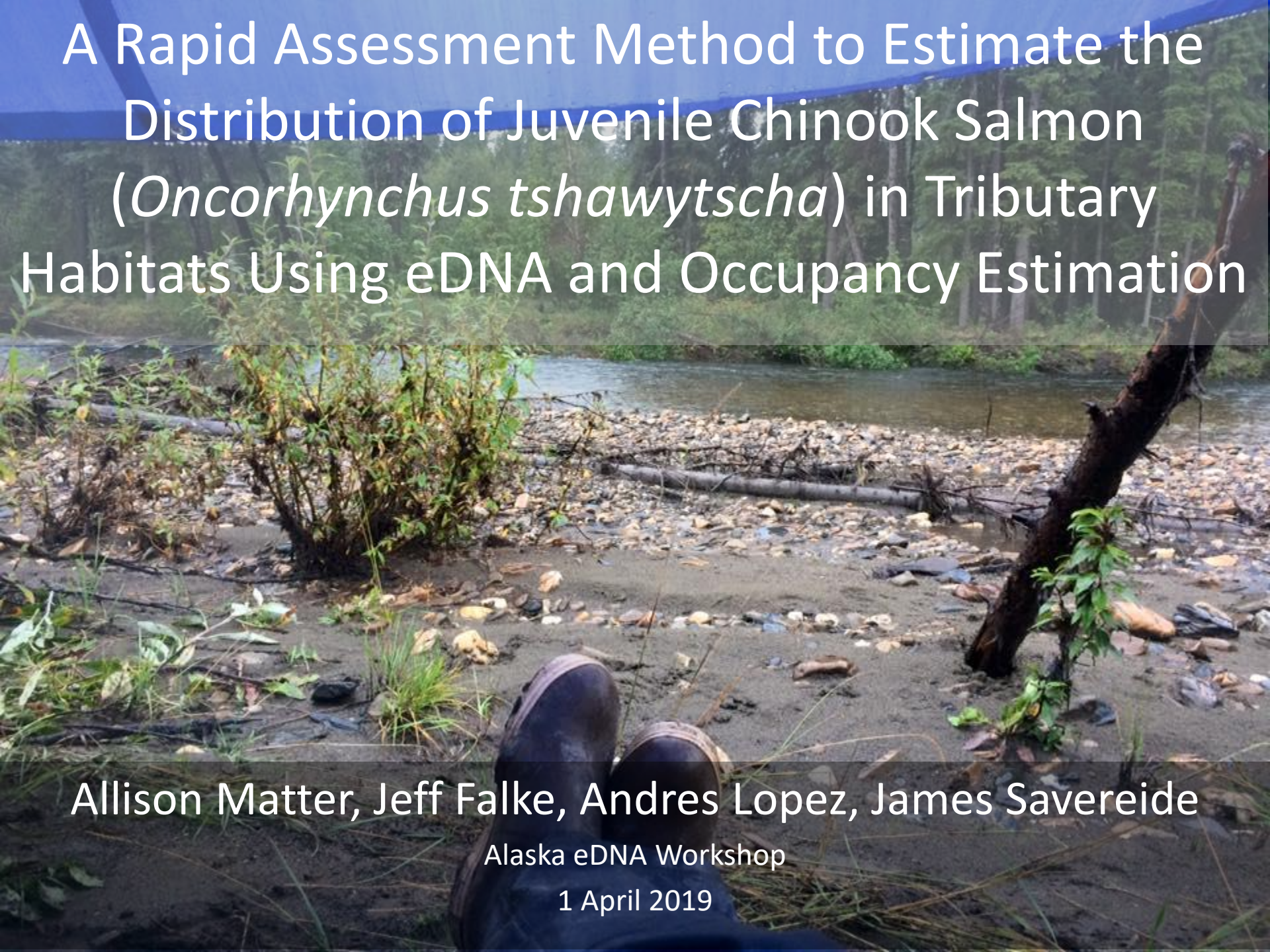
A Rapid Assessment Method to Estimate the Distribution of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in Tributary Habitats Using eDNA and Occupancy Estimation



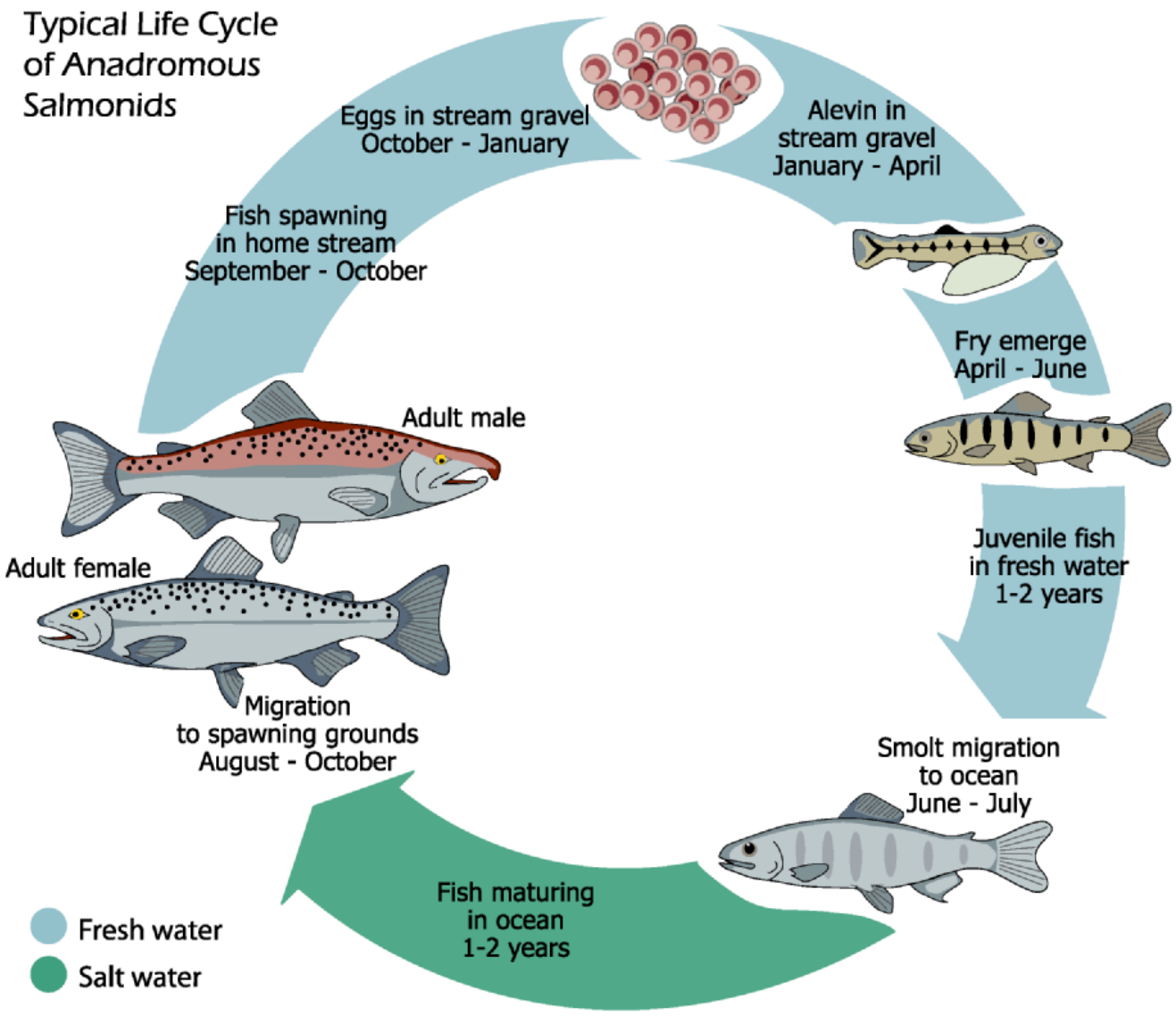
Allison Matter, Jeff Falke, Andres Lopez, James Savereide

