

Heartbeat of the Yukon

Exploring the linkage between in-river mortality
and *Ichthyophonus* infection in king salmon



M.S. Fisheries Candidate: Keith Herron

UAF Committee: Jessica Black, Courtney Carothers, Morag Clinton, Peter Westley

Indigenous Lands



photo by Allison Heaslet (ANSEP) near Fort Yukon

Salmon



photo by Scott T. Walter (USFWS) at Rapids

People

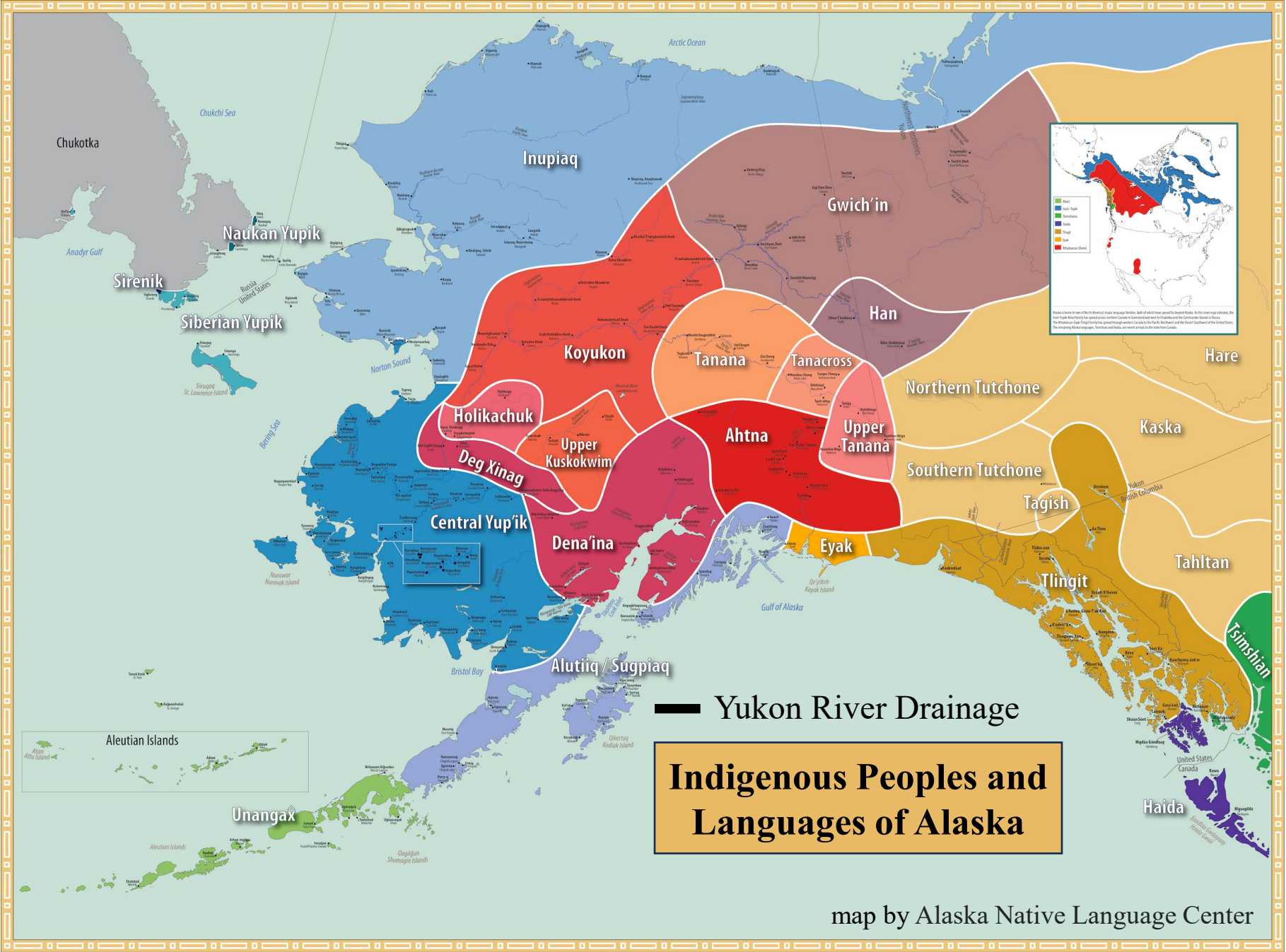


photo by Scott T. Walter (USFWS) at Rapids

Place

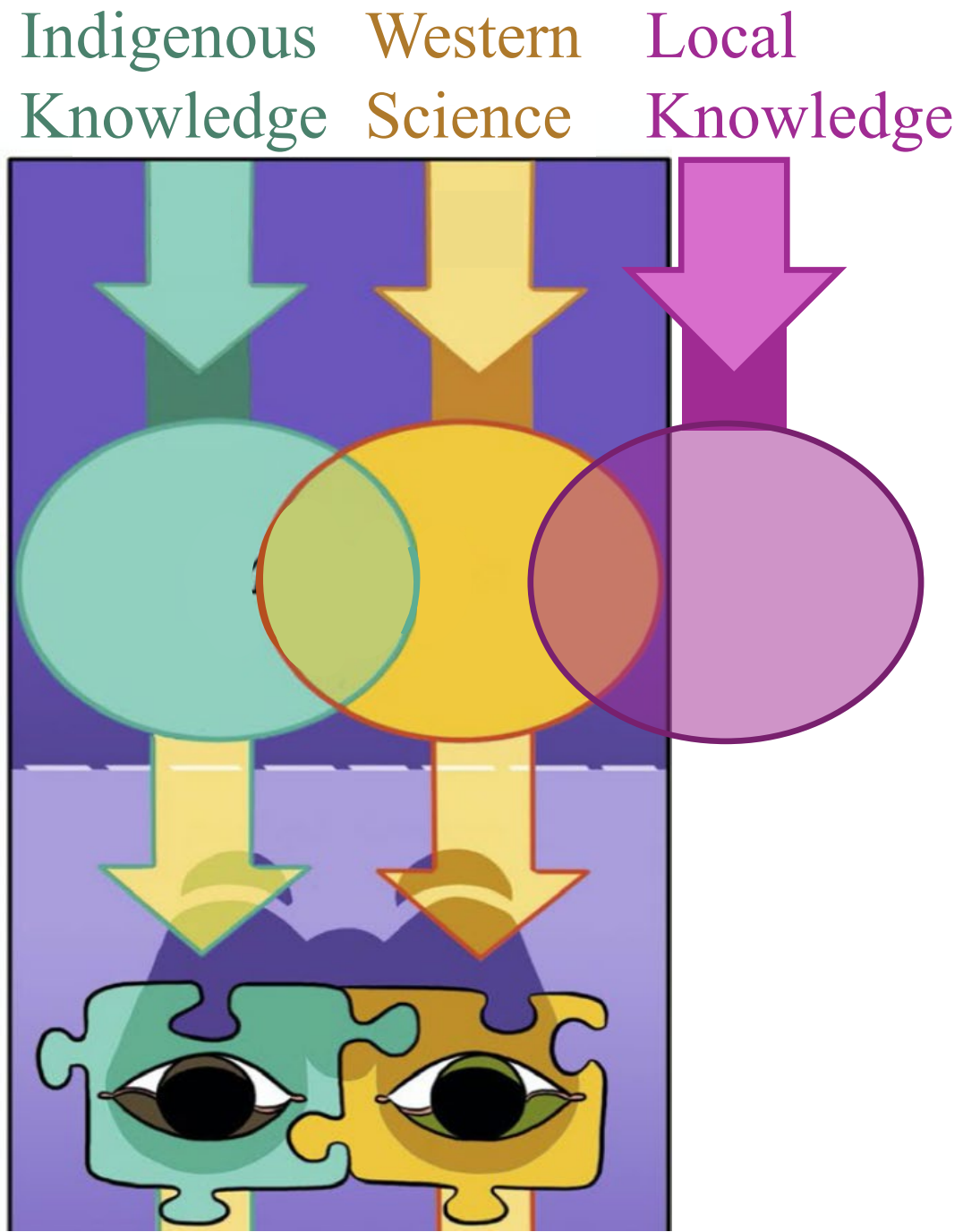


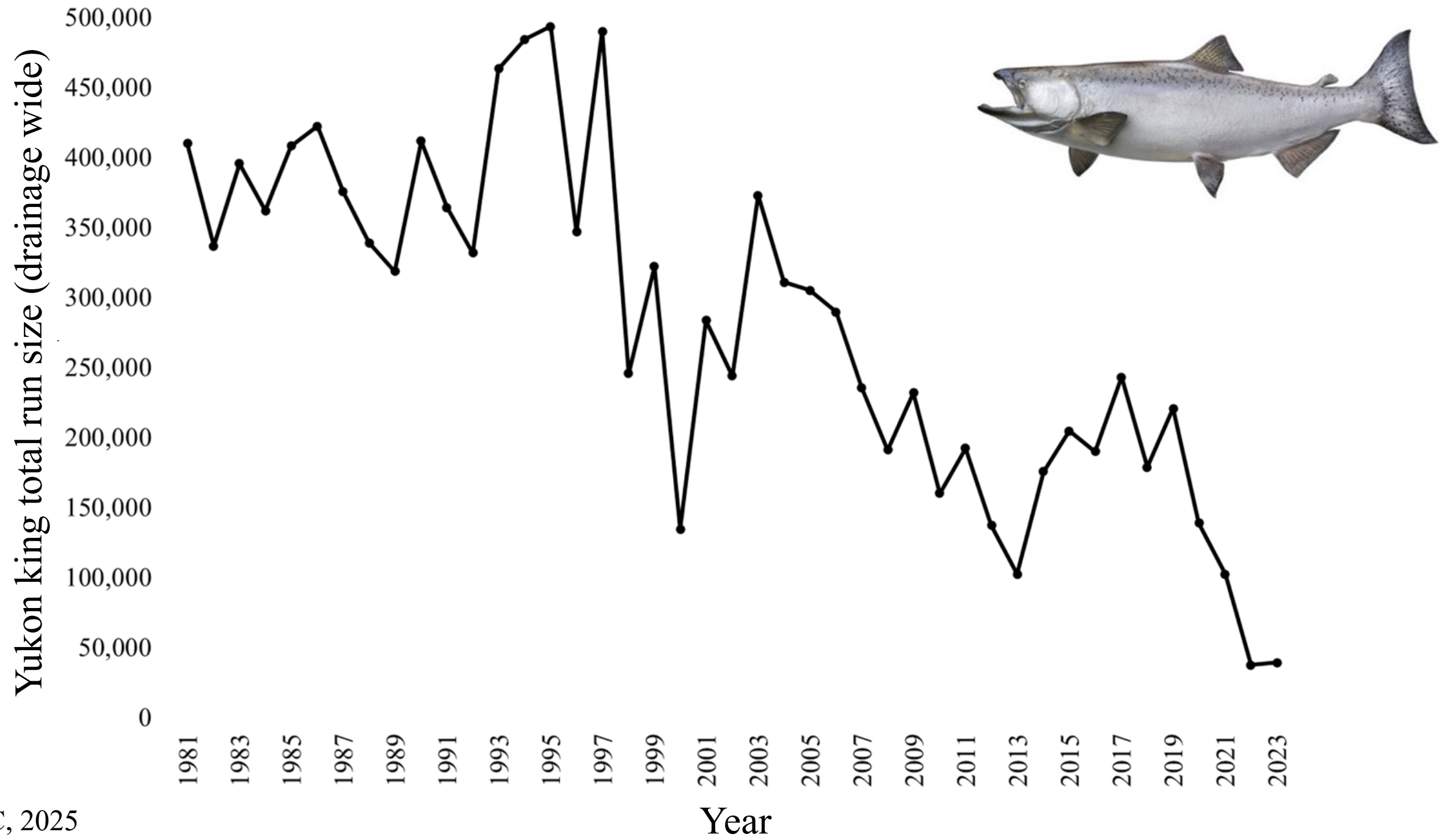
photo by Scott T. Walter (USFWS) at Rapids

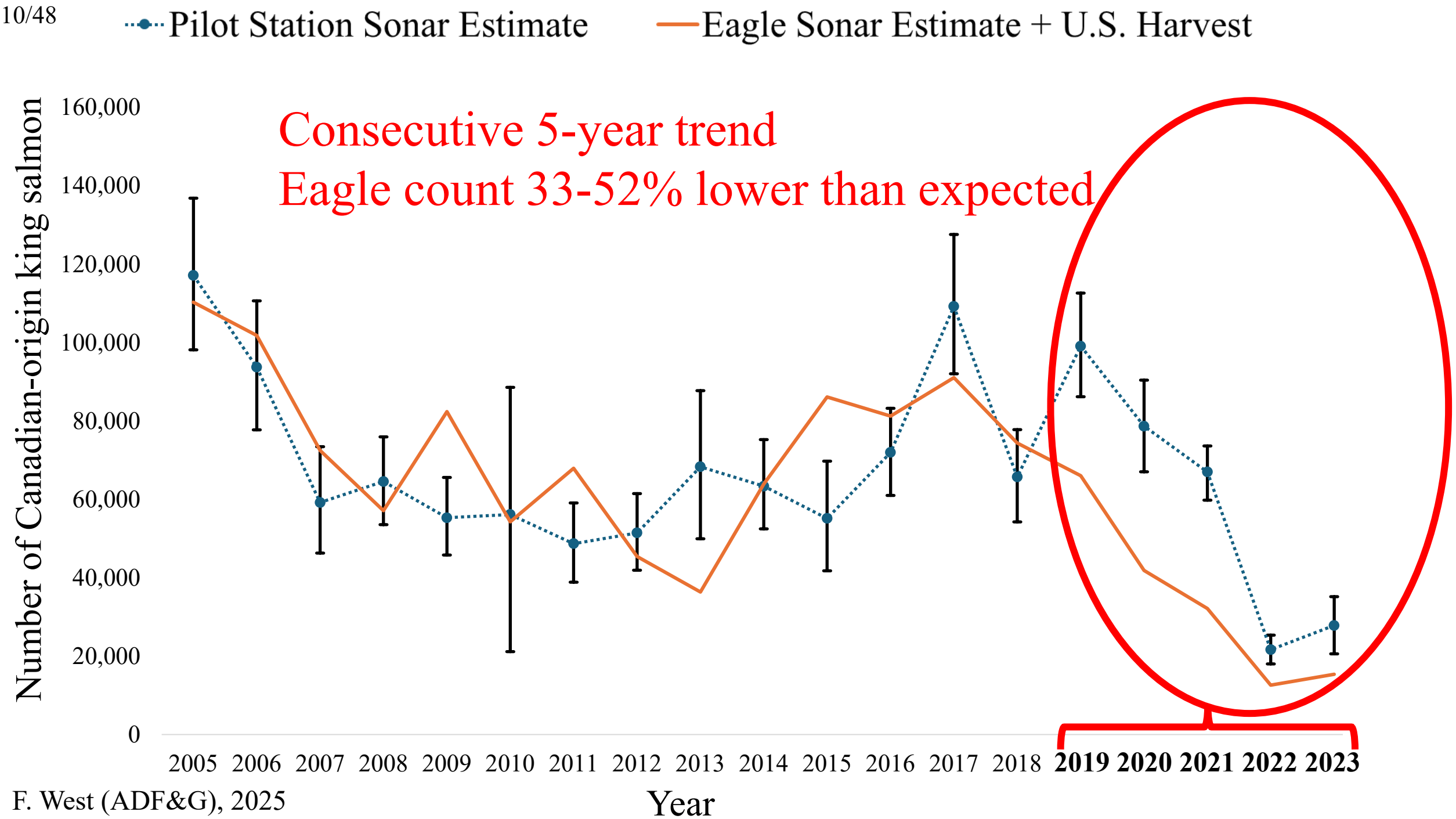




Knowledge Coexistence







Ichthyophonus Prevalence at Rapids

based on histopathology

2019: No data (low report) & hot water

2020: 44%

2021: 39%

2022: 34%

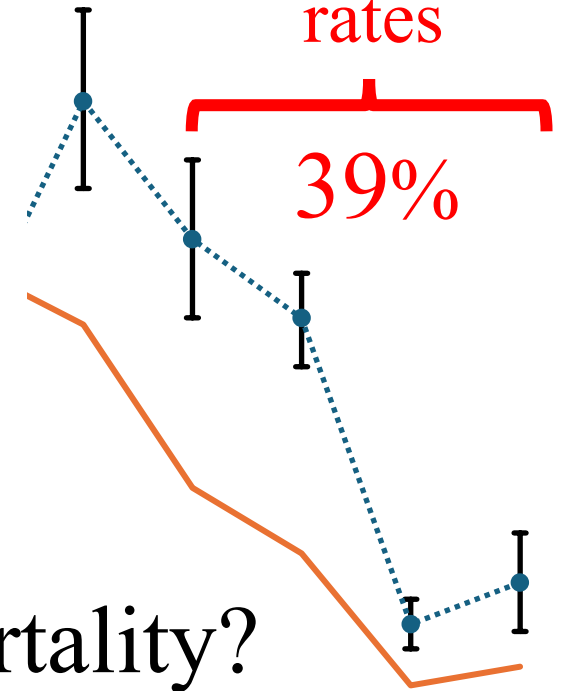
2023: 39%

High
Ichthyophonus
rates

39%

Is *Ichthyophonus* one source of in-river mortality?

2019 2020 2021 2022 2023



Indigenous & local knowledge

specific to Ichthyophonus in king salmon

Abnormal lesions documented in the Yukon River harvest since 1986 align with infection

Fishermen report:

- Mushy fillets
- Sweet or tangy smell
- White spots on internal organs
- Fish not drying properly

Occurrence varies by harvest location in river



Local-led *Ichthyophonus* monitoring

Stanley Zuray, Rapids (2004 - 2021)

Collaborative project followed his methods (2022 - 2023)

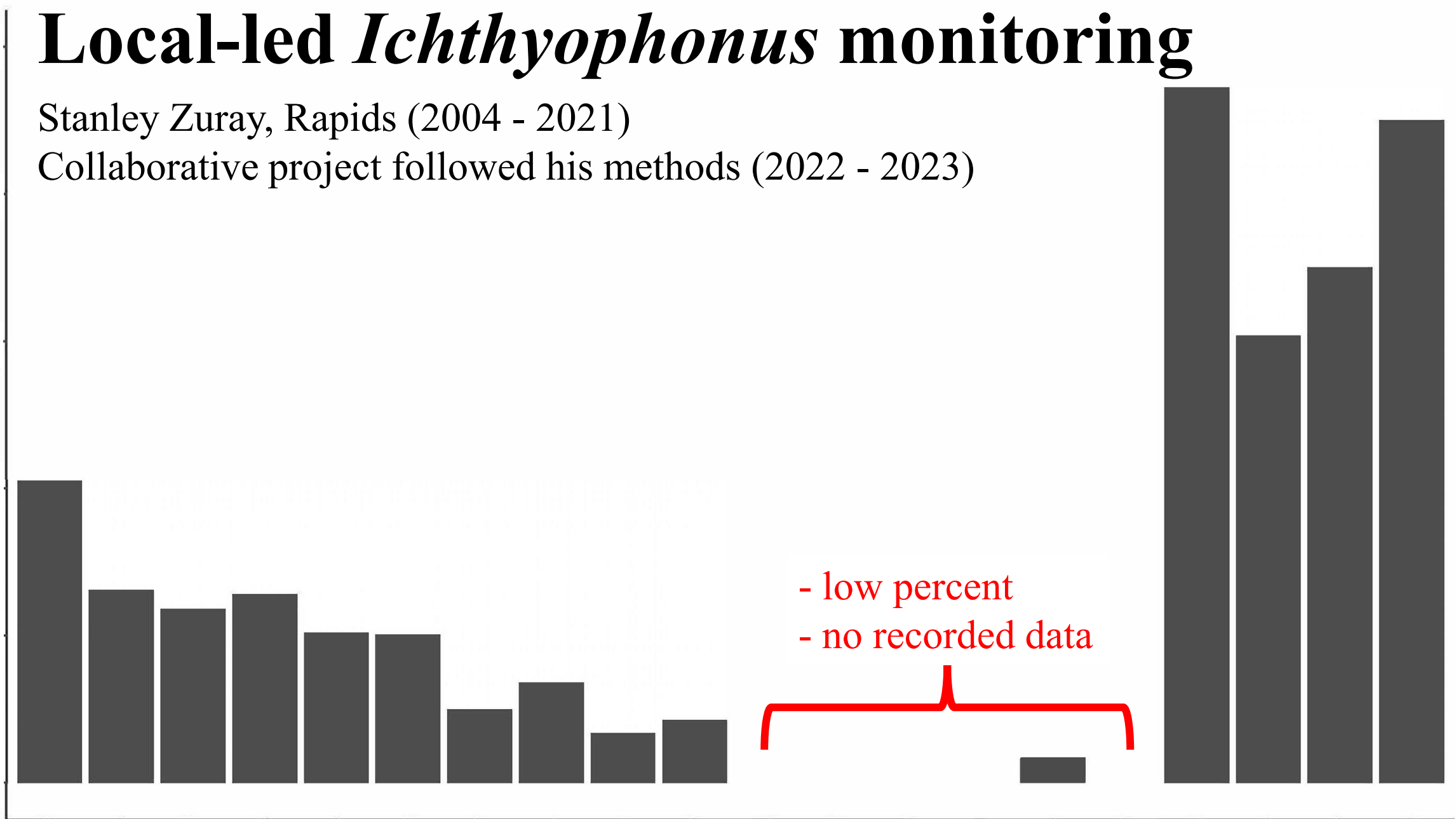
Visual heart lesion percent in harvest

50%
40%
30%
20%
10%
0%

- low percent
- no recorded data

2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023

Year



Western science

***Ichthyophonus* in Yukon king salmon**

Parasite infection starts in marine life stage

Reduces swimming performance

Impacts proper heart and organ function

Do not naturally clear infection

Infection can lead to mortality

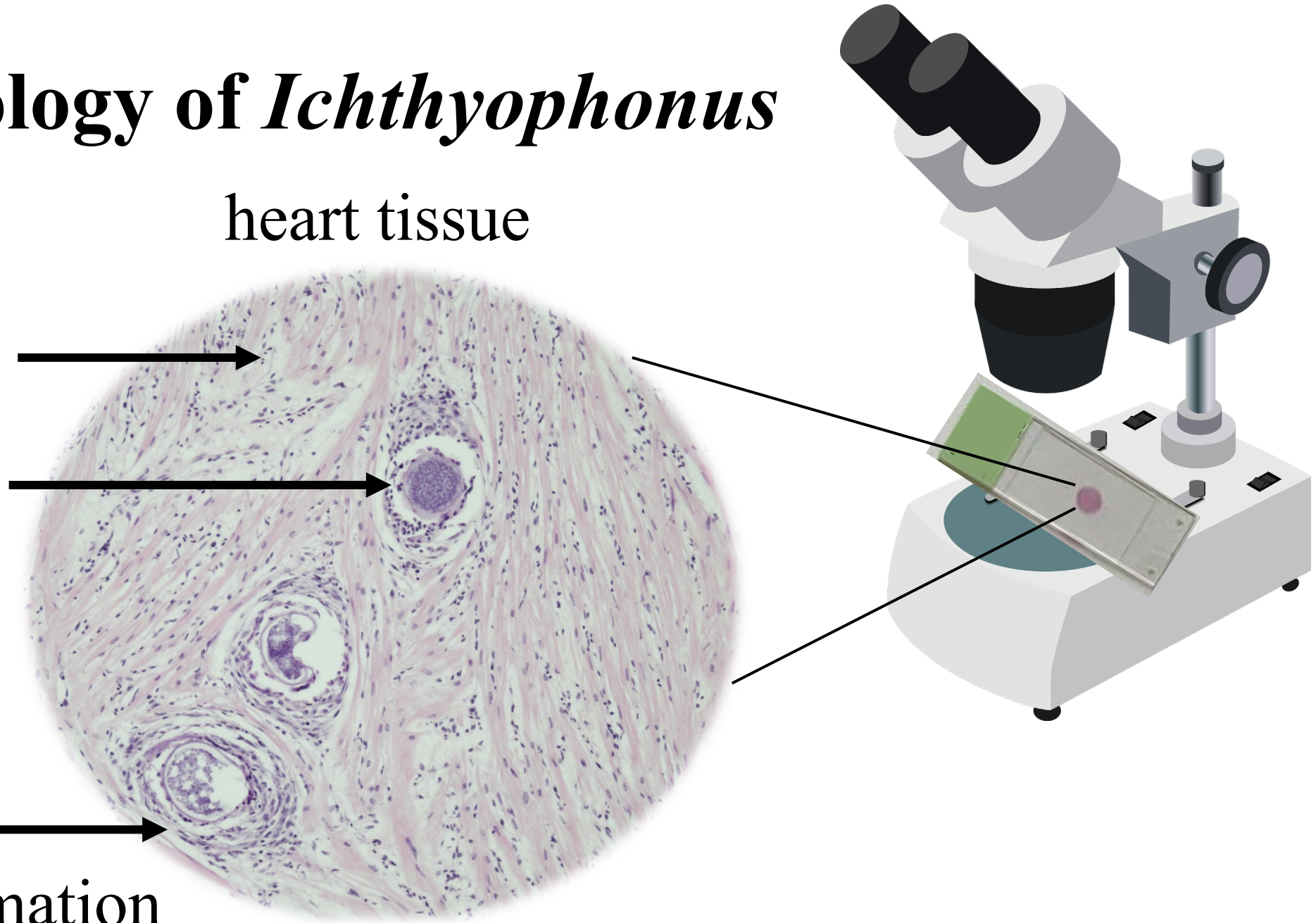
Histopathology of *Ichthyophonus*

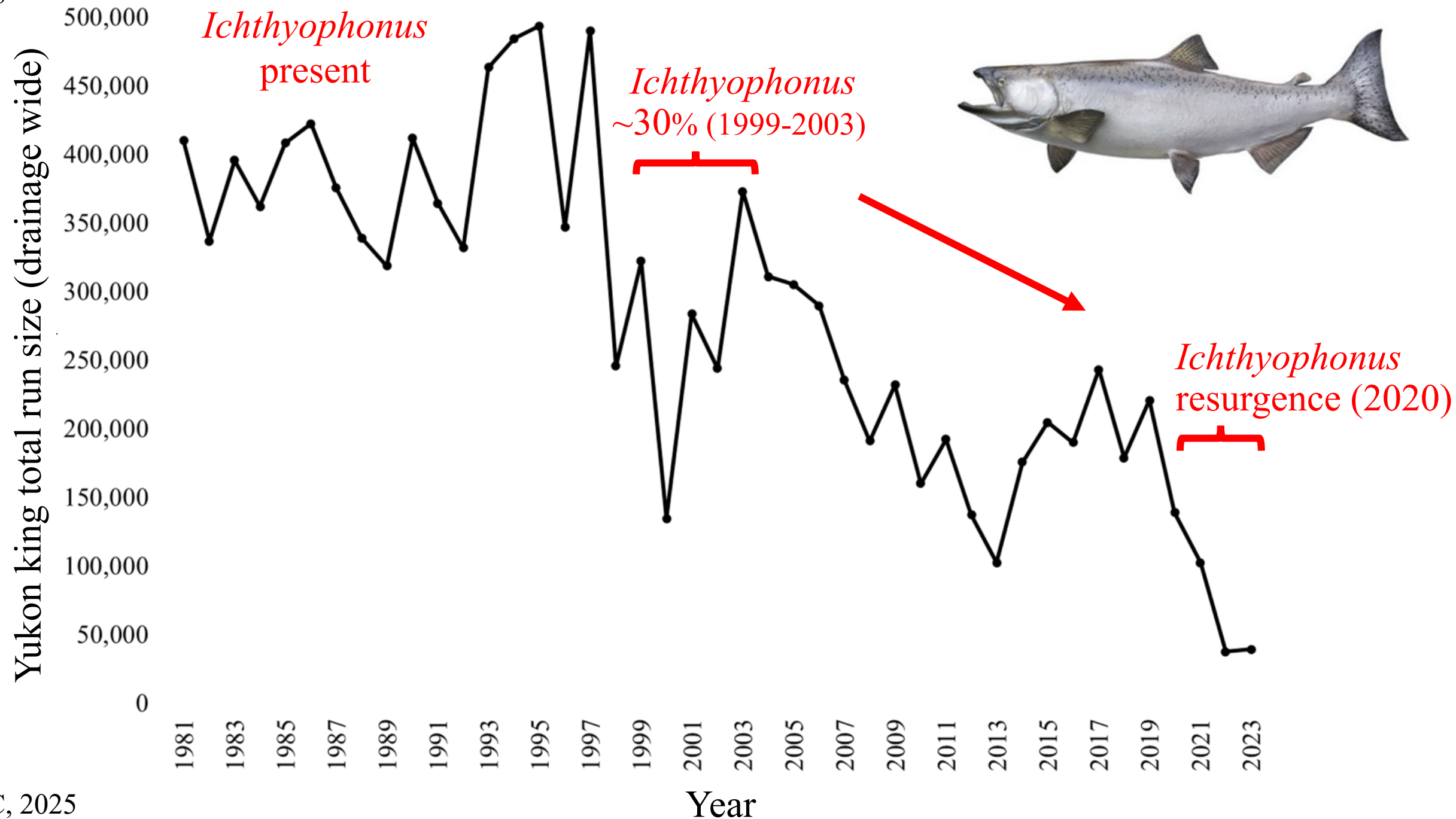
heart tissue

normal

parasite
(schizont)

damage &
visual inflammation





Overall Thesis Objectives / Flow

Harvest and sampling methods

Investigate *Ichthyophonus* progression during upriver migration

Co-interpret results with Tribal Government Councils and community members

Final thoughts

Harvesting

Hired fishermen at Rapids and Fort Yukon

ADF&G Pilot Station and Eagle sonar test fisheries

Gear type

Pilot Station/Eagle: drift gillnets

Rapids/Fort Yukon: fish wheels

Project dates

June to August 2022 - 2023



Sampling

Sample size

878 king salmon across 4 sites

Sex ratio

63% Male, 37% Female

Average length

714 mm (283 - 930 mm)

Average age

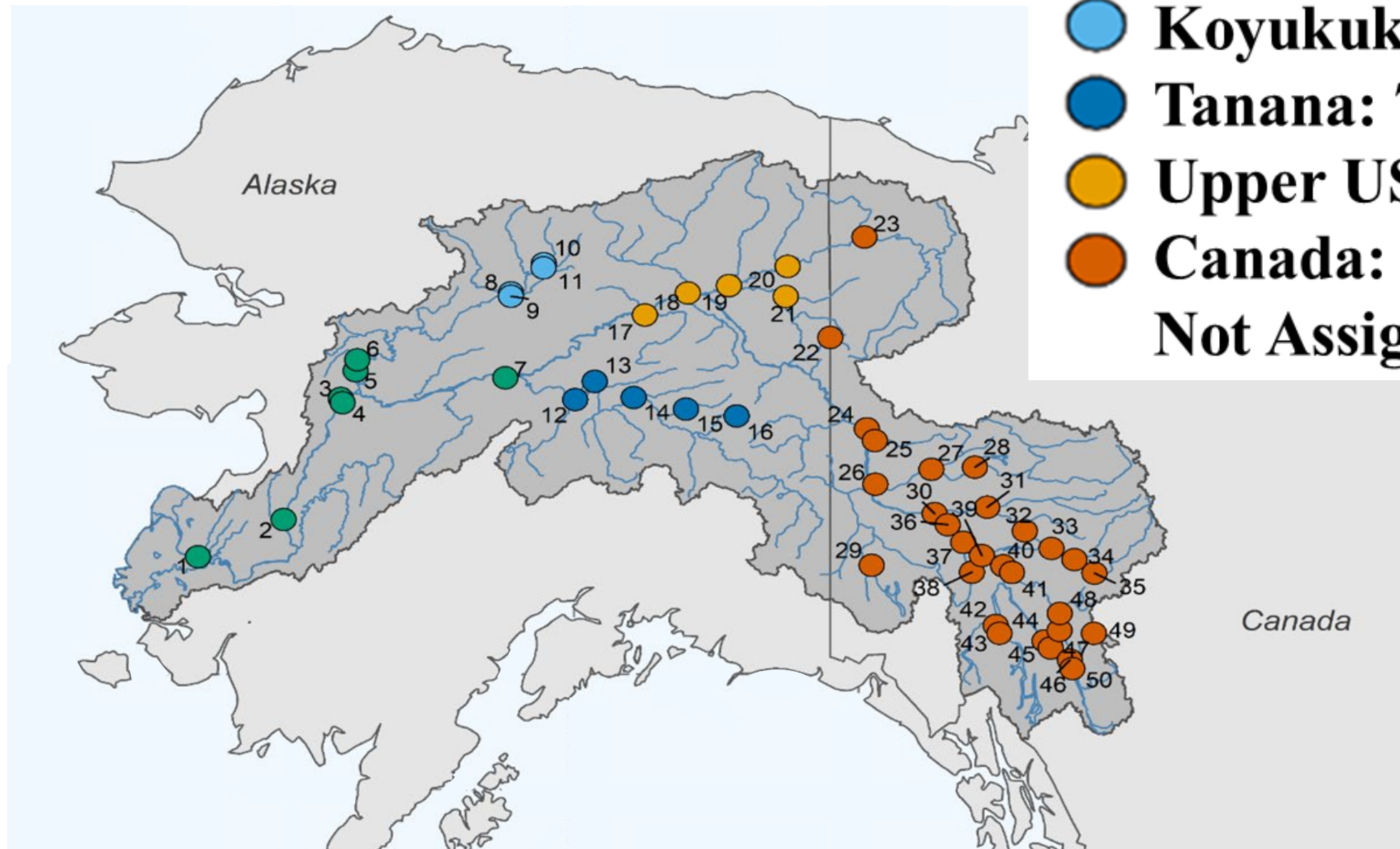
Male: 5 years (3 - 8 years)

Female: 6 years (5 - 7 years)



photo by Allison Heaslet (ANSEP) near Fort Yukon

Samples assigned genetic group



- Lower US: 13%
- Koyukuk: < 1%
- Tanana: 7%
- Upper US: 8%
- Canada: 69%
- Not Assigned: 2%

Visual heart lesions



Visual heart lesions



No spots



1000+ spots



Ichthyophonus diagnosis

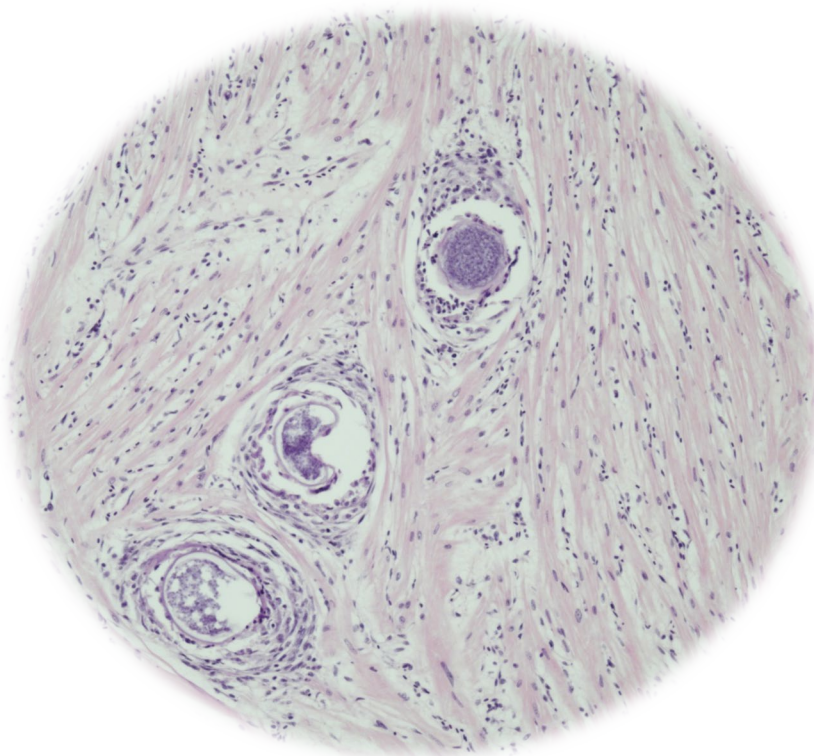


Ichthyophonus prevalence and severity

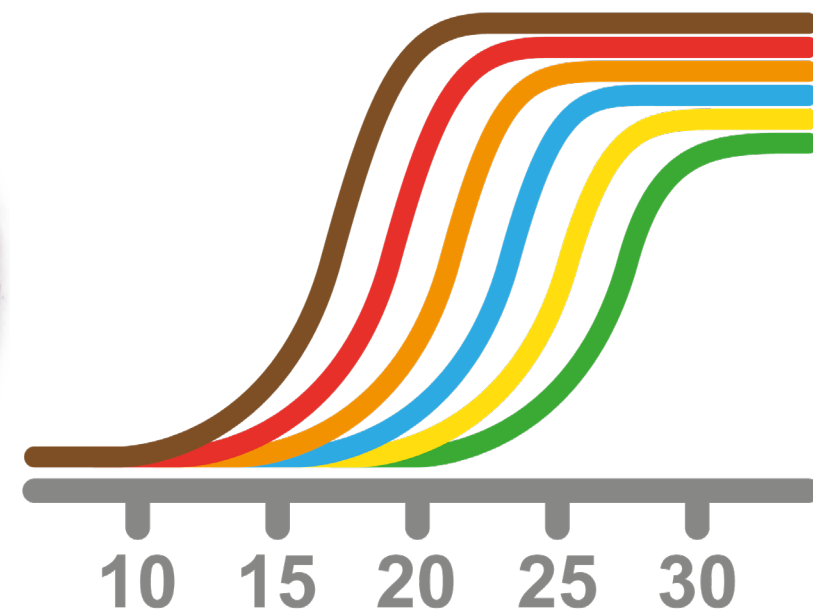
Visual (field)



Histopathology (lab)



qPCR (lab)

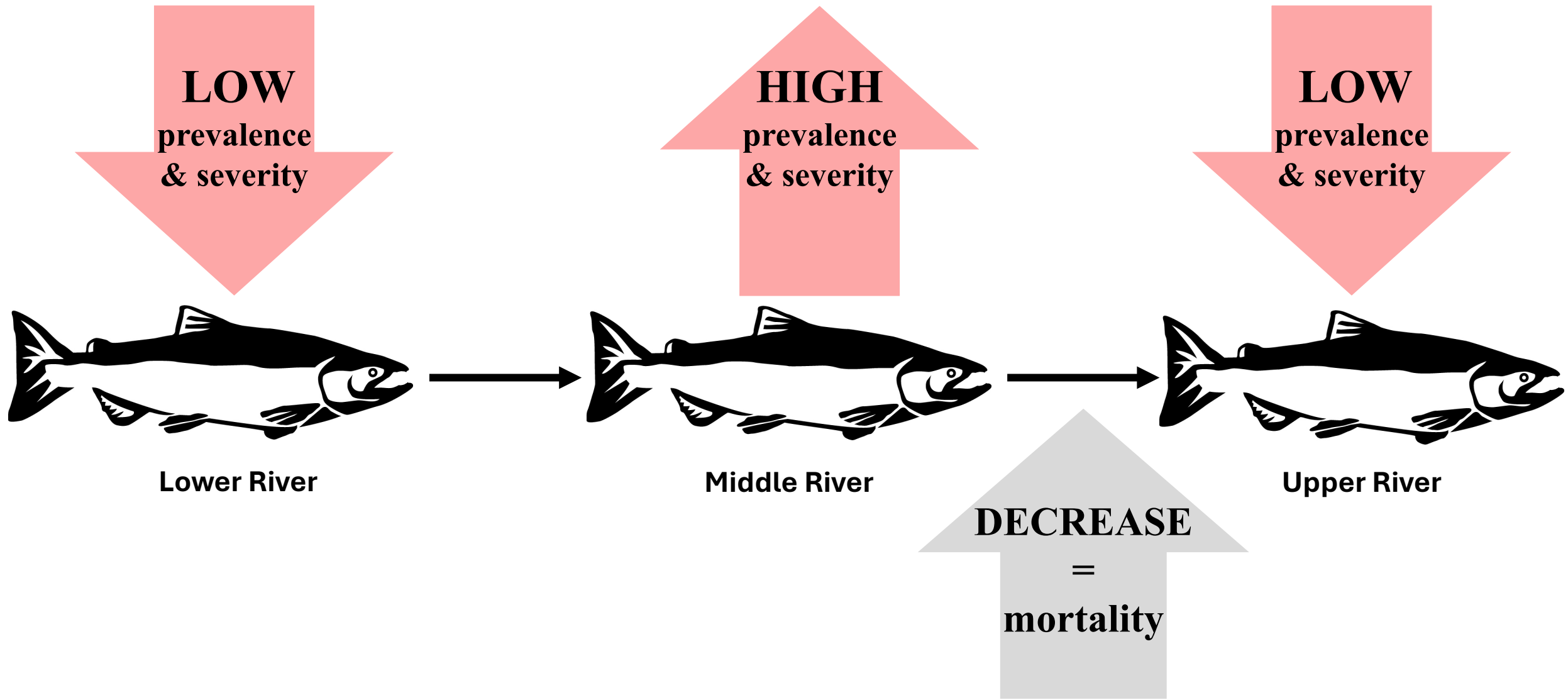


***Ichthyophonus* progression during upriver migration**

Used histopathology prevalence and severity rates to compare between sampling sites controlling for:

- Age
- Sex
- Length
- Day of year
- Genetic grouping
- Capture method
- Water temperature

Hypothesis based on multiple knowledges



Prevalence & severity variable selection

- Sample site
- ~~Age~~
- Sex
- Length
- Day of year
- ~~Genetic grouping~~
- ~~Capture method~~
- ~~Water temperature~~
- Tissue volume

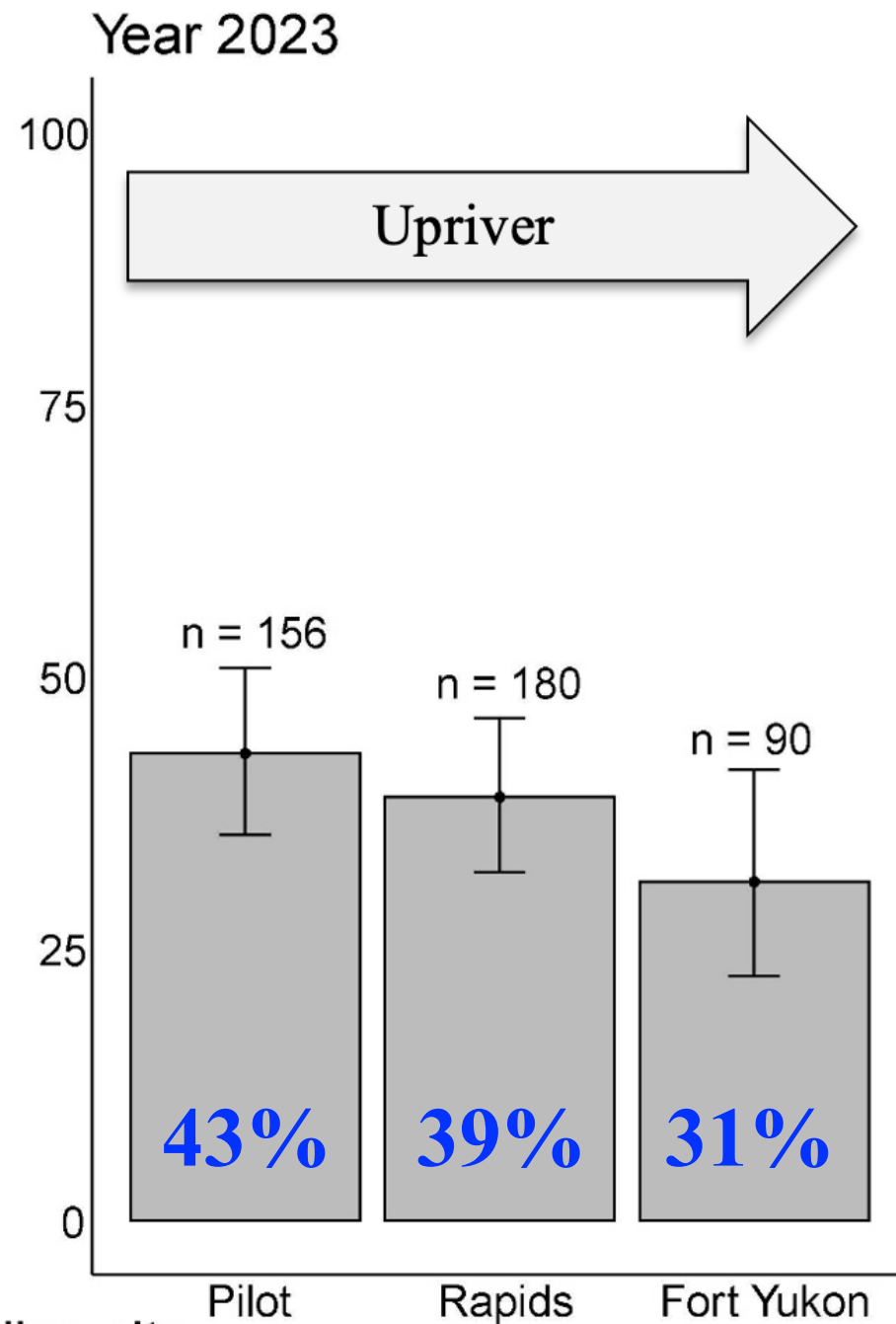
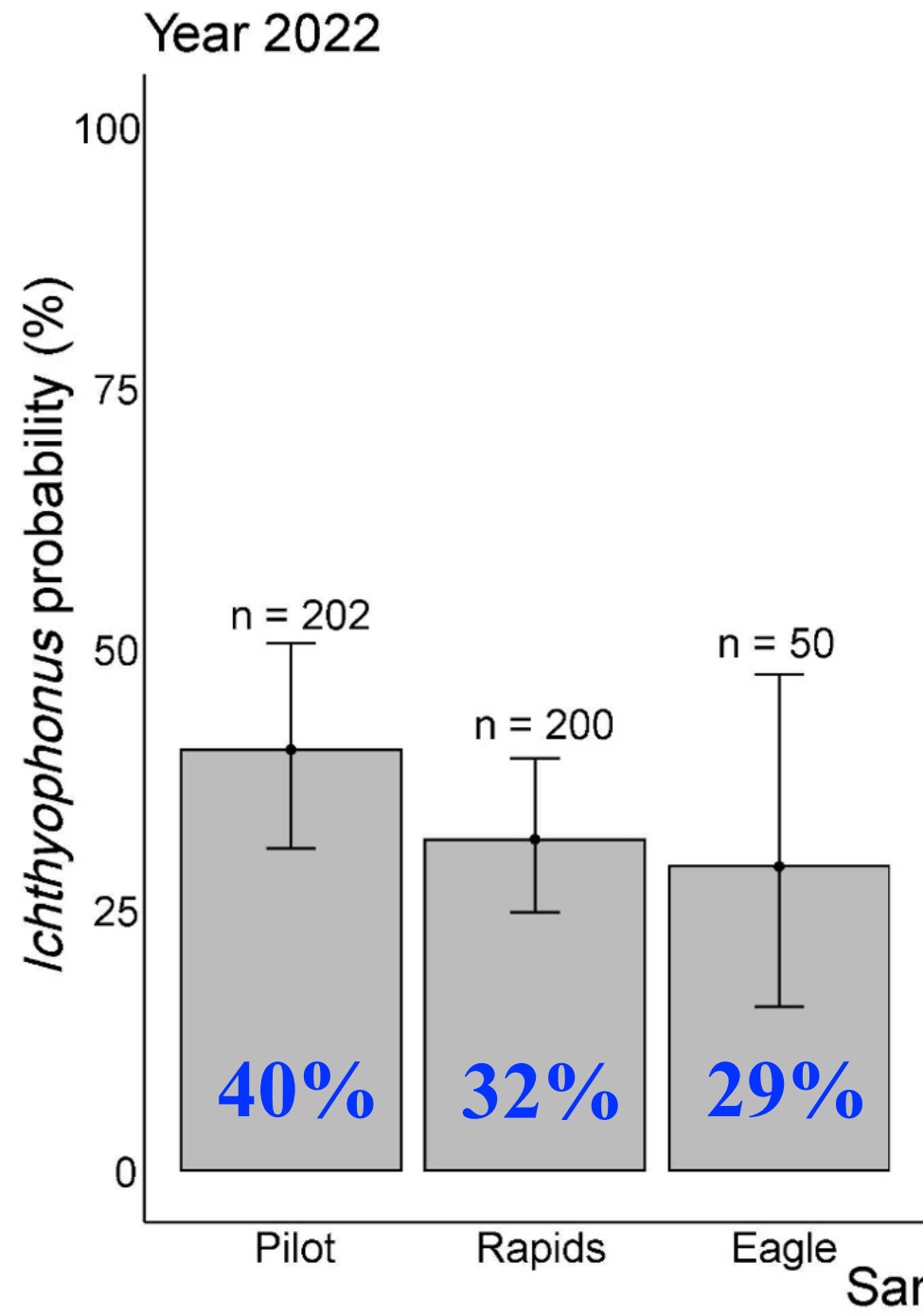
Prevalence model type

Logistic Binomial Regression

Used to model binary outcomes: 1 = infected, 0 = no infection

$$\text{logit}(\pi_i) = \ln \left(\frac{\pi_i}{1 - \pi_i} \right) = \beta_0 + \beta_1 x_{1i} + \cdots + \beta_p x_{pi}$$

Provides an estimate for probability of infection



Prevalence findings

Counter to predictions, no difference between sites

Sensitivity of histopathology diagnostic at low infection rates

Good for disease surveillance and annual monitoring

Potentially less reliable to quantify in-river mortality

Severity model type

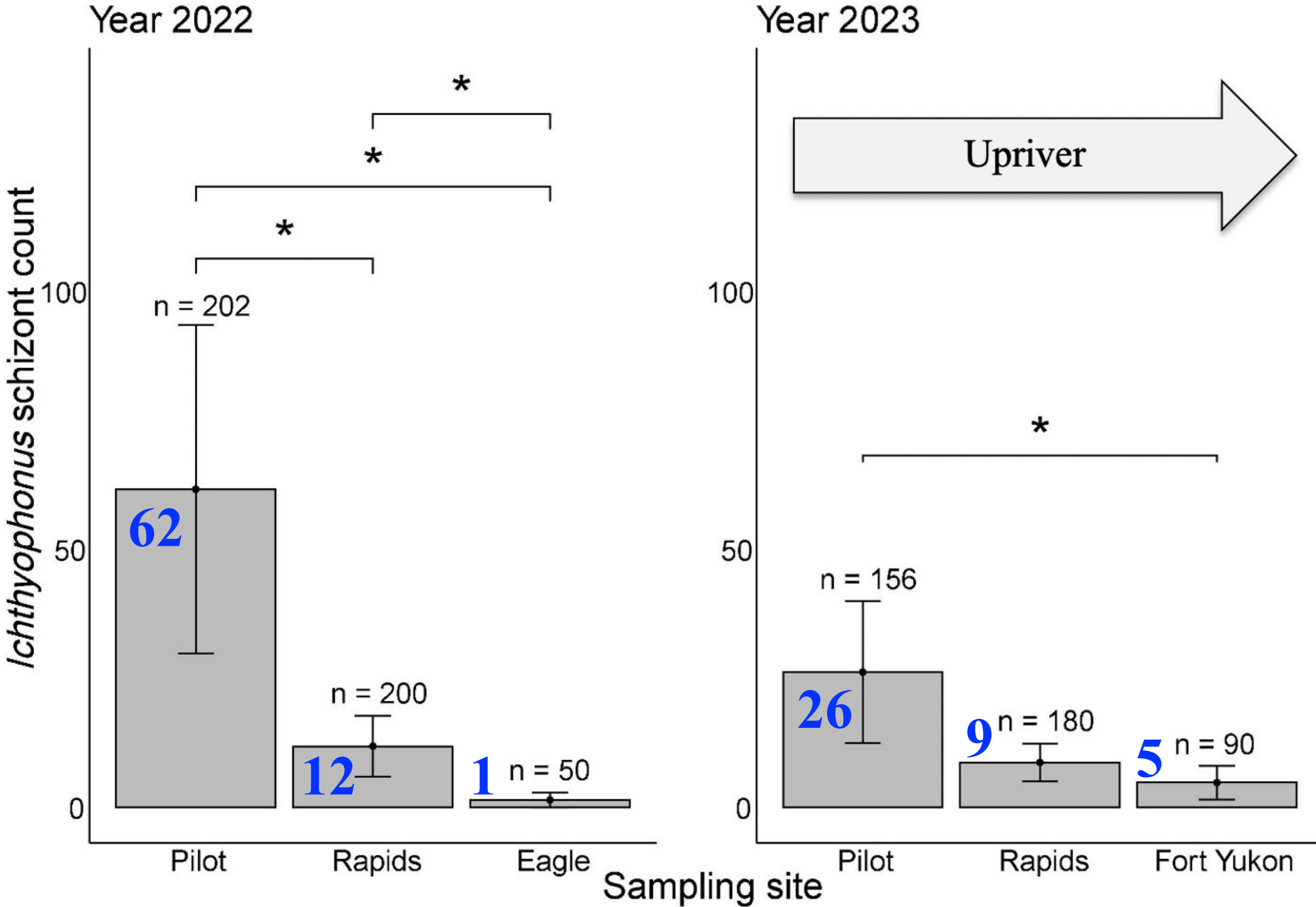
Zero-inflated negative binomial

Accounts for excess zeros and overdispersion in count data

Negative binomial part:

$$\ln(\mu_i) = \beta_0 + \beta_1 x_{1i} + \cdots + \beta_p x_{pi} + \ln(\text{offset}_i)$$

Provides an estimate for predicted parasite count in tissue



Severity findings

In contrast to prevalence, infection severity decreases during upriver migration

Consistent with mortality hypothesis of highly infected fish

Infection highest in lower river

Infection severity important to quantify in-river mortality

Caveats

Only two years of data during high *Ichthyophonus* rates

Excluded several variables that could impact rate of infection

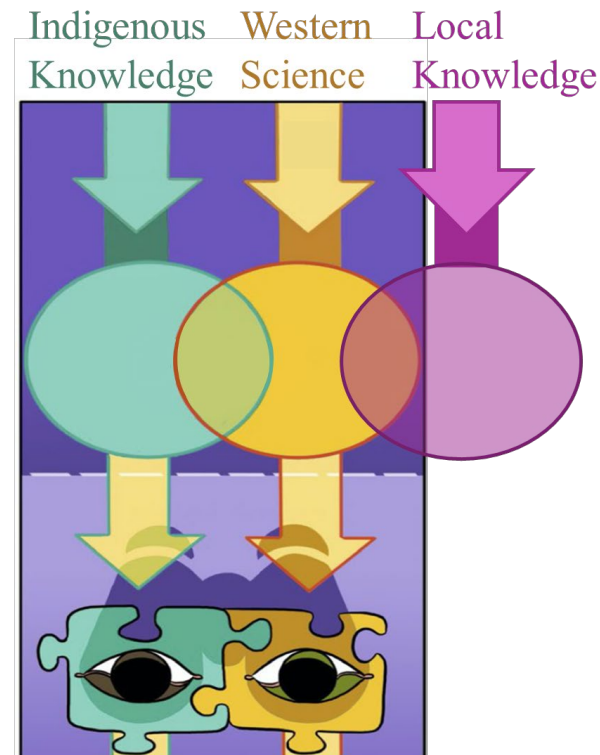
No direct comparison with other known stressors

Paired samples were collected for further investigation

Co-interpret results with Tribal Government Councils and community members

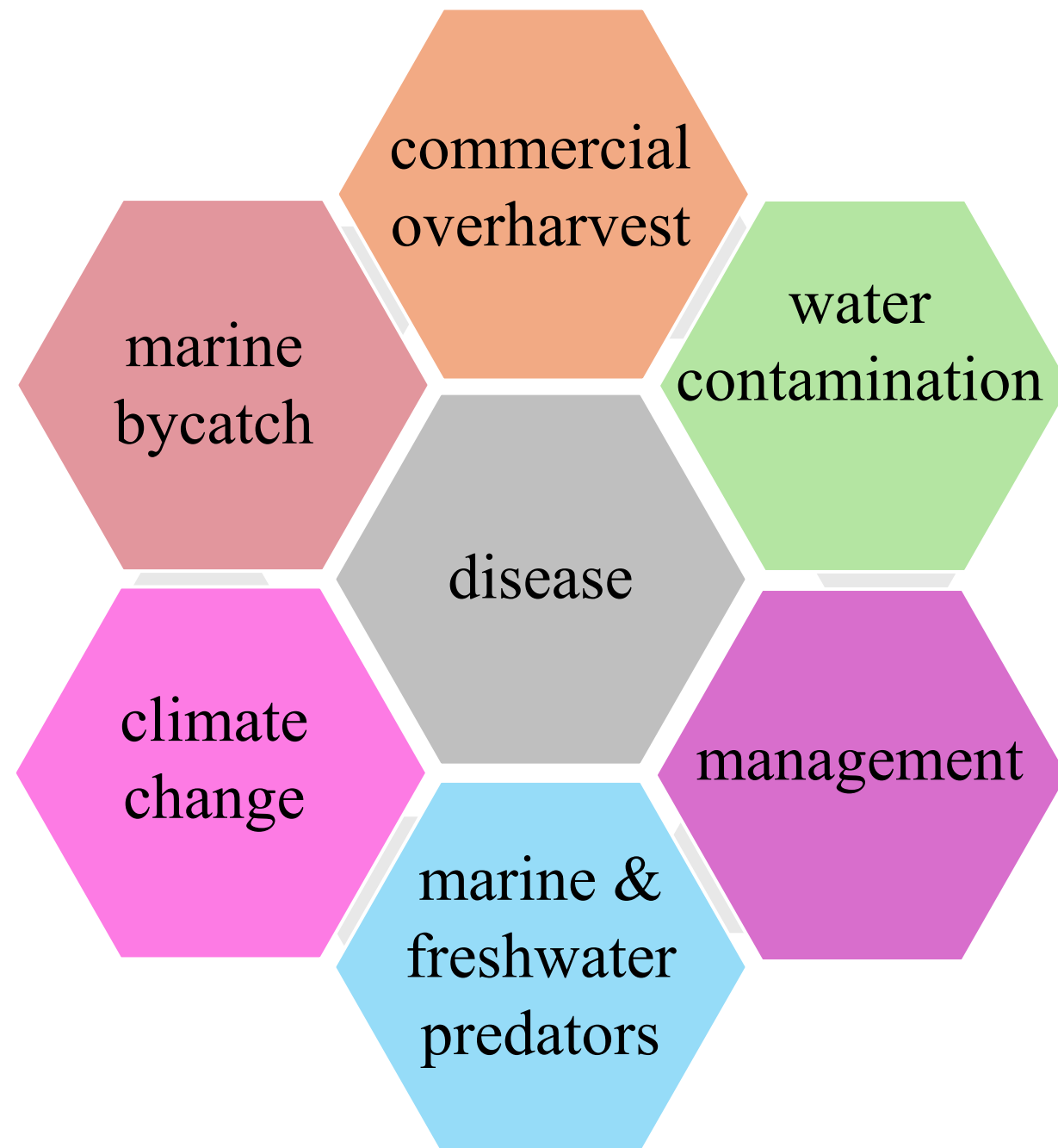
Shared preliminary results at community meetings

Shape thesis outcomes based on multiple knowledge systems

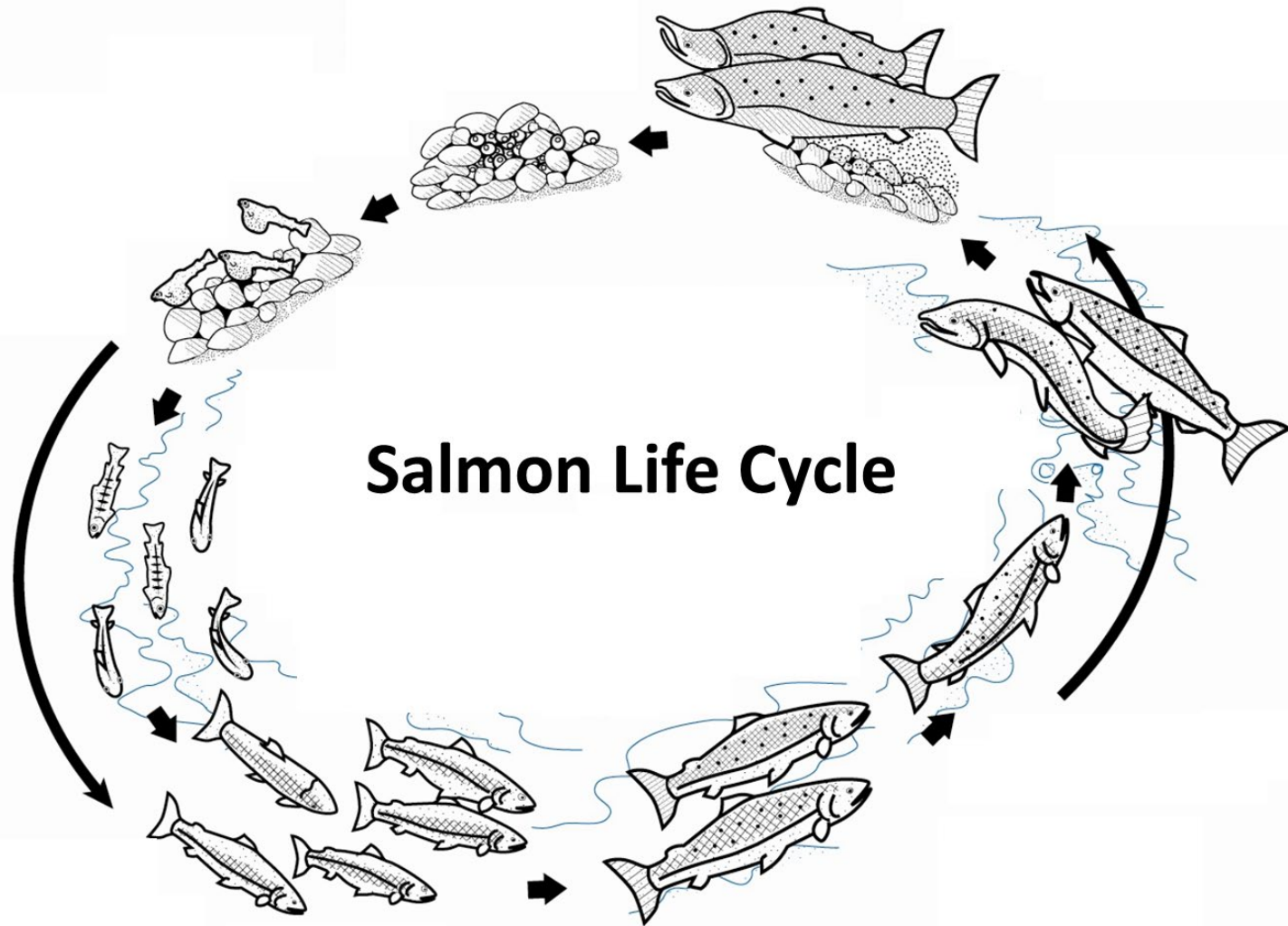


Community meeting process





Community meetings helped shape results



Participants stated

“See spots in the organs...spend more time looking at meat and less at hearts”

“See white spots all the time on the heart”

“Salmon are smaller and have lower oil now”

“If [*Ichthyophonus*] is the reason fish are dying in-river, why wouldn't Yukon River residents see kings washed up on the riverbanks? Dog [chum] salmon wash up on gravel bars when they die, why don't we see dead kings on the riverbanks?.... I have not heard reports of that from the people on the river”

“Large kings will sink and not be seen in the vast Yukon mainstem”

“Salmon are traveling to tributaries they have never travelled before. People that fish keep bringing it up that salmon are going down different waterways and ‘disappearing’...”

Tribal-led, -informed, & -designed research

“We (the community) should have our own say and our own way of monitoring things, and we (the community) should be the ones doing this (sampling) ourselves but are grateful (the research team) is here to tell us what they did. However, it would be better for our community to do that work.”

“We don’t see researchers and biologists, they don’t visit.... As fishery biologists and employees of organizations that help manage land and water resources and conduct research, they should visit, and that the community has already sacrificed too much.”

“Researchers need to work together with Yukon Tribes and come up with a plan so there is accountability for the lack of fish and we the people can help to ensure fish are present for generations to come in the water for subsistence.”

“Research needs to include people and knowledge from the Yukon River, and get more youth involvement”

Local-led *Ichthyophonus* monitoring

Used Stanley Zuray methods to count heart spots

Compared to histology or qPCR confirmation at all sites

Heart spots = *Ichthyophonus*

96% (229/238)

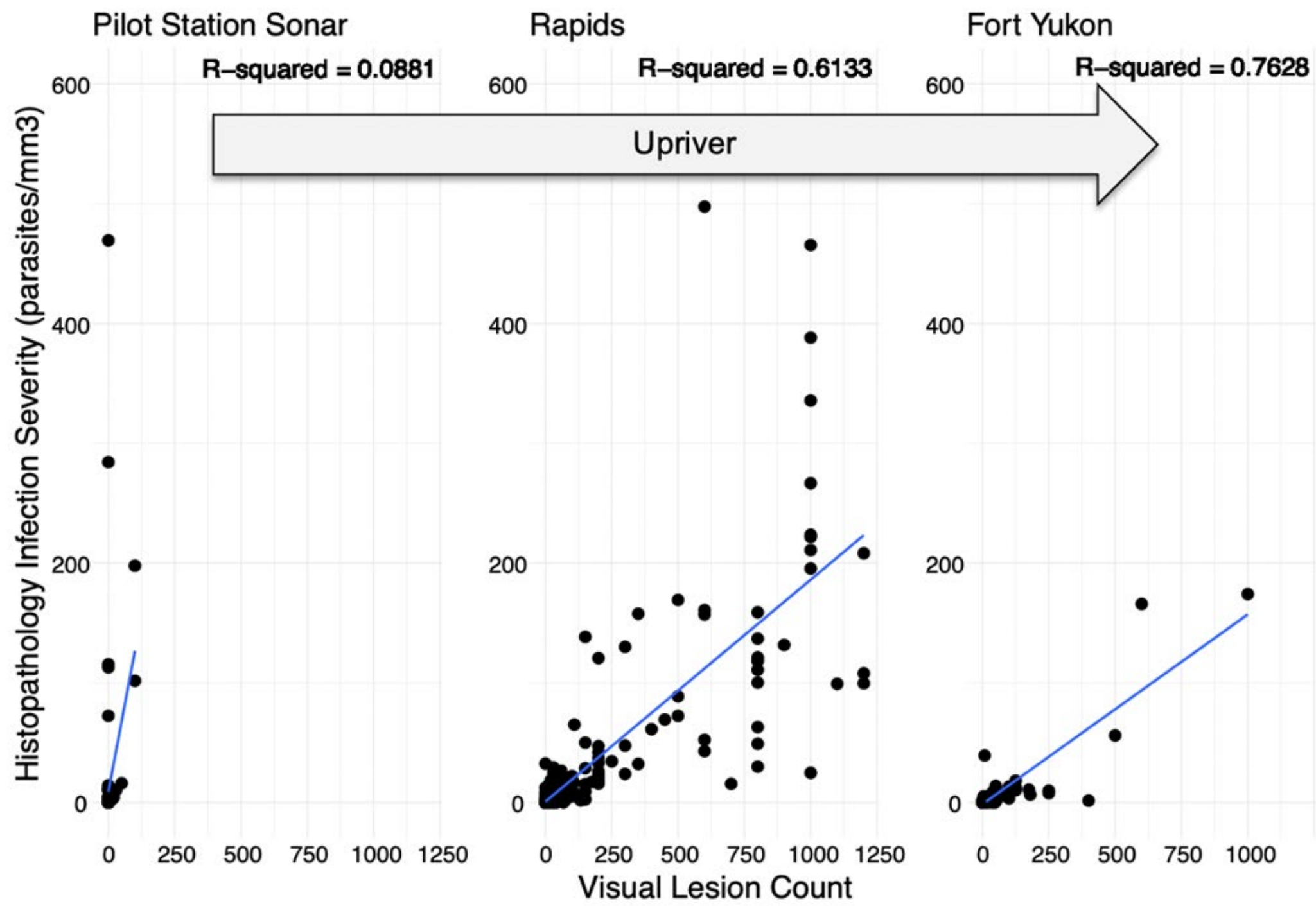


Local-led *Ichthyophonus* monitoring

Heart spots as a diagnostic tool at each site

Sampling site	Overall Agreement
Pilot Station Sonar	38/152 (25%)
Rapids	149/163 (91%)
Fort Yukon	31/ 33 (94%)
Eagle Sonar	11/ 20 (55%)





Why this is important

Supports Tribal-led monitoring efforts

Empowers communities and fosters trust in data

Includes multiple ways of knowing in research process

People on the river can see changes in real time

Low *Ichthyophonus* report in harvest in upper river

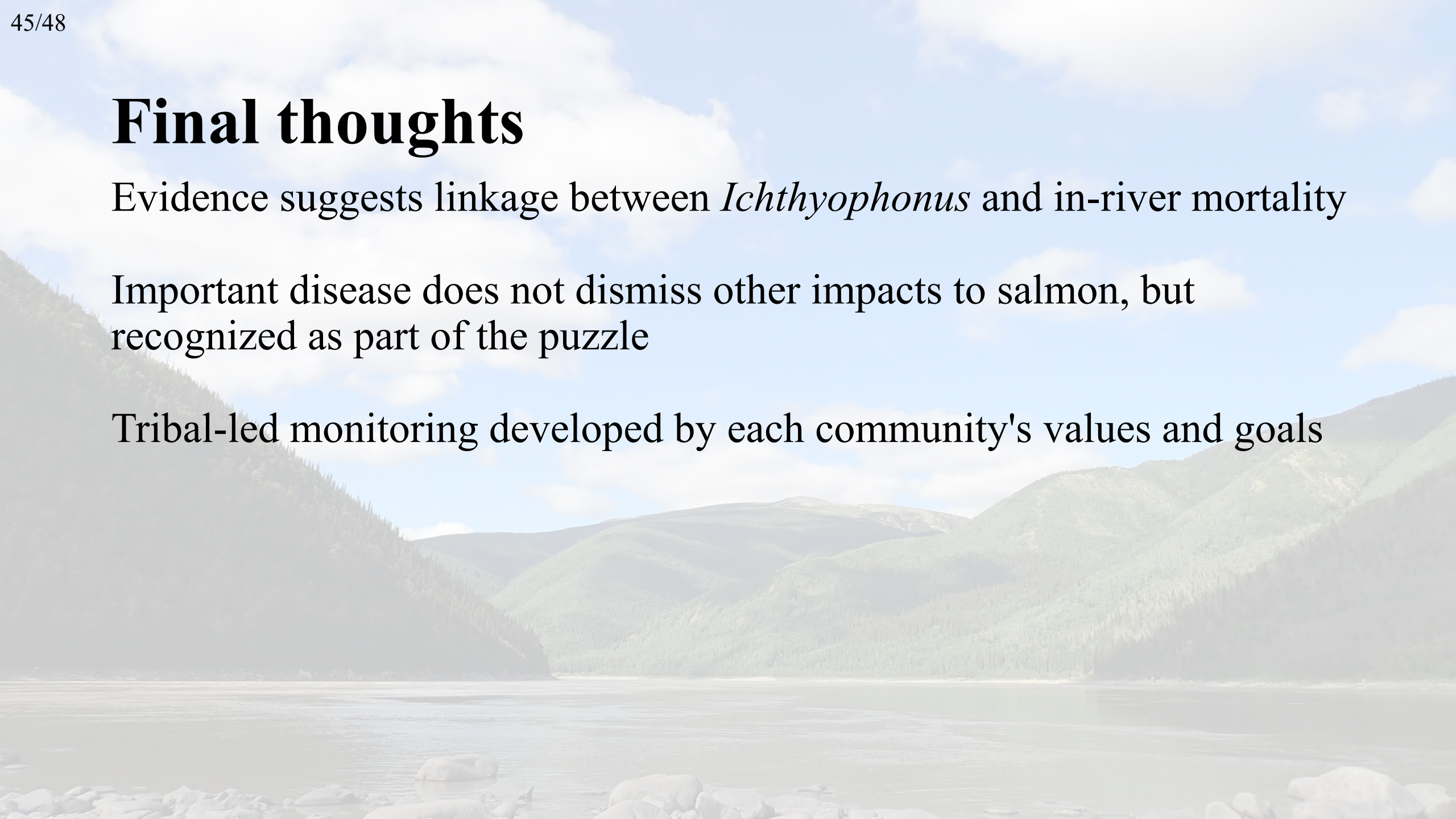
Highly infected kings with noticeable spots could be dying

Final thoughts

Evidence suggests linkage between *Ichthyophonus* and in-river mortality

Important disease does not dismiss other impacts to salmon, but recognized as part of the puzzle

Tribal-led monitoring developed by each community's values and goals



Buoys = Tribal governance



Mesh = Tribal leaders,
advocates, allies,
managers, researchers,
communities, youth,
cultures, Indigenous
values, IK, LK, WS

Knots = Bonds
formed through
reciprocal
relationships,
common
interests

Anchors/sinking line = People on the land

Research Acknowledgements

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ADF&G

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Canada

USGS

Washington Animal Disease
Diagnostic Laboratory

Tribal Government Partners

- Tanana Tribal Council
- Rampart Village Council
- Gwichyaa Zhee Tribal Government

Project Partners:

- Dr. Richard Kocan
- Stan Zuray
- Fishermen experts

Field technicians

Tamamta (NSF #2022190)

ANSEP



Thank you for listening Questions?

Email

kdherron@alaska.edu

keith_herron@fws.gov

photo by Allison Heaslet (ANSEP) near Fort Yukon