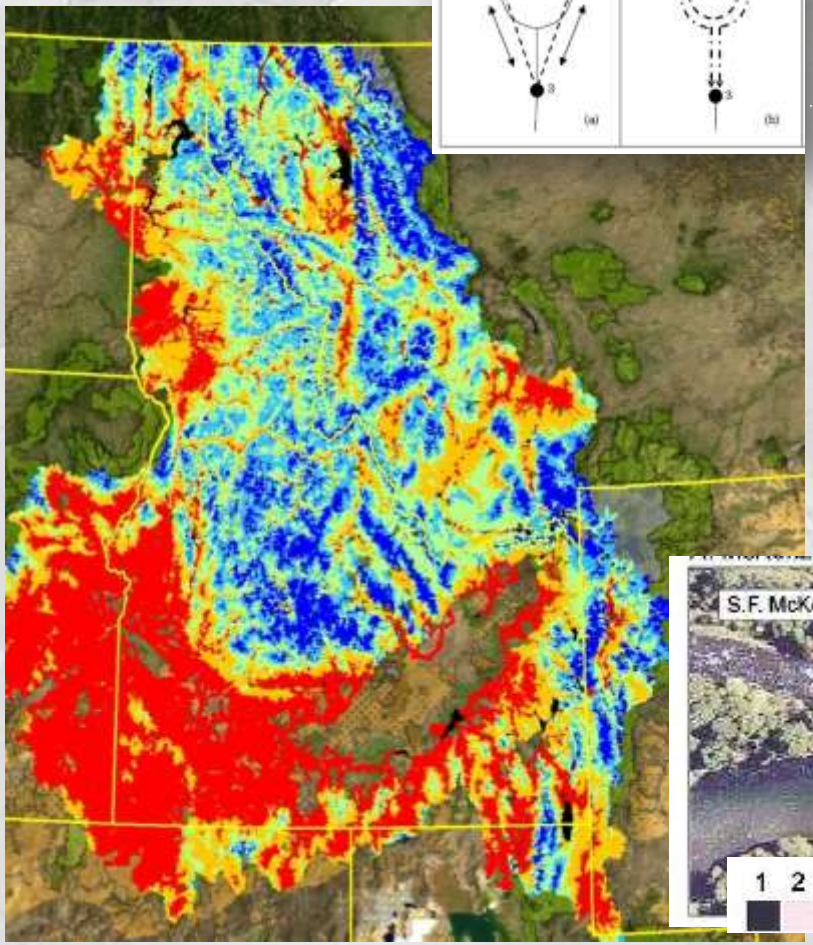
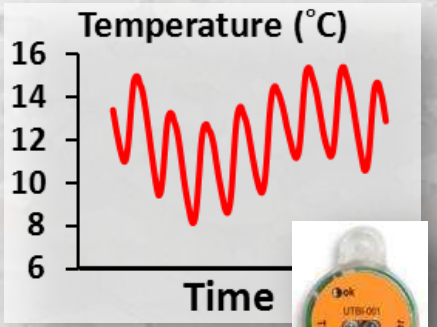
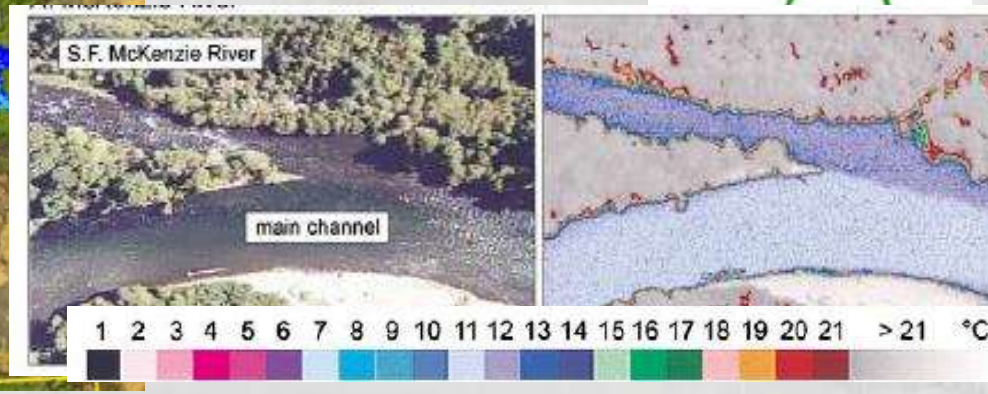
Towards Continuous Space-Time Monitoring, Modeling, & Forecasting of Temperatures in Salmon Rivers