Alaska eDNA Workshop

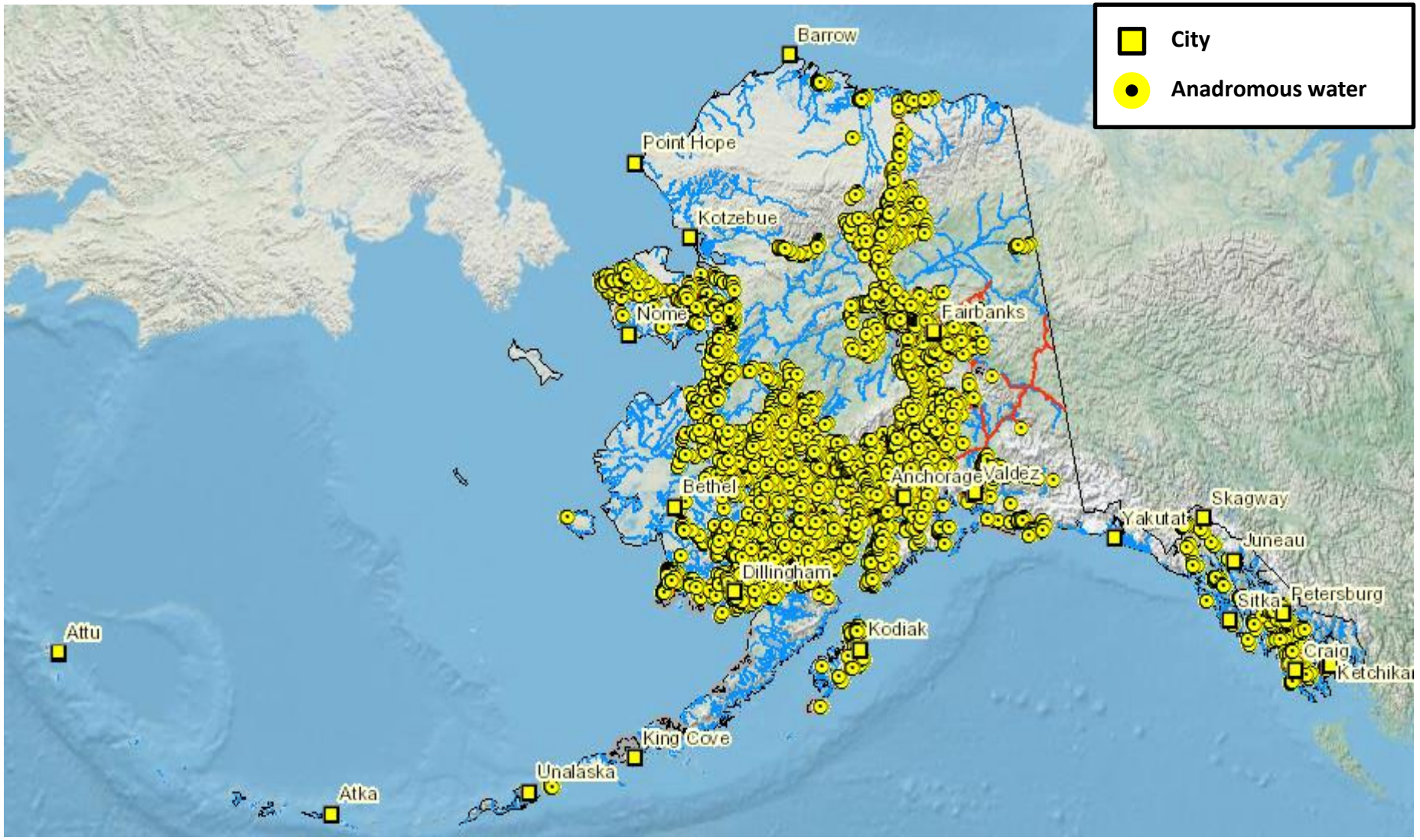
1 April 2019

Challenges to Mapping Fish Distributions

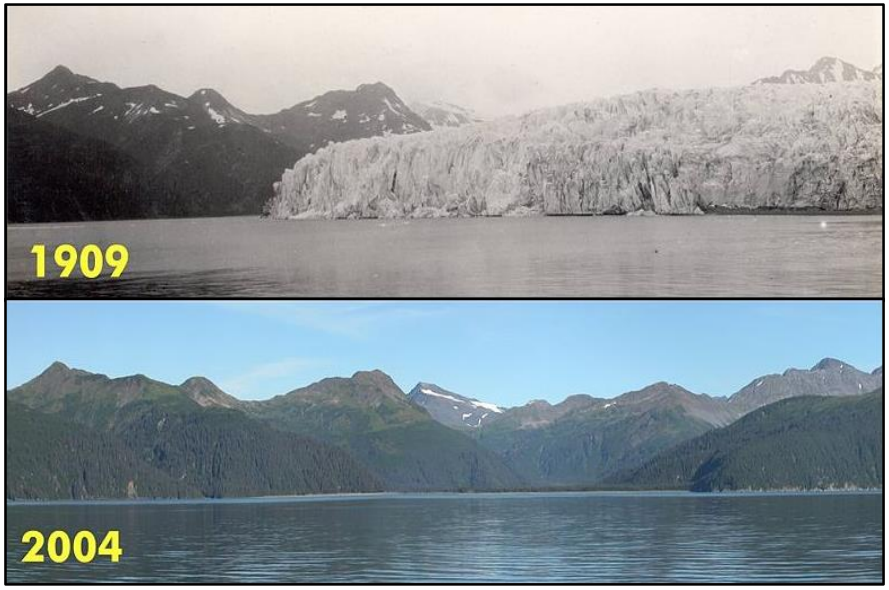
Challenges to Mapping Fish Distributions



Anadromous Waters Catalog (AWC)



Climate and Land Use Impacts



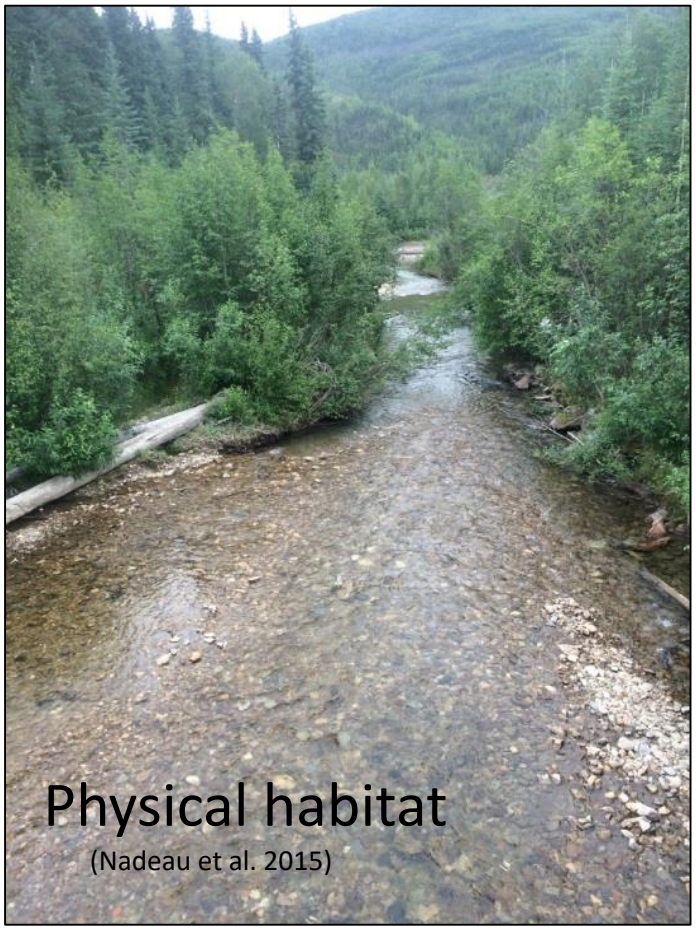
Traditional Sampling Techniques

Rapid Assessment: Qualities and Examples

Qualities:

1. Rapid
2. Efficient
3. Precise

Aquatic examples:



Rapid Assessment for Distribution

Ideal characteristics

- Reduced cost and effort
- Increased detection
- Non-invasive

Application

1. Predictive model to prioritize sampling
   - Habitat potential model
2. Inform survey design
3. Assessment via sampling
   - Snorkeling, eDNA, electrofishing, etc.

Research Objectives

Overall goal: develop rapid assessment techniques to estimate the distribution of juvenile salmon in interior Alaska rivers

Basin-scale

1) Intrinsic potential habitat modeling

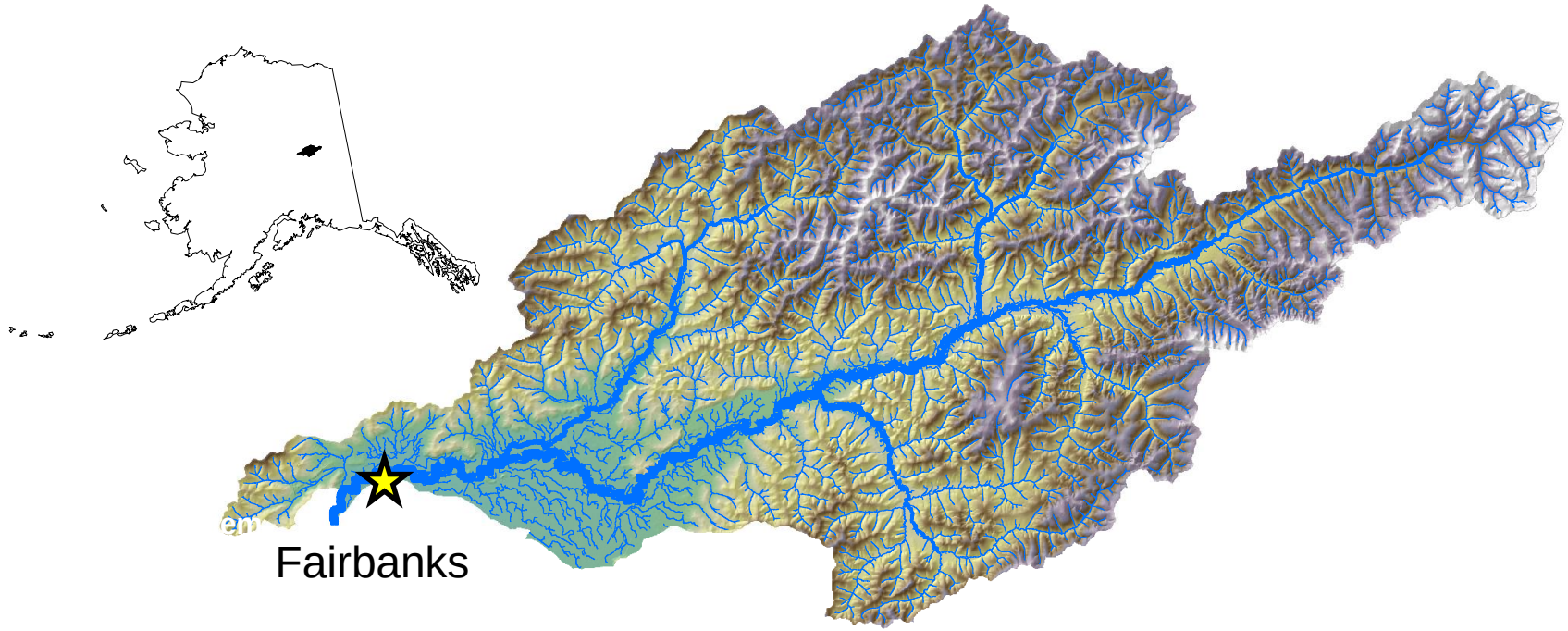
Catchment-scale

2) eDNA occupancy estimation

Habitat unit-scale

3) Snorkeling to determine upstream extent and validate eDNA estimates

Study Area – Chena River Basin



Juvenile Life History

- Interior Alaska - stream-type life history
- Juveniles disperse from redds
  - Passive or directed movements
  - Use multiple rearing habitat types

