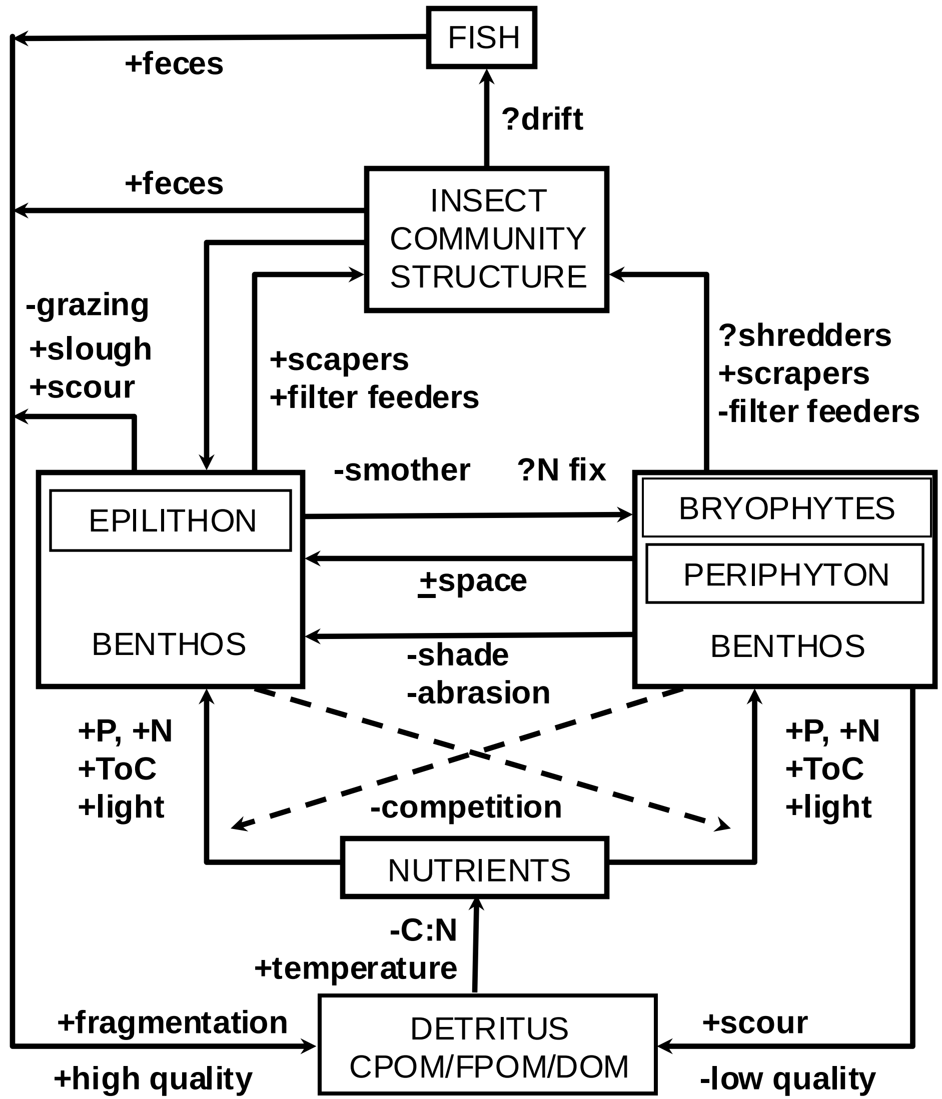


Slavik et al. 2004

Take Home Message

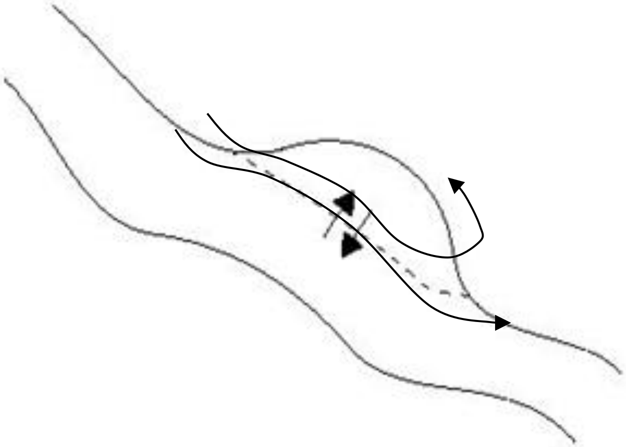
Bottom-up
and
Top-down
Influences on
Stream Ecosystems

Stream Bryophyte Group (1999)

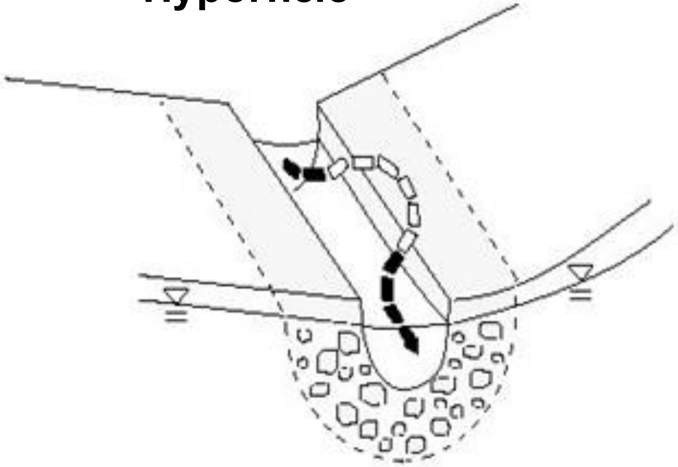


Foundation:
Transient Storage Dynamics in Arctic Streams

Lateral eddies



'Hyporheic'

