

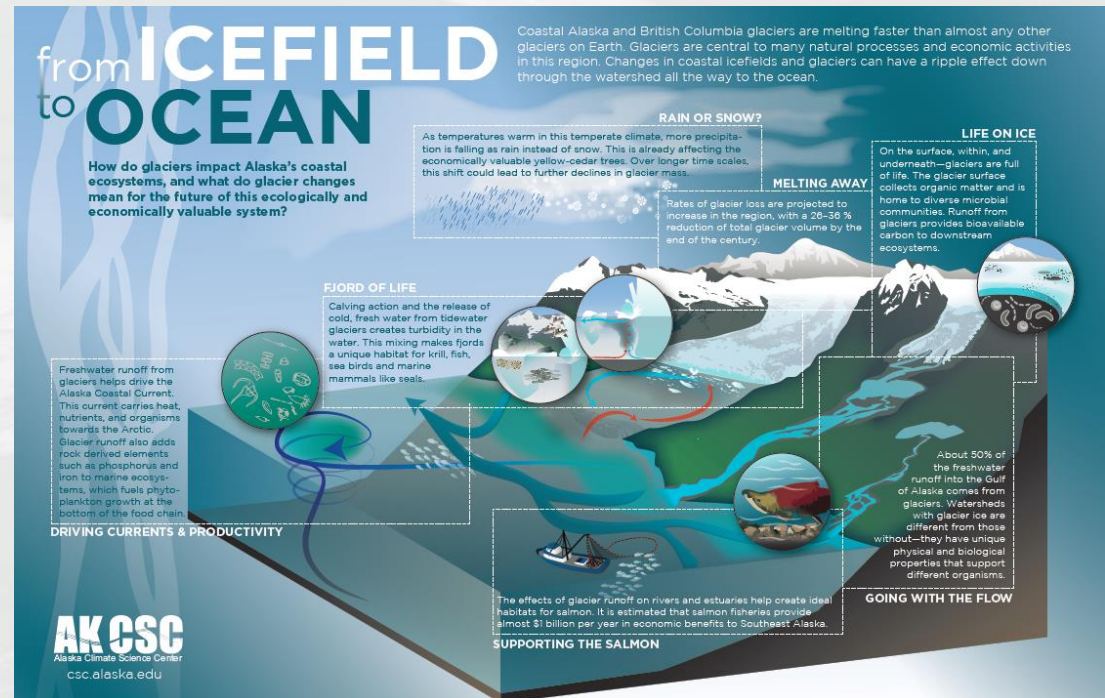
# Spatial-Temporal Analysis of Stream Temperatures in Southeast Alaska

