Informing Sustainable Management of Water Resources and Anadromous Fisheries, April 12 2016

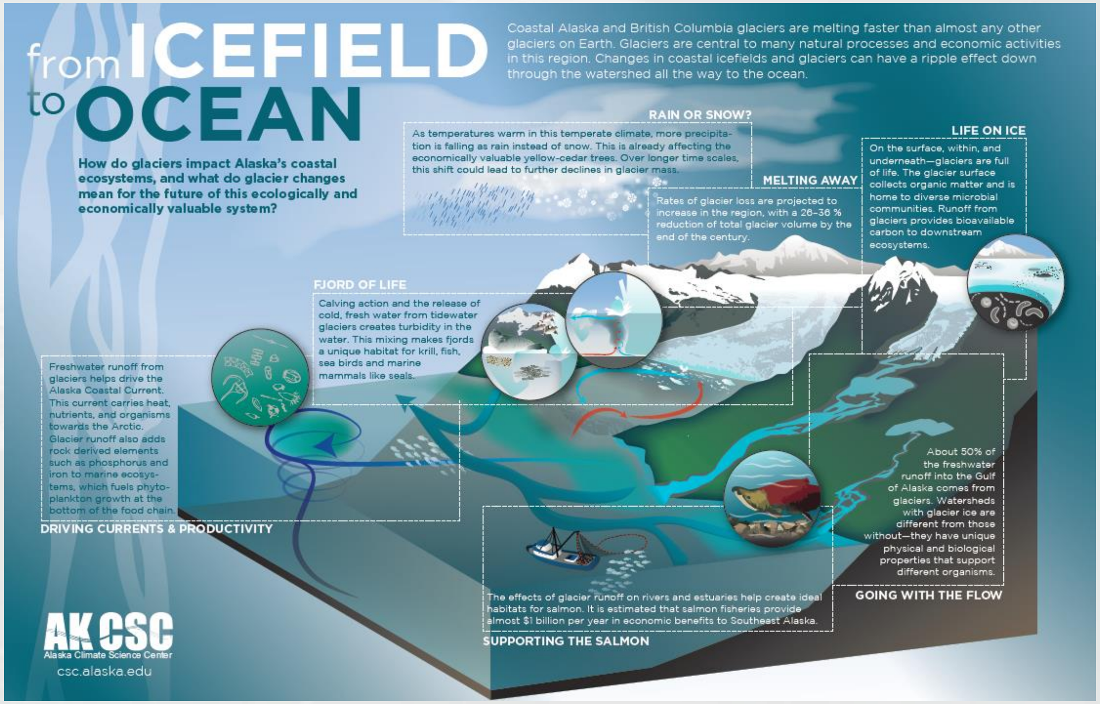
# Spatial-Temporal Analysis of Stream Temperatures in Southeast Alaska