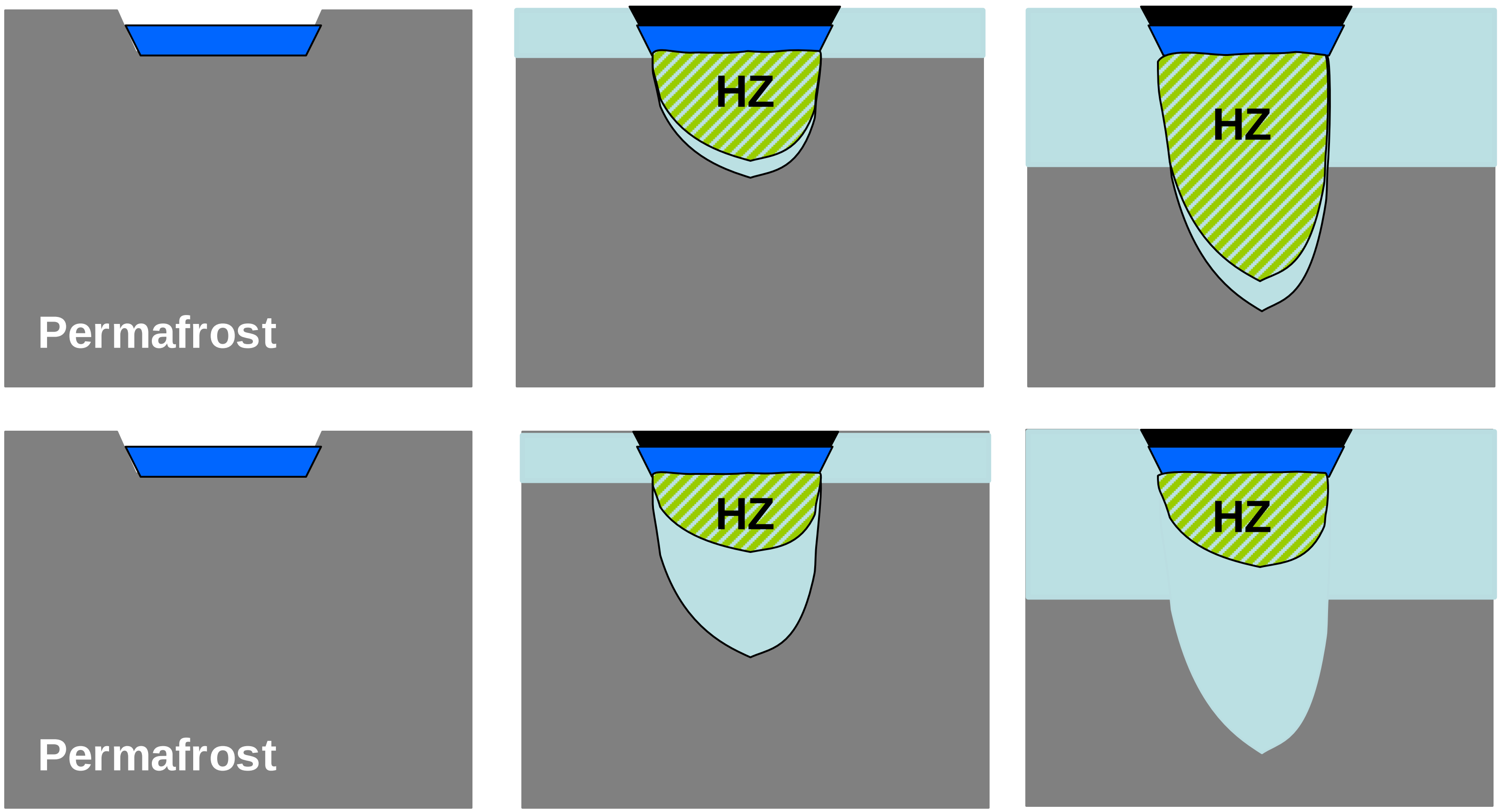


From Runkel (1998)

Why is the hyporheic zone of interest?

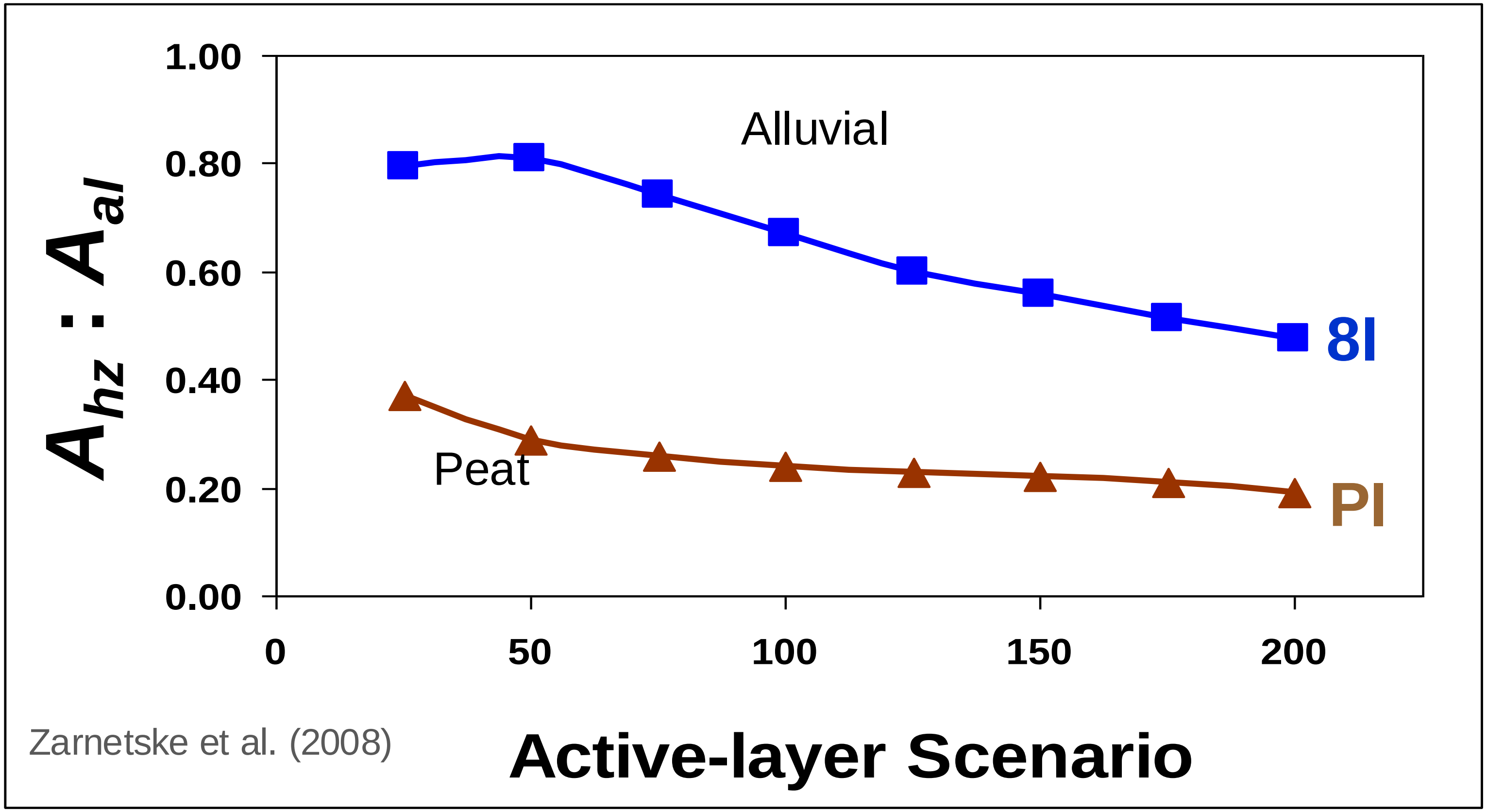
- In some places, unique organisms live there
- Considerable biogeochemical cycling goes on in the hyporheic zone – gravel filter
- There is good reason to think that climate warming could change the nature of hyporheic processing in permafrost-dominated streams

Primary Question



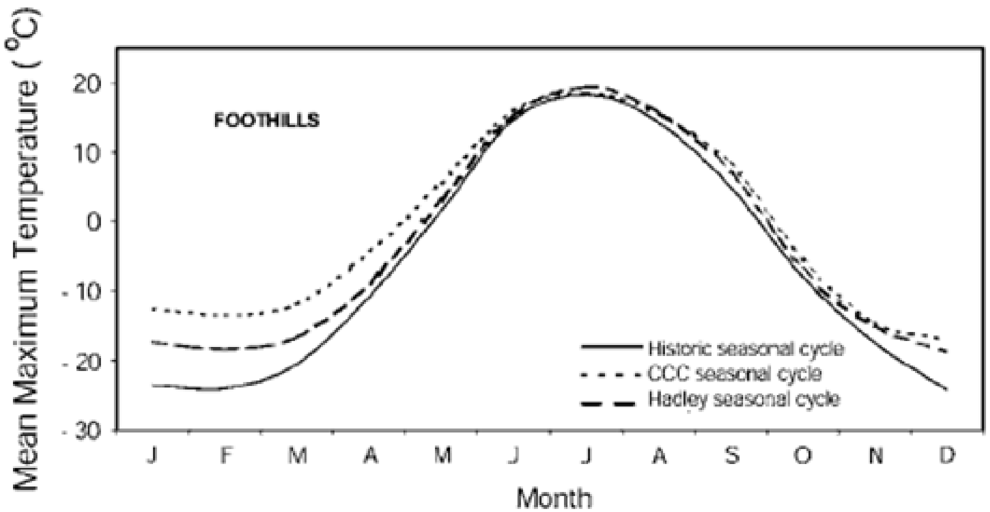
As the extent of the active-layer increases through a thaw season, does the physical extent of the HZ also increase?