*S. Pyare, E.W. Hood, E. Nichols & S. Ellison*

*University of Alaska Southeast*

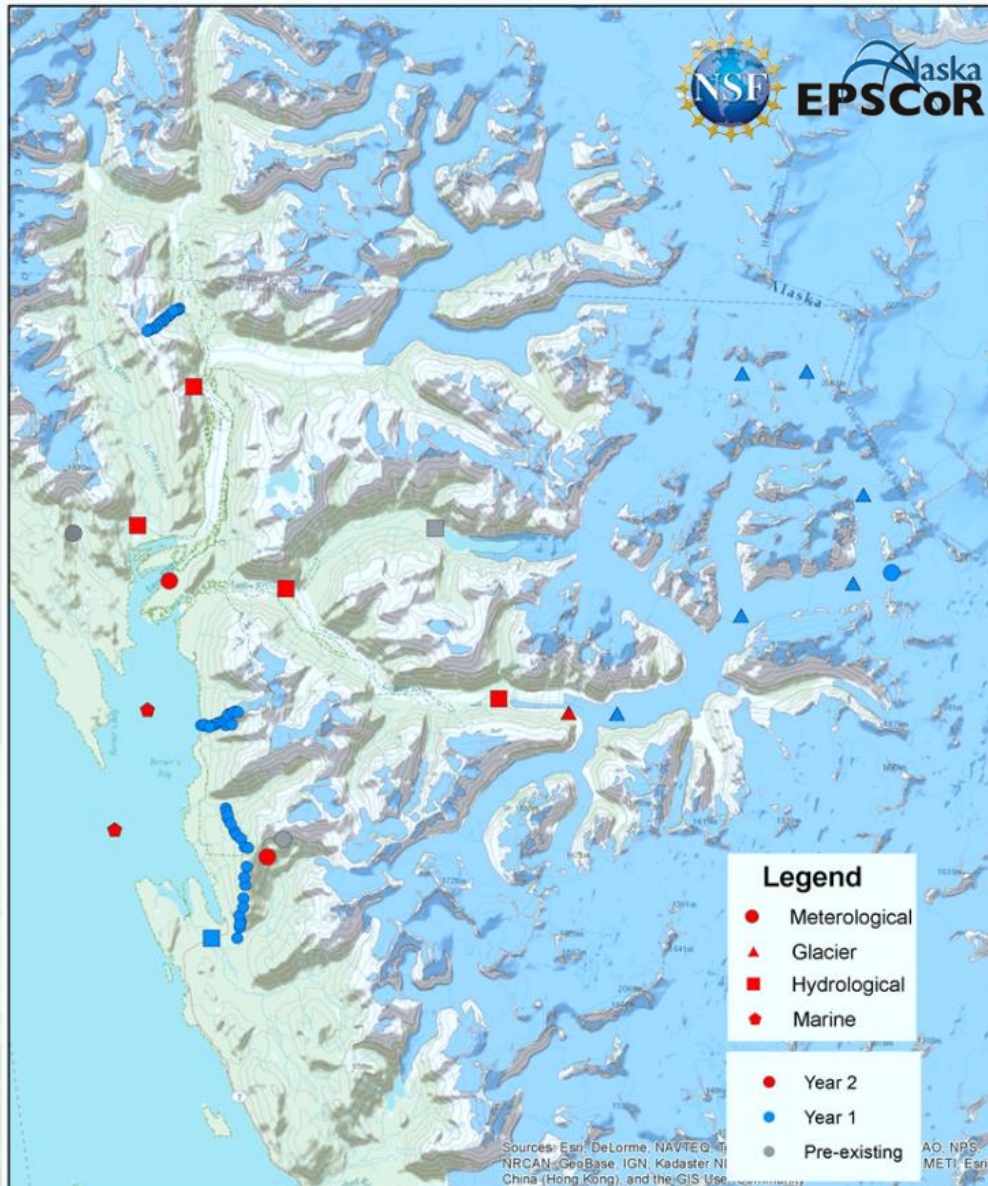


- National Science Foundation program to “stimulate research” by investing in university research capacity
- In emerging and “transformational” research areas
- 5 year project (2012-2017) involving all 3 UA campuses and a number of partners

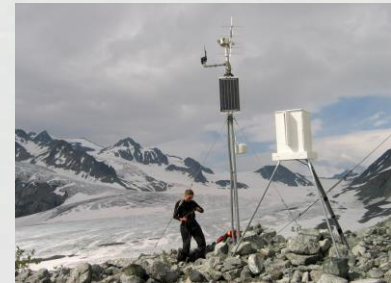




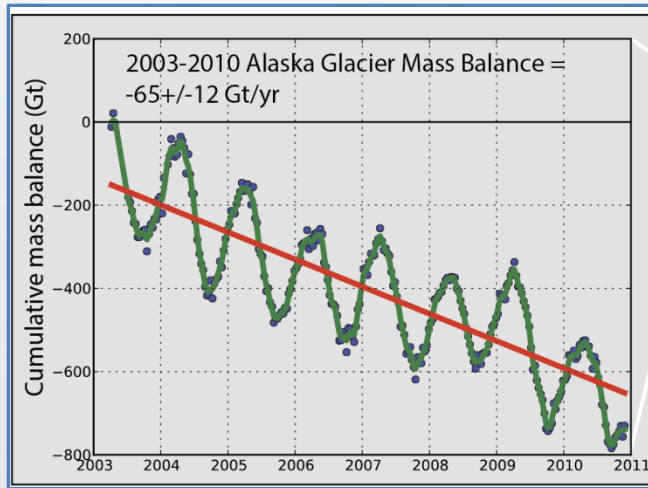
# Expansion of Hydro-meteorological Instrumentation & Data Storage



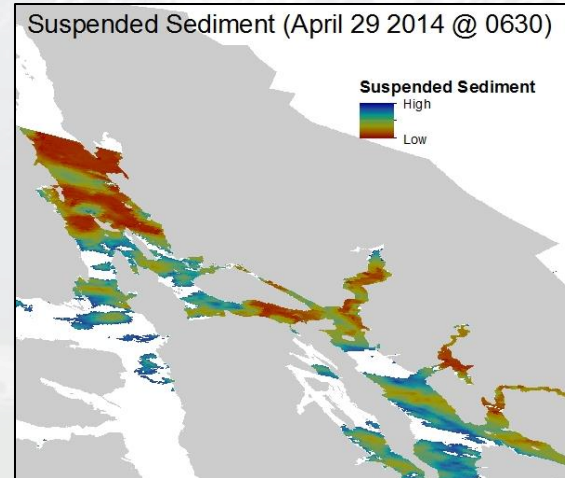
- Mass Balance
- Meteorological
- SNOTEL
- Lapse Rate Data
- Ocean Buoys
- Hydrology
- Remote Sensing



# Expand Capacity to Integrate & Analyze Datasets

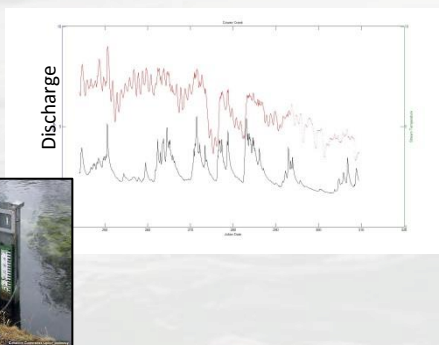


GRACE Satellite (10-day)

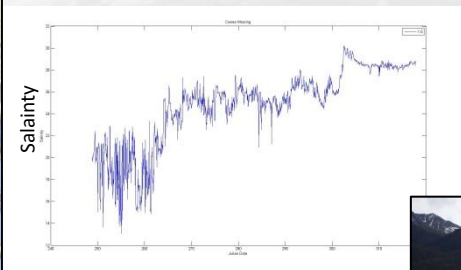


MODIS Satellite (Daily)

In Situ Instrumentation Array



Gauge (Hourly)



Estuarine Buoy (Hourly)



## Promote Productivity of Integrative Research, e.g. Hydro-climatology

nature  
geoscience

**Storage and release of organic carbon from glaciers and ice sheets**

Polar ice sheets and mountain glaciers, which cover roughly 11% of the Earth's surface, are a significant source of freshwater. However, the impact of climate change on these ice masses is a topic of ongoing research. A recent study by **Ernan Hood<sup>1</sup>, Tom J. Battin<sup>2</sup>, Jason Fellman<sup>3</sup>, and others** (see full list of authors on page 10) has shed light on this issue. The study found that the impact of climate change on these ice masses is likely to be larger than previously estimated, with significant implications for global water resources. The researchers compiled published data on dissolved inorganic carbon (DIC) and found that the impact of climate change on these ice masses is likely to be larger than previously estimated, with significant implications for global water resources. A compilation of published data on dissolved inorganic carbon (DIC) and found that the impact of climate change on these ice masses is likely to be larger than previously estimated, with significant implications for global water resources.