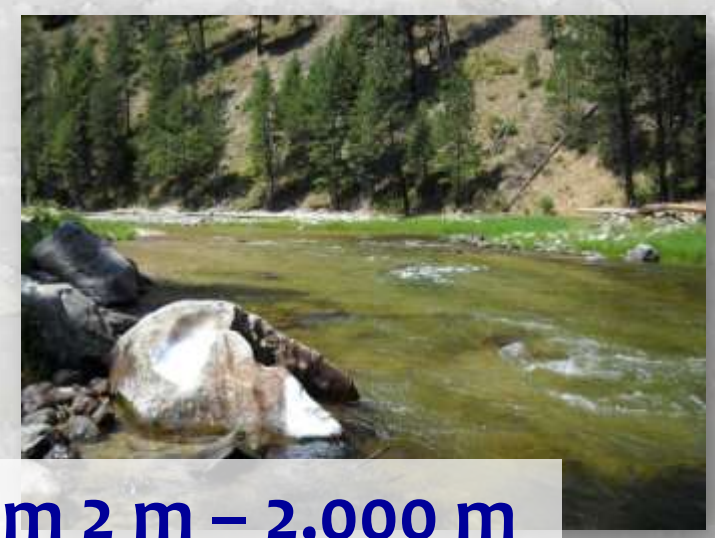



Columbia River Basin
Columbia River Basin
WASHINGTON
OREGON
IDAHO
MONTANA
WYOMING
CALIFORNIA
NEVADA
UTAH
Pacific

Northwest U.S. Stream Climates

Cold, high elevation mountain rivers

Warm deserts & regulated lowland rivers



Salmon spawn from 2 m – 2,000 m

Migrate 1 km – 1,300 km inland

Thermal Constraints on Salmon Populations are Common

Symptoms include…

1) Migration delays & clustering near coldwater refuges

2) Fishing season closures

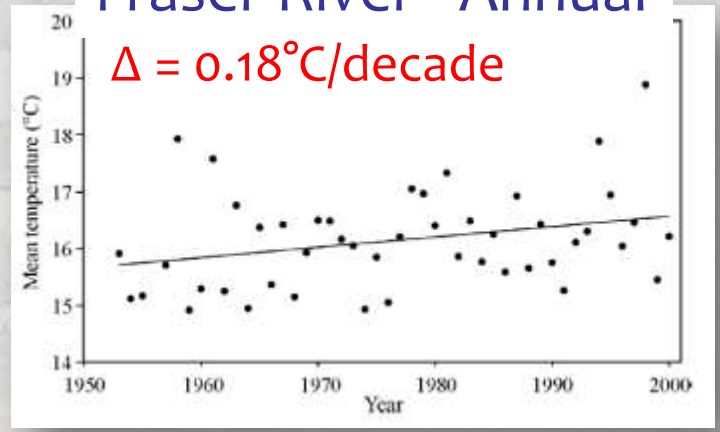
3) Selective gradients based on run timing

4) Mass mortality events:
   a) upriver stocks of Fraser river sockeye "disappear"
   b) spawning ground fish kills

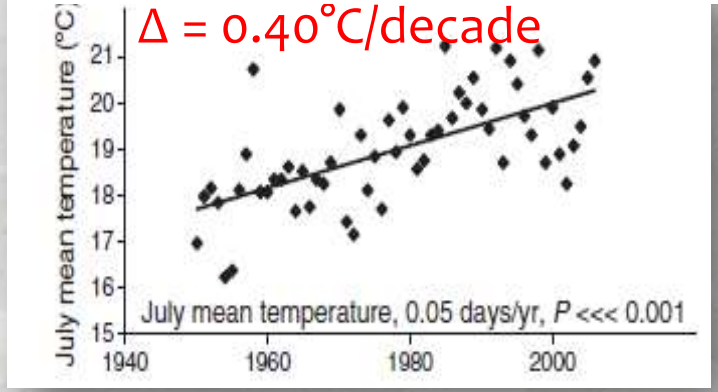
Keefer et al. 2008; Keefer et al. 2010; Caudill et al. 2013