Take Home Message: Only a portion of the thaw bulb is hyporheic

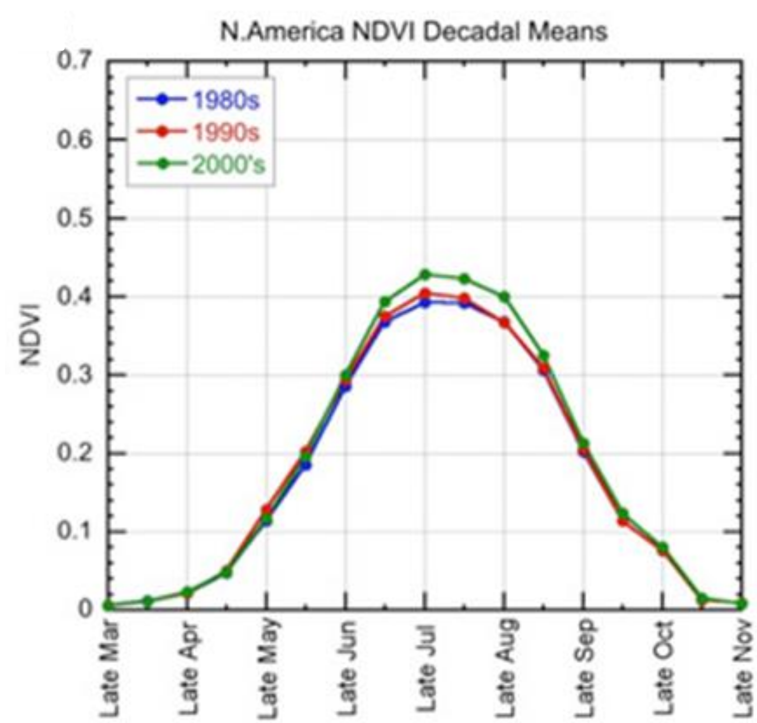


- Rate of change for both sites decreases as they approach 200%
- 8I alluvial HZ exchanges across more of the active-layer
- Morphology important to HZ exchange utilization of potential area

Changing Seasonality rather than Warming *per se*, is the Key Driver

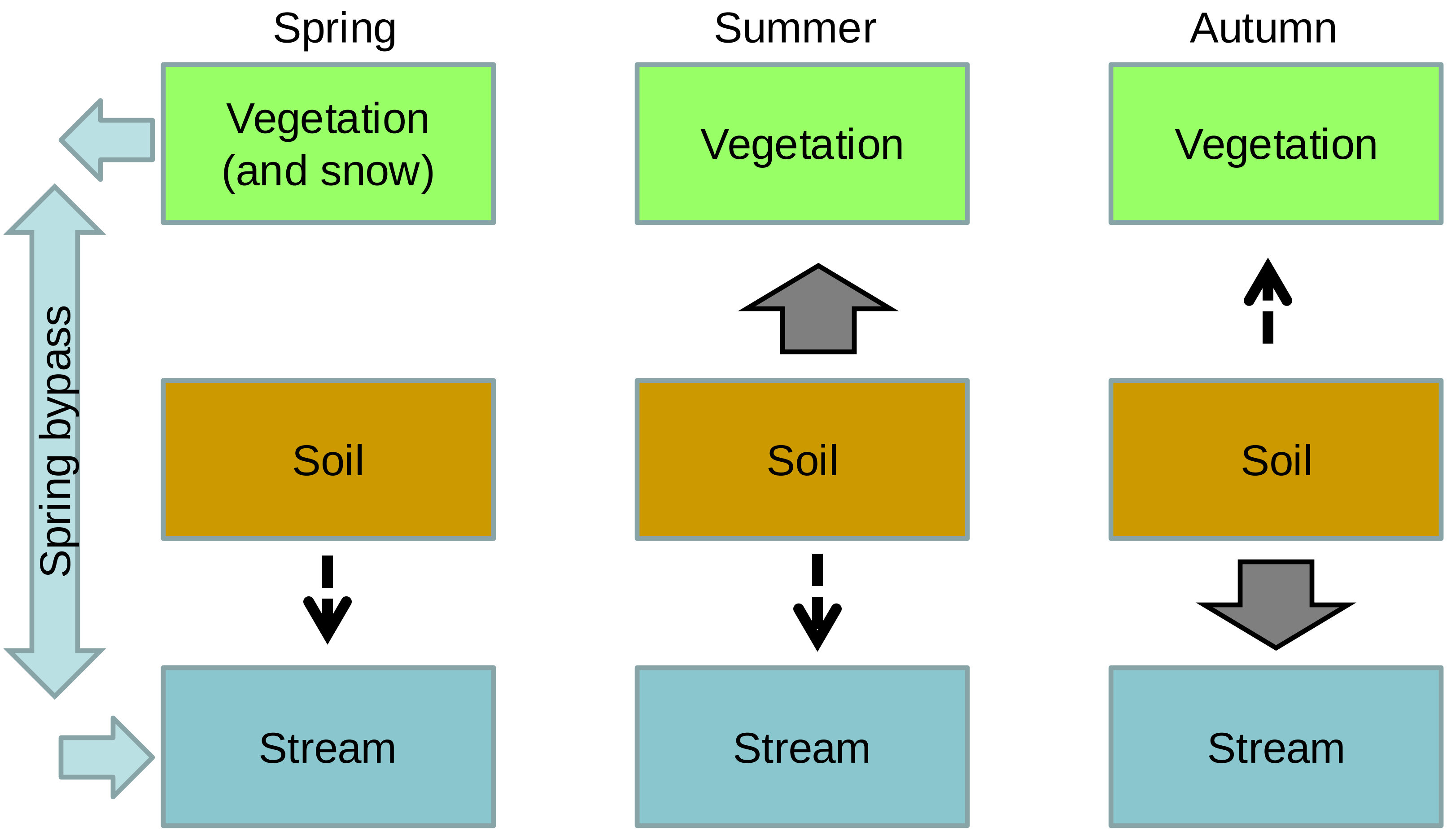


Kittel et al. (2011)