Climatic Change (2015) 130:155–170  
DOI 10.1007/s10584-015-1355-9

# Climate change implications in the northern coastal temperate rainforest of North America

Climate change and coastal temperate rainforests

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**Abstract** We synthesized an expert review of climate change implications for hydrology and terrestrial ecological systems in the northern coastal temperate rainforest of Alaska. Our synthesis is based on an analysis of projected temperature, precipitation, and permafrost changes for five climate change scenarios, stratified by eight biogeoclimatic provinces and three vegetation zones. Five global climate models (GCMs) and two representative concentration pathways (RCPs) were used to project changes in mean annual temperature increasing from a current average of 3.5°C to 6.5°C by 2050. The projected changes in precipitation are less certain, with some models projecting an increase in precipitation and others a decrease. The projected changes in permafrost are also less certain, with some models projecting a decrease in permafrost and others an increase. The projected changes in temperature, precipitation, and permafrost are likely to have significant impacts on the hydrology and terrestrial ecological systems of the northern coastal temperate rainforest of Alaska.

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PUBLISHED ONLINE 19 JANUARY 2015 | DOI: 10.1038/NGE02331

## Global Change Biology

Global Change Biology (2015) 21, 1821–1833, doi: 10.1111/gcb.12829

# Temporal patterns in adult salmon migration timing across southeast Alaska

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## Abstract

[illegible]

**Keywords:** climate change, heterogeneity, migration timing, phenology

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## Introduction

**Introduction**

Pacific salmon (*Oncorhynchus* sp.) are critical components of ecosystems throughout coastal areas of the northern Pacific Ocean (Willson & Halupka, 1995; Gende et al., 2002; Hocking & Reynolds, 2011), and the timing of their migration into freshwater directly influences numerous consumers (e.g. Ben-David, 1997; Schindler et al., 2013) and the phenology of other organisms (Moore & Schindler, 2010; Liu & Schindler, 2011). While circadian-induced phenological changes are well-described for many organisms (Parrsen, 2006), our understanding of phenological trends in fish, including salmon, is limited (Parrsen, 2007; Thackeray et al., 2010). This is surprising given that changes in Pacific salmon migration timing could have ecosystem level consequences (e.g. impact consumer phenol-

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ogy, resource use, and even food web dynamics) (Gende *et al.*, 2002; Moore & Schindler, 2010; Lisi & Schindler, 2011; Schindler *et al.*, 2013), alter the availability of salmon for commercial harvest (Schindler *et al.*, 2010), and influence Pacific salmon population dynamics and evolutionary trajectories (e.g. Martins *et al.*, 2010; Crozier *et al.*, 2011; Hinch *et al.*, 2012; Kowach *et al.*, 2012).

The timing of adult salmon migration into freshwater for reproduction is a critically important life-history trait that often differs among populations because of strong local adaptation to heterogeneous environmental conditions, including climatic variation (Taylor, 1991; Quinn & Adams, 1996; Ekason *et al.*, 2011; Lisi *et al.*, 2013). Variation in freshwater and oceanic conditions (e.g. temperature and stream discharge) can affect salmon migration timing by altering environmental cues and selection for certain migratory phenotypes (e.g. Quinn & Adams, 1996; Hodgson *et al.*, 2006; Mundy &

# Icefield-to-Ocean Linkages across the Northern Pacific Coastal Temperate Rainforest Ecosystem

Overview Articles

SHAD O'NEEL, ERAN HOOD, ALLISON L. BIRN  
EVAN BURGESS, CHRISTOPHER  
JOEL M. BIRN

*Watershed Glacier Coverage Influences  
Dissolved Organic Matter Biogeochemistry  
in Coastal Watersheds of Southeast Alaska*

son B. Fellman, Eran Hood, Robert M. Spencer, Aron Stubbins & Peter Raymond

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2014) 17:1014-1025  
s10021-014-9777-1

810021-014-9777-1

**ECOSYSTEMS** Volume 17 • Issue 3 • September 2005

Mini-review: Climate-independent Fire Regime Shifts  
Forest Disturbances Affect Carbon and Charcoal Stocks  
Migratory Ungulates Facilitate N Transport  
Hydrologic Regimes Affect Wetland Ecosystem Services  
Glacier Coverage and DOM Dynamics in Coastal Watersheds

 Springer

# Stream Temperature as an Ecosystem Integrator

- Instream  $\Delta$
- Sensitivity to high-elevation  $\Delta$
- Downstream and “lateral” effects