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

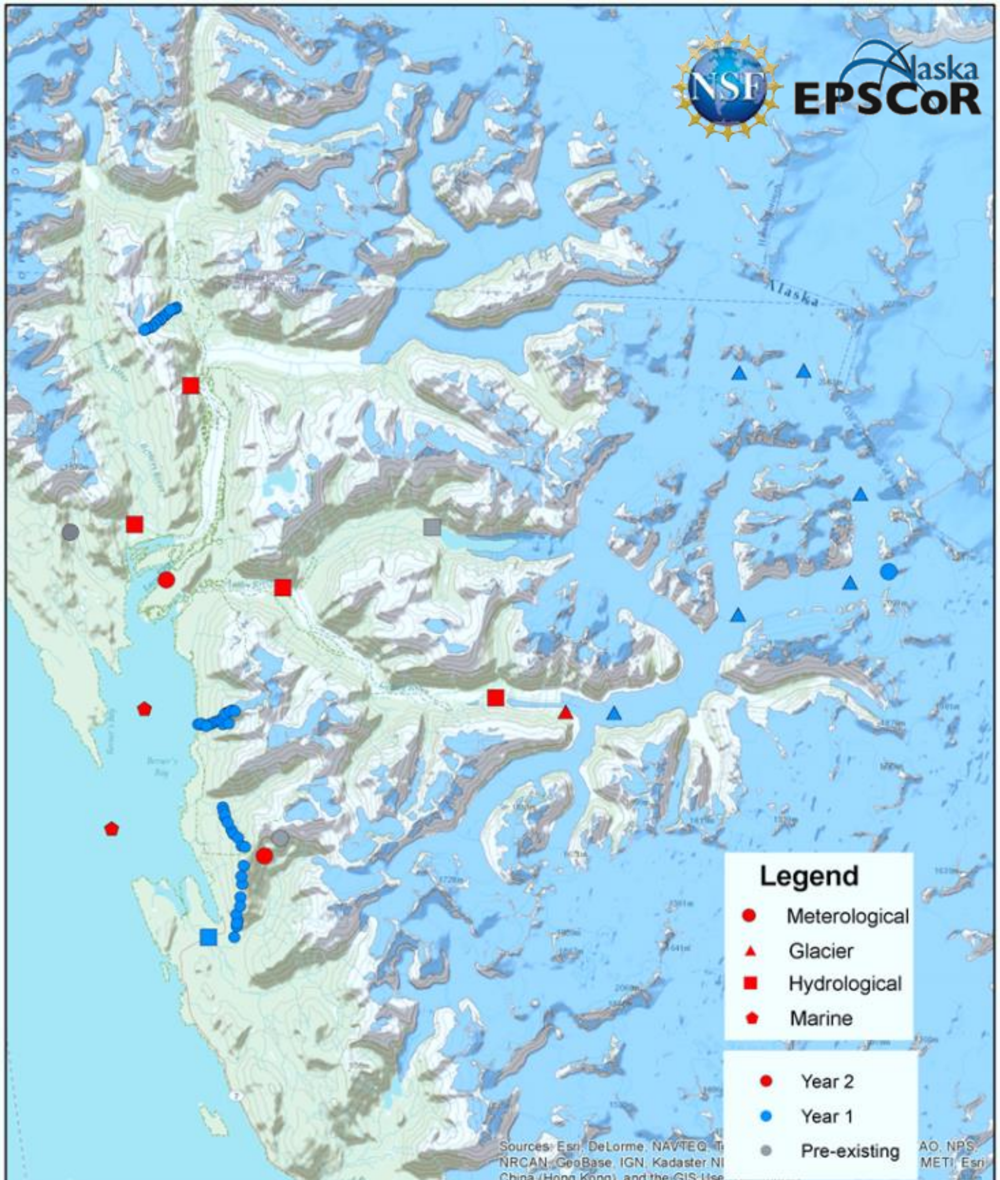
*University of Alaska Southeast*

## Context / Motivation

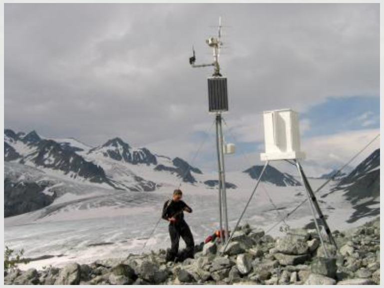
- National Science Foundation program to “stimulate research” by investing in university research capacity
- In emerging and “transformational” research areas
- 5 year project (2012-2017) involving all 3 UA campuses and a number of partners



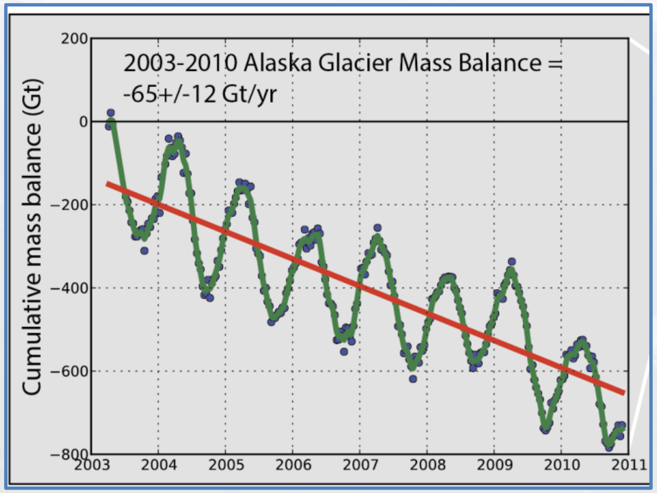
# Expansion of Hydro-meteorological Instrumentation & Data Storage



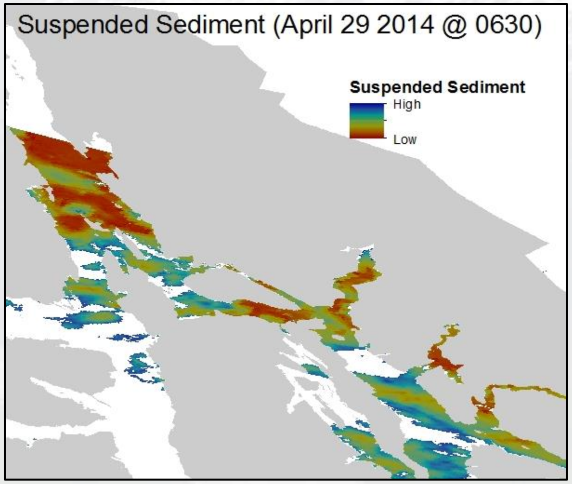

- Mass Balance
- Meteorological
- SNOTEL
- Lapse Rate Data
- Ocean Buoys
- Hydrology
- Remote Sensing



# Expand Capacity to Integrate & Analyze Datasets

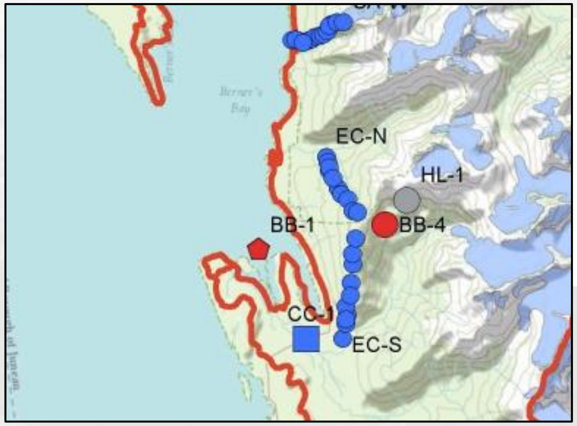


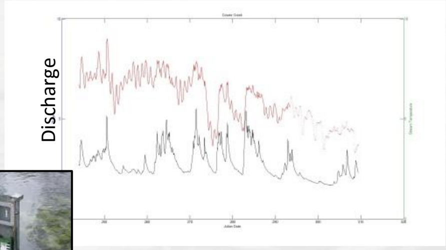

GRACE Satellite (10-day)



