Yukon River Panel
December 8, 2022
Agenda item: # 11

Investigating the impacts of *Ichthyophonus* on Yukon River Chinook Salmon

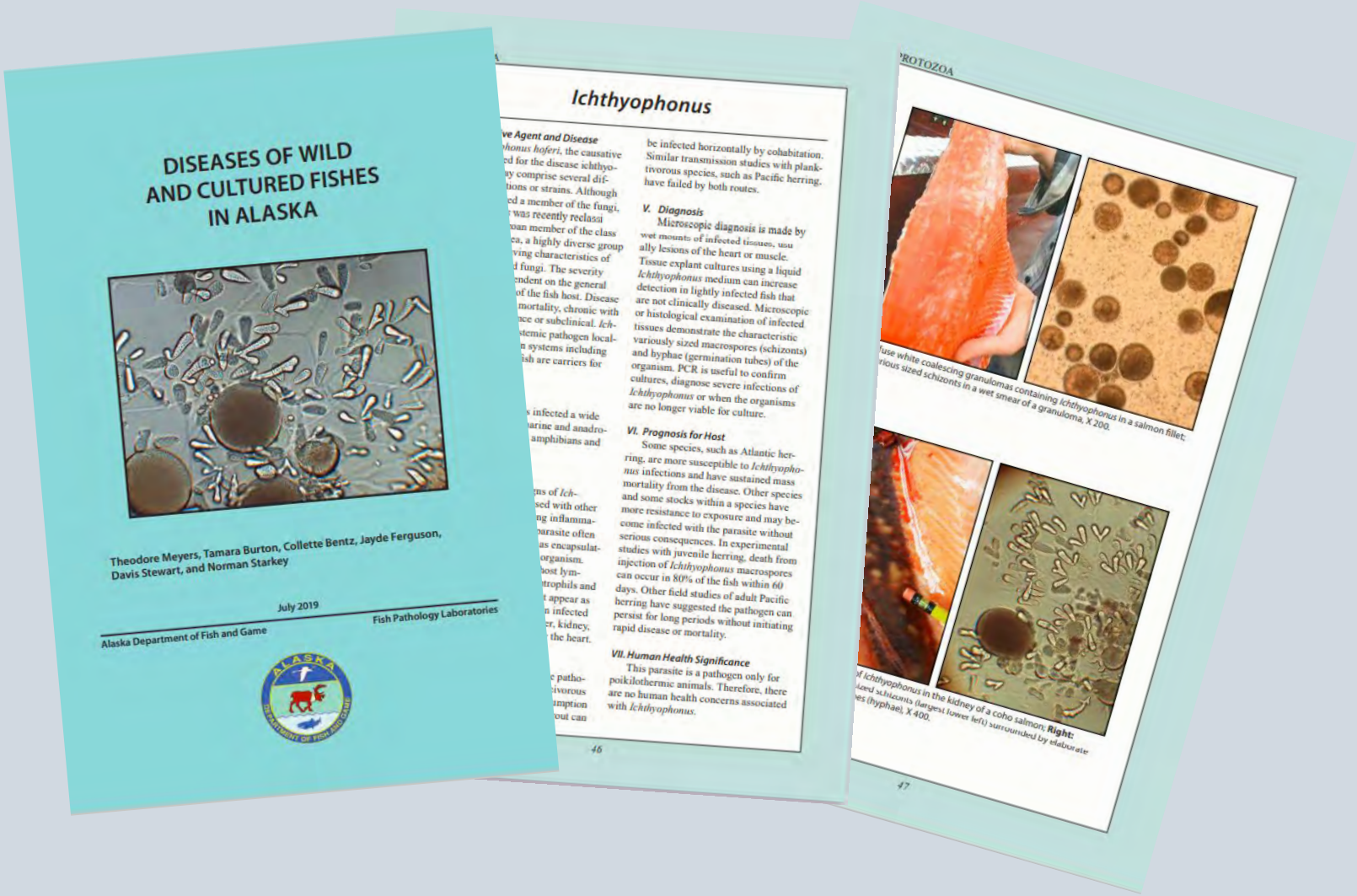
Ichthyophonus can display as white spots or streaks in a salmon fillet

Outline

1) What is *Ichthyophonus*?
2) What is known about *Ichthyophonus* and Yukon River Chinook Salmon?
3) Why is *Ichthyophonus* being studied again?
4) What sampling was done in 2021 and 2022?
5) What has been learned from this study?
6) What are the plans moving forward?

What is *Ichthyophonus*?

Lots of publicly available information



- Cause of infection
- Host species
- Transmission
- Signs of infection
- Diagnosis
- Disease
- Prognosis for host
- Human health significance

https://www.adfg.alaska.gov/static/species/disease/pdfs/fish_disease_book.pdf

Human Health Significance

Ichthyophonus is a fish disease, and it can not harm people or dogs. The flesh may not be appetizing to look at or taste, and it may not dry properly. However, fish infected with Ichthyophonus are safe to eat.

Cause of Infection

- *Ichthyophonus spp.* are single-celled marine organisms that act as parasites in fish.
- Genetic studies have indicated that *Ichthyophonus* may be a complex group of species which infect different groups of host fishes.
- The life-cycle of the *Ichthyophonus* parasite is not well known.

The parasite is a **mesomycetozoan** meaning it has both fungus and animal characteristics

- Meso = between
- Myco = fungus
- Zoa = animal

Host Species

Ichthyophonus infection has been documented in over 140 fish species worldwide.

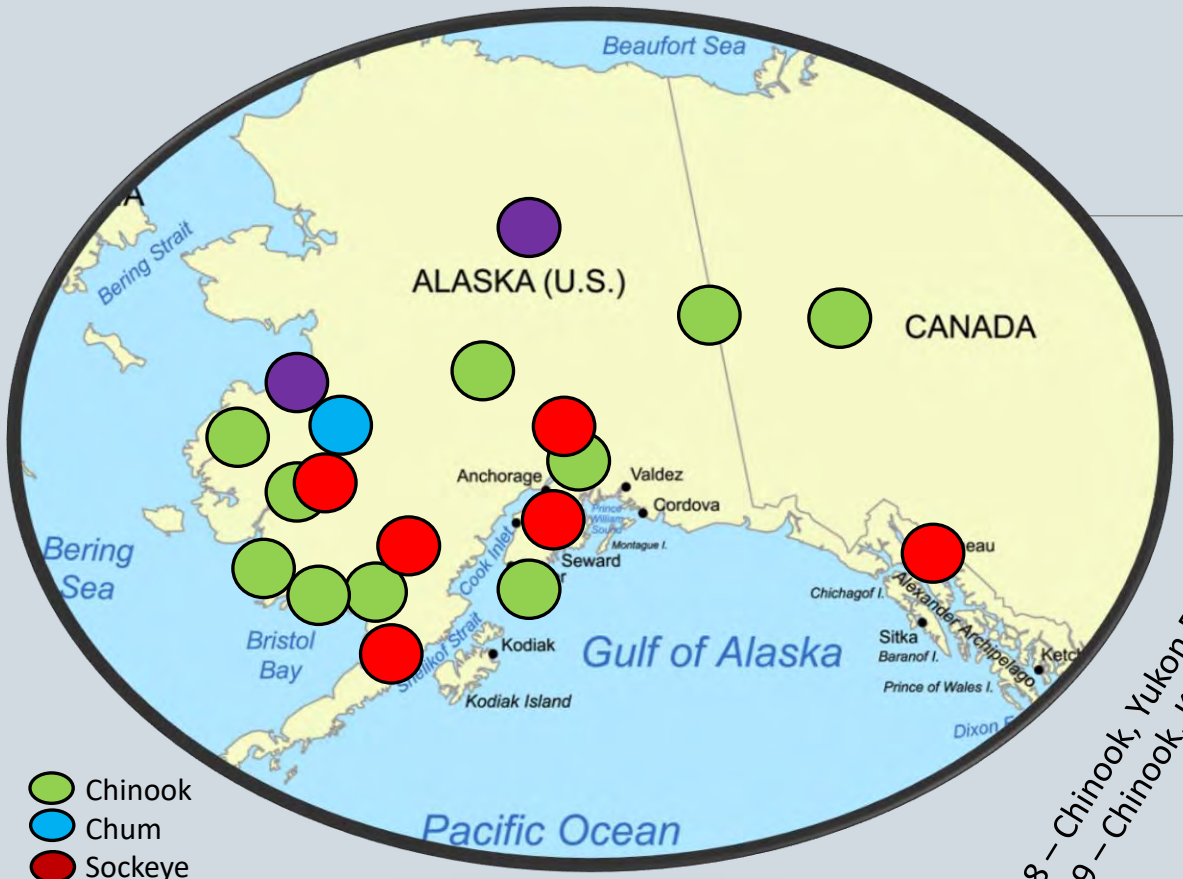
The parasite infects both marine and freshwater species.

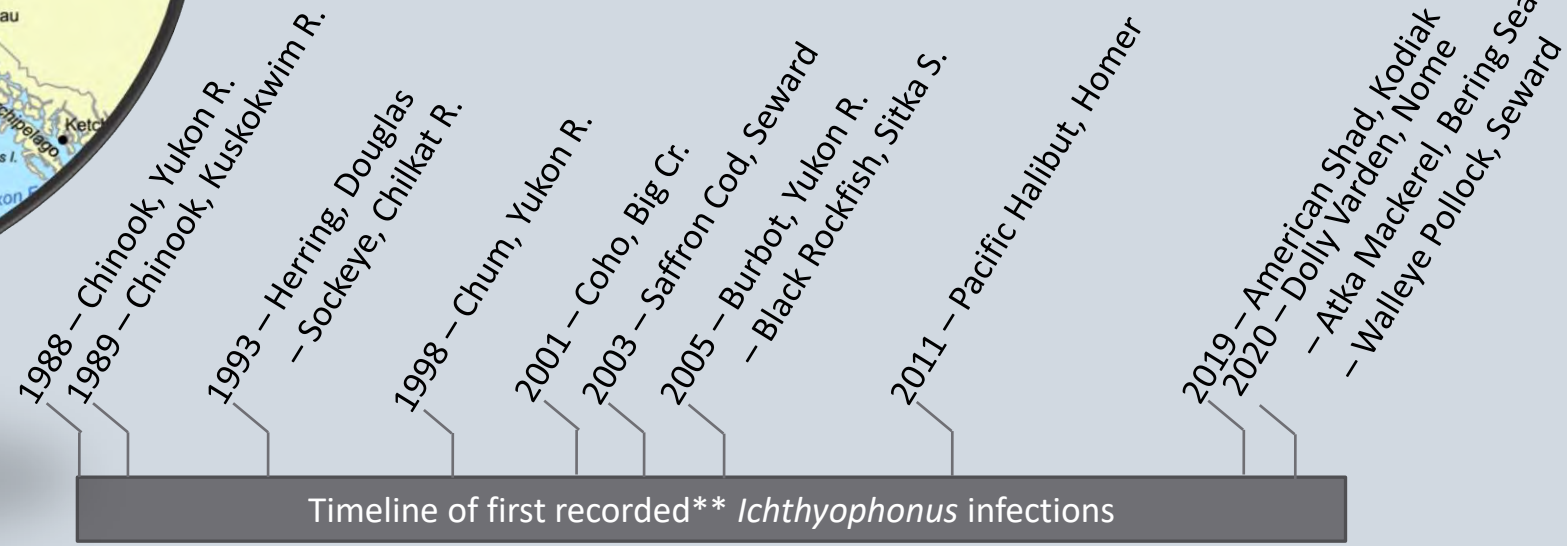
Herring species are possibly the most affected.