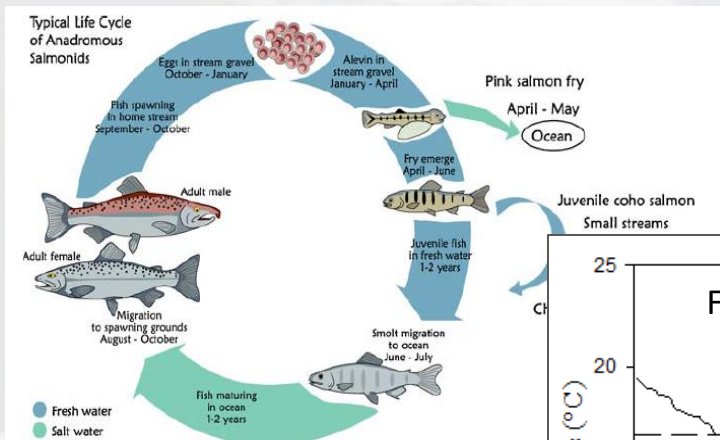
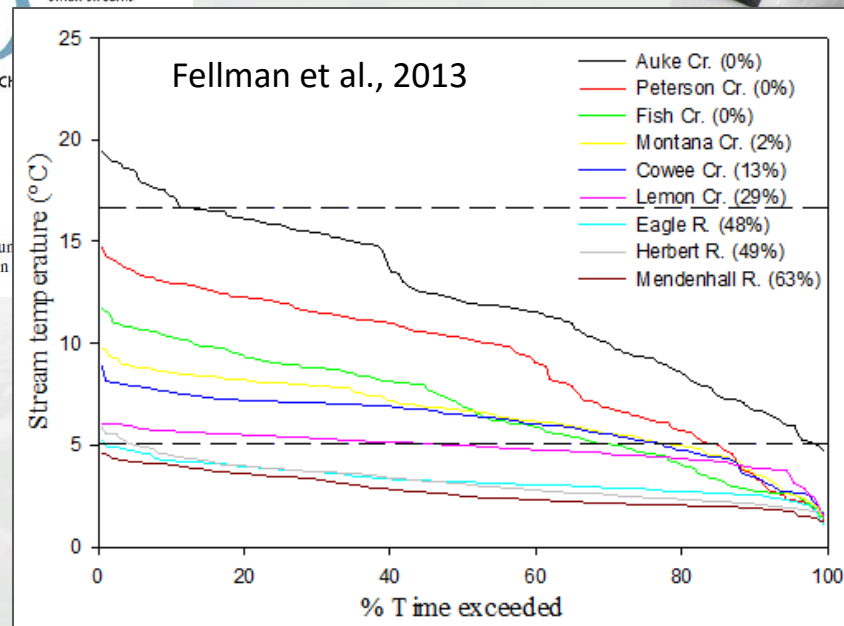
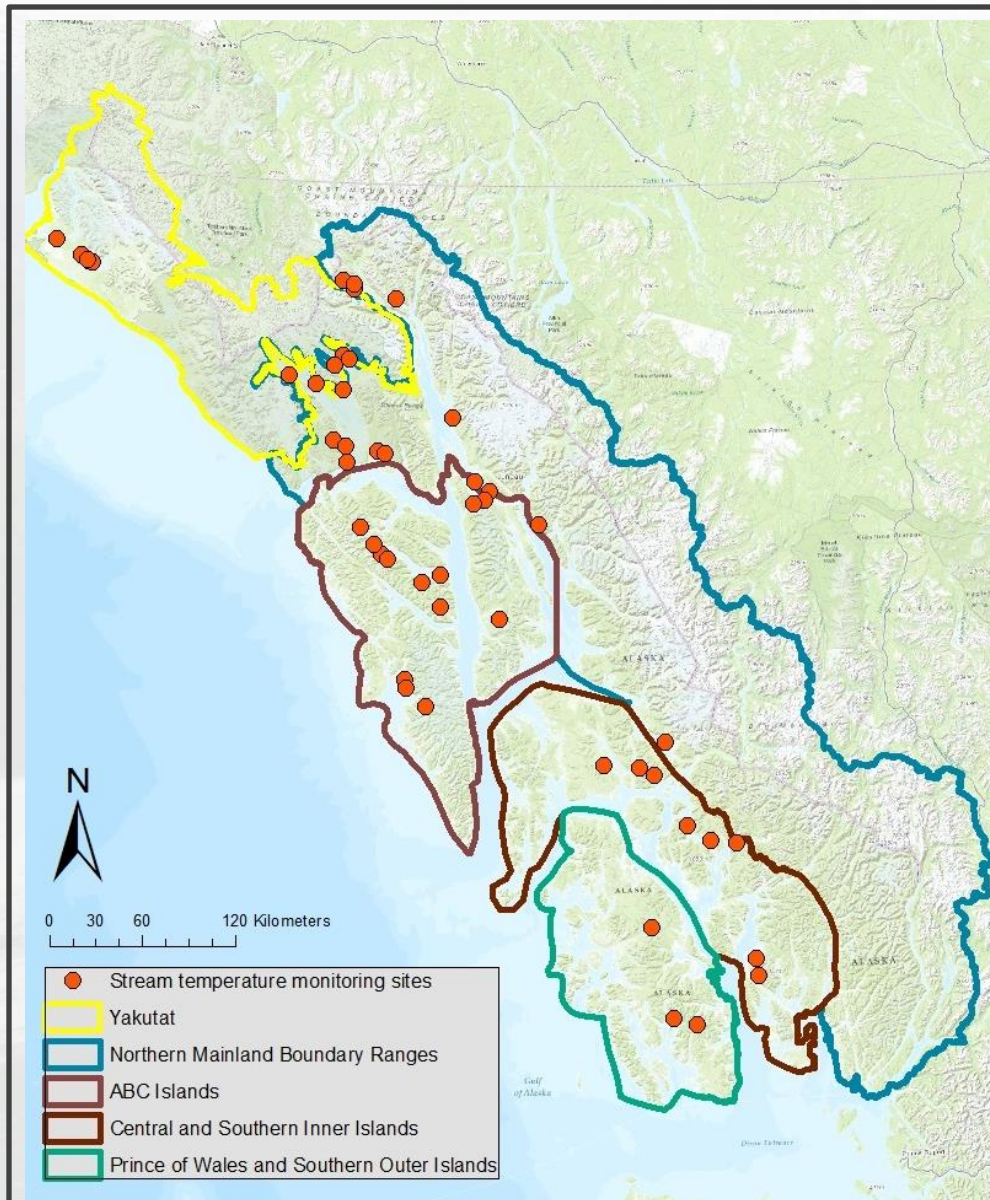


Fig. 1 Life cycle strategies of the five species of salmon (*Oncorhynchus*) four with those that rear in freshwater and those that migrate directly to the ocean





# Contemporary Stream Temperature Study (2014-16)



- 42 streams + existing
- TNF and partners
- Range of watershed conditions

# Retrospective Stream Temperature Study (1960-2015)

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- What's out there for data?
- What can we say about  $\Delta$  stream temperature  $\sim$  last half century?
- What can we infer about future  $\Delta$ ?