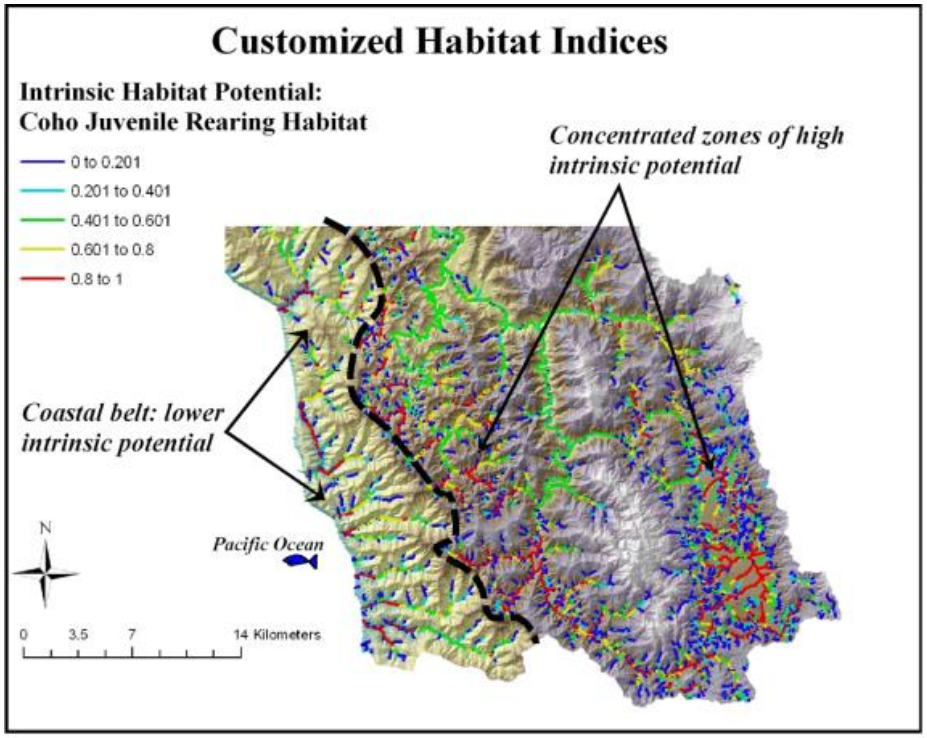
Habitat Potential Modeling

Intrinsic potential (IP) = *a metric that reflects species-specific associations between fish use and persistent geomorphic stream attributes* (*Burnett et al. 2007*)

Examples:

- Oregon Coastal Province juvenile coho and steelhead rearing habitat (*Burnett et al. 2007*)

- Columbia River – adult Chinook spawning habitat (*Busch et al. 2011*)



Environmental DNA (eDNA)

- Non-invasive presence and abundance
- Sources of eDNA
- Imperfect detection
- Not location specific

http://fishbio.com/field-notes/conservation/traces-left-behind

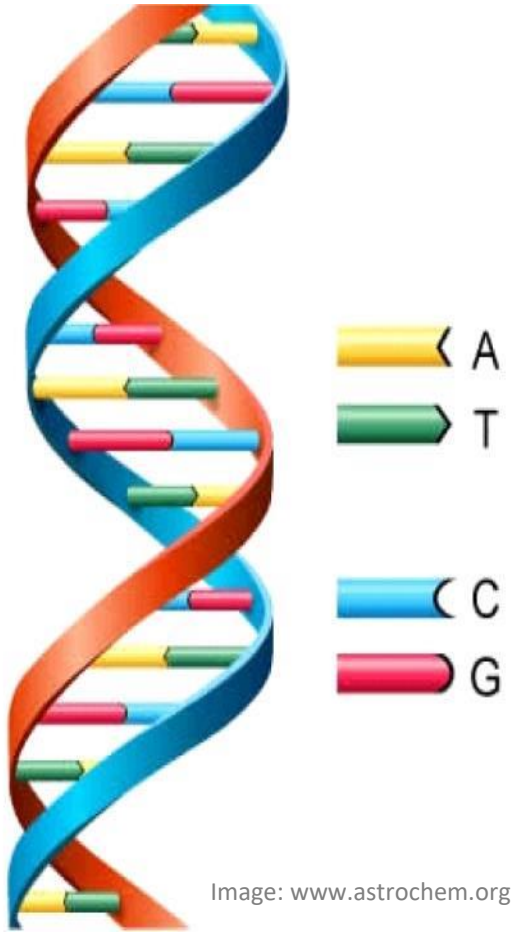
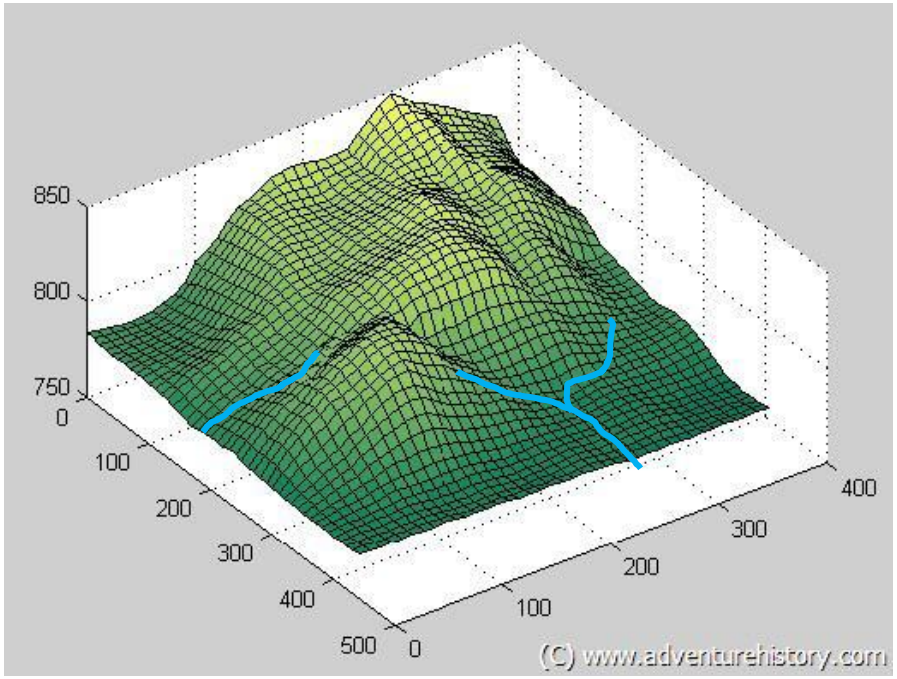


Image: www.astrochem.org

Methods: Intrinsic Potential Modeling

NetMap = *A system of "digital landscapes" for conducting environmental assessments*
(Benda et al. 2007)



Chena River NetMap

1. Digital elevation model (DEM)
   - 5 – 10 m^2 resolution
2. Synthetic stream network
   - 50-m reaches
3. Geomorphic attributes

Alaska basins in NetMap:

- Tongass NF
- Copper River Basin
- Nome River
- Mat-Su basin
- Tanana tributaries

Methods: Intrinsic Potential Modeling

Geomorphic attributes

Reach gradient (%)

- Velocity barriers

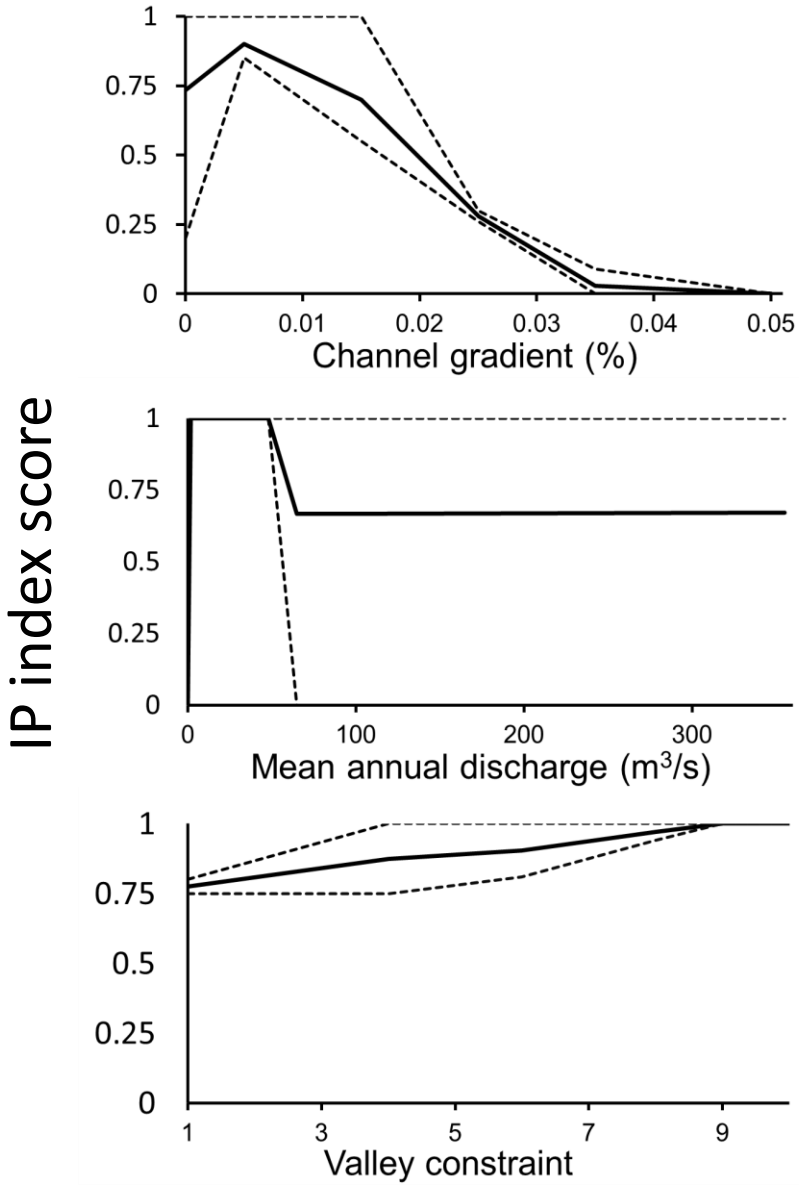
Mean annual discharge (m^3/s)