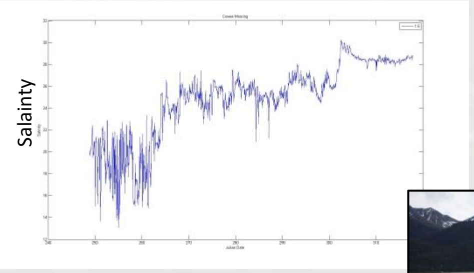

MODIS Satellite (Daily)

In Situ Instrumentation Array




Gauge (Hourly)




Estuarine Buoy
(Hourly)

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

nature geoscience

PROGRESS ARTICLE

PUBLISHED ONLINE: 19 JANUARY 2015 | DOI: 10.1038/NGEO2331

Storage and release of organic carbon from glaciers and ice sheets

Eran Hood, Tom J. Battin, Jason Fellman, Shad O'Neel ... G. M. Spencer

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

Colin S. Shanley · Sanjay Pyare · Michael I. Goldstein · Paul B. Alaback · David M. Albert · Colin M. Beier · Todd J. Brinkman · Rick T. Edwards · Eran Hood · Andy MacKinnon · Megan V. McPhee · Trista M. Patterson · Lowell H. Suring · David A. Tallmon · Mark S. Wipfli

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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

RYAN P. KOVACH, STEPHEN C. ELLISON, SANJAY PYARE and DAVID A. TALLMON

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

Overview Articles

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

ECOSYSTEMS

Springer

# Stream Temperature as an Ecosystem Integrator

- Instream Δ
- Sensitivity to high-elevation Δ
- Downstream and "lateral" effects