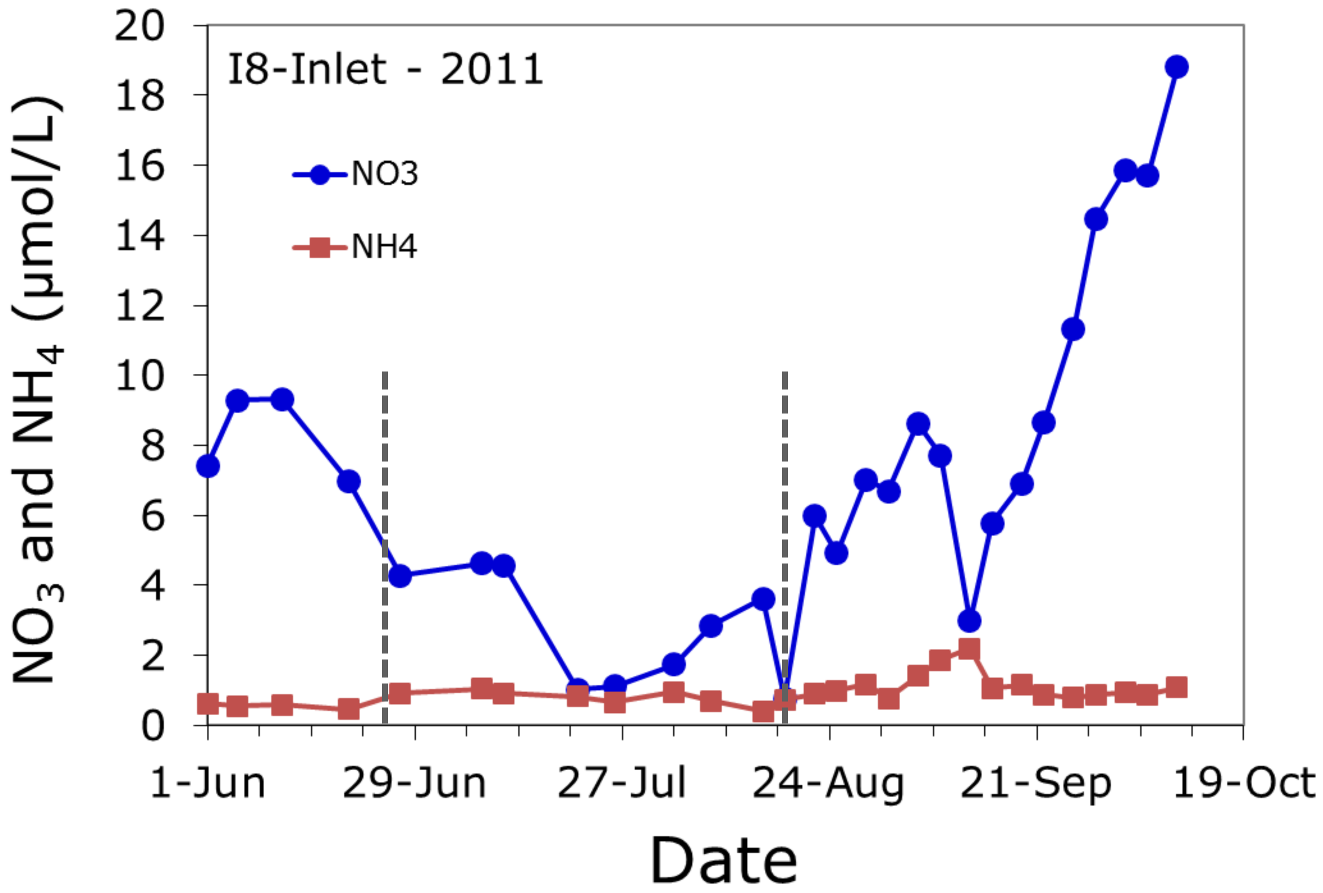


Walker et al. (2011Arctic Report Card)

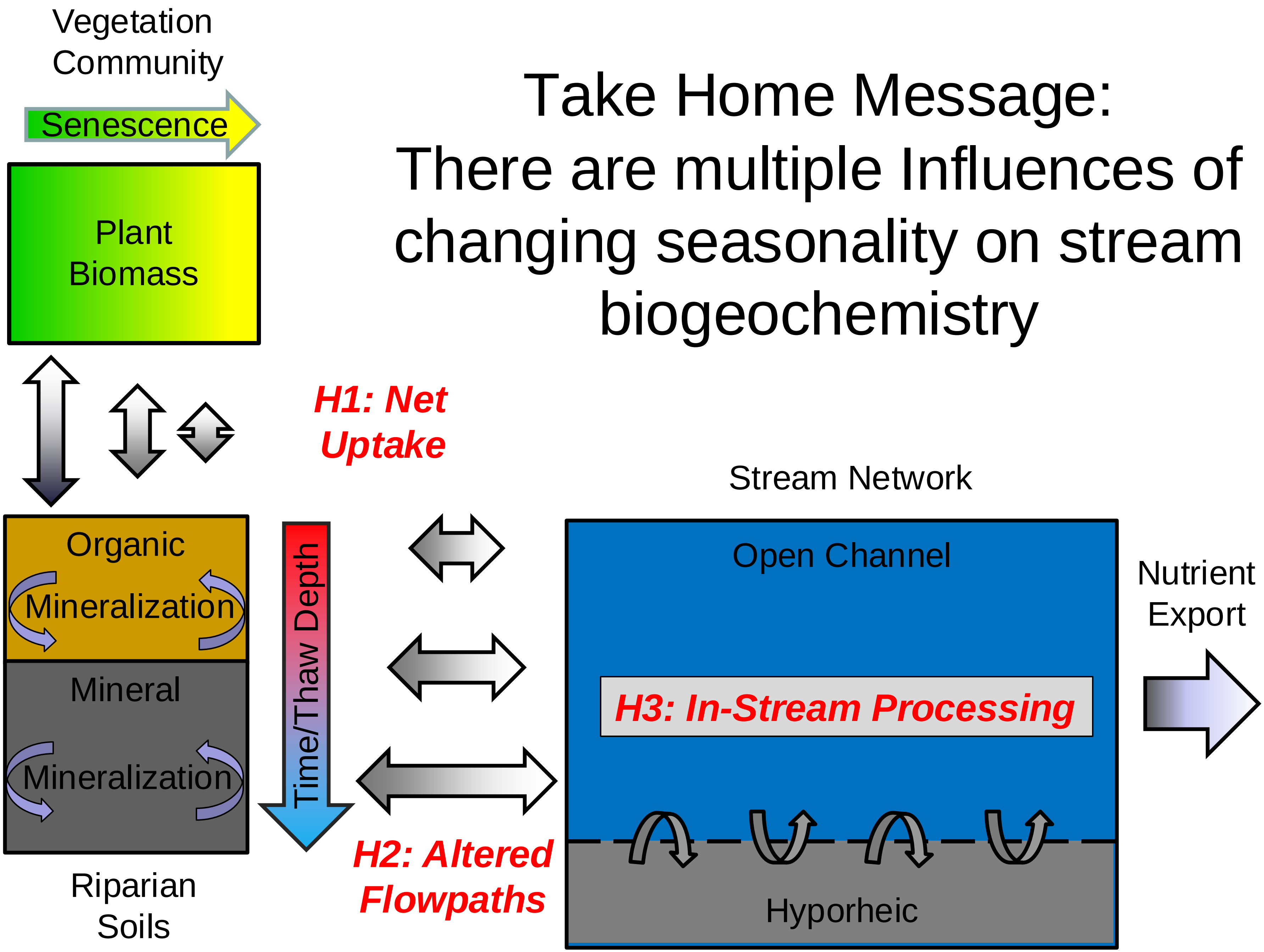
Current Research: Seasonal Asynchrony in microbial production and plant demand