- Juvenile Chinook associated with larger streams

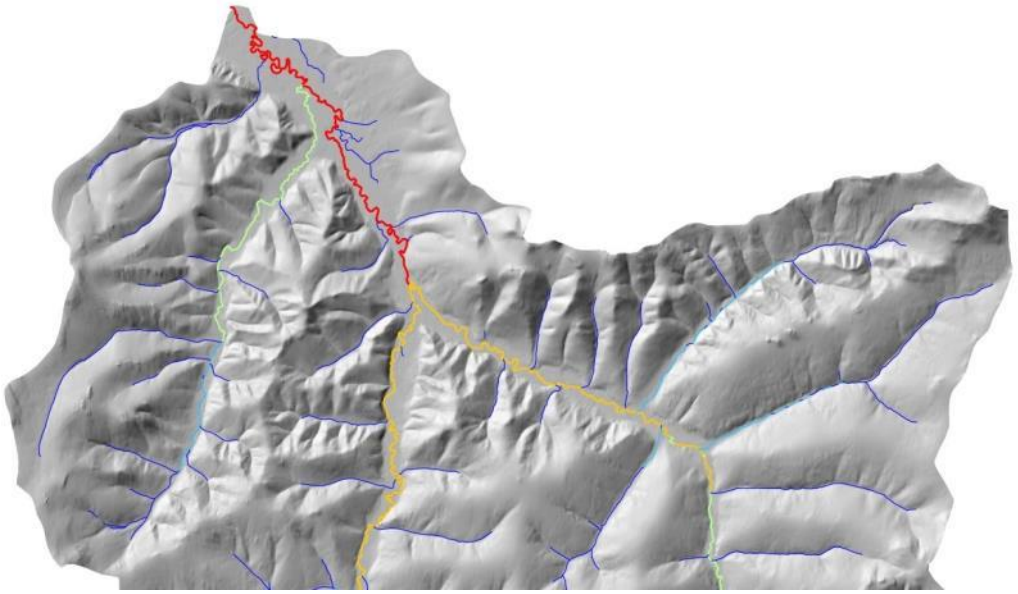
Valley constraint (bankful width:valley width)

- Unconstrained reaches have high habitat complexity
- Large wood accumulation

Methods: Intrinsic Potential Modeling



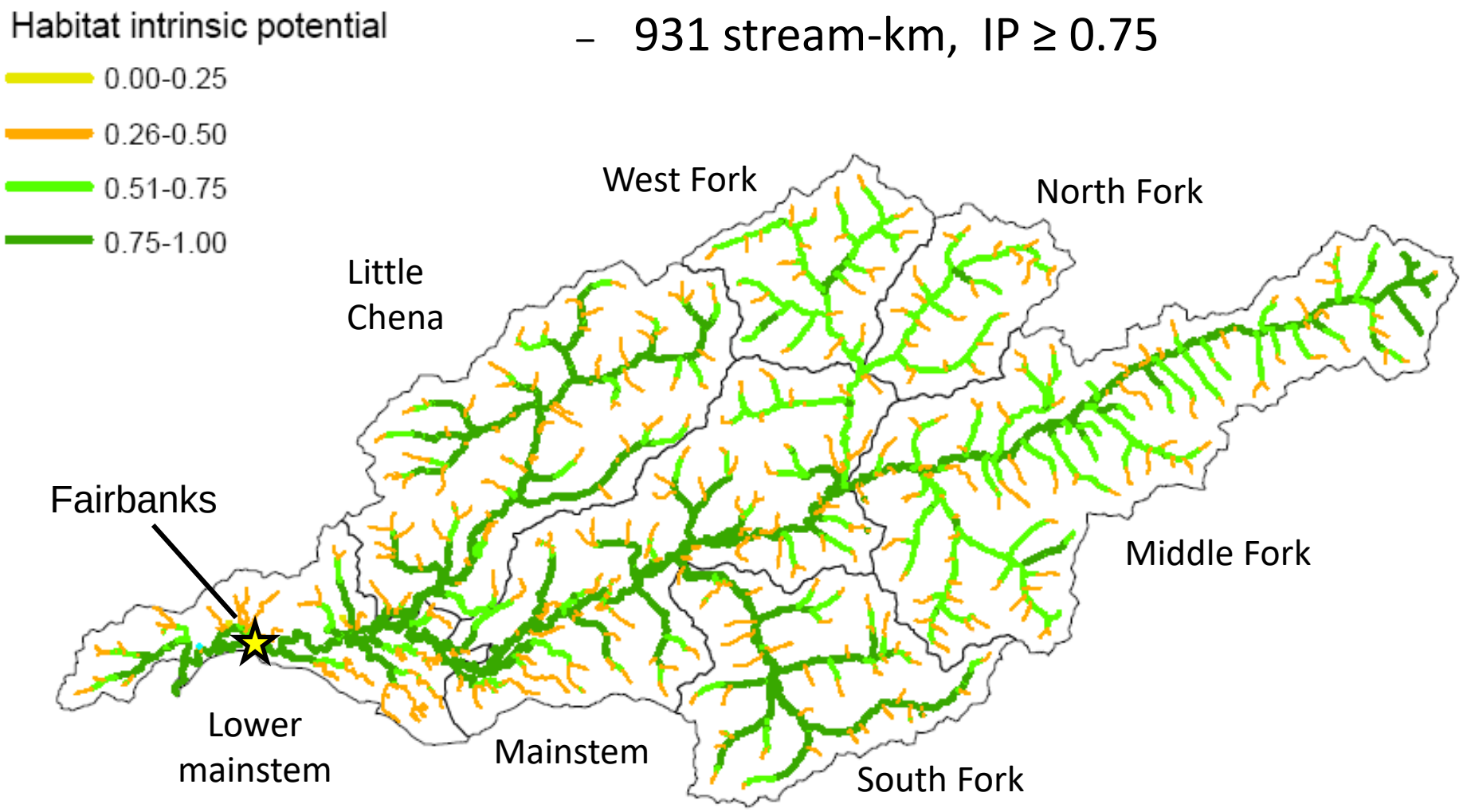
- Assess reach-scale habitat potential
- Preference (index) curves
- $IP = (V_1 * V_2 * V_3 \ldots V_n)^{1/n}$
- First pass: Columbia, Copper River IP's



Chinook spawning IP (Busch et al. 2013)

Methods: IP Results and Site Selection

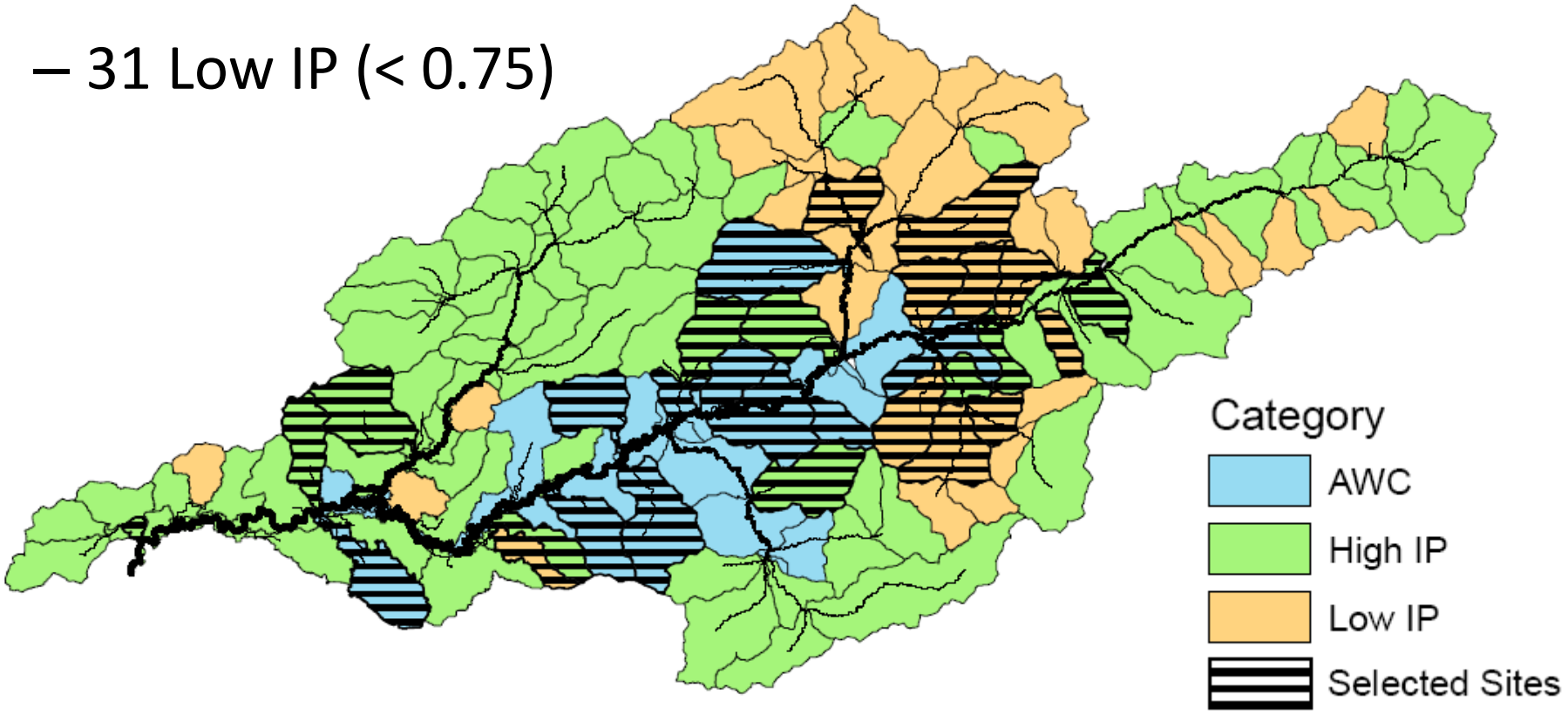
- 2,265 total stream-km
- 931 stream-km, IP ≥ 0.75