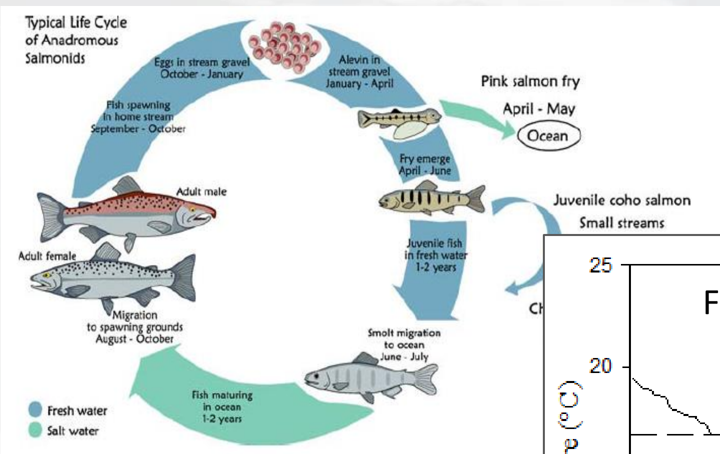
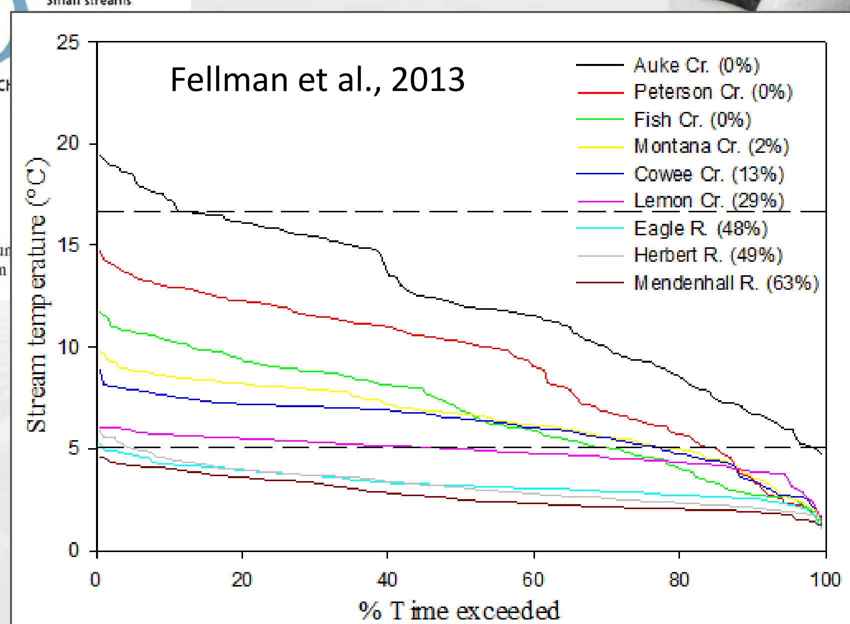
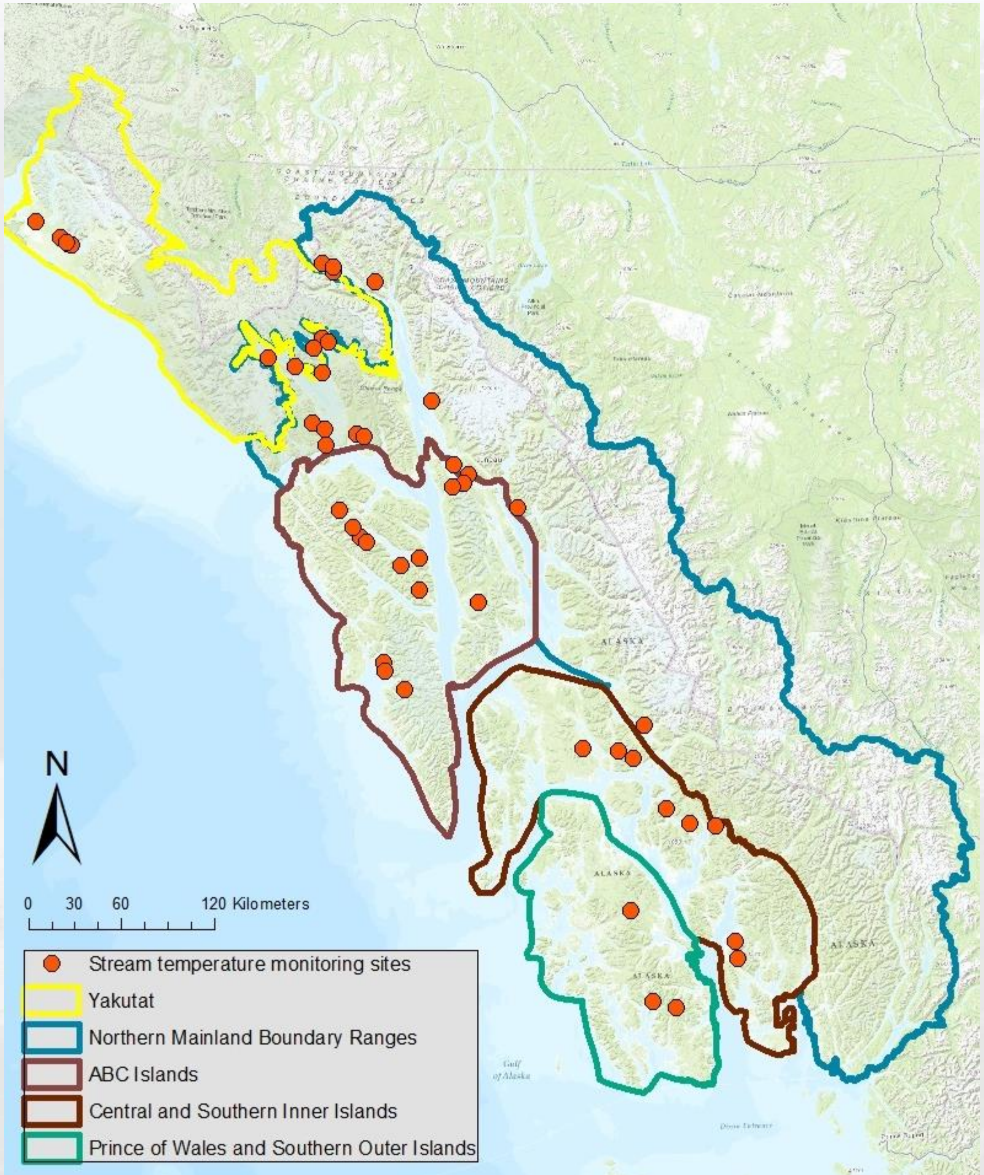



Fig. 1 Life cycle strategies of the five species of salmon (*Oncorhynchus*) four
with those that rear in freshwater and those that migrate directly to the ocean



# Contemporary Stream Temperature Study (2014-16)





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

# Retrospective Stream Temperature Study (1960-2015)

- What's out there for data?
- What can we say about Δ stream temperature ~ last half century?
- What can we infer about future Δ?

## Data Rescue

Main Database: **76** streams

- ≥ 2 yrs of data
- Semi continuous, resampled to daily intervals
- Data collection standards known (±0.2°C)
- Does not yet include additional **42** streams from 2+ yr contemporary study (M. Winfree)