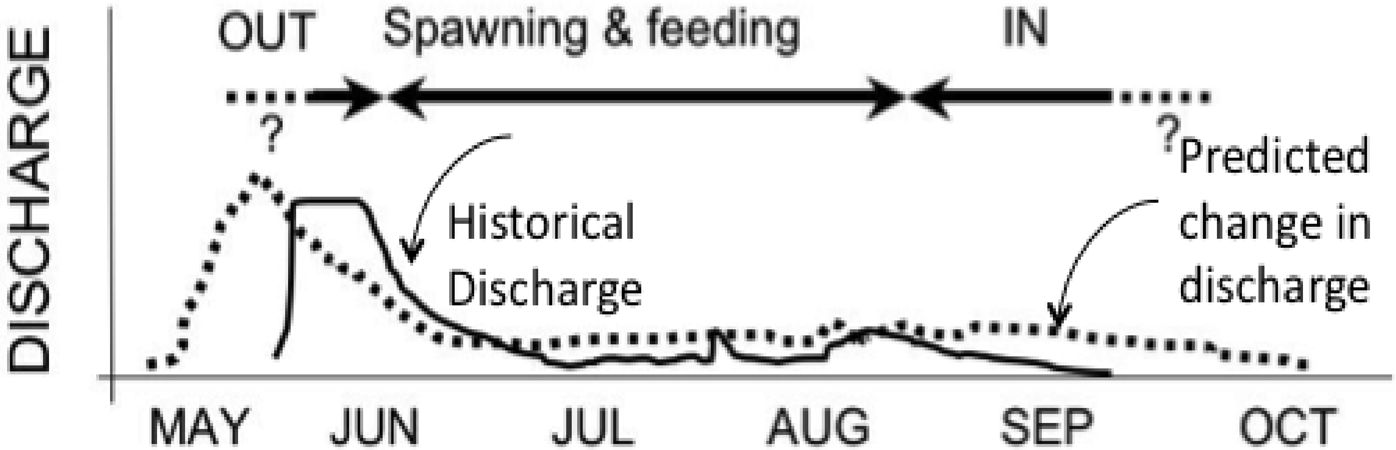
Nitrate concentrations increase in the fall



G Waldvogel and WB Bowden, unpublished data

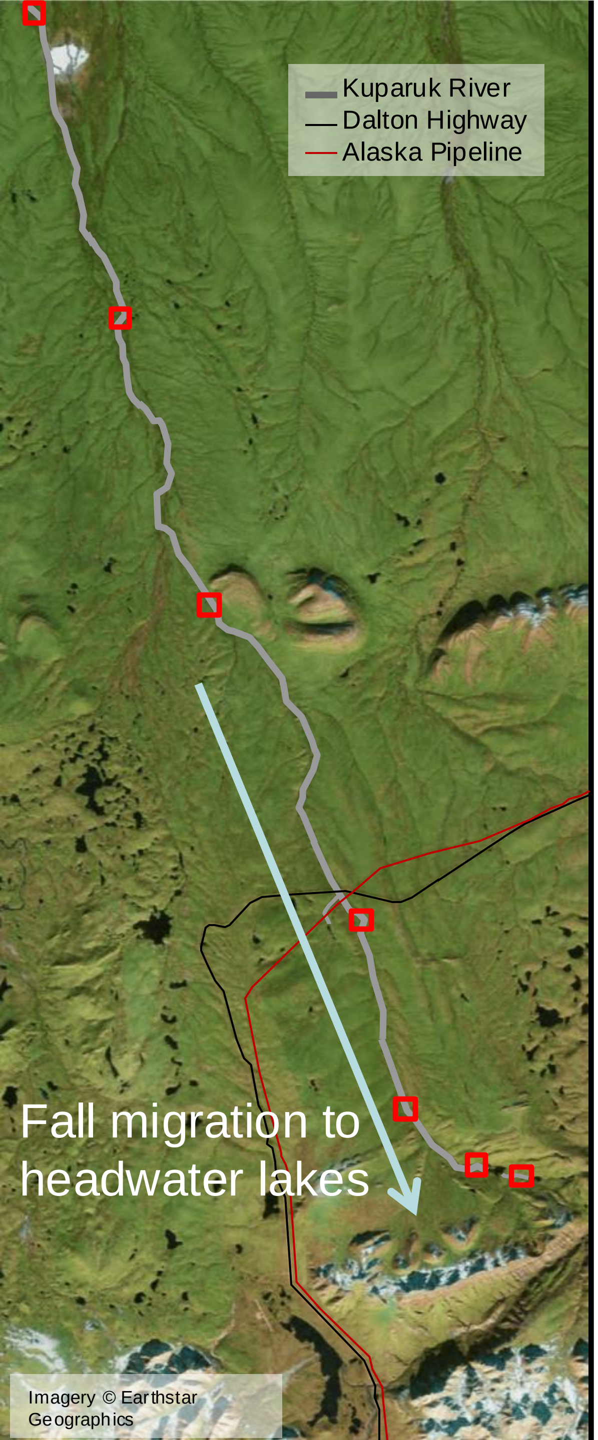

Take Home Message:
There are multiple Influences of changing seasonality on stream biogeochemistry
Vegetation Community
Senescence
Plant Biomass
H1: Net Uptake
Organic
Mineralization
Mineral
Mineralization
Riparian Soils
Time/Thaw Depth
H2: Altered Flowpaths
Stream Network
Open Channel
H3: In-Stream Processing
Hyporheic
Nutrient Export

Current Research - FISHSCAPES: Seasonality and synchrony of ecological processes in arctic streams



-Earlier spring melt
-Later fall freeze up
-Less rain late season
-Increased stream temperatures

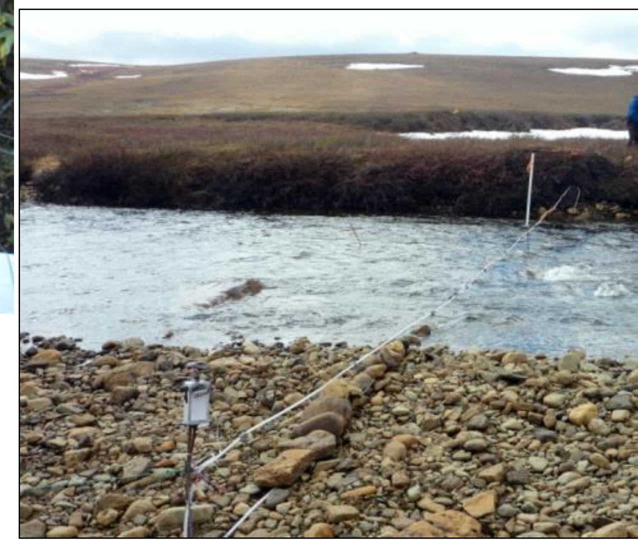
Survival depends on a fall migration to a “safe” lake

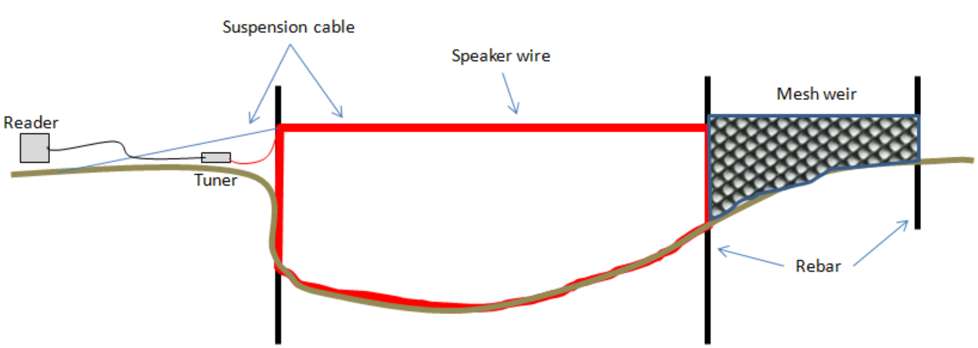


PIT tagging grayling adults (>25cm)