Methods: Field Site Selection

Catchments categorized by known use (AWC) and IP score

- 32 AWC
- 86 High IP (≥ 0.75)
- 31 Low IP (< 0.75)



Methods: eDNA Field

- 1-L water samples
- Three replicates
- *N* = 49 catchments (26 multi-year)
- 2014-2015

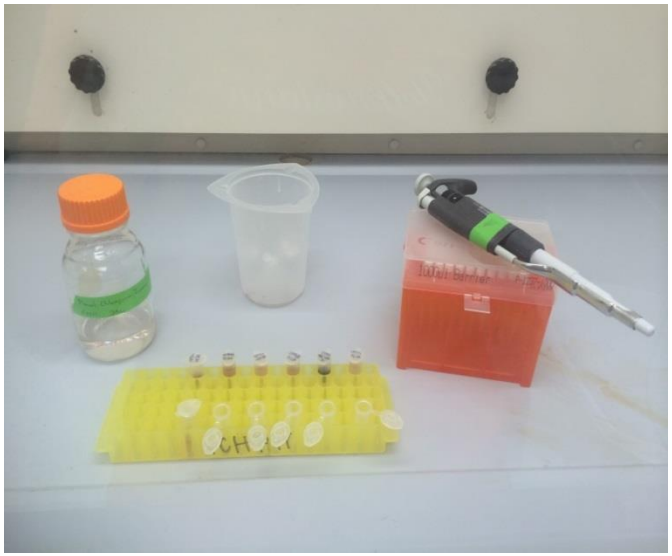
Methods: eDNA Lab

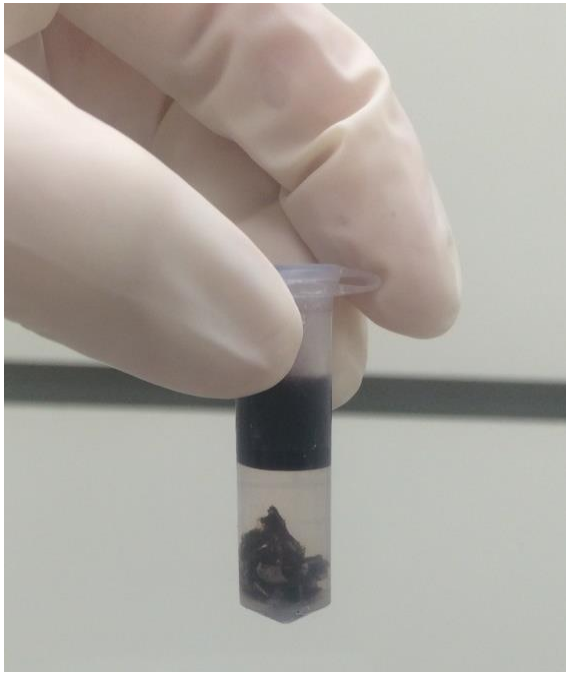
1. Water samples filtered

   - 0.45µm cellulose nitrate

2. DNA extracted from filters

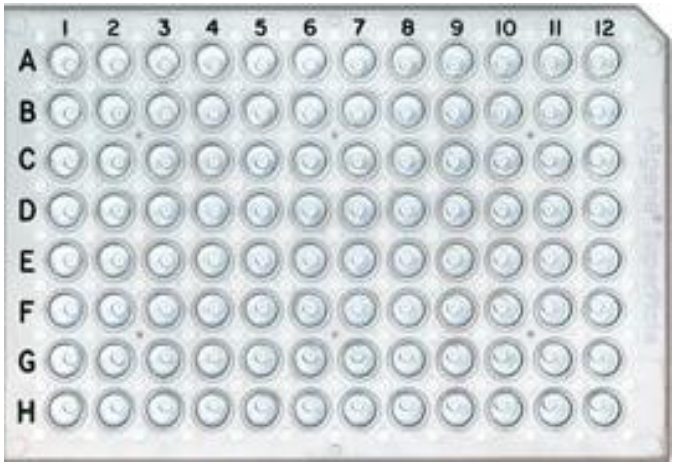
   - Phenol-chloroform-isoamyl alcohol





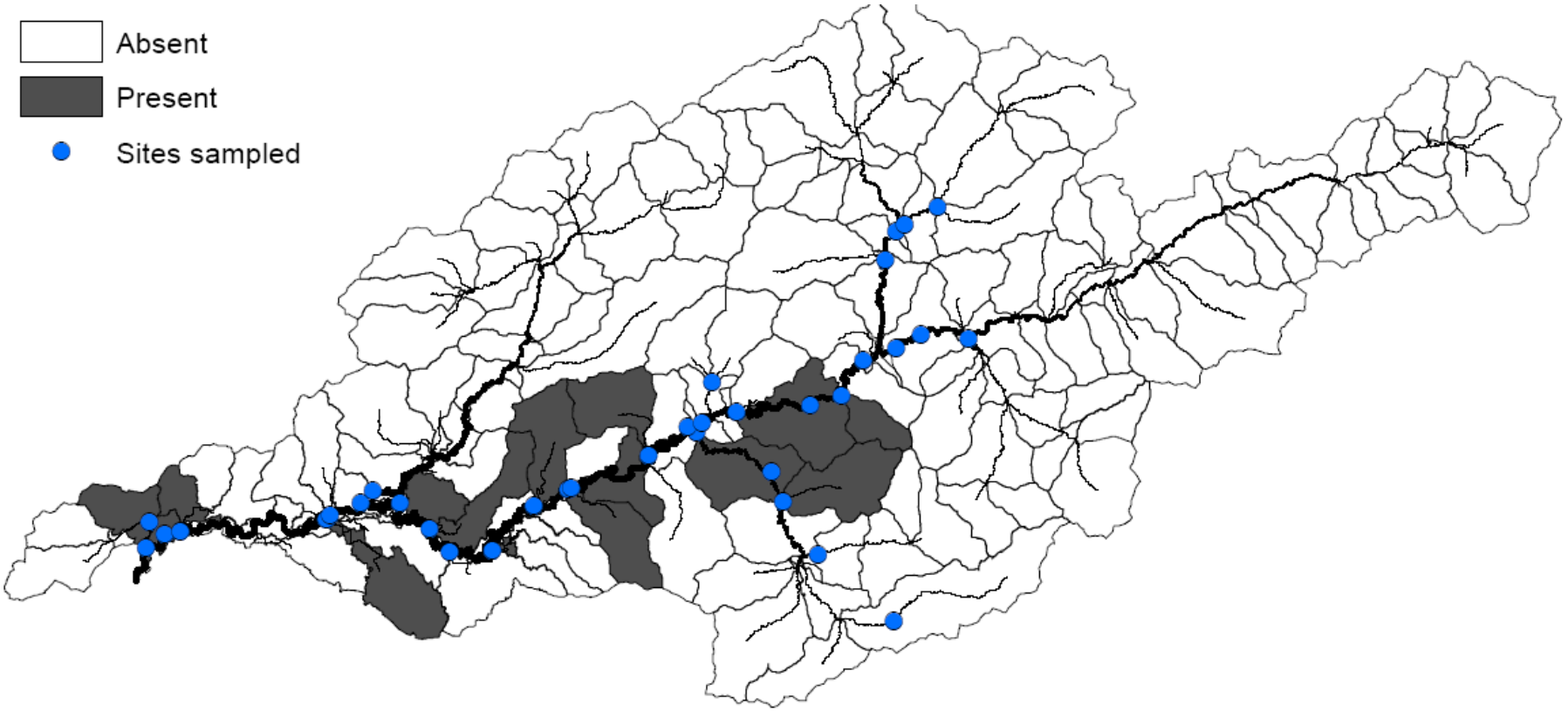
Methods: eDNA Lab

3. Amplified DNA using real-time qPCR
   - Chinook Salmon primers (*Laramie et al. 2014*)
   - Internal positive control
   - Controls
     - Negative
     - Positive
     - Serial dilutions
   - Inhibitors
     - Humic acid?