# Data Rescue

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## Main Database: **76** streams

- $\geq 2$  yrs of data
- Semi continuous, resampled to daily intervals
- Data collection standards known ( $\pm 0.2^\circ\text{C}$ )
- Does not yet include additional **42** streams from 2+ yr contemporary study (M. Winfree)

## Ancillary Data: **40** streams

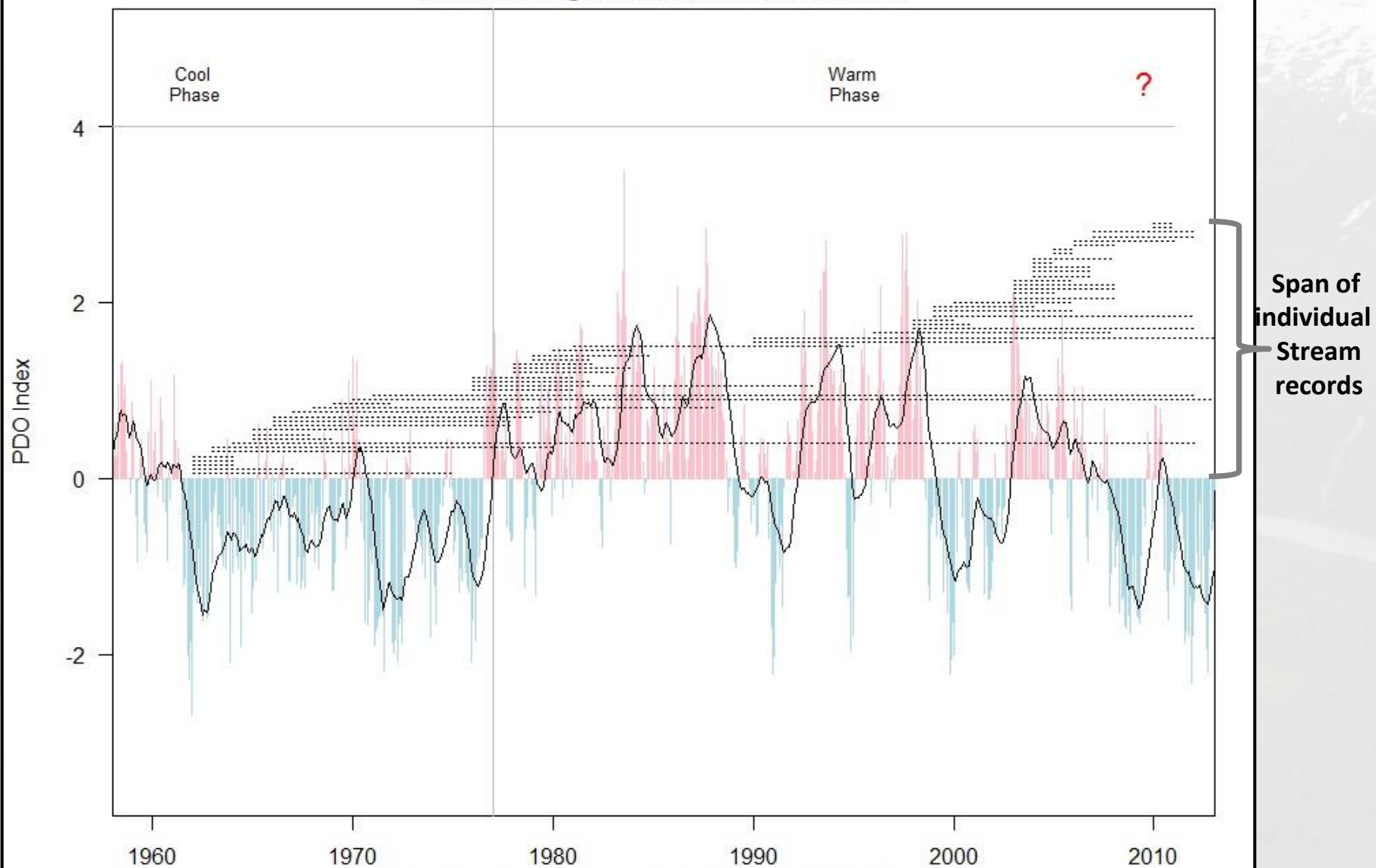
- Seasonal data (3 mos – 7 years)

## No effort:

- Grab samples
- Lentic systems
- Anything on dot matrix paper or in loose-leaf binders!

# The Data

Pacific Decadal Oscillation (PDO)  
Univ of Washington, JISAO: Jan., 1960 to Dec, 2013





# Retrospective Analysis

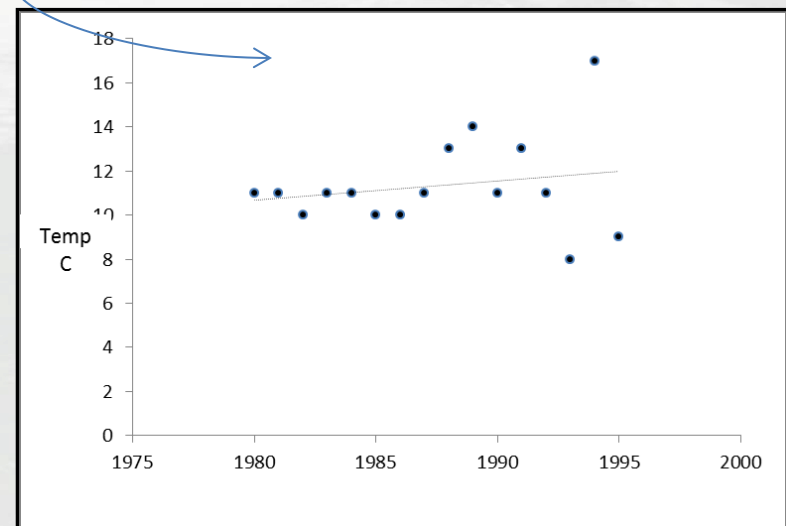
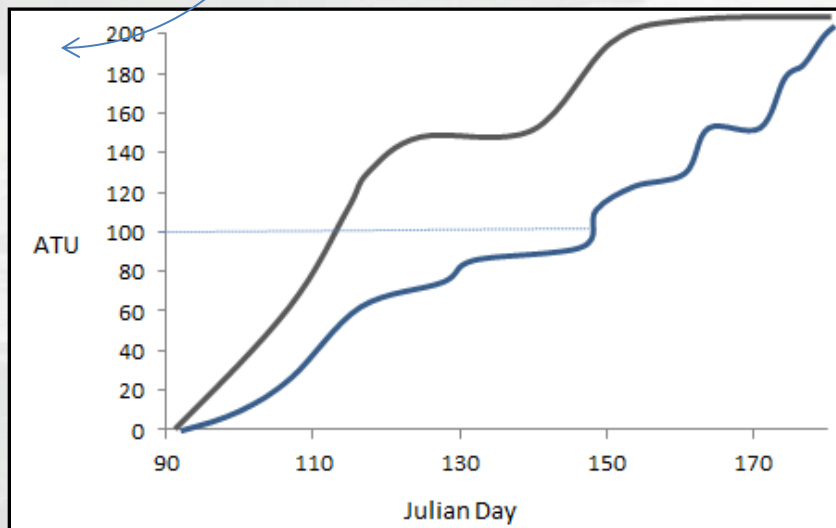
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- Subset of 17 streams with > 10 years of data
- Mean span ~18 yrs and Range 2 – 45 yrs
- No transboundary and primarily non-glacial
- PDO Phases: 5 Cool, 6 Warm, 6 Cross