Image credits: C. MacKenzie

PIT tag antenna installation





When and where “dry reaches” occur is critical

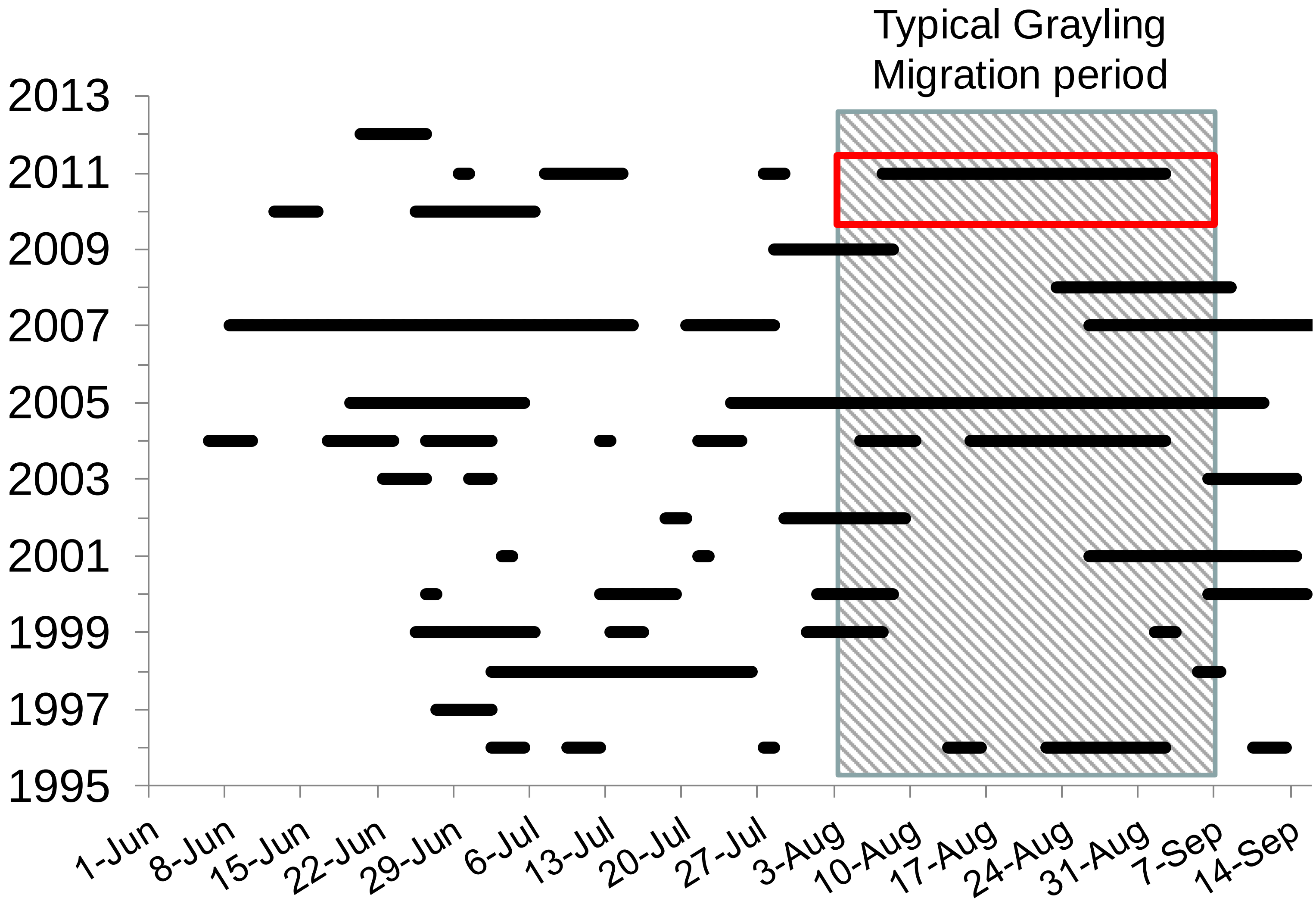
Photo credit:
W. Bowden

Photo credit: A. Huryn

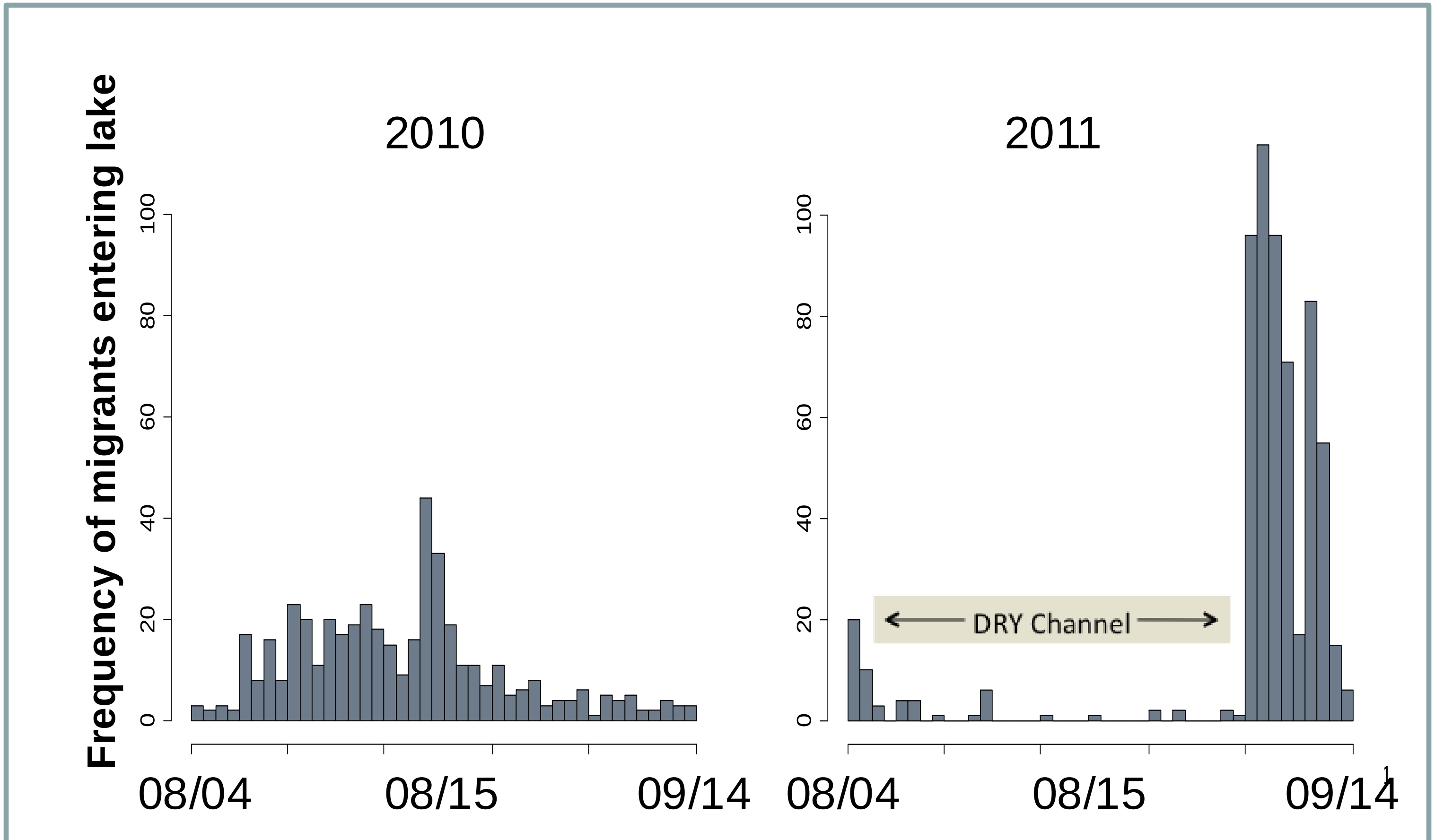
Photo credit: C. Mackenzie

Kuparuk River – Pool of grayling trapped in main-stem below dry channel (≈1000 adults)