Results: Raw Occurrence - eDNA

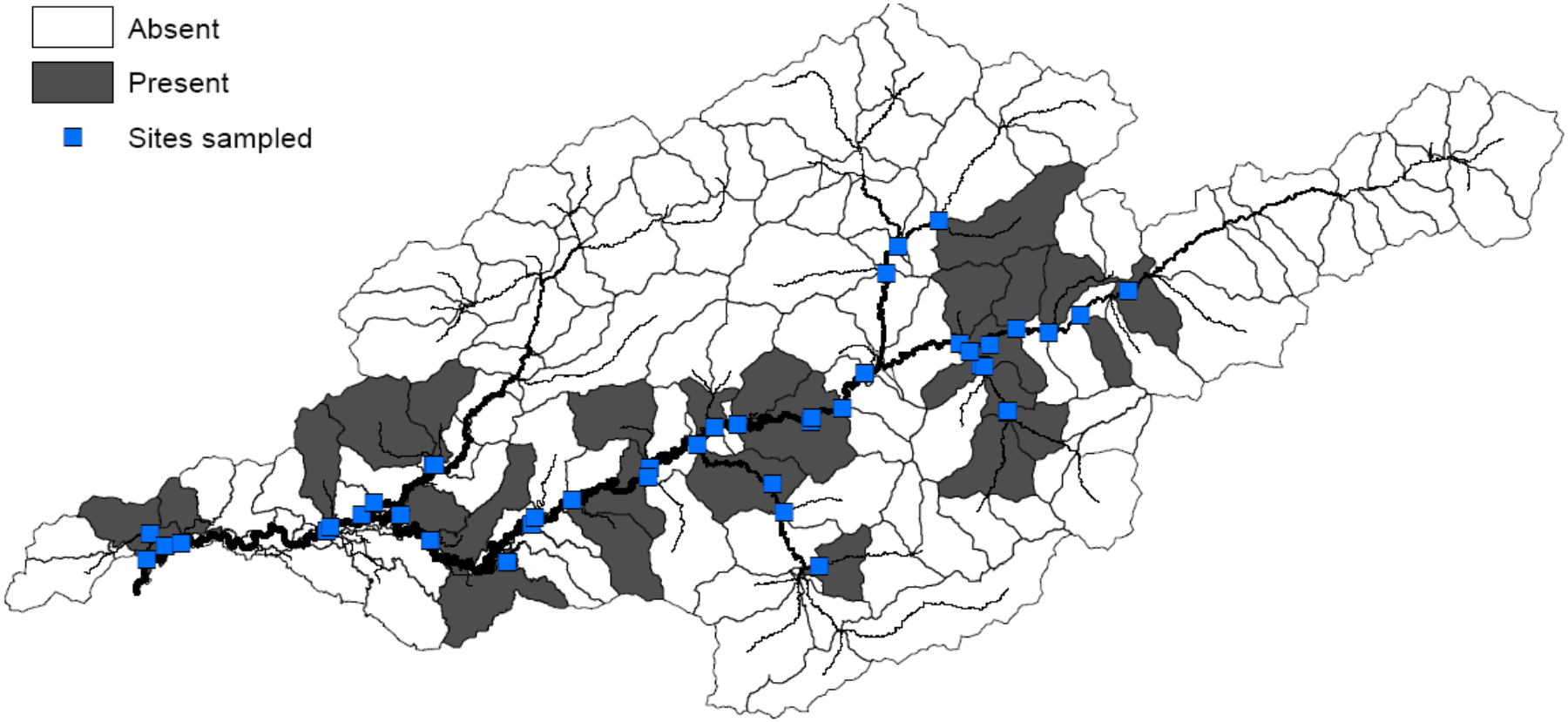
2014



16/35 sites (46%)

Results: Raw Occurrence - eDNA

2015



29/40 sites (73%)

Data Analysis: eDNA Occupancy

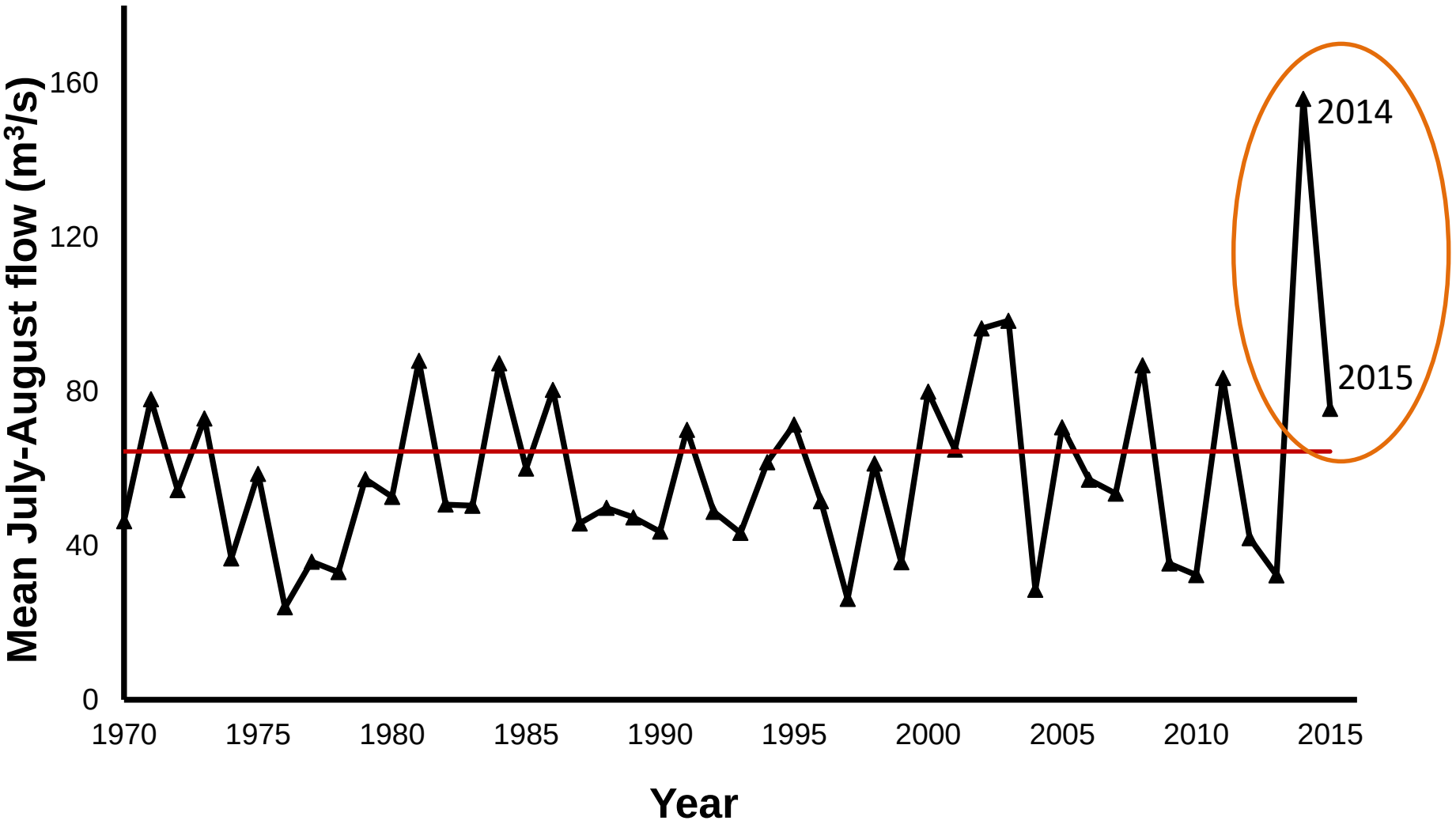
Single-season occupancy model (MacKenzie et al. 2002; 2006)

- Allows for joint estimation of detectability and proportion of sites occupied
  - adjusted for imperfect detection

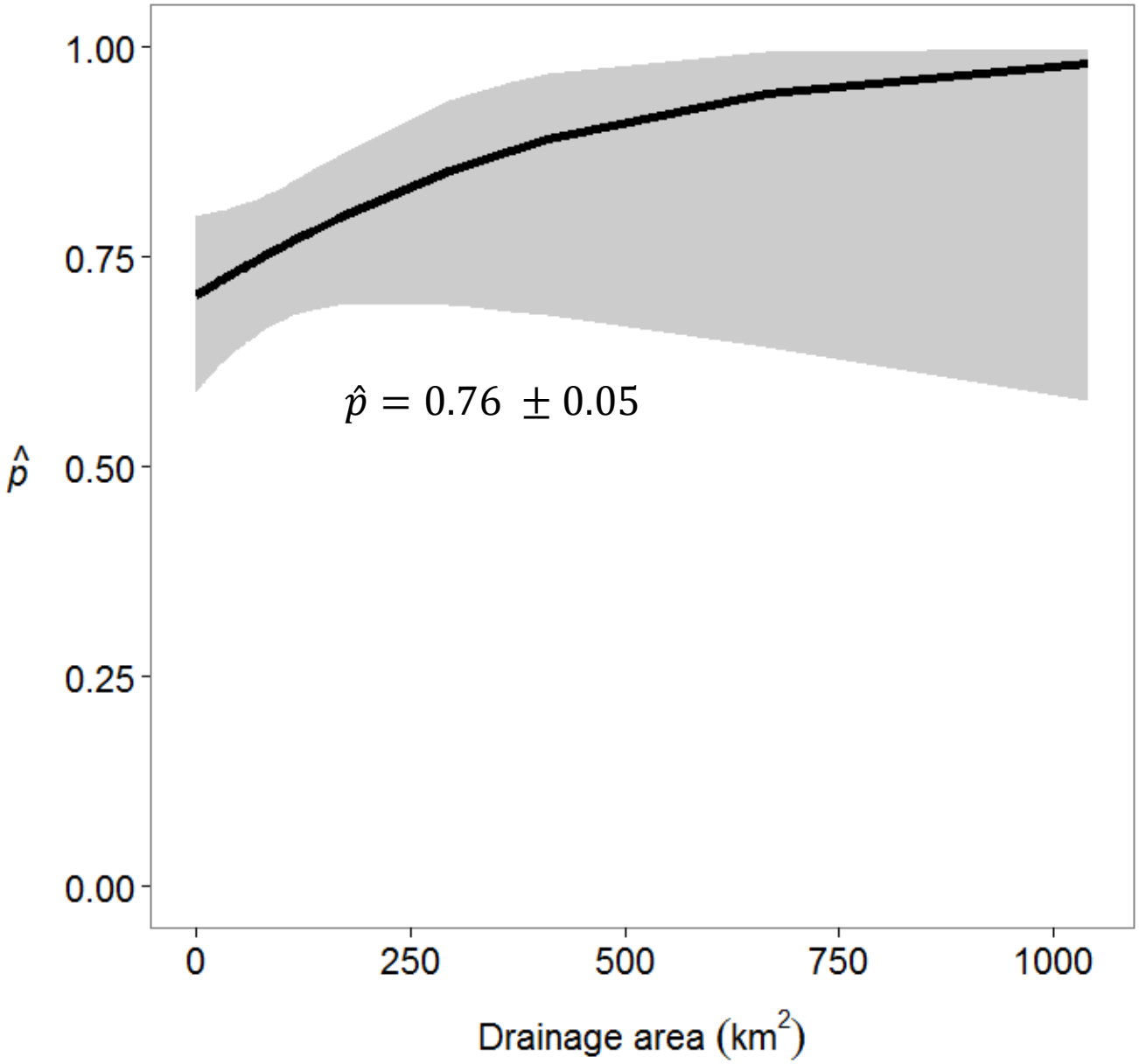
Detectability (p)