	Fine Scale	Broad Scale
Temporal	Individual stream trajectories	Aggregate change during warm vs. cool phase PDO
Spatial	Landscape controls (e.g., alpine)	Aggregate change relative to climatic zones

# Retrospective Analysis – Stream Patterns

- Evaluated season-specific changes across years
  - 3 main variables:
    - Temperature (mean) trends
    - Accumulated heat (ATUs/Degree Days)
    - Phenology trends (Median ATUs dates)
- ...and *trends in the variability* (residuals) of these 3





# Retrospective Analysis – Stream Patterns

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## Fall:

- $> \frac{3}{4}$  of streams with  $\uparrow$  trends in temperature, *adding* 1.1 °C per decade

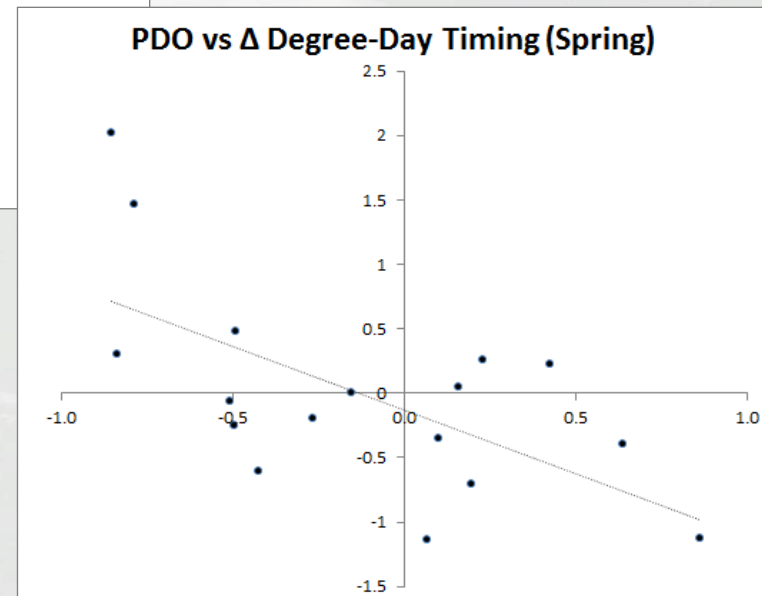
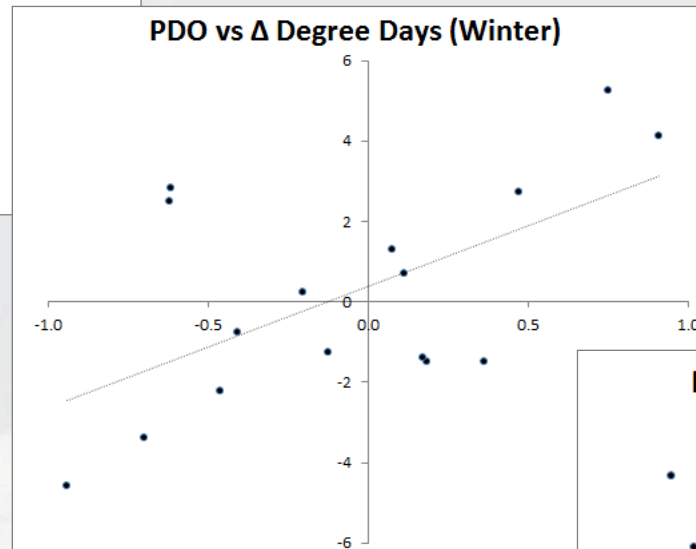
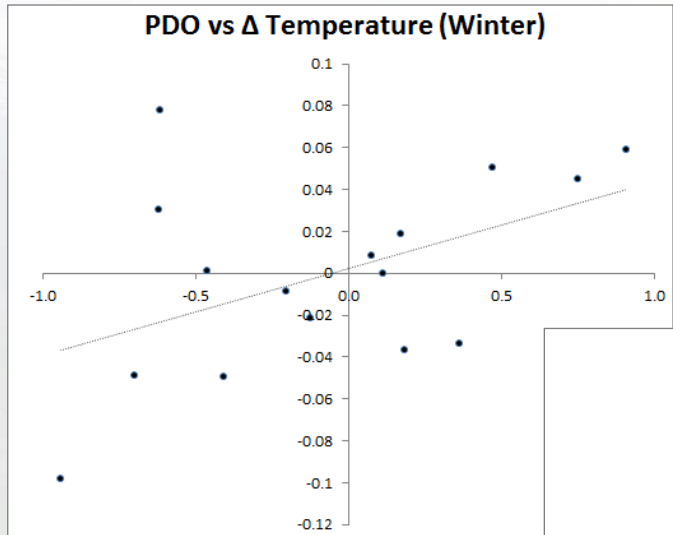
## Winter:

- $> \frac{3}{4}$  of streams with  $\uparrow$  trend in degree-day distribution, shifting 16 days *later*/decade

## Spring & Summer:

- $> \frac{3}{4}$  of streams with an  $\uparrow$  trends in degree days, *adding* 43.7 DD and 138.3 DD / decade
- $\sim \frac{3}{4}$  of streams with  $\uparrow$  trends in variability of timing of DD

# Retrospective Analysis – Stream Patterns & Large-Scale Forcing

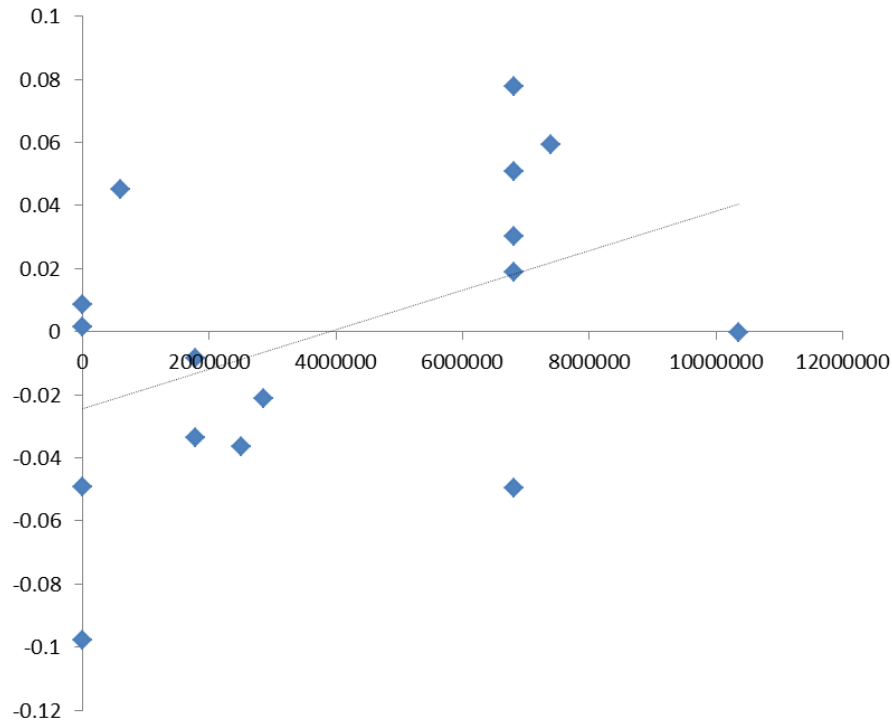




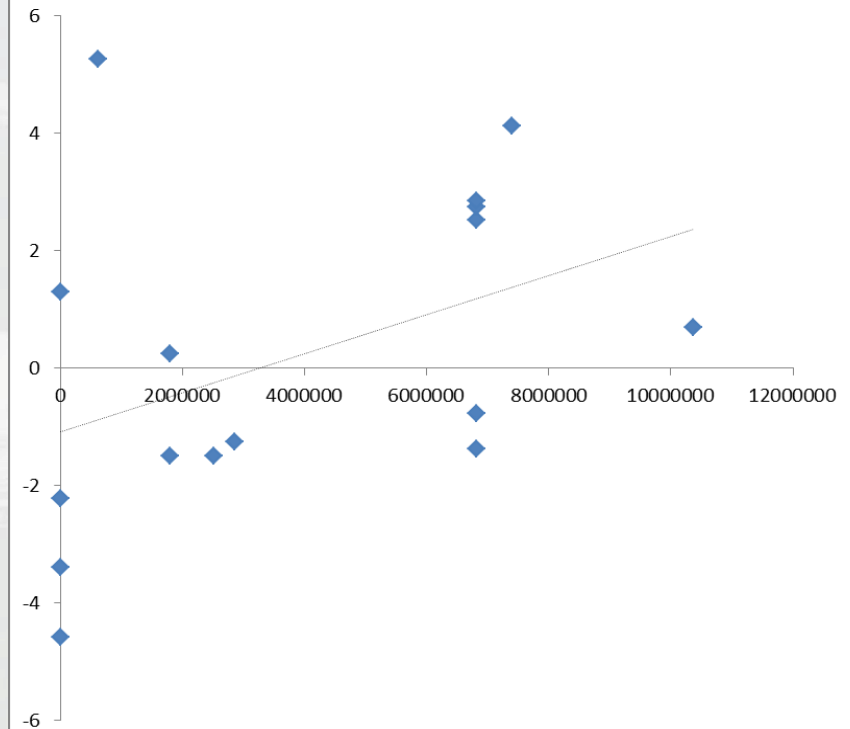
## Retrospective Analysis – Landscape Control

- Among 9 landscape variables, only alpine area exhibited a visible relationship with observed trends