Historical periods of hydrological discontinuity in the Kuparuk River

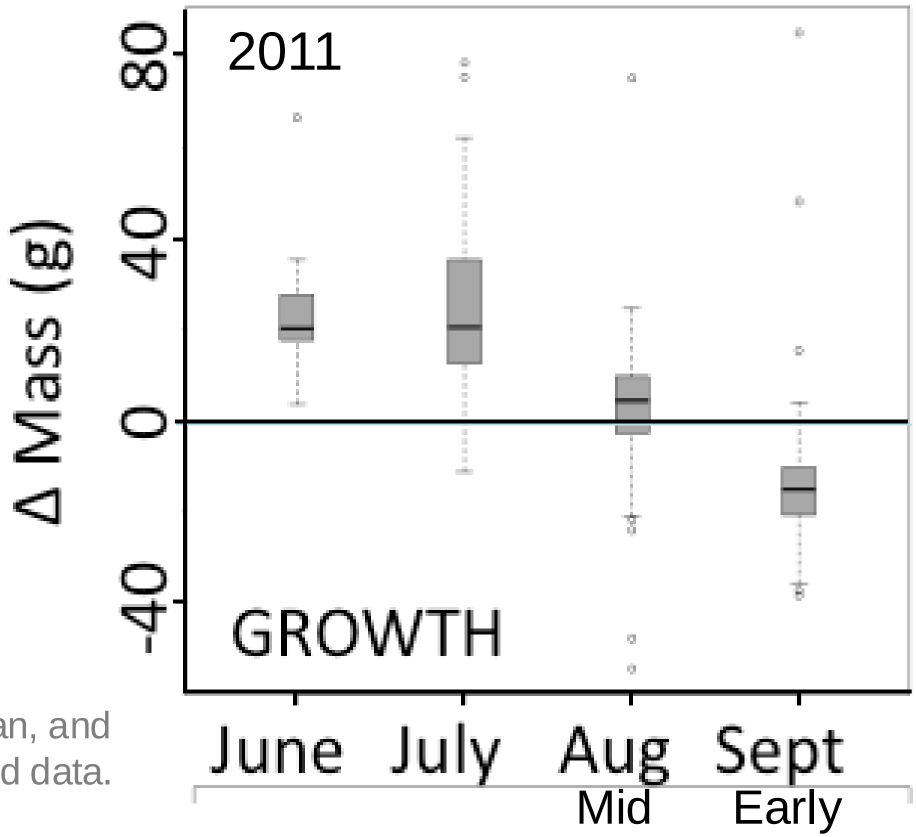


Fish could not reach the lake and crowded in the river in 2011



C. MacKenzie, L. Deegan, and B. Peterson, unpublished data.

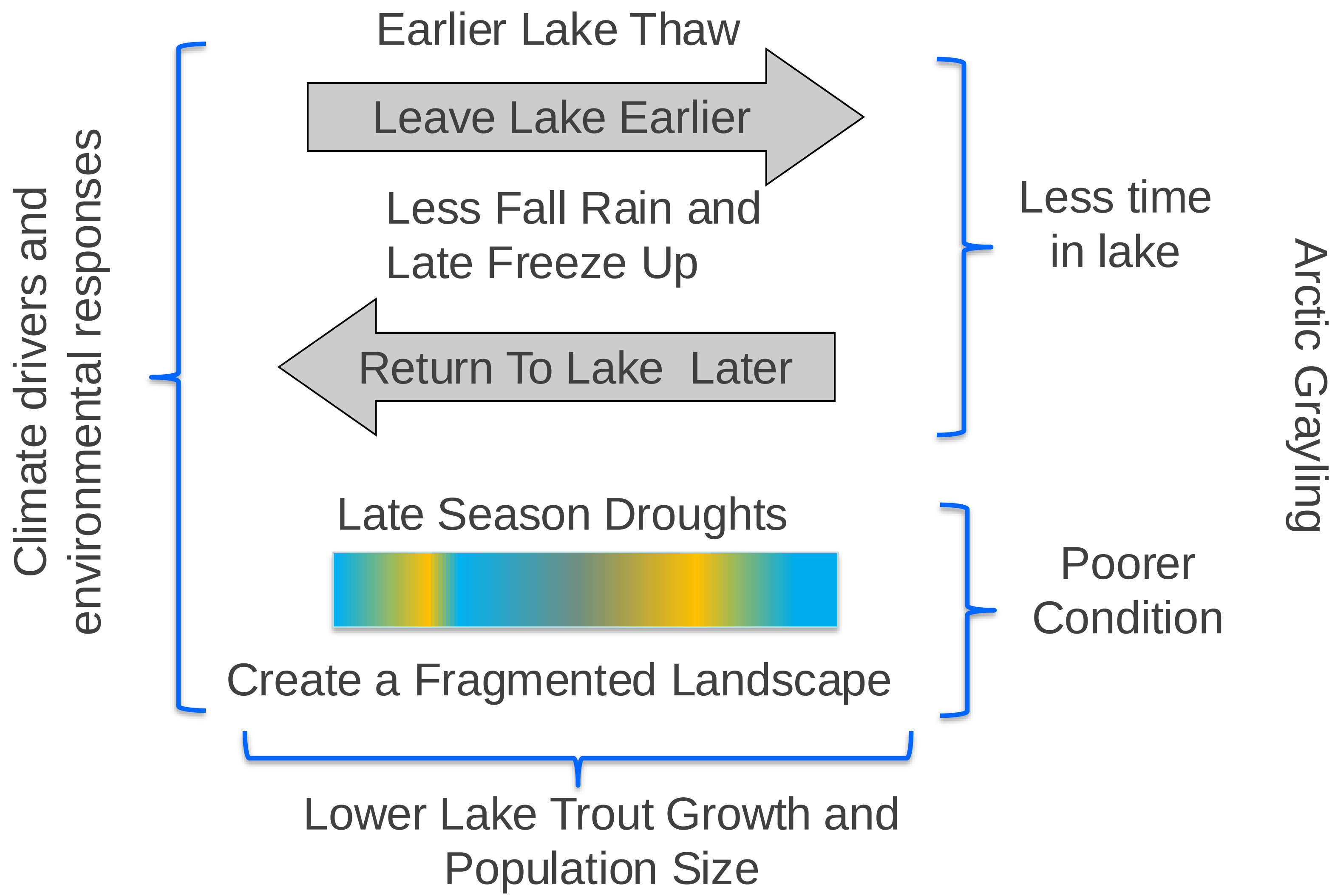
Crowding, competition and lack of food impeded fish growth