Temperature Trends In Northwest Rivers

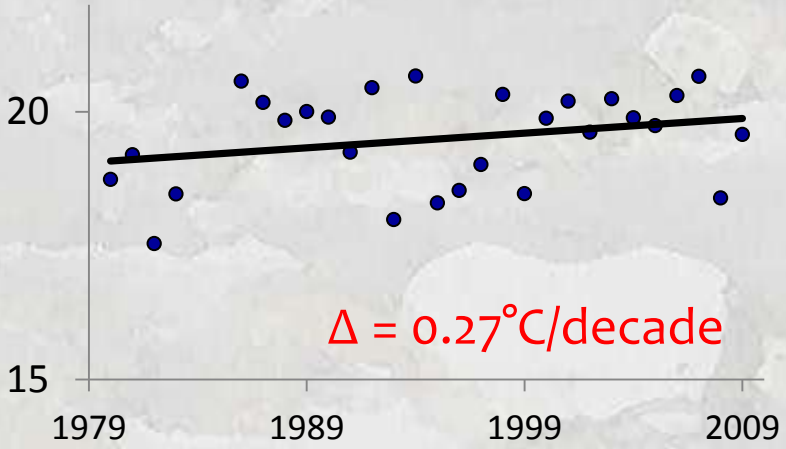
Fraser River - Annual



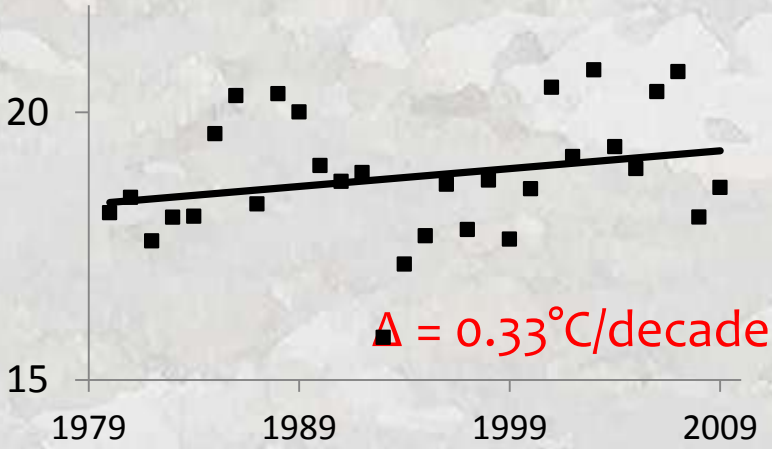
Columbia River - Summer



Snake River, ID - Summer



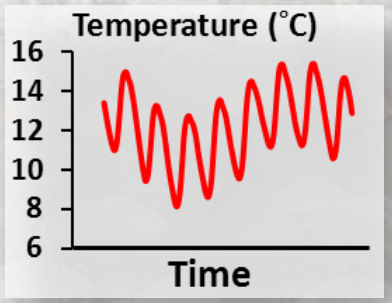
Missouri River, MT - Summer

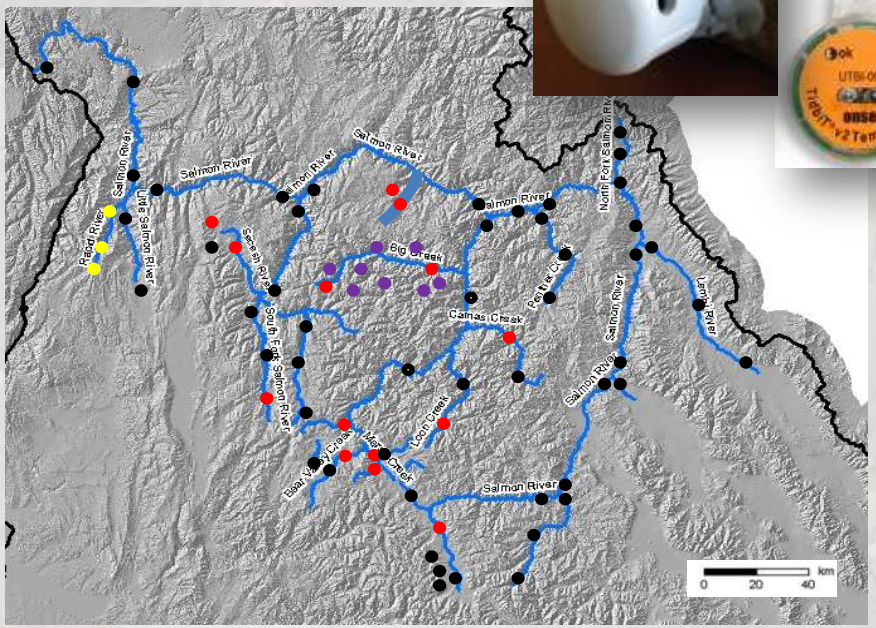


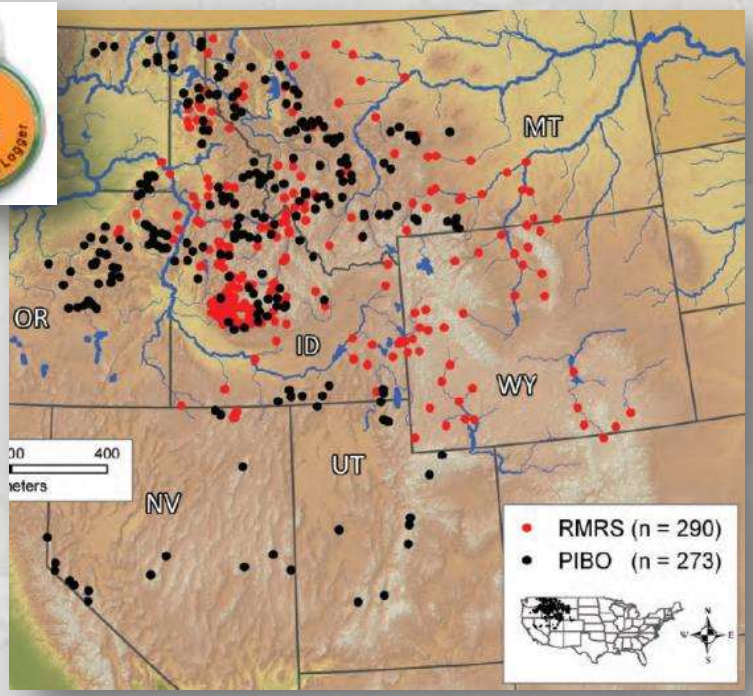
Creating the Salmon ThermalScape:

1) Large array of inexpensive sensors recording stream temperatures continuously

Buy as many as possible & deploy throughout the river network that salmon use



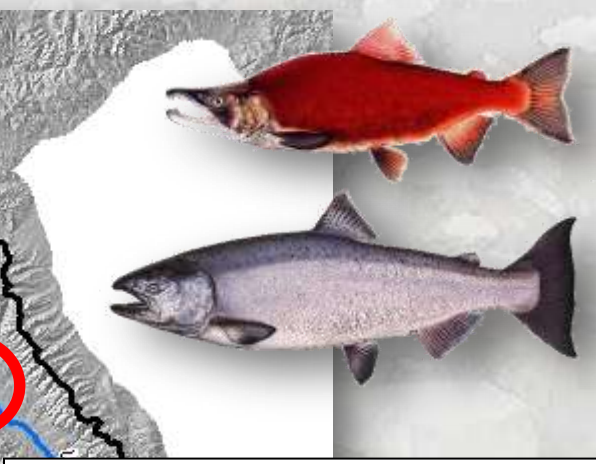


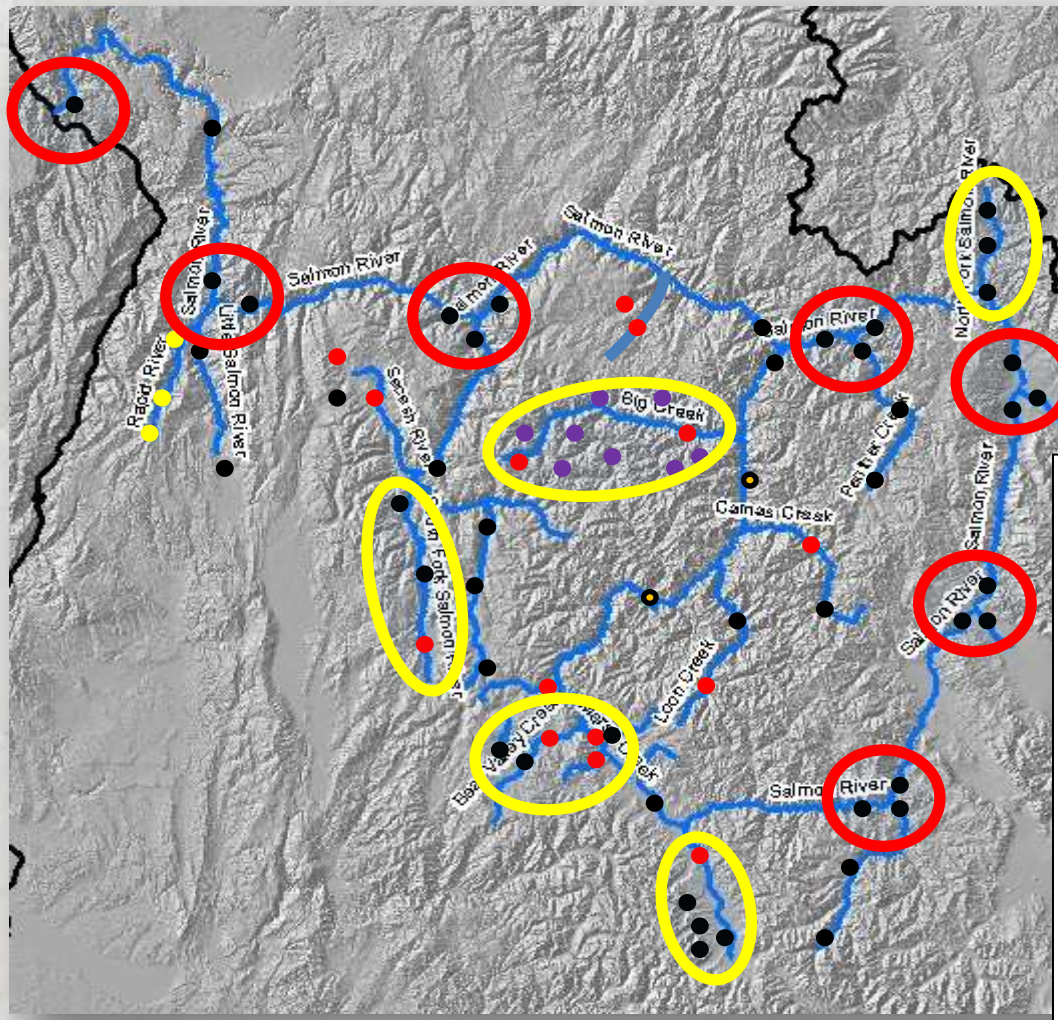


Salmon River Temperature Network

Sampling design: 1) river segments along migratory corridor
2) spawning/rearing reaches