Common in Pacific and Atlantic salmon and trout.

Common in cod, pollock, shad, rockfish, flat fishes, sculpin, and more…

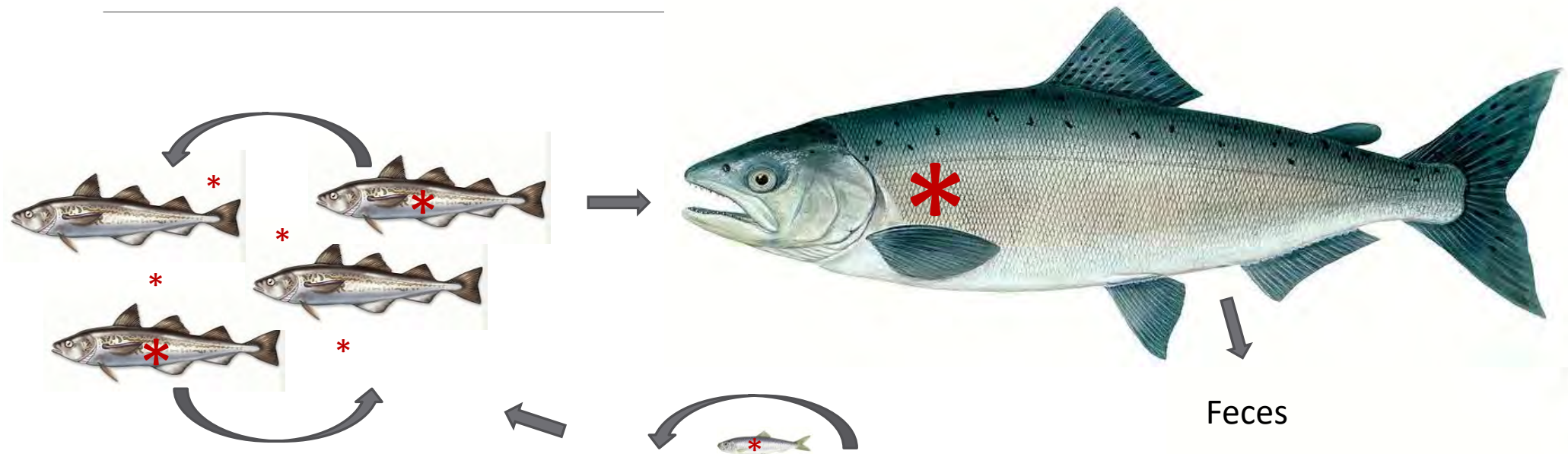
Host Species** - Alaska





** Opportunistic samples evaluated by ADF&G Pathology Lab. A wide range of species and locations can be impacted by *Ichthyophonus*.

Transmission – Marine



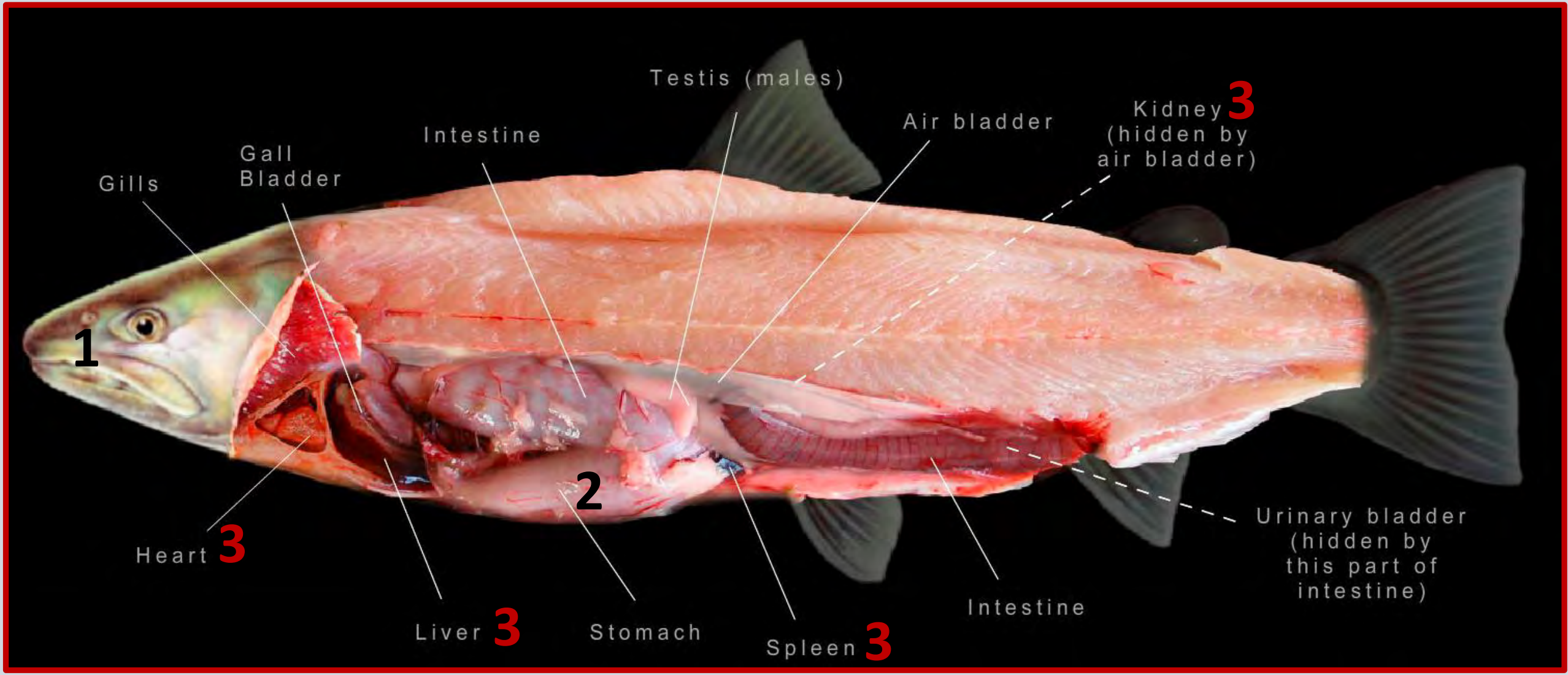
Feces

Ingestion of infected prey

Waterborne infected cells

Diagram modified from Kocan et al. 2004

Photo credit: Chinook Carlyn Iverson
Herring: Scandinavian Fishing Year Book
Pollock: NOAA FishWatch

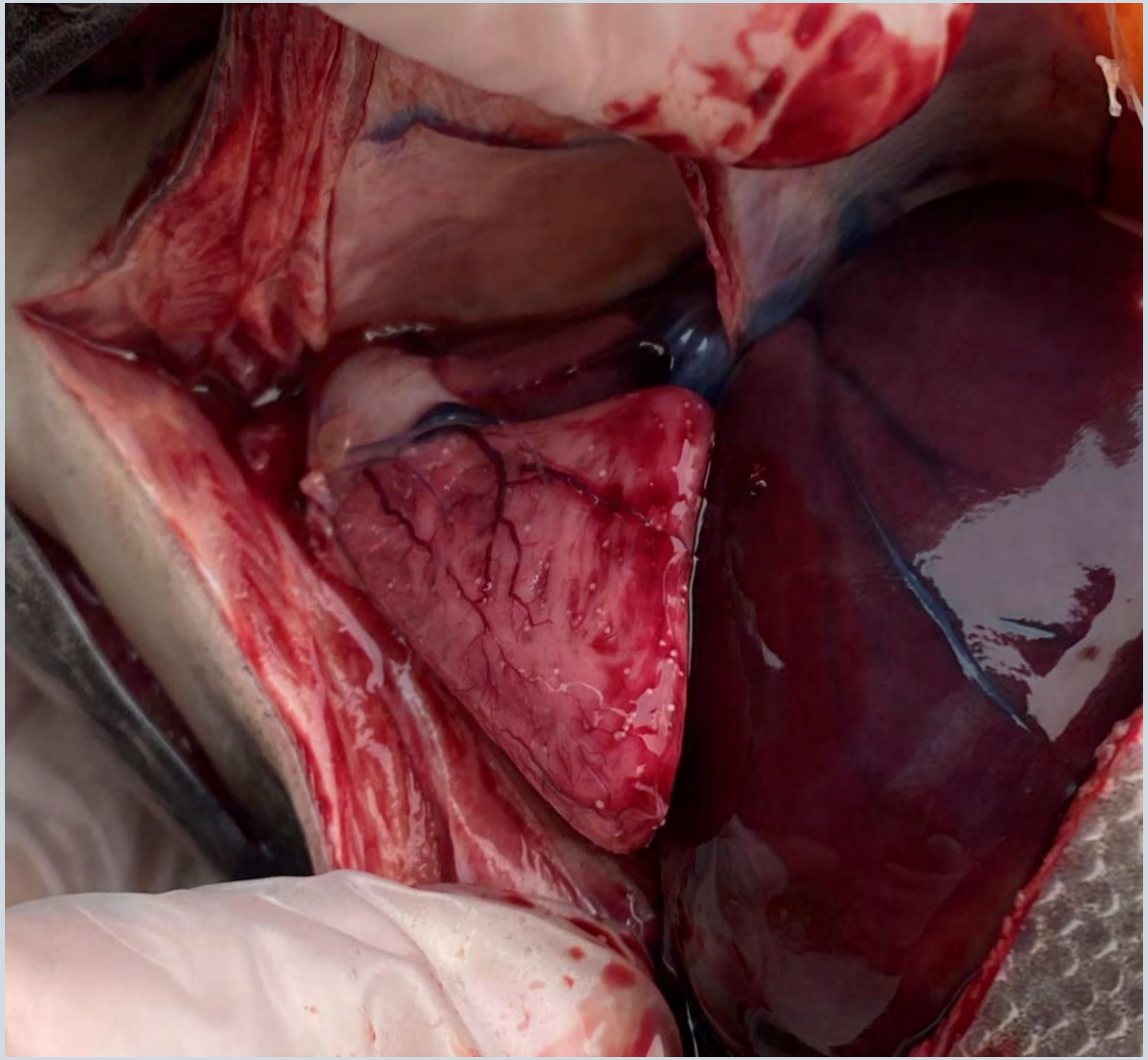


1. Infected tissue is ingested
2. “Amoeba” like infectious cells invades the stomach lining and enters the bloodstream
3. Infectious cells lodge in blood filtering organs (e.g., heart, liver, kidney, and spleen)
4. Parasite increases in size to form a large schizont (resting phase) that becomes encapsulated in white inflammation tissue

Meat has white “streaks” &” fruity” smell

Blood organs have white spots

Visual signs of infection



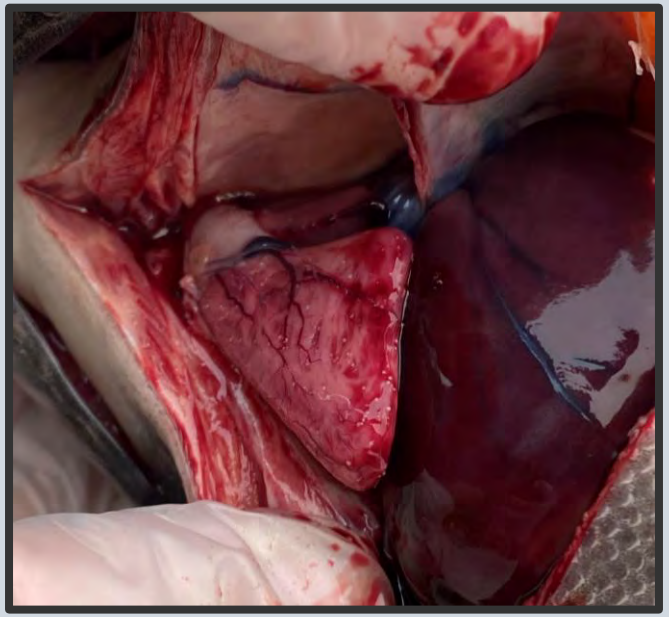
Diagnosis – not all infected fish become diseased

LABORATORY EXAMINATION OF TISSUE (I.E., TYPICALLY THE HEART) IS REQUIRED TO DIAGNOSE ICHTHYOPHONUS

THERE ARE CURRENTLY NO NON-LETHAL METHODS AVAILABLE

Diagnostic methods

1.



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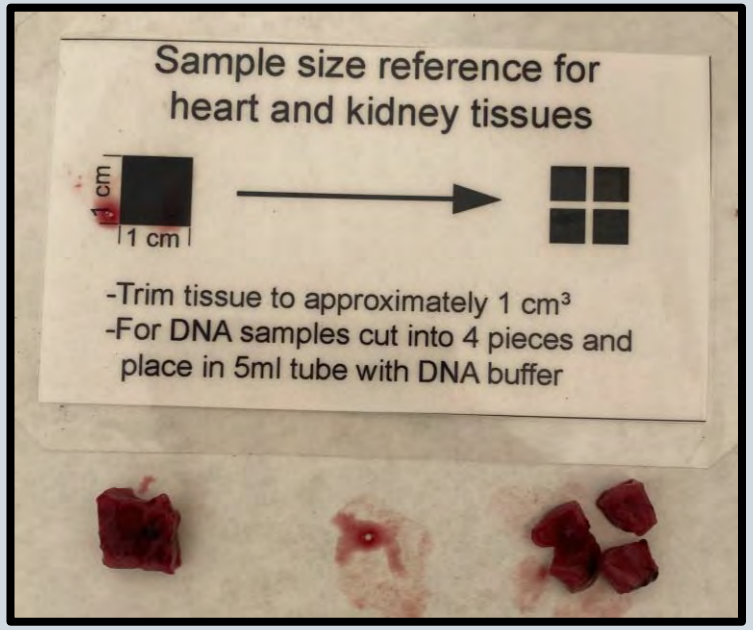

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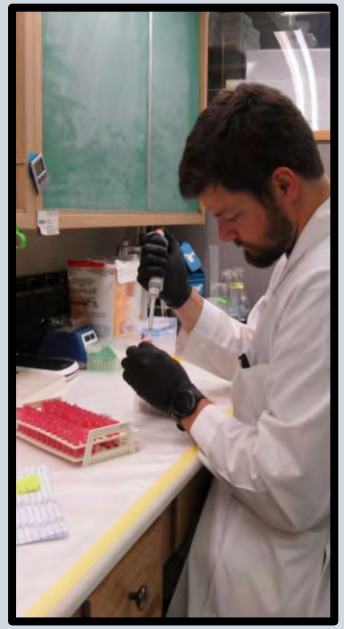
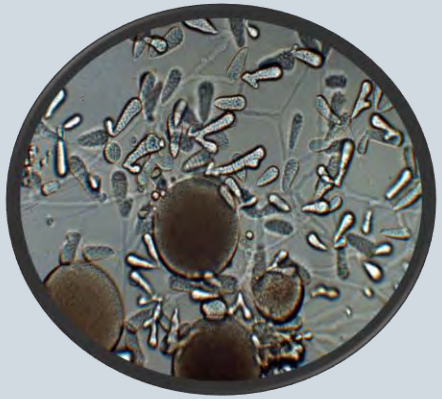


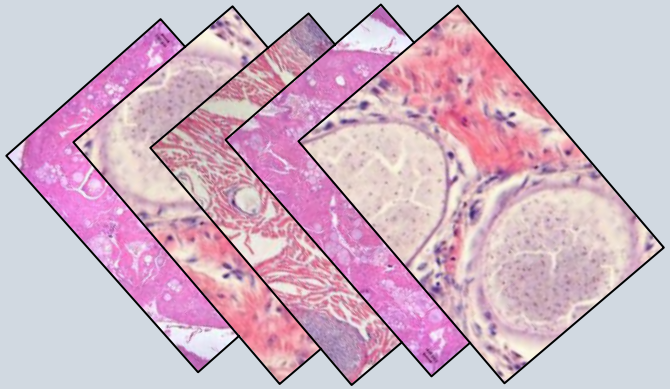
Select lab method that is "fit for purpose"

Explant culture



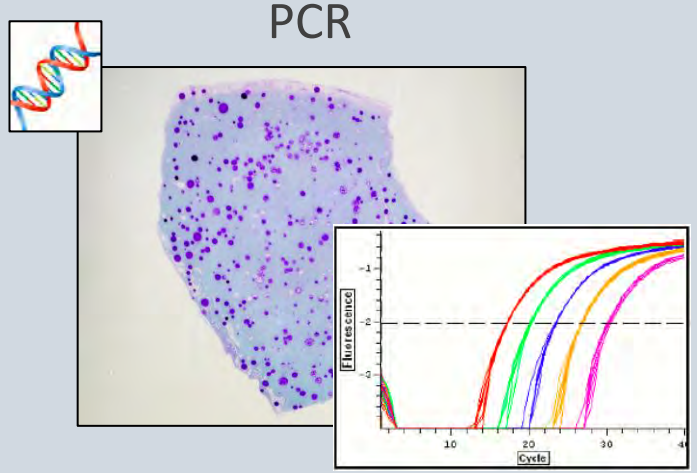
presence only

Histopathology



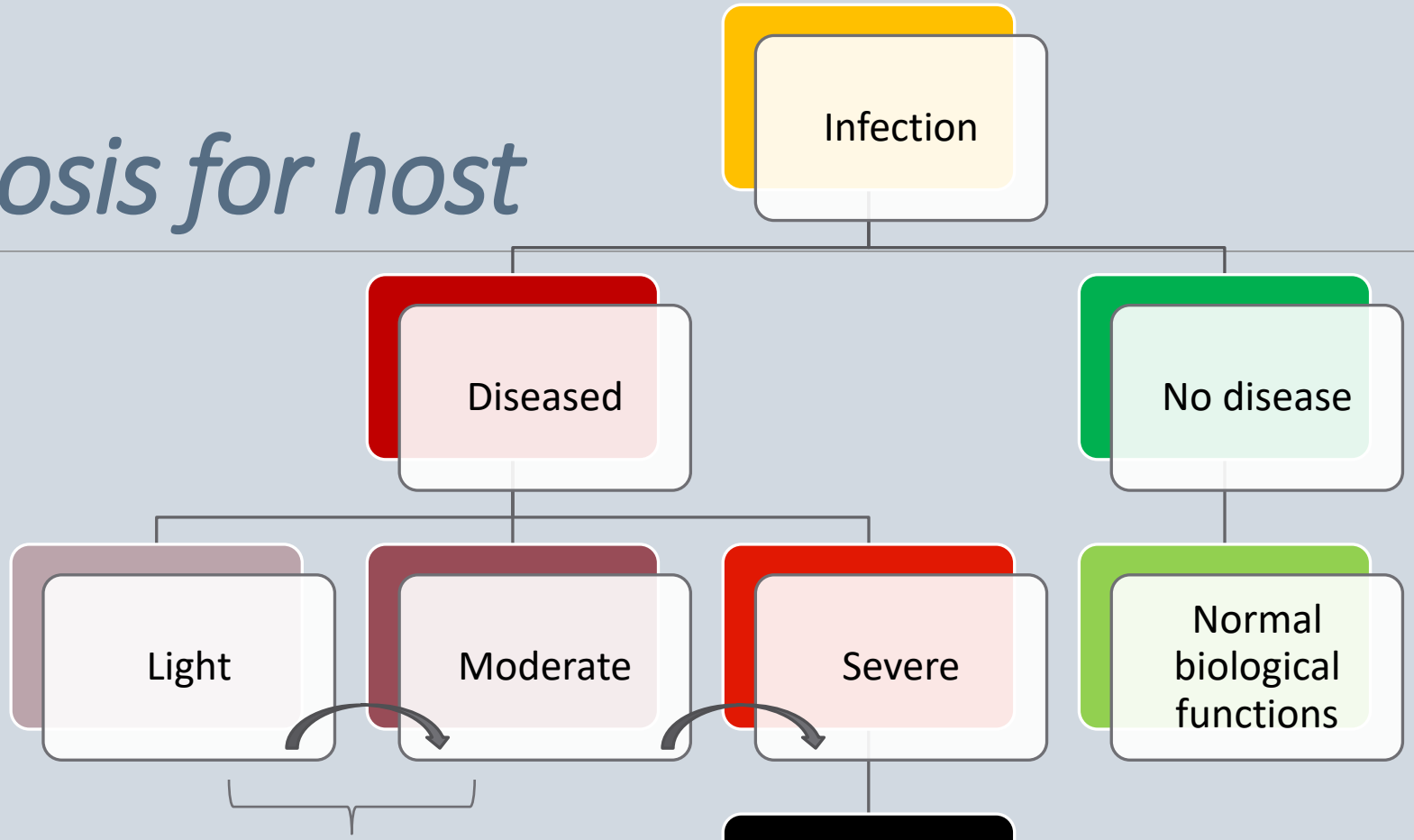
presence & severity

PCR



presence & severity

Prognosis for host



Compromised biological functions:

- Cardiac stress ↑
- Plasma cortisol levels ↑
- Hemoglobin and red blood cells ↓
- Swimming speed ↓

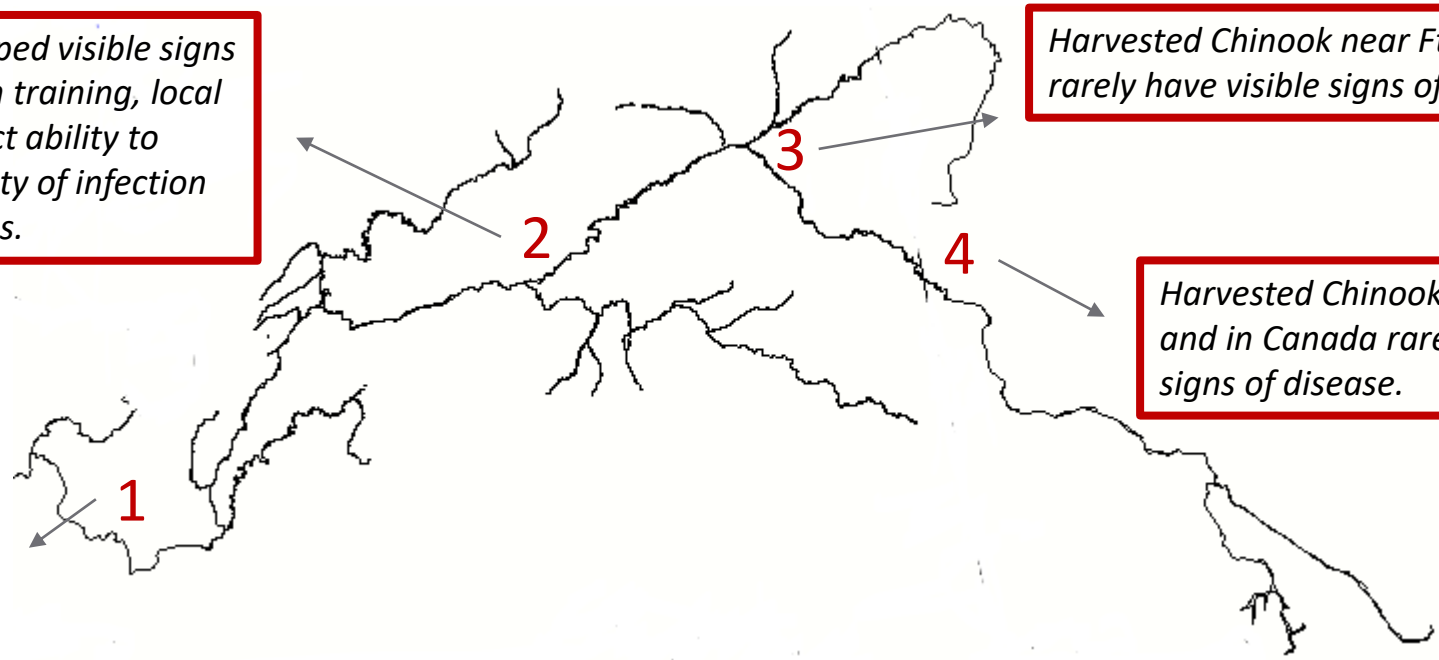
What is known about *Ichthyophonus* and Yukon River Chinook?

Local Knowledge

- First detected by local Yukon River fishers in the mid 1980s.
- Local fishers raised concerns throughout the 1990s and 2000s about the impact of diseased fish on subsistence and commercial harvest – prompted research action by academics and fishery management agencies.
- Tremendous insight from monitoring health of harvested fish.
- Rapids Research Center (Mr. Stan Zuray) bridged local and western science to advance understanding.

Chinook display well-developed visible signs of disease near Rapids. With training, local fishers achieve a near perfect ability to identify diseased fish. Severity of infection increases as the run progress.

Harvested Chinook near Ft. Yukon rarely have visible signs of disease.



Harvested Chinook near Eagle AK and in Canada rarely have visible signs of disease.

Chinook rarely have visible signs of disease in lower river.

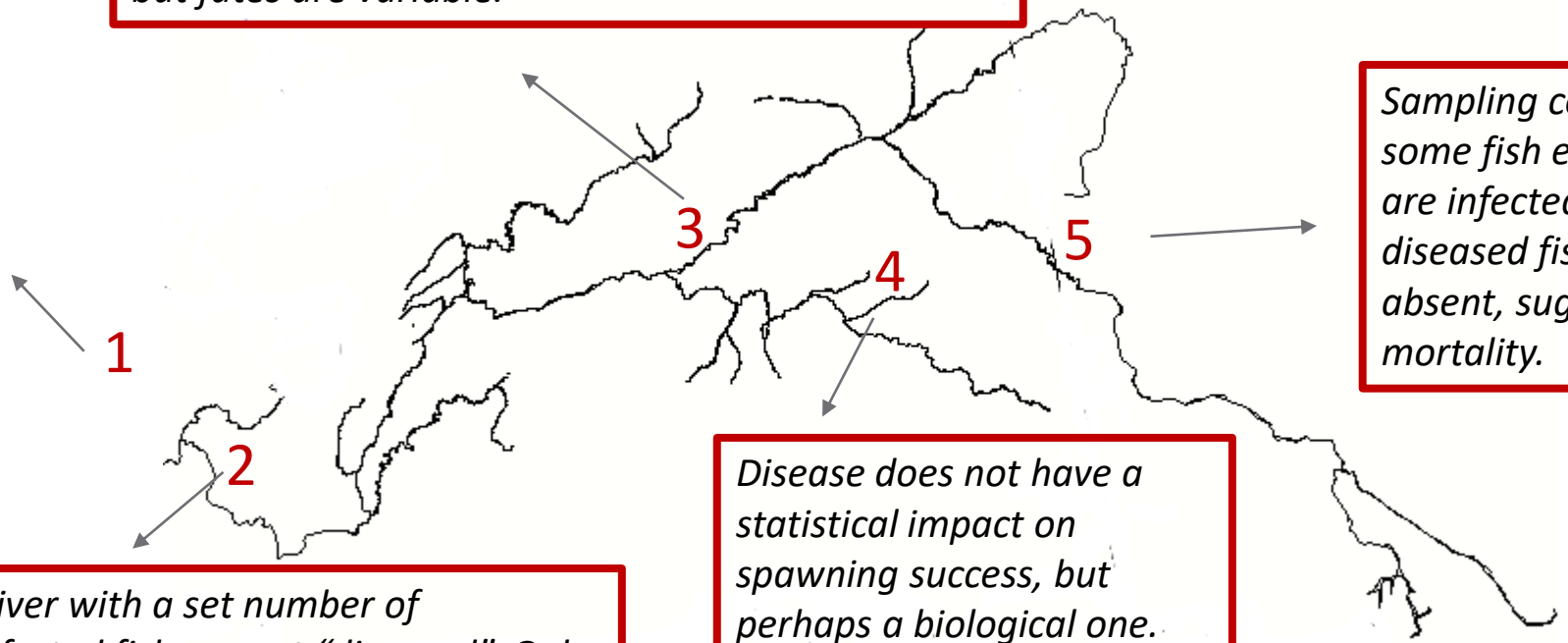
River mile 123 —— 731 —— 1,002 —— 1,224

Western Science

- Impact to Yukon River Chinook salmon is the result of an "emerging disease" first documented in 1988.
- The strain of "*Ich*" that infects Yukon Chinook is different than the strain observed in PNW and Atlantic

Disease severity reaches a "peak" near the middle river. Disease progresses faster in warm water (e.g., >15 C). Fish do not recover from the disease, but fates are variable.

Infection occurs though consumption of unknown infected prey in the marine environment. In some years females may be infected more than males.

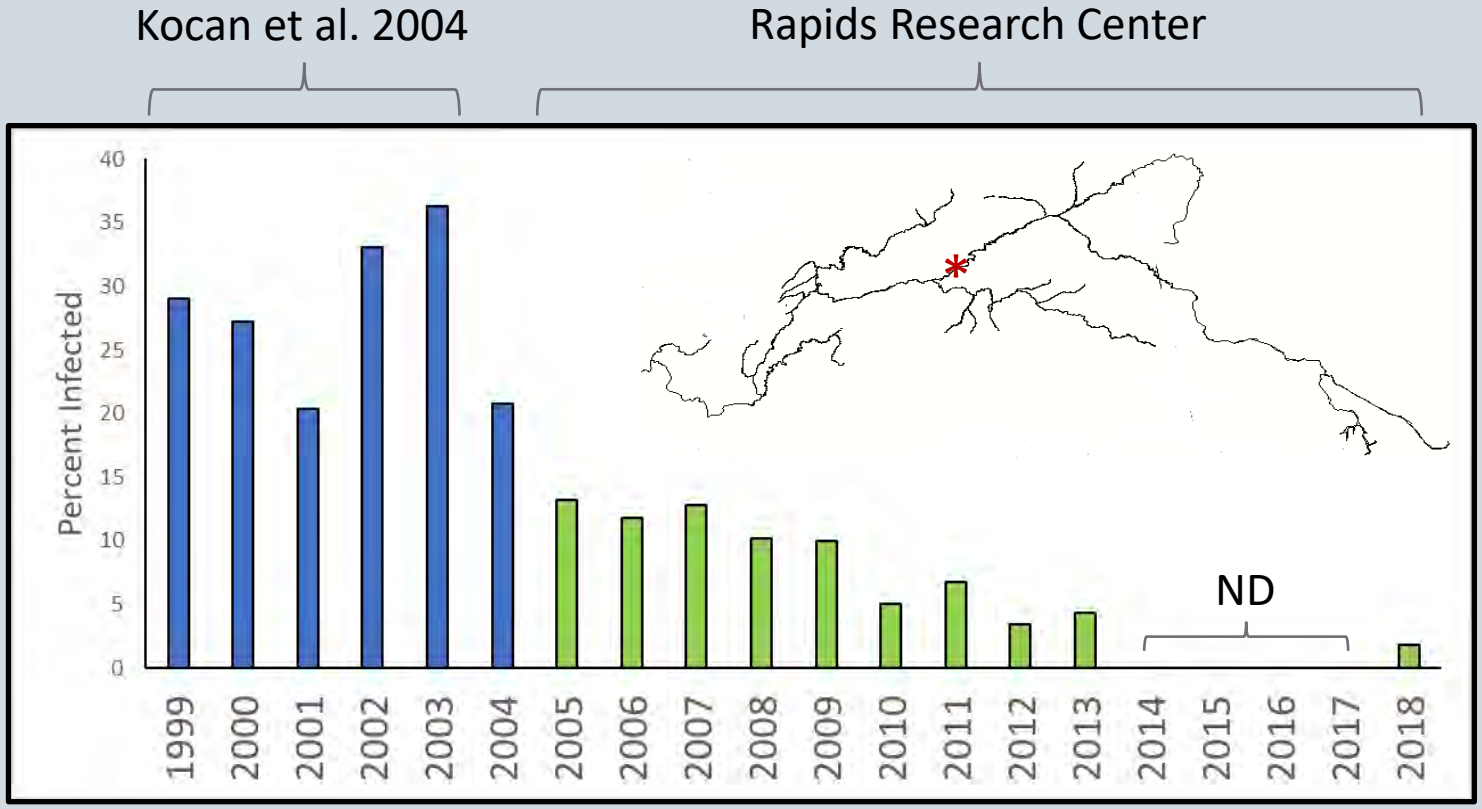


Sampling confirms that some fish entering Canada are infected. Severely diseased fish are generally absent, suggesting enroute mortality.

Disease does not have a statistical impact on spawning success, but perhaps a biological one.

Fish enter the Yukon River with a set number of infections, but most infected fish are not "diseased". Only most sensitive lab tests can detect "lightly infected" fish.

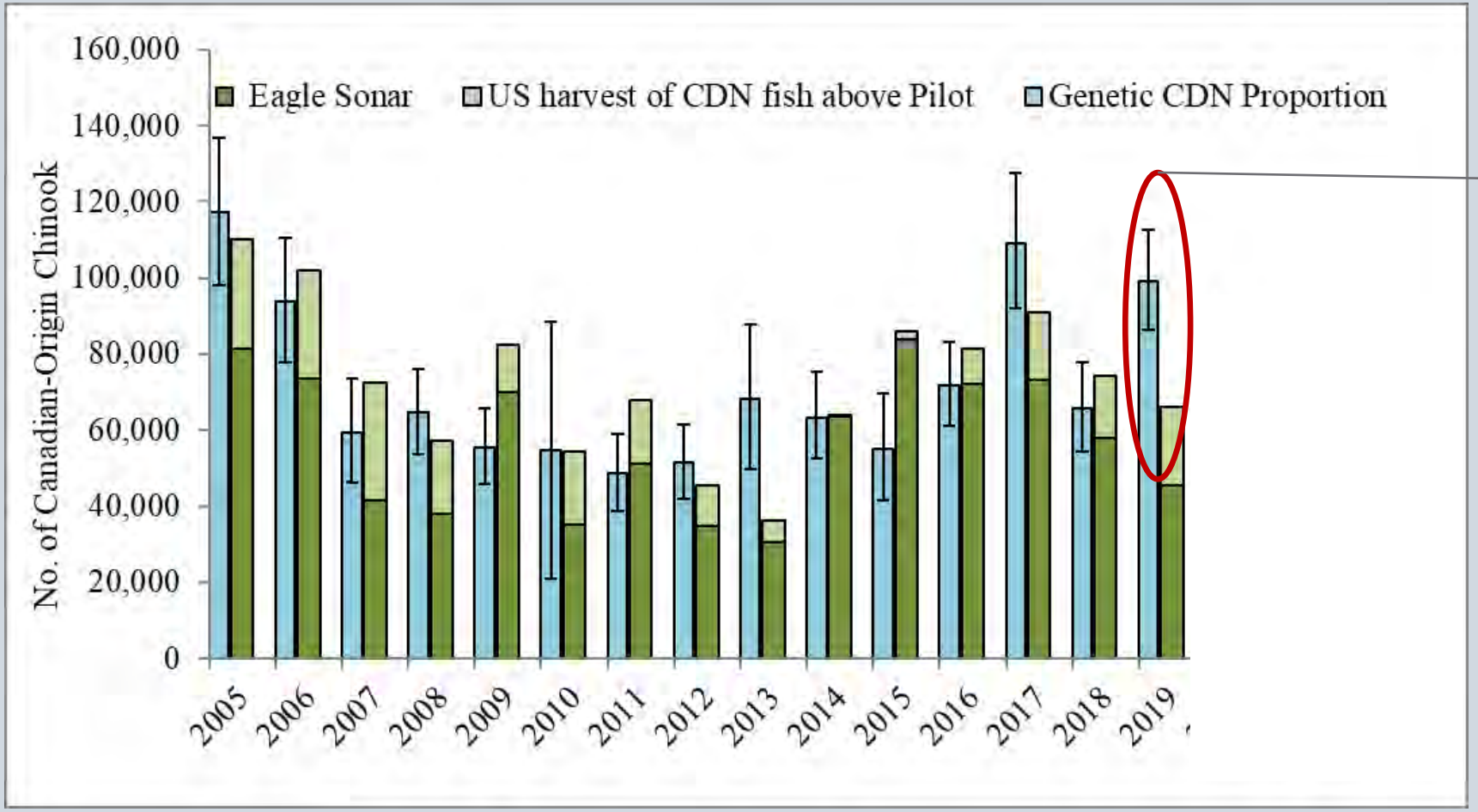
River mile 123 731 1,224



Trends in Yukon River Chinook salmon infection prevalence at Rapids Research Center – *a local and academic partnership*

Why are the impacts of *Ichthyophonus* on Yukon River Chinook being studied again?

Unexplained poor abundance of Canadian-origin Chinook salmon passing the U.S./Canada Border



Fisheries Magazine

Feature | Full Access

Premature Mortality Observations among Alaska's Pacific Salmon During Record Heat and Drought in 2019

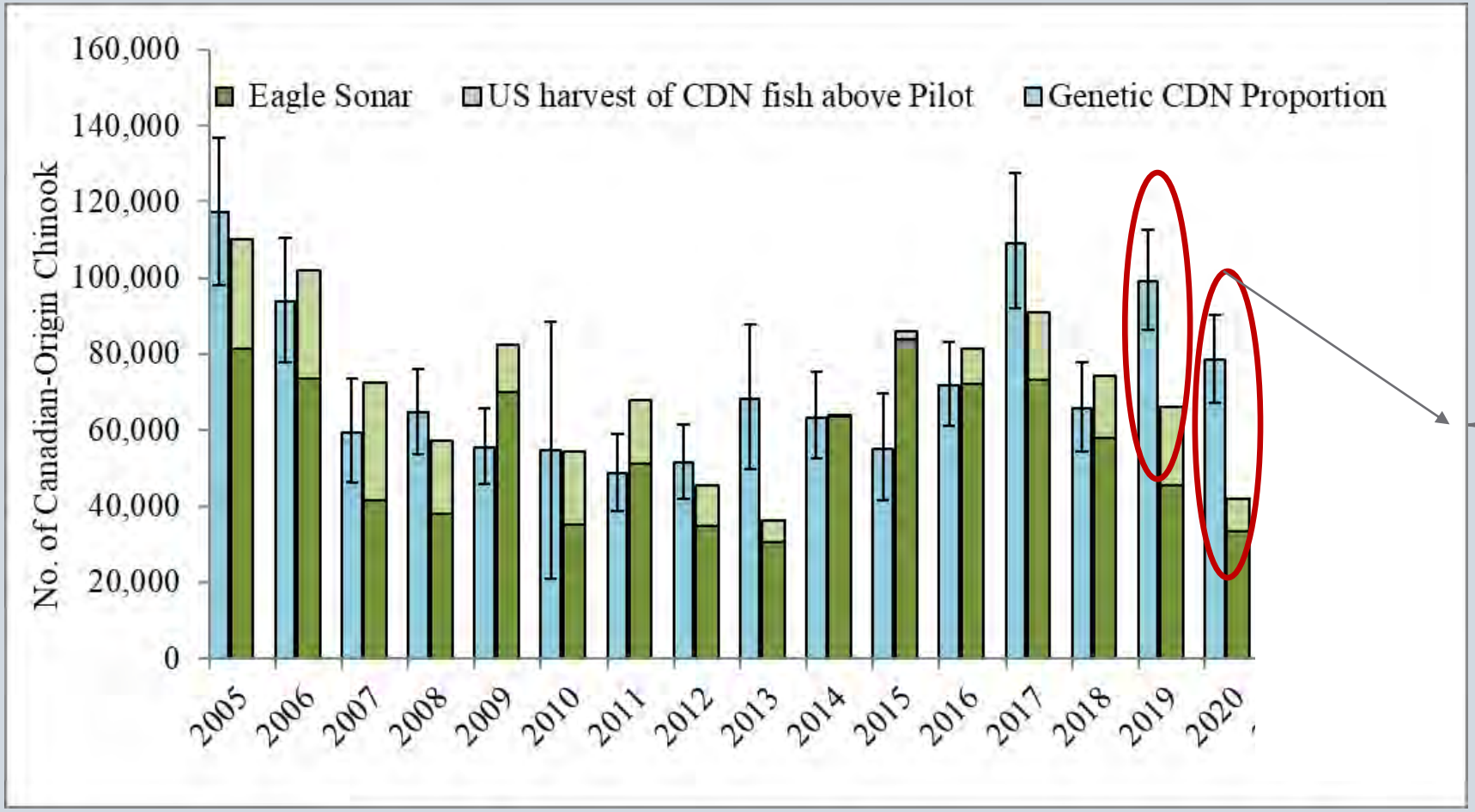
Also, in 2019

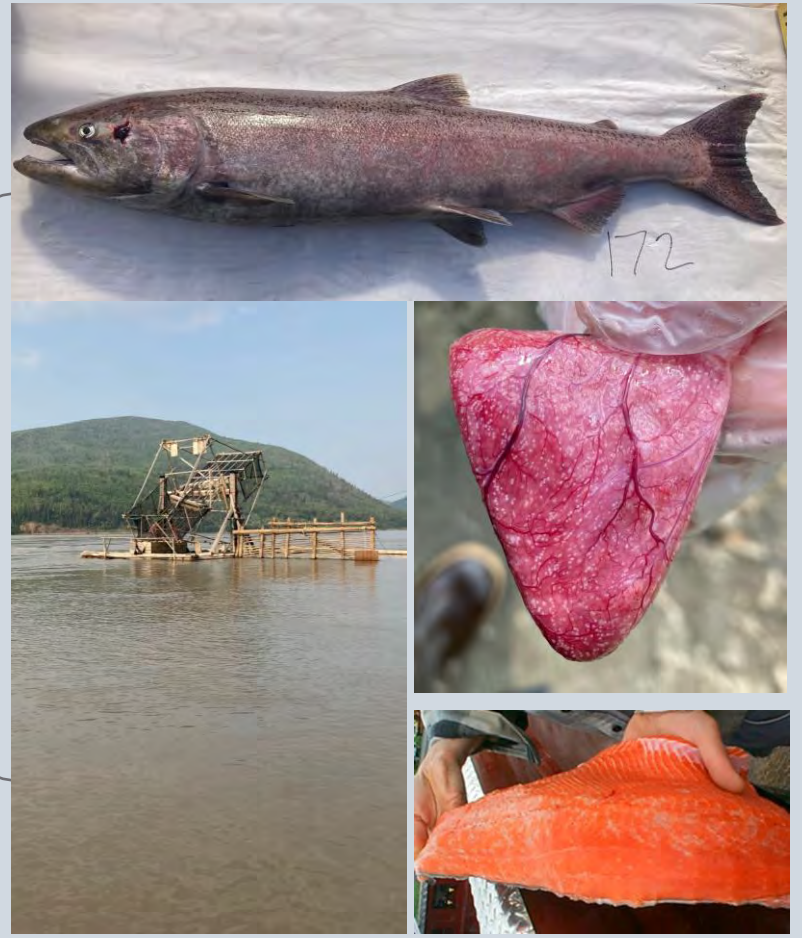
Warmer Water Means More Parasites In Kuskokwim Salmon

KYUK | By Anna Rose MacArthur

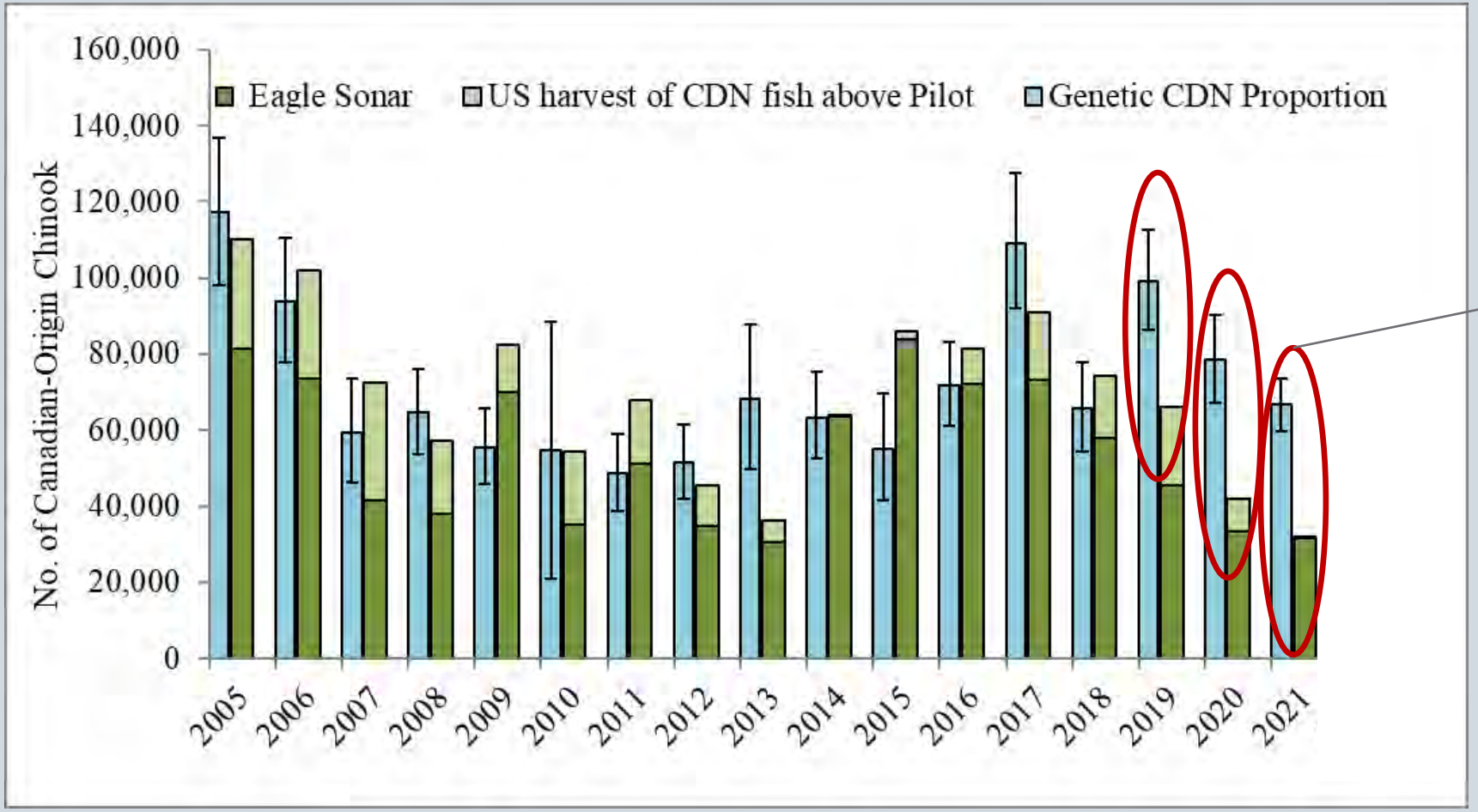
"missing fish" … "ghost fish"… "difference between estimates"…

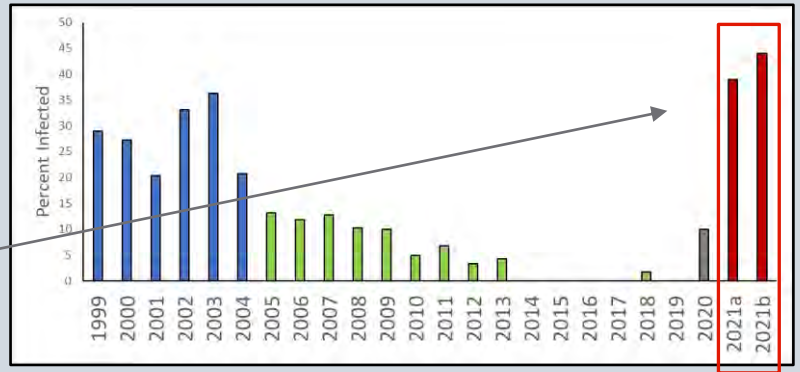
Unexplained poor abundance of Canadian-origin Chinook salmon passing the U.S./Canada Border





Unexplained poor abundance of Canadian-origin Chinook salmon passing the U.S./Canada Border



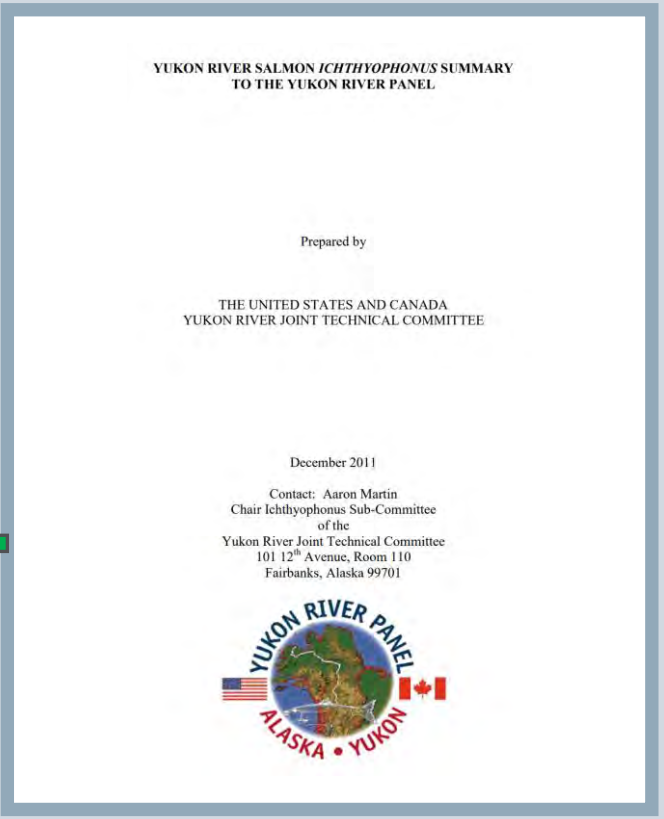


Resurgence of Ichthyophonus at previously undocumented levels

2021a – Pilot station
2021b – Rapids, small mesh gillnets

Ichthyophonus - associated *en route* mortality is the **leading hypothesis** to explain the difference between sonar estimates

Bi-lateral and multi-agency acknowledgement that Ichthyophonus research is needed while prevalence is high



YUKON RIVER SALMON *ICHTHYOPHONUS* SUMMARY
TO THE YUKON RIVER PANEL

Prepared by

THE UNITED STATES AND CANADA
YUKON RIVER JOINT TECHNICAL COMMITTEE

December 2011

Contact: Aaron Martin
Chair Ichthyophonus Sub-Committee
of the
Yukon River Joint Technical Committee
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YUKON RIVER PANEL
ALASKA • YUKON

JTC guidance to re-initiate Ichthyophonus directed research when prevalence exceeds 25%

What sampling was done in 2022?

PROJECT OBJECTIVES

- √ Develop an annual *Ichthyophonus* monitoring program and build a new predictive tool capable of providing timely information about the level of Chinook salmon mortality associated with *Ichthyophonus* disease.
- √ If after years* of development this project is successful, it will provide necessary information to encourage precautionary management when disease levels are high and allow for a better management and protection of Chinook salmon for years to come.

***Anticipated three-year effort to develop these new tools and actionable advice.**

ADF&G & USFWS collaboration

with support by local fishers and communities.

Study Design

Pilot Station Sonar

1) Proposed site of a future annual *Ichthyophonus* monitoring location.
2) Fish arrive with infections
3) Severity of infections at this site MAY provide information about disease progression and mortality upriver.

Rapids

1) Located mid-river.
2) Infection reaches "max" before fish die.
3) Samples over the next 3 years are needed to understand disease progression "rate" upriver from Pilot Station.

Eagle

1) Measures infection in "survivors" to Eagle.
2) Samples over the next 3 years are needed to measure the "die-off" of infected fish between Rapids and Eagle.
3) Estimate a "lethal threshold".

Eagle Samples are Critical

Without Eagle samples all other samples will yield inconclusive results and fall short of providing actionable information.

River mile 123 —— 731 —— 1,224

1. Pilot Station Sonar

200 representative samples from sonar gillnet test fishery

2. Rapids

200 representative samples from fish wheel

3. Eagle

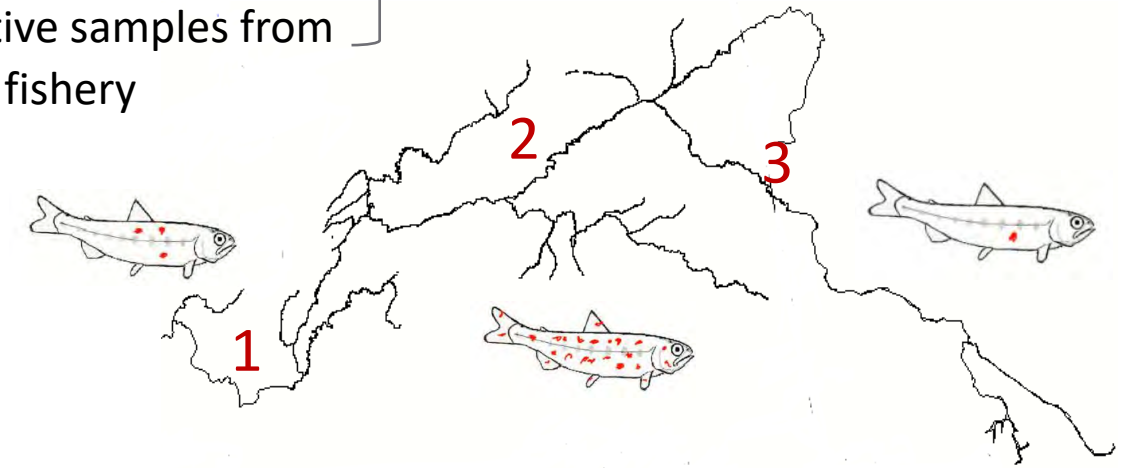
200 representative samples from sonar gillnet test fishery

Paired datasets will help define how fast the disease progresses before *en route* mortality is hypothesized to occur. Estimate new parameter called "ramp rate".

Paired datasets will help determine the disease severity level that is associated with *en route* mortality. Estimate new parameter called "lethal threshold"

The combination of "ramp rate" and "lethal threshold" will allow for estimating en route mortality in future years based only on samples collected from Pilot Station test fish mortalities

No additional mortality



Study Design

Fish Capture

Pilot and Eagle

Gillnet test fisheries (variable mesh sizes)

Rapids

Fishwheel

****Chinook salmon larger than 925 mm (36 in. or 3 ft.) were released alive.**

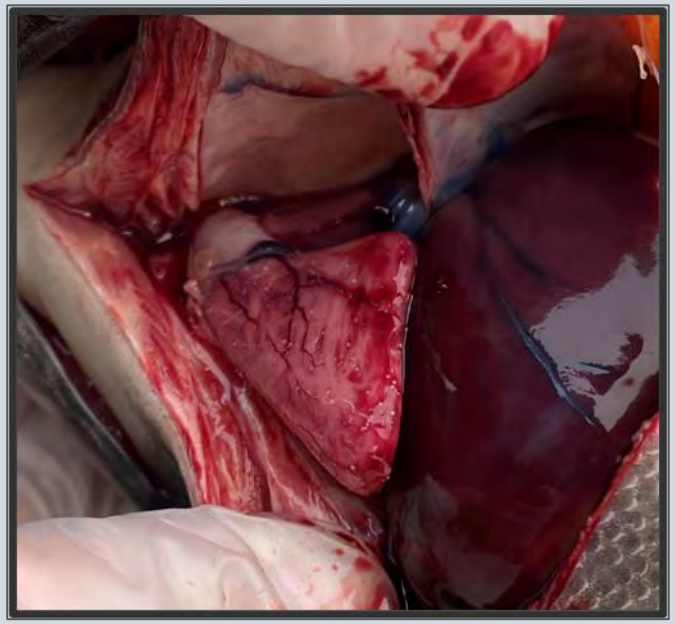
Age, sex, length, weight, girth, and genetic information was collected for all sampled fish

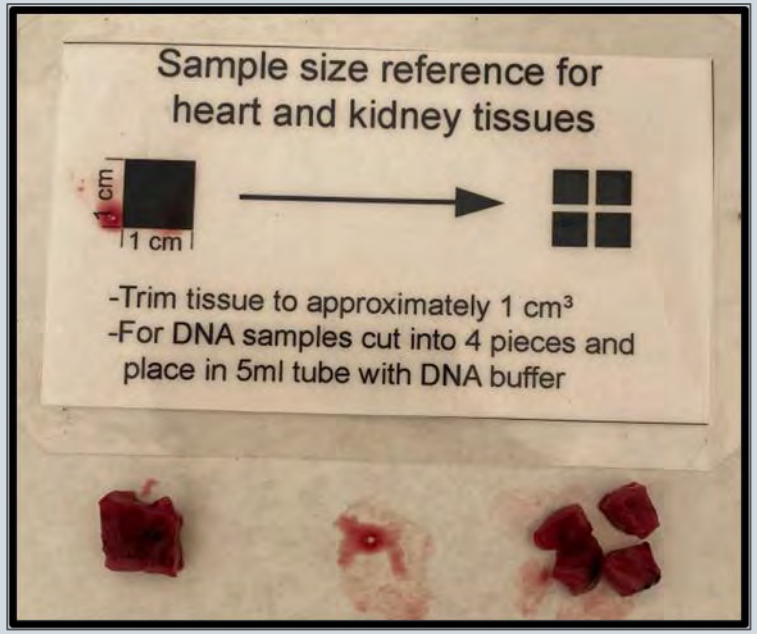
Sample preparation

Pilot and Eagle

Rapids

Ichthyophonus sampling





Heart is located, removed, and placed on a sterile surface. A 1 cm^3 pieces were cut using a razor blade. Samples were cut into smaller pieces and preserved for laboratory analysis.

Extensive multi-agency effort to coordinate sampling to learn as much as possible from each fish

1 Muscle biopsy to evaluate for heat stress and investigate non-lethal methods to index *Ichthyophonus* disease.

Not shown – blood was taken from Pilot Station samples to evaluate non-lethal methods to index cardiac stress.

2 Otoliths provided to Canadian First Nations researcher to evaluate life history.

3 Eggs to evaluate Thiamine, which is essential for egg and fry survival. Eggs were also used to update fecundity datasets to evaluate quality of escapement.

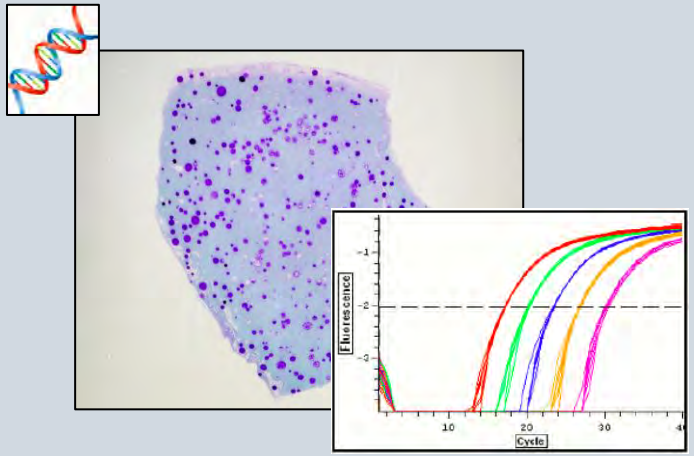
Not shown – Kidney samples were taken to test for proliferative kidney disease which is an emerging fish disease in Alaska salmon.

Sampled fish were donated for customary and traditional subsistence uses

- Pilot Station samples were distributed locally
- Rapids samples were donated to communities of Rampart and Tanana.
- Eagle Chinook were distributed equally to Canada (50%) and Eagle Tribe and City of Eagle.

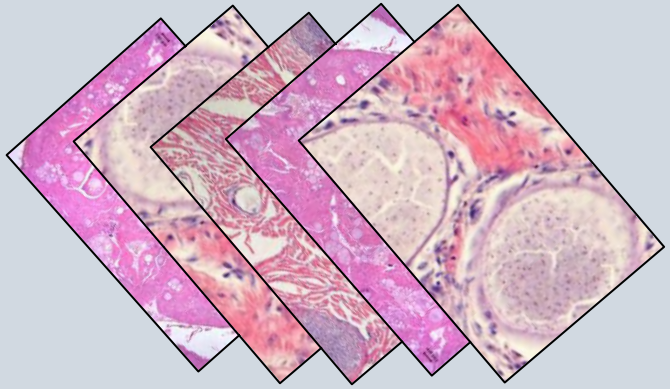
Laboratory Methods

qPCR



Number of gene copies used as an index of disease severity. Fast method for screening for disease prevalence and quantifying infection.

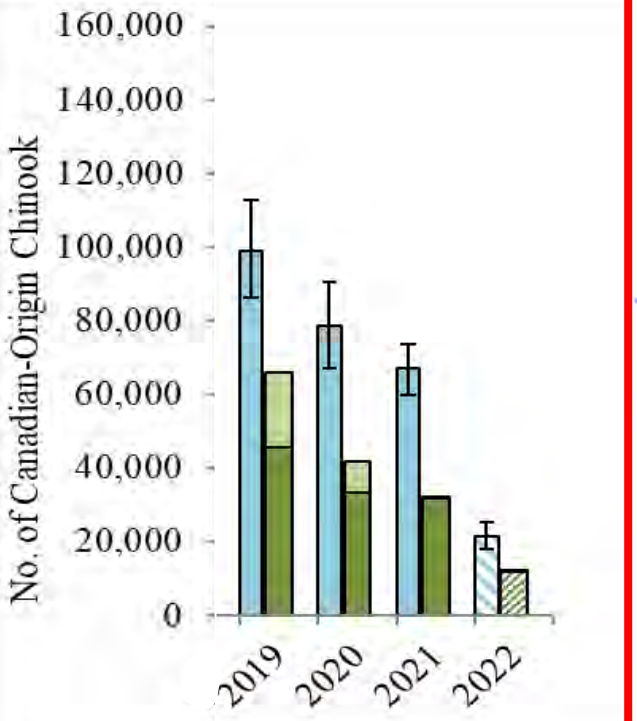
Histology

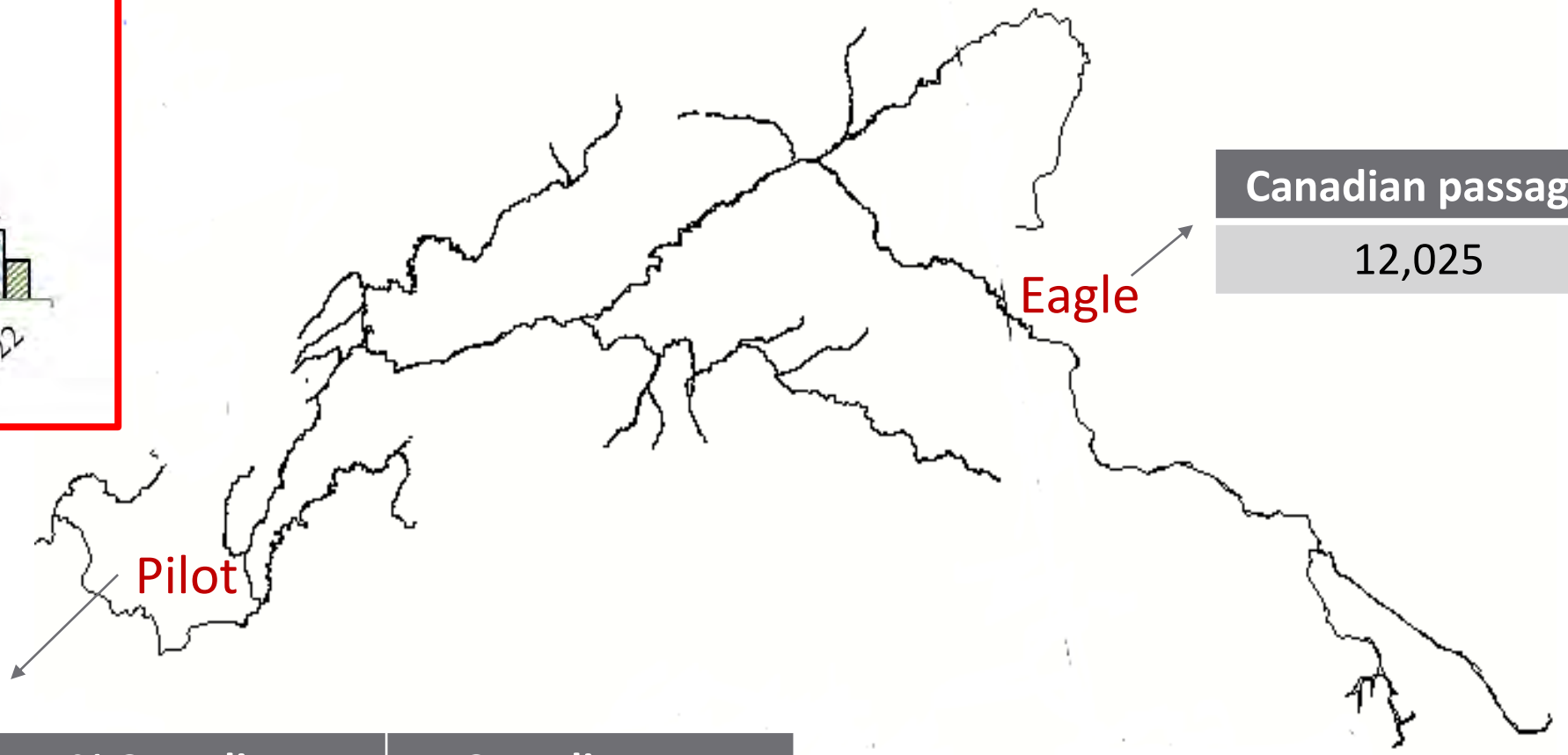


Number of schizonts per volume of tissue used as a measure of disease severity. Labor intensive, but considered the “gold standard”.

What was learned from the 2022 sampling?

Fourth Consecutive Year of "Difference Between Estimates"

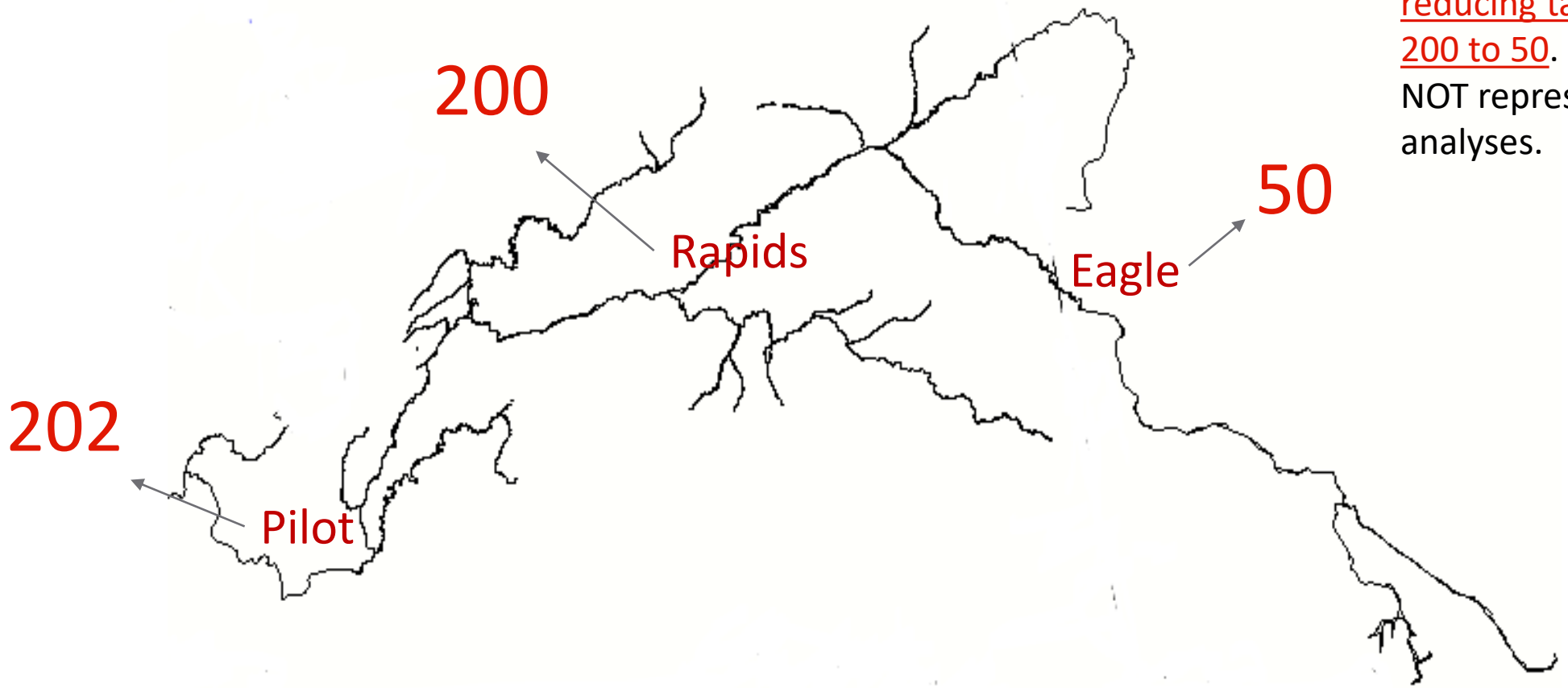




Canadian passage
12,025

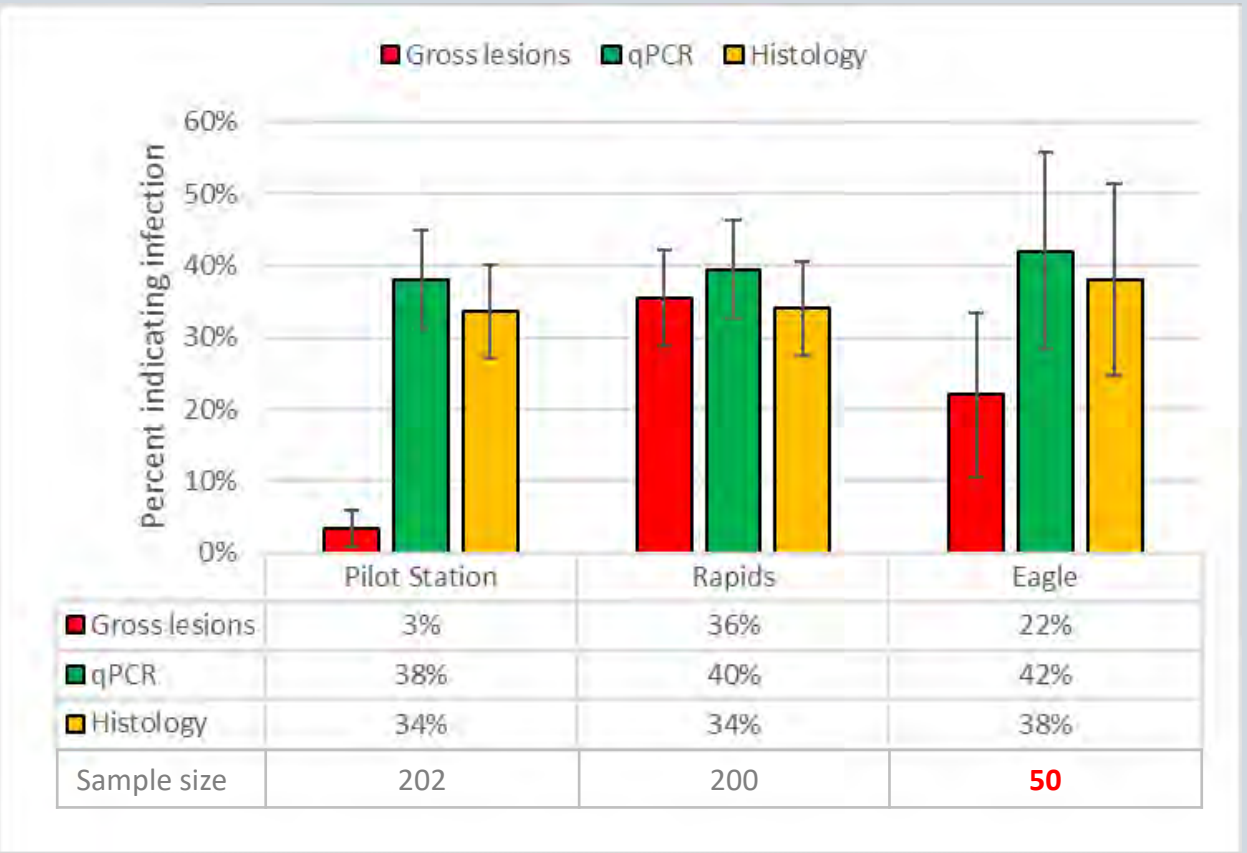
All Stocks	% Canadian	Canadian run
48,439	45%	21,648 ± 5,000

Sample Sizes Achieved



Requests from Canada DFO to discontinue sampling resulted in reducing target sample size from 200 to 50. Achieved samples are NOT representative and limit analyses.

River mile 123 — 731 — 1,224



	Pilot Station	Rapids	Eagle
Gross lesions	3%	36%	22%
qPCR	38%	40%	42%
Histology	34%	34%	38%
Sample size	202	200	**50**

Percentages of Chinook salmon with Ichthyophonus infections