1) Drainage area (km^2)
2) Summer flow (year-specific; m/s^3)

Results: Interannual Flow Variability



Results: eDNA - Detectability



Detection history	# of Sites
0 0 0	30 (40%)
0 0 1	9 (12%)
0 1 1	13 (17%)
1 1 1	23 (31%)
Total	75

Data Analysis: eDNA Occupancy

Occupancy model

- Allows for joint estimation of detectability and proportion of sites occupied
  - adjusted for imperfect detection

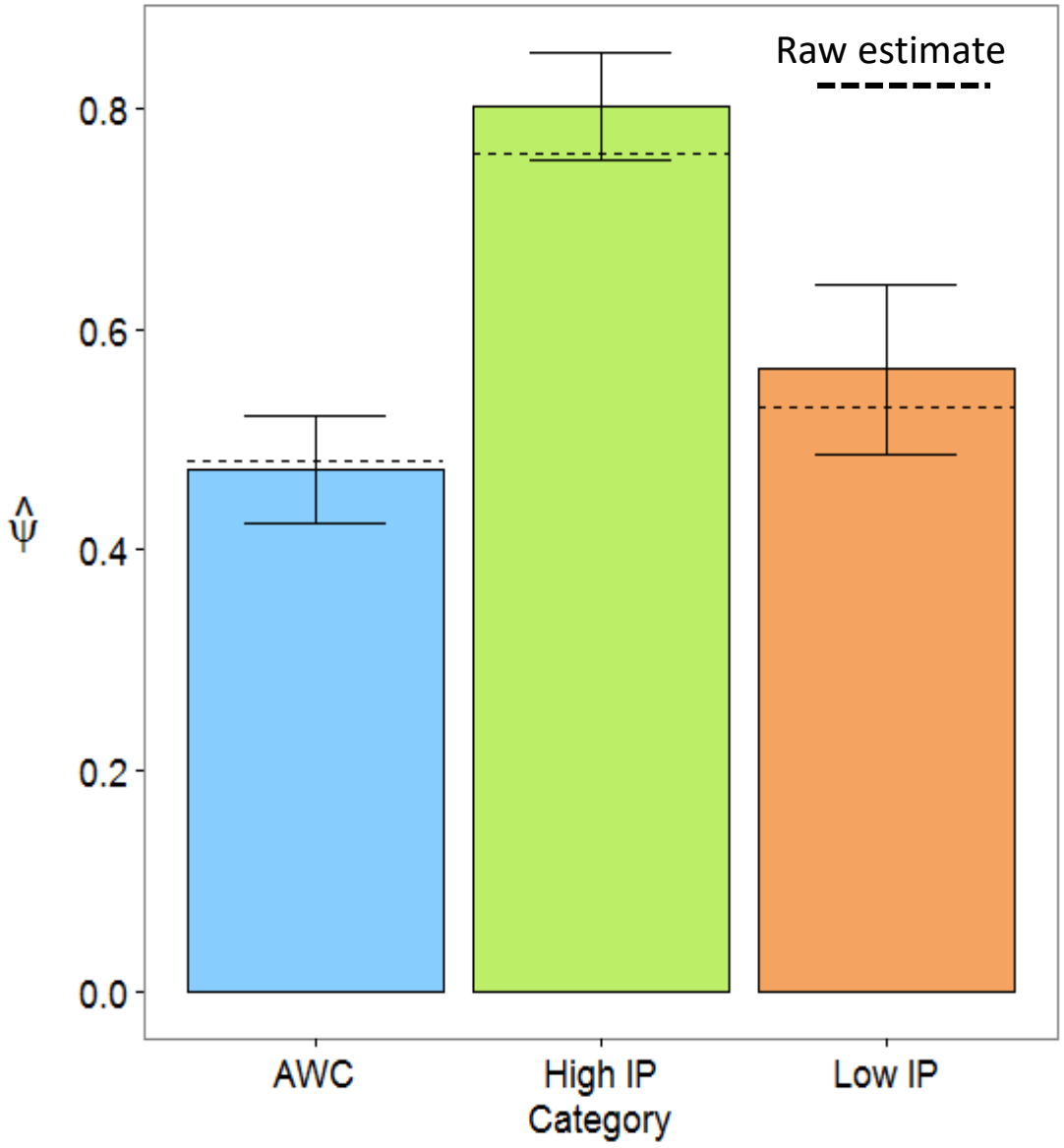
Detectability (p)

1) Drainage area (km^2)
2) Summer flow (year-specific; m/s^3)

Occupancy (Ψ)

1) Drainage area (km^2)
2) Category (Low, AWC, High)
3) Summer flow (year-specific; m/s^3)
4) Year (2014 or 2015)

Results: eDNA - Occupancy



- High IP
  - vs. IP model
- Low IP
  - Higher than expected
  - Threshold?
- AWC
  - Lower than expected
  - Interannual variability?

Methods: Power Analysis

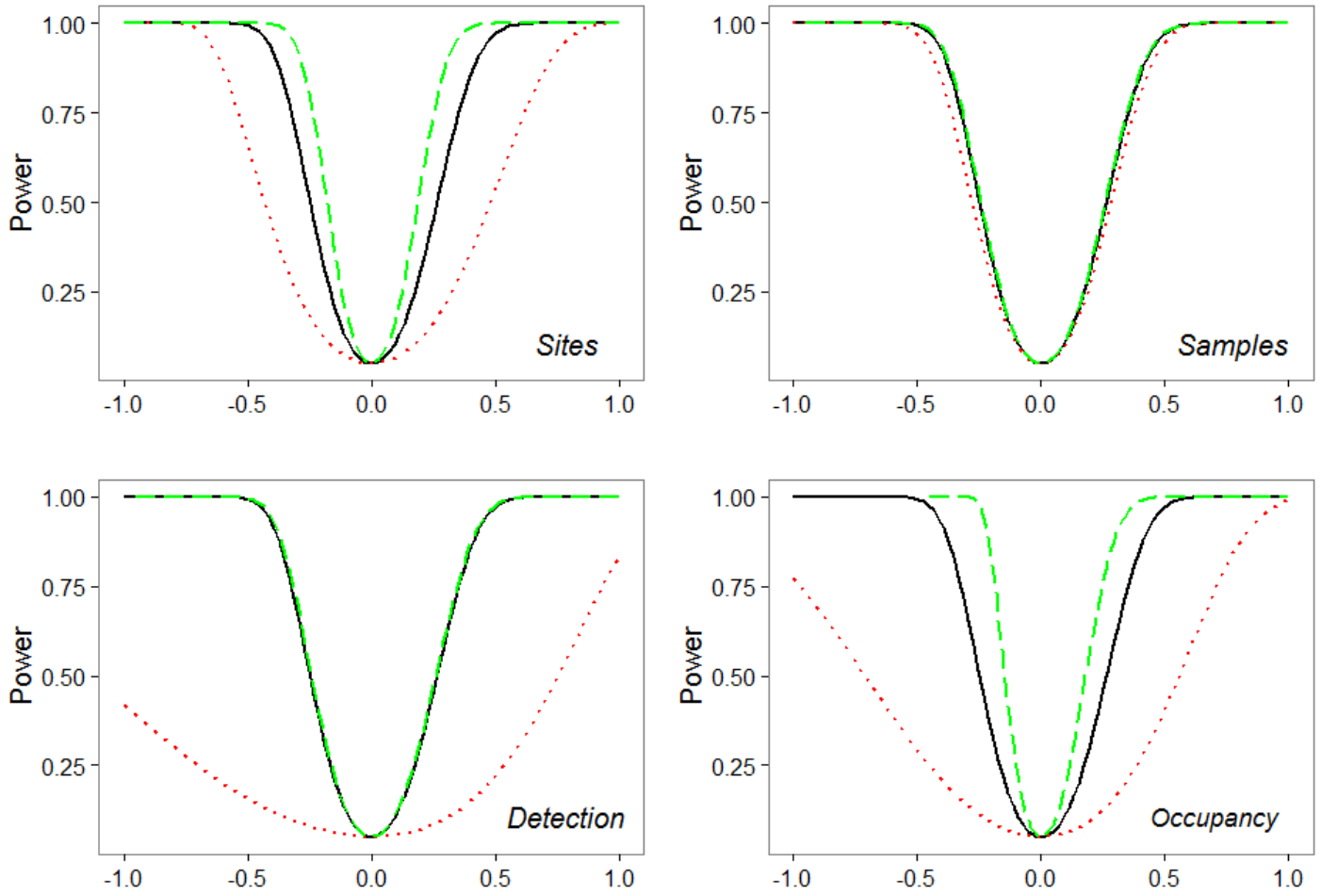
- Can we detect changes in occupancy?
  - (Guillera-Arroita and Lahoz-Monfort 2012)