C. MacKenzie, L. Deegan, and B. Peterson, unpublished data.

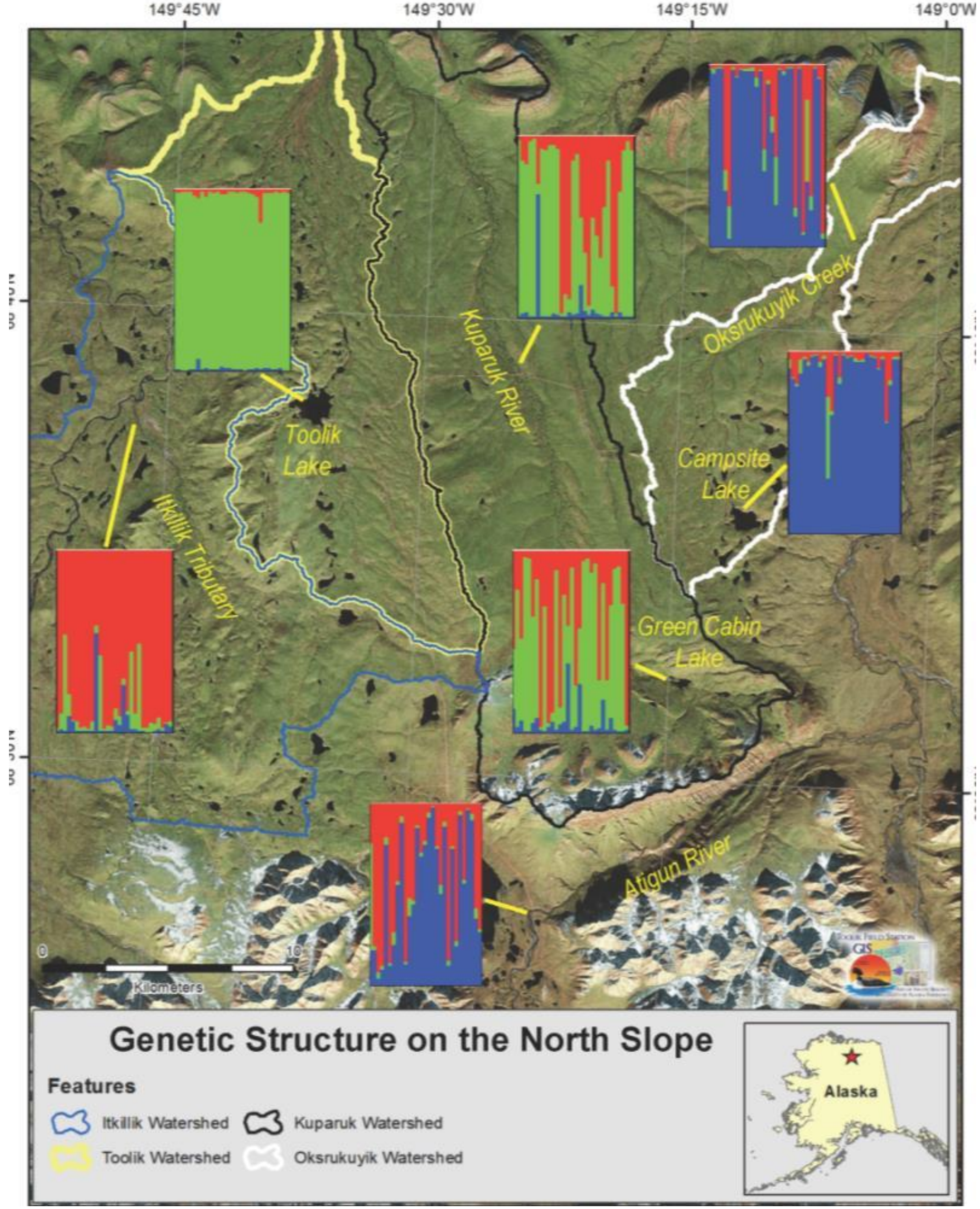
Gained mass in June and July during good flow and then lost mass during September low flow period and isolation in pools.

Take Home Message:
Climate impacts on hydrology may make rivers less hospitable for some fish

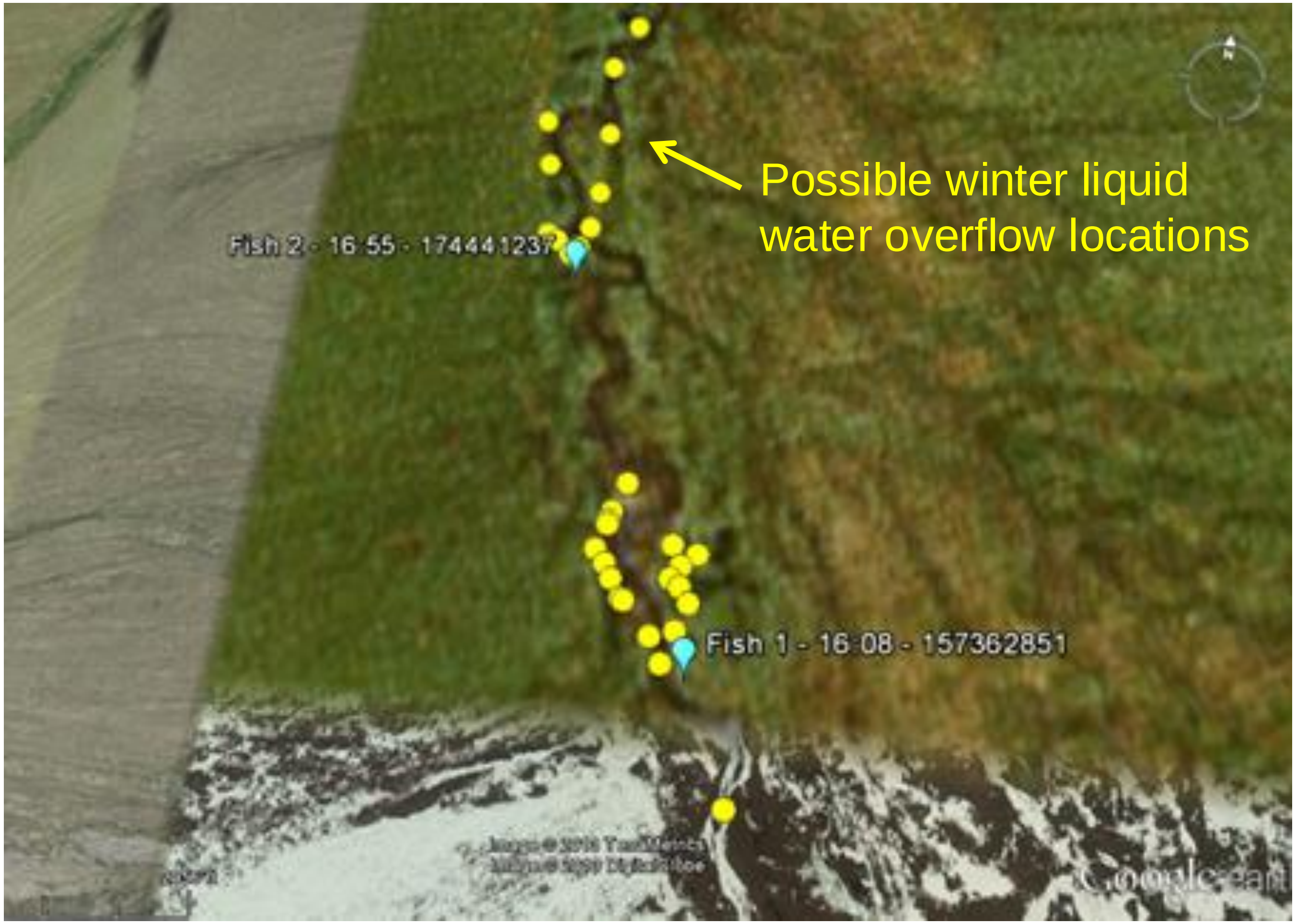


What does the loss of a migratory population mean to the function of lakes and streams in the landscape?

Heidi Golden
Mark Urban
University of Connecticut



Exciting, breaking news! Fish under spring ice



Courtesy of Heidi Golden and Cam MacKenzie

Mapping ArcLTER Objectives to Streams Research

ArcLTER Shared Objectives

1. How does climate control ecosystem states, processes, and linkages?
2. How do disturbances change ecosystem states, processes, and linkages?
3. How do climate and disturbance interact to control biogeochemical cycles and biodiversity at catchment and landscape scales?

Take home messages about the Streams research (This talk)

- Physical factors (freezing, Q) define key habitats.
- Top down effects are more subtle than bottom up.
- Hyporheic duration is more important that hyporheic extent.
- Changing seasonality is creating important biogeochemical asynchronies
- Changing seasonality may threaten the survival of important fish species in these streams.
- The ArcLTER provides a critical base for a diverse program of Streams research.

Thank you!