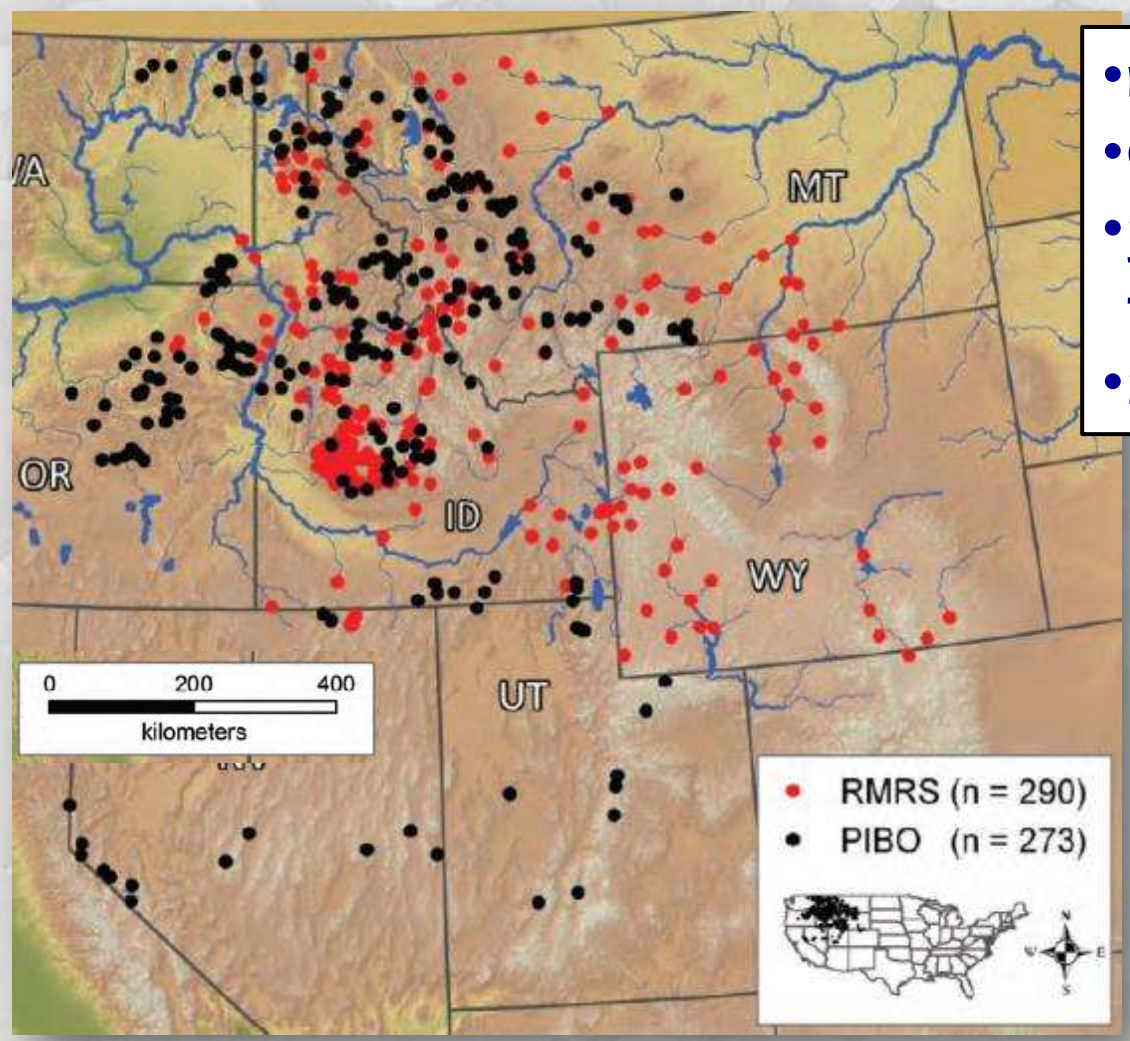
Species of Concern



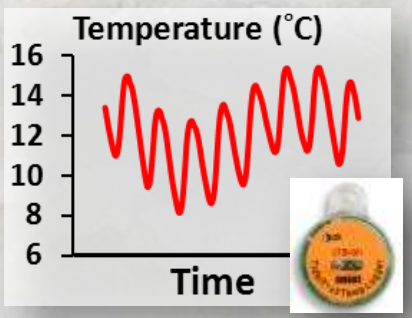


Sites: n = 70
Installation: 2 people, 2 weeks
Initial Cost: $10,000
Maintenance Cost: $1,000 per year
2 people, 2 weeks to visit sensors (download & replace)