- Based on data results
  - Sites sampled (75 sites)
  - Samples at each site (3 replicates)
  - Detection probability (p = 0.76)
  - Proportion of sites occupied (psi = 0.61)

Results: Power Analysis

Reference line:
Sites = 75
Samples = 3
Detection = 0.76
Occupancy = 0.61

Sites = 21 - 150
Samples = 2 - 6
Detection = 0.2 - 1.0
Occupancy = 0.2 - 0.8



Proportional change in occupancy

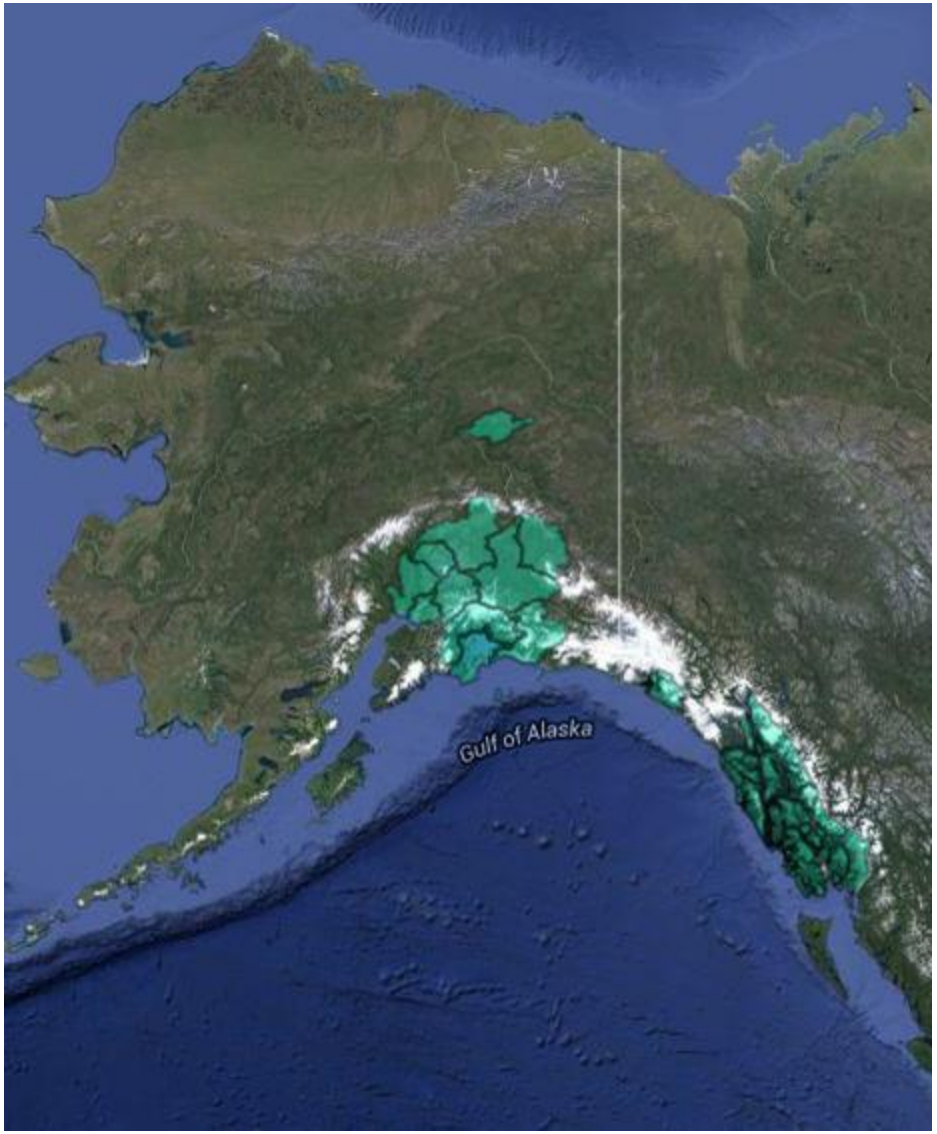
Rapid Assessment: Advantages and Disadvantages

	IP	eDNA
Data needed?	+/-	+
Cost	+/-	+
Effort	+	-
Life history specific	+	-
Sensitive species?	+	+
Cover large extents	+	+/-
Detectability	+/-	+

- Estimates habitat but needs to be ground truthed	- High but different for every study

Recommendations: Intrinsic Potential Modeling

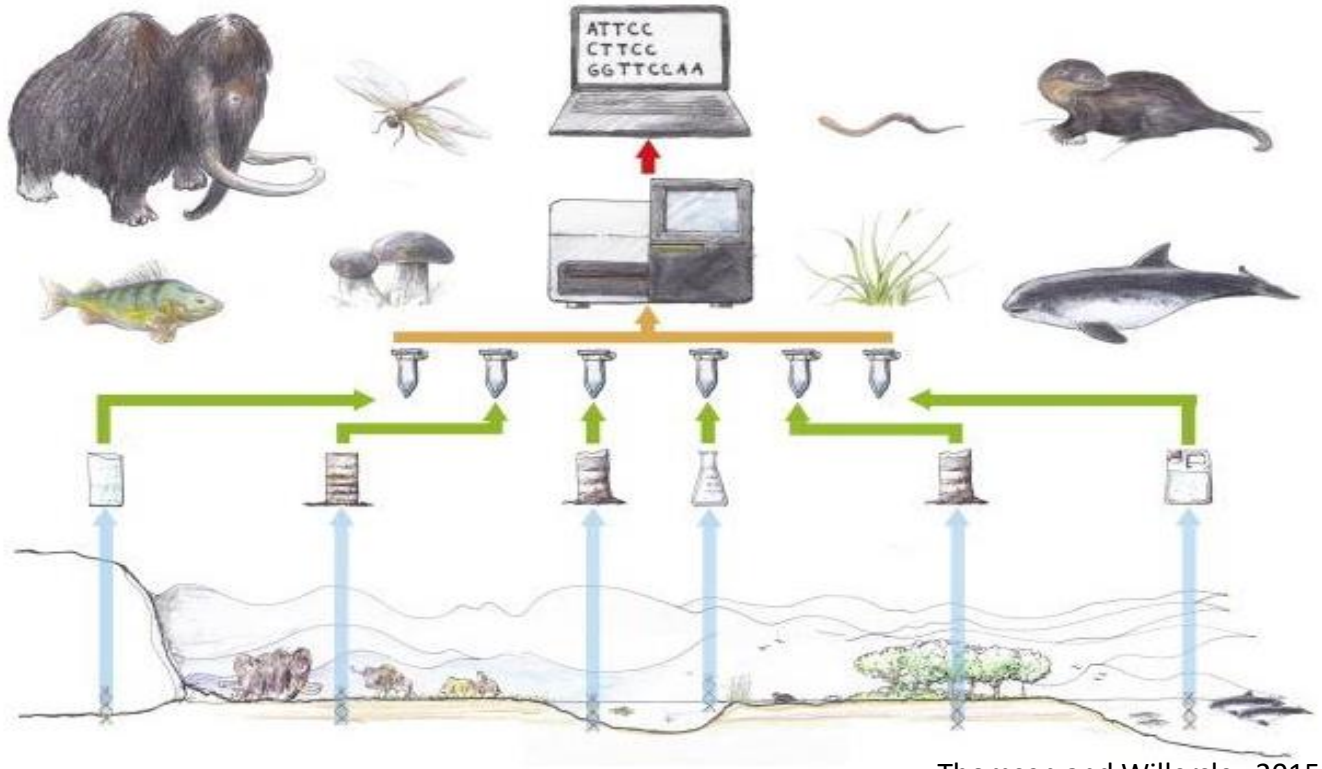
- Increase spatial data coverage
- Calculate IP for other basins in AK
- Expand suitability curves to other species and life stages
  - Region specific?



Terrain Works 2016

Recommendations: eDNA Sampling

- Develop primers for other species
- Continue to improve methodology
- Evaluate as a monitoring tool



Thomsen and Willerslev 2015

Acknowledgements:

- Committee Members
  - Dr. Trent Sutton
- Field help:
  - Justin Pomeranz
  - Sierra Corsetti
  - Dr. Brock Huntsman
  - Lauren Bailey
- ADF&G logistical support
  - Chad Bear
  - Revolving door of technicians

North American Journal of Fisheries Management 38:223–236, 2018

ISSN: 0275-5947 print / 1548-8675 online
DOI: 10.1002/nafm.10014

ARTICLE

A Rapid-Assessment Method to Estimate the Distribution of Juvenile Chinook Salmon in Tributary Habitats Using eDNA and Occupancy Estimation

Allison N. Matter*
College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Post Office Box 757220, Fairbanks, Alaska 99775, USA

Jeffrey A. Falke
U.S. Geological Survey, Alaska Cooperative Fish and Wildlife Research Unit, University of Alaska Fairbanks, Post Office Box 757020, Fairbanks, Alaska 99775, USA

J. Andrés López
University of Alaska Museum, Post Office Box 756960, Fairbanks, Alaska 99775, USA; and
College of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Post Office Box 757220, Fairbanks, Alaska 99775, USA

James W. Savereide
Alaska Department of Fish and Game, Division of Sport Fish, 1300 College Road, Fairbanks, Alaska 99701, USA