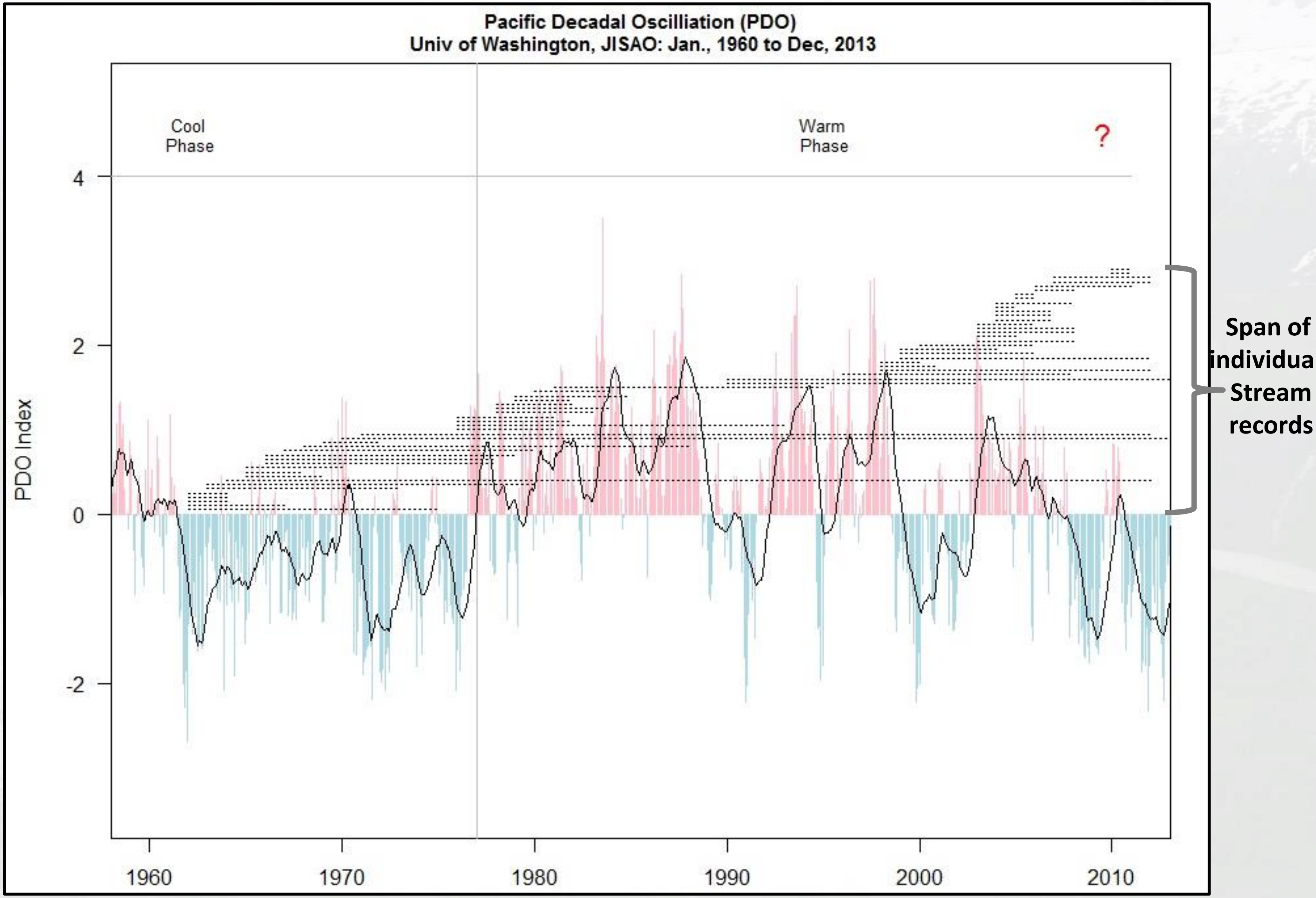
Ancillary Data: **40** streams

- 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 Oscilliation (PDO)
Univ of Washington, JISAO: Jan., 1960 to Dec, 2013
Cool Phase
Warm Phase
?
PDO Index
4
2
0
-2
1960
1970
1980
1990
2000
2010
Span of individual Stream records

# Retrospective Analysis

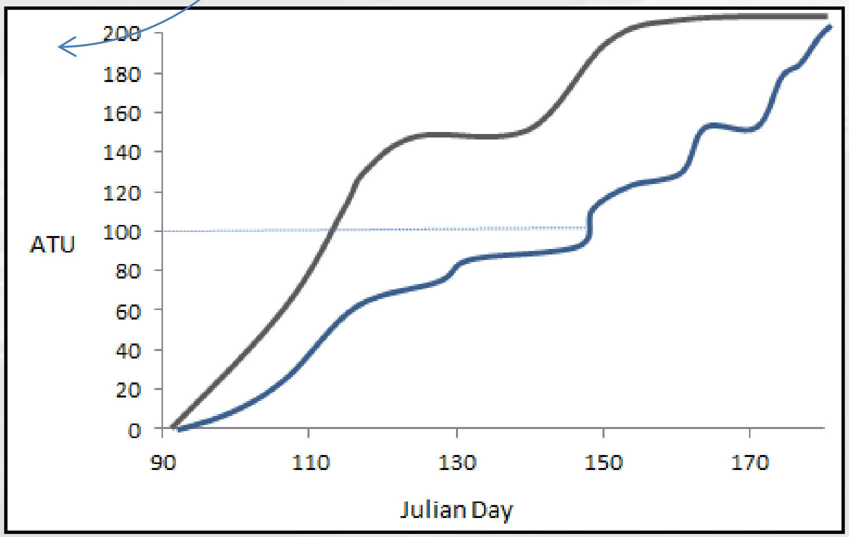
- Subset of 17 streams with > 10 years of data
- Mean span ~18 yrs and Range 2 – 45 yrs
- No transboundary and primarily non-glacial
- PDO Phases: 5 Cool, 6 Warm, 6 Cross

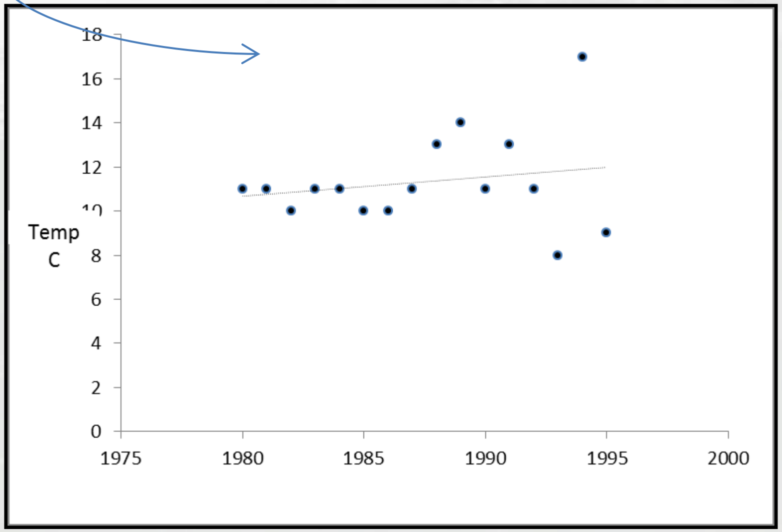
| | **Fine Scale** | **Broad Scale** |
|---|---|---|
| **Temporal** | Individual stream trajectories | Aggregate change during warm vs. cool phase PDO |
| **Spatial** | Landscape controls (e.g., alpine) | Aggregate change relative to climatic zones |

# 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

Fall:

- > ¾ of streams with ↑ trends in temperature, *adding* 1.1 °C per decade

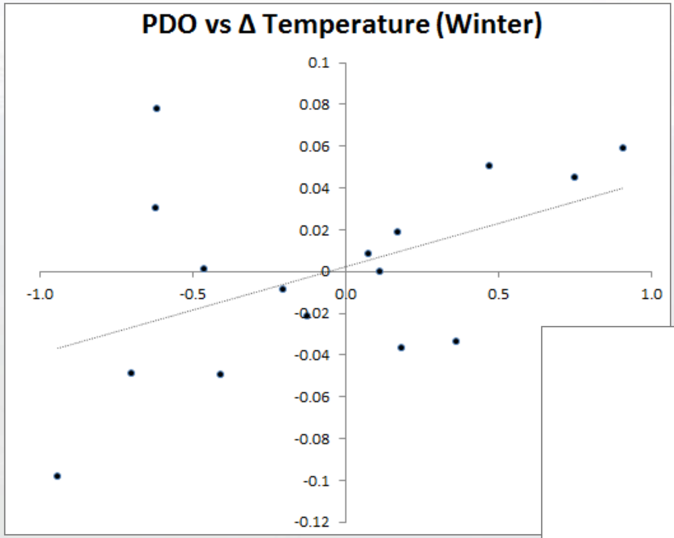
Winter:

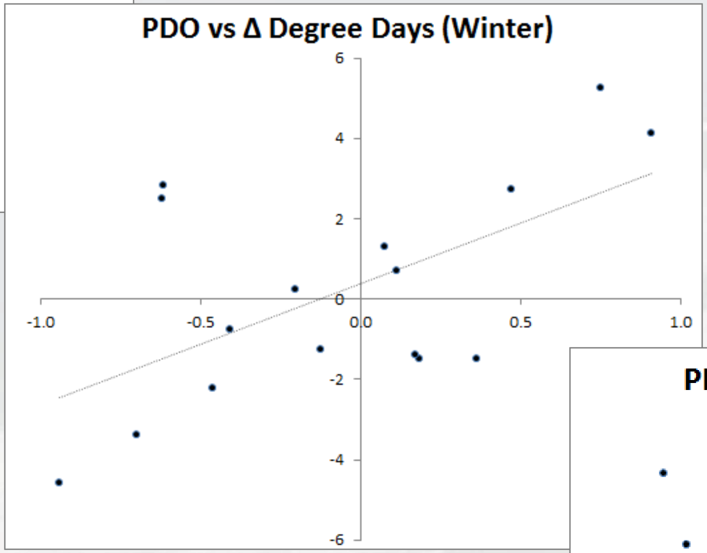
- > ¾ of streams with ↑ trend in degree-day distribution, shifting 16 days *later*/decade

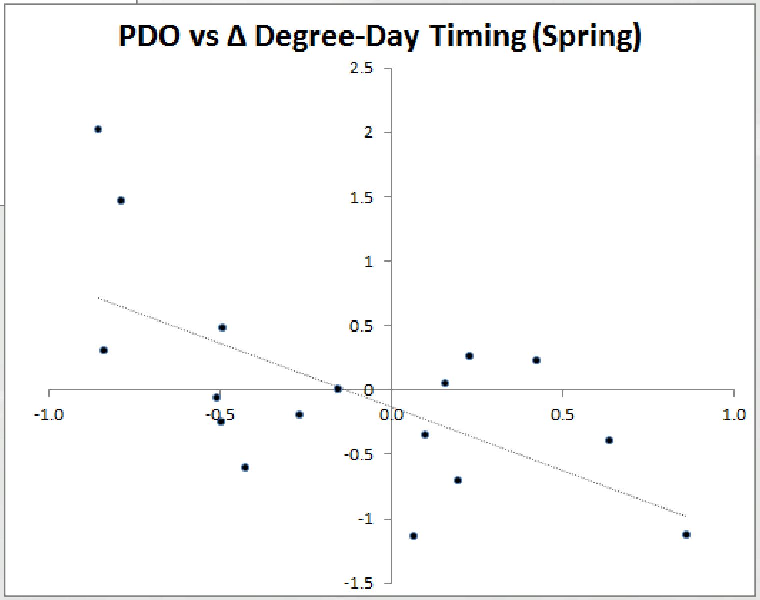
Spring & Summer:

- > ¾ of streams with an ↑ trends in degree days, *adding* 43.7 DD and 138.3 DD / decade
- ~ ¾ of streams with ↑ trends in variability of timing of DD

# Retrospective Analysis – Stream Patterns & Large-Scale Forcing

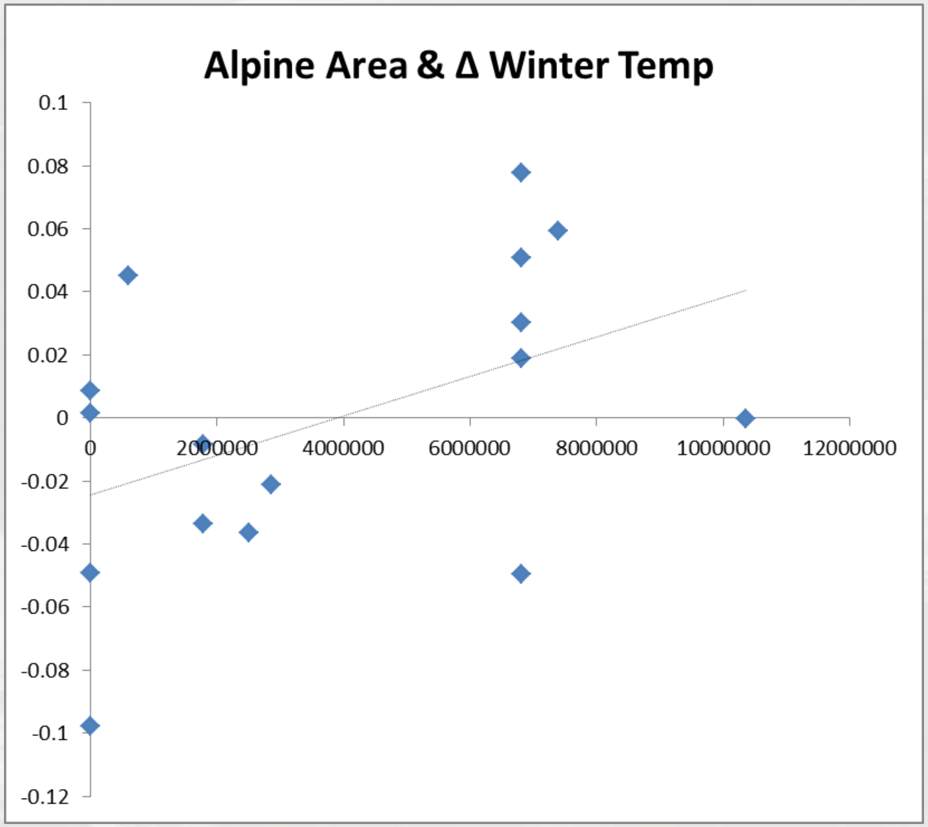


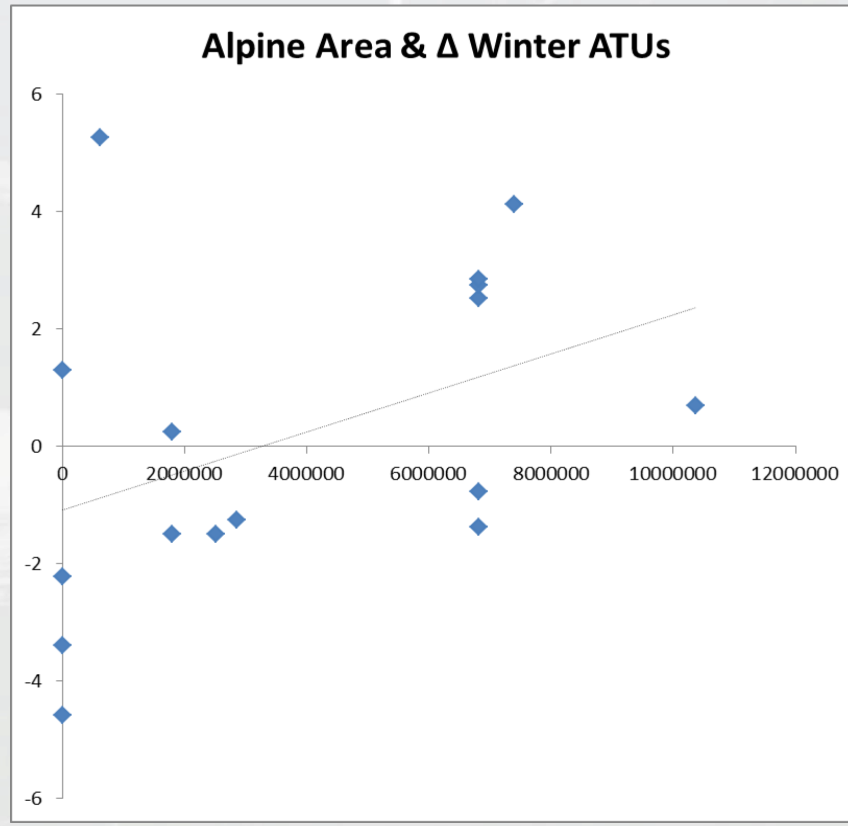



# Retrospective Analysis – Landscape Control

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



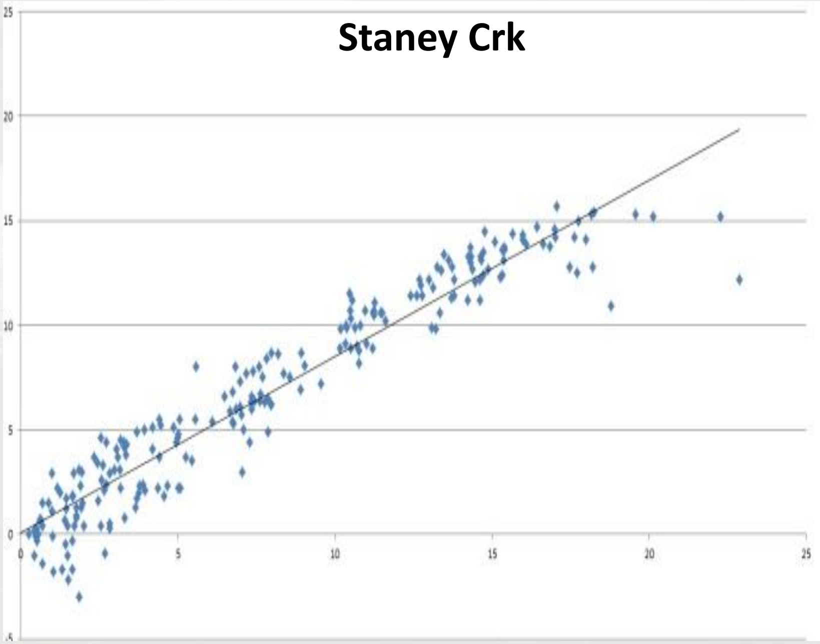



## Climate – Stream Temperature 'Downscaling'

- 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 Δ:
  - 0.3-1.1 °C
  - 9.8-37% in ATU



## Future Steps

- Data publication - Dec 2016
- Historical vs current comparison (25+ datasets $\geq$ 5 yrs)
- Climate - stream temperature downscaling – modeling uncertainty
- Project Δ 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)
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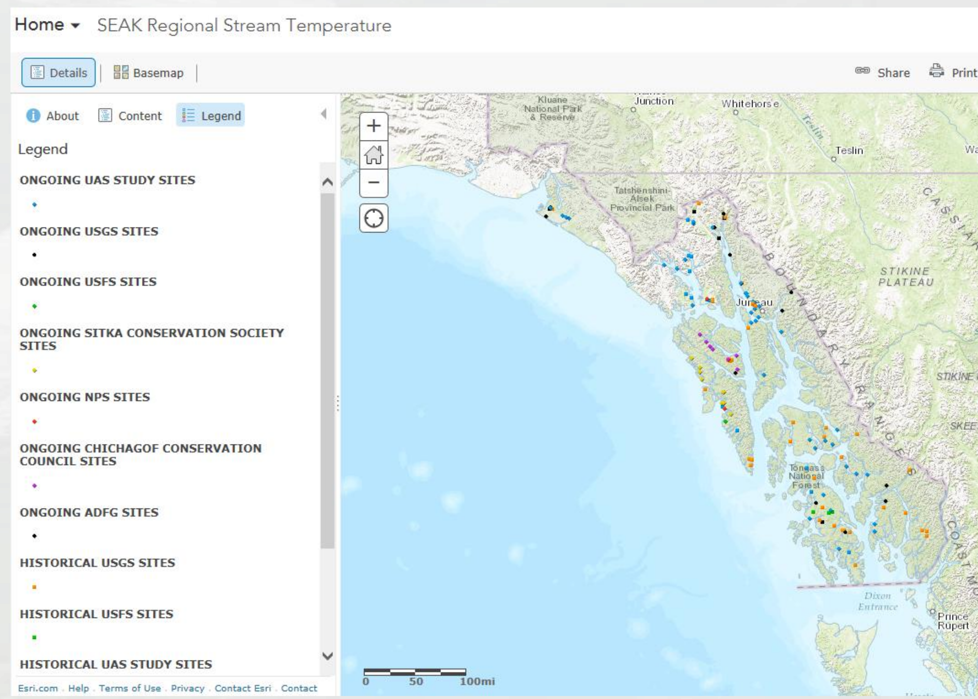
- National Park Service (C. Sergeant)
- PNW Station (R. Edwards, B. Wright)
- Chichagof Conservation Council (M.Kemp, N Olmstead)
- Alaska Climate Science Center
- UAF – SNAP
- UAS (J Fellman, M Winfree)


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




Emails: spyare@uas.alaska.edu , ewhood@uas.alaska.edu