NoRRTN: Northern Rockies River Temperature Network



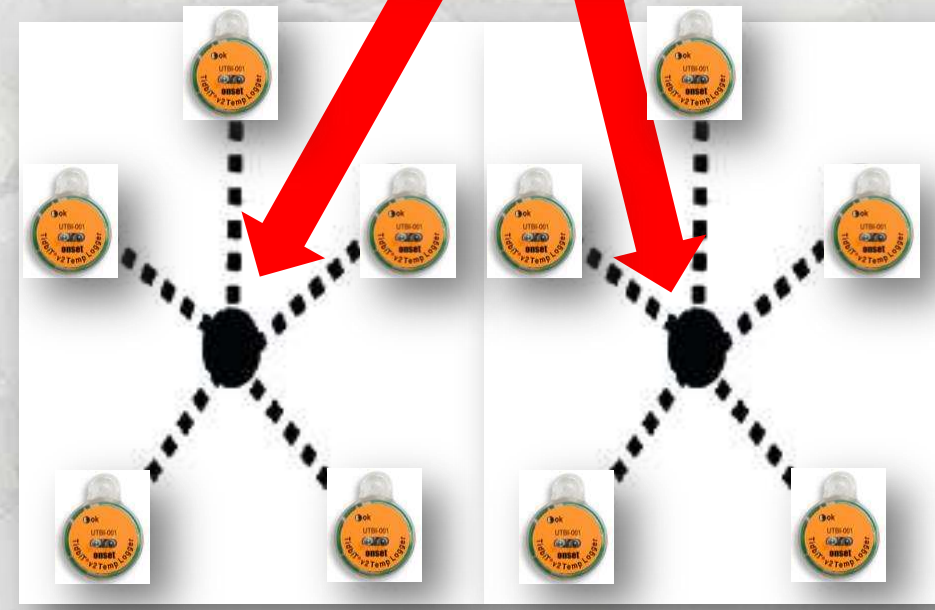
- n = 563 sites;
- Cost = $100,000;
- 3 months time for 2 technicians;
- 2,500 years data



Creating the Salmon ThermalScape:

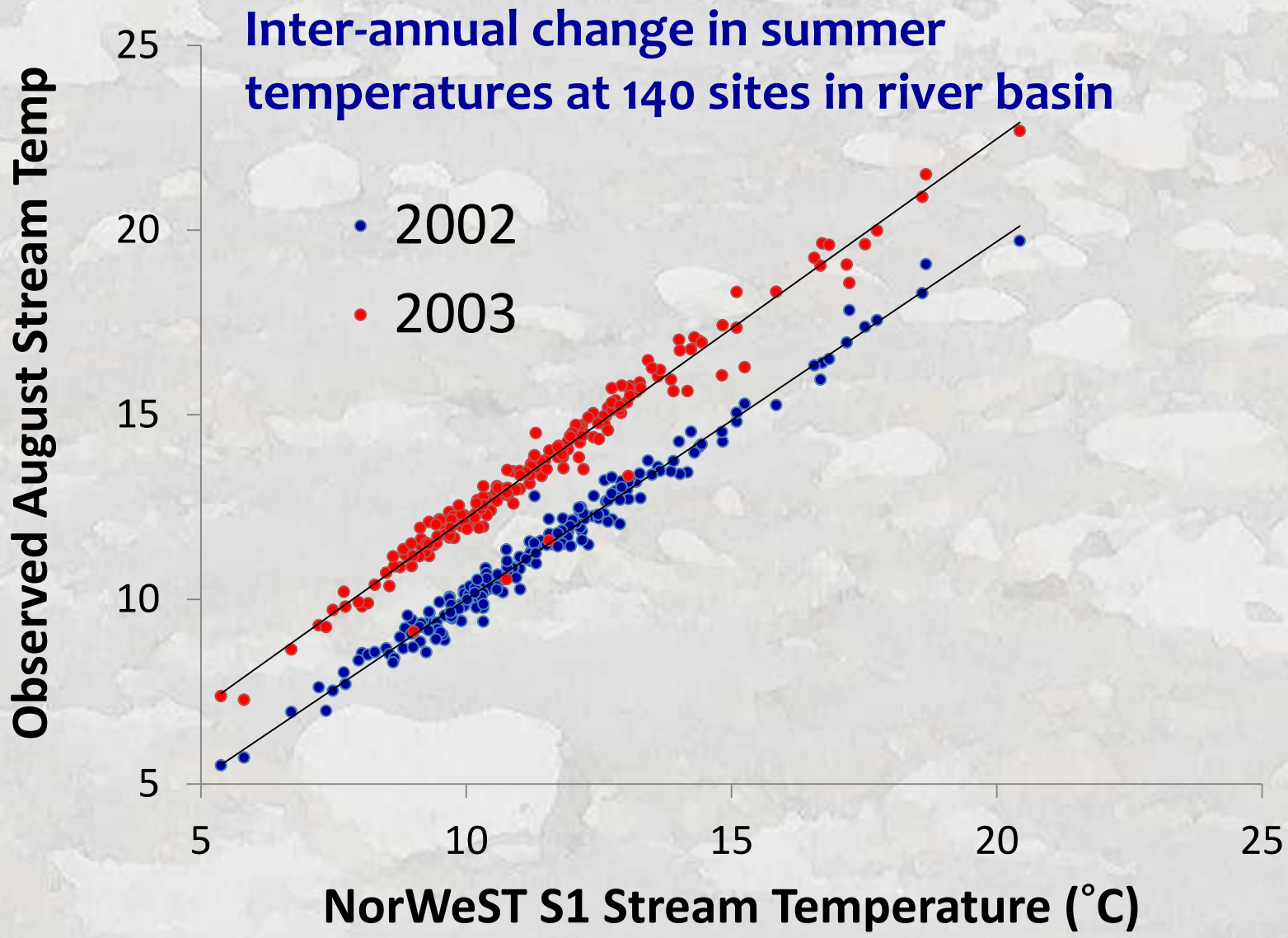
2) Small number of realtime, wireless sensors placed strategically across region

Correlations between wireless sensors & large sensor array leverage information across much larger areas



Porter et al. 2005;
Porter et al. 2011

Temporal Variation Among Stream Sites is Strongly Synchronized



Creating the Salmon ThermalScape:

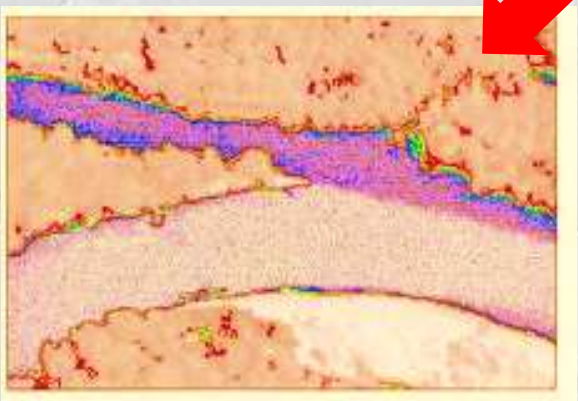
3) Spatially continuous thermal census of all rivers

TIR

Torgersen et al. 1999, 2001

Flight during thermally stressful period identifies refuges

Calibration provided by existing large array sensor



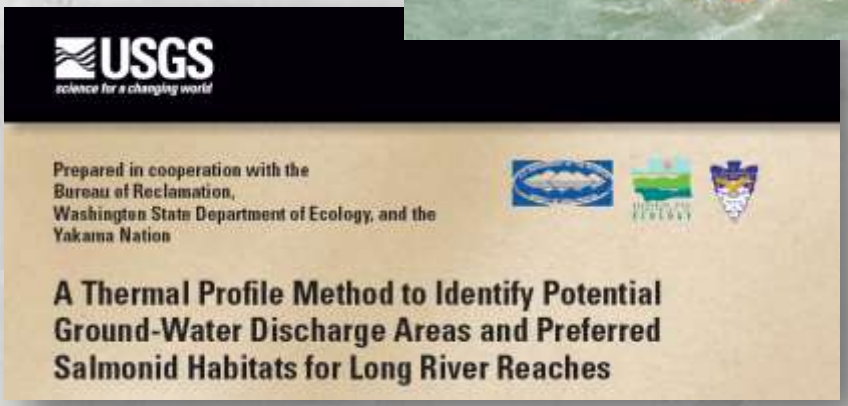
Repeat flight describes temporal variation

Dugdale, Bergeron, and St-Hilaire 2013

Torgersen et al. 2012. Primer for identifying cold-water refuges to protect and restore thermal diversity in riverine landscapes. Region 10, EPA 910-C-12-001.

Less Expensive (& More Fun) Alternatives for Thermal Censusing

Tow temperature sensors on float trips

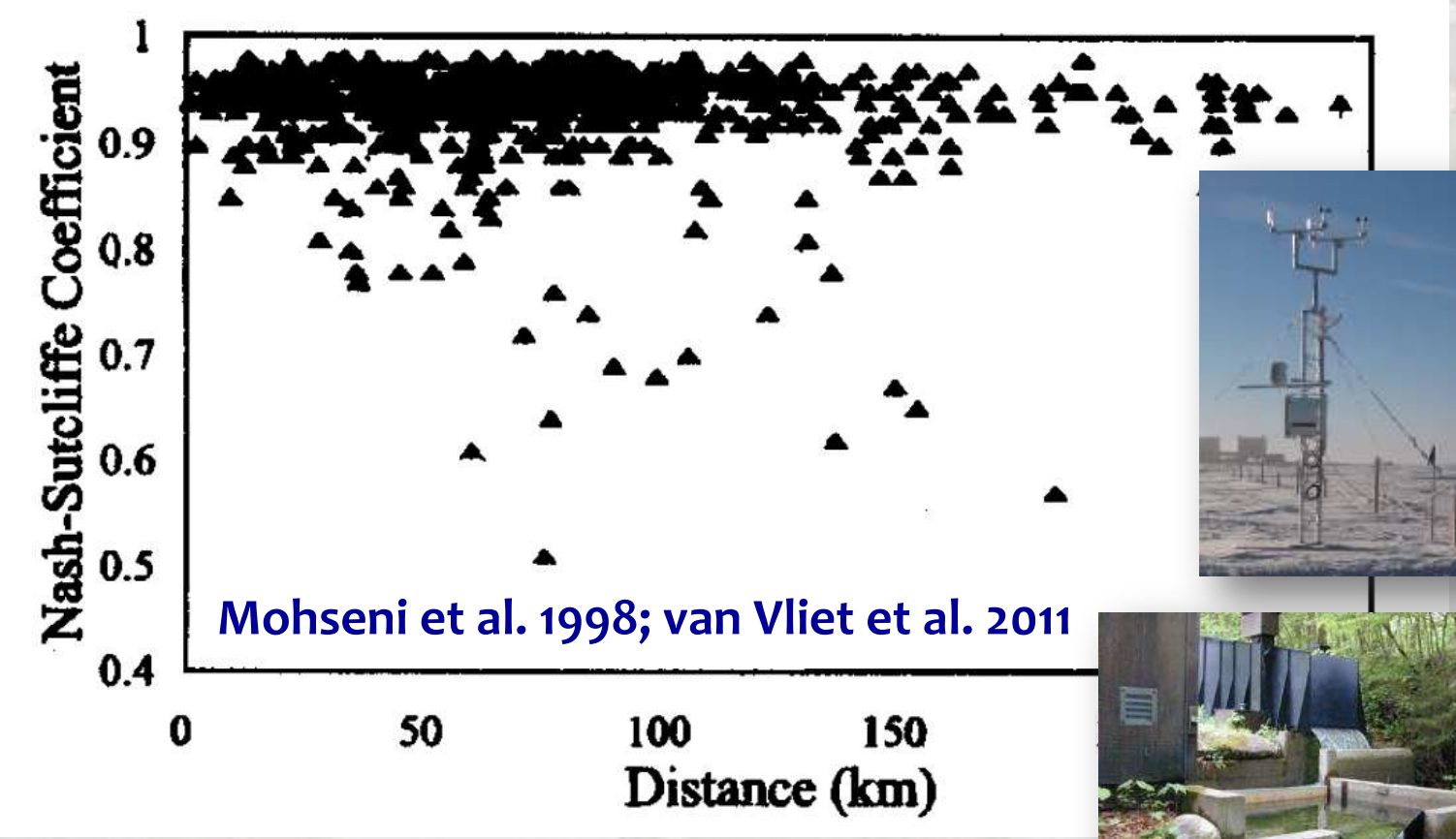


Vaccaro & Maloy. 2006.

Drone mounted cameras

Creating the Salmon ThermalScape:

4) Link continuous space/time stream temperature information to real-time weather stations



Remote stations for air temperature and discharge can be used for accurate predictions

Creating the Salmon ThermalScape:

5) Develop thermal stress criteria by referencing biological patterns against modeled stream temperatures at same date/location

Biological data sources:

Traditional

- Telemetry w/temperature tags
- Distribution/abundance surveys
- Weir/dam passage counts & timing

Non-traditional (partnership opportunities with managers, anglers & citizenry)

- Fish kills
- Clustering at cold-water sources

***Document when/where thermal stress events occur**

We'll Know We're There When…

We see our first fish weather forecast by…

SALMONMAN