**Alpine Area &  $\Delta$  Winter Temp**



**Alpine Area &  $\Delta$  Winter ATUs**



## Climate – Stream Temperature ‘Downscaling’

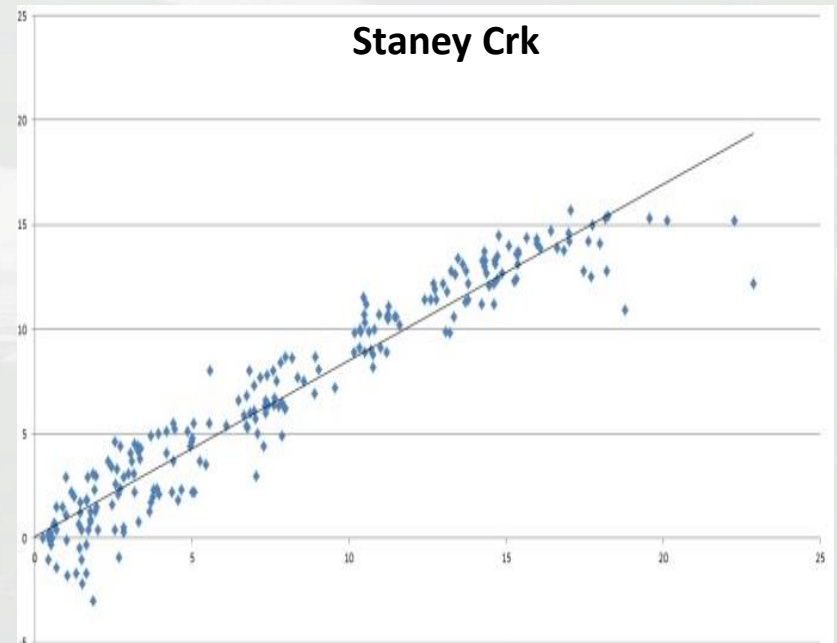
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- How well do climate models ‘predict’ past stream temperatures?
- 58 streams  $\geq$  2 yrs
- Data resampled to monthly & seasonal scales
- GCMs: SNAP and ClimateWNA (ensemble models)
- Modeled both temperature and degree-days as a function of GCM temperature



## Climate – Stream Temperature ‘Downscaling’

- No seasonal, PDO, and particular landscape differences.
- Uniformly strong correlations between GCM and temperatures/degree days (all  $R > 0.70$ ; majority  $> 0.90$ )
- Thru 2085, per decade, average  $\Delta$ :
  - 0.3-1.1 °C
  - 9.8-37% in ATU



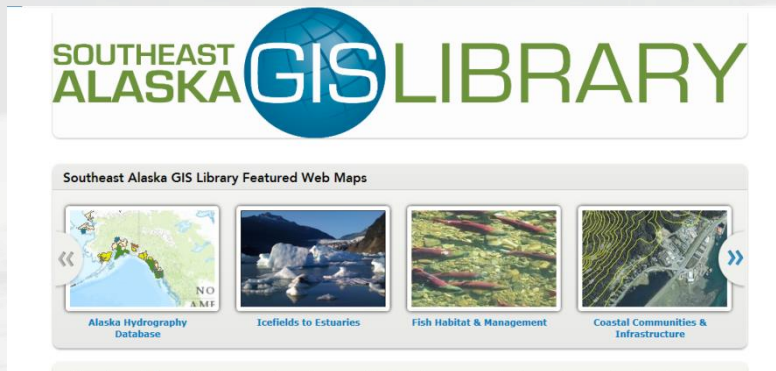
## Future Steps

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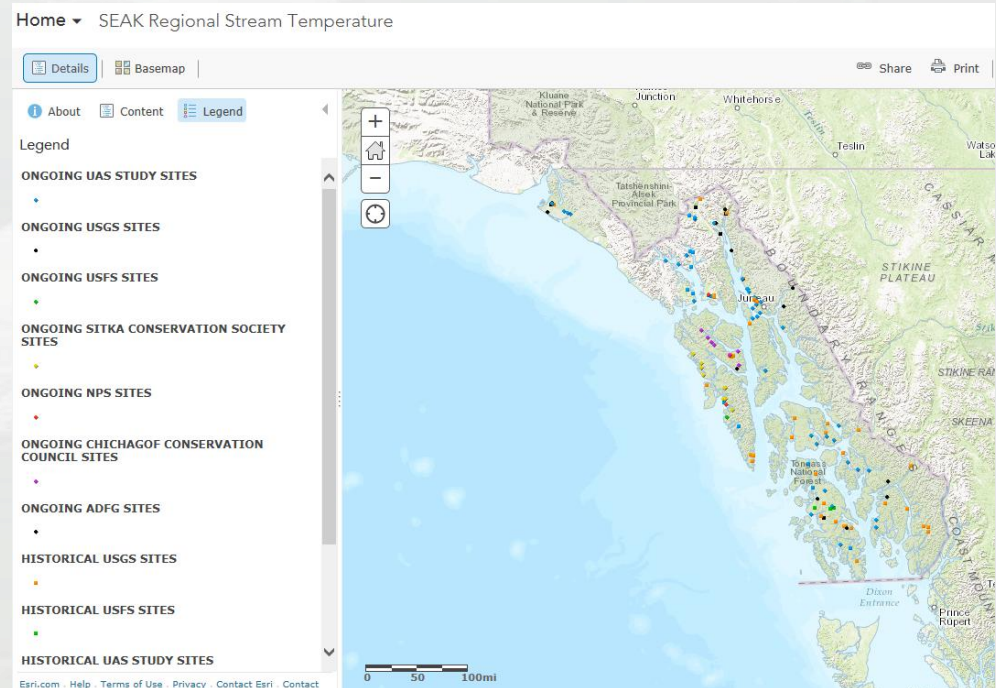
- Data publication - Dec 2016
- Historical vs current comparison (25+ datasets  $\geq$  5 yrs)
- Climate - stream temperature downscaling – modeling uncertainty
- Project  $\Delta$  thermal habitats & salmonid developmental considerations
- Promote collaboration/continuity of data collection at 42+ streams in regional monitoring study (a half decade?)

# Thanks especially to these data contributors:

- Alaska Dept of Fish and Game (J Sowa)
- USFS – Tongass and Region (E. Tucker)
- U.S. Geological Survey (R. Host)
- National Park Service (C. Sergeant)
- PNW Station (R. Edwards, B. Wright)
- Chichagof Conservation Council (M.Kemp, N Olmstead)
- Alaska Climate Science Center
- UAF – SNAP
- UAS (J Fellman, M Winfree)



<http://seakgis.maps.arcgis.com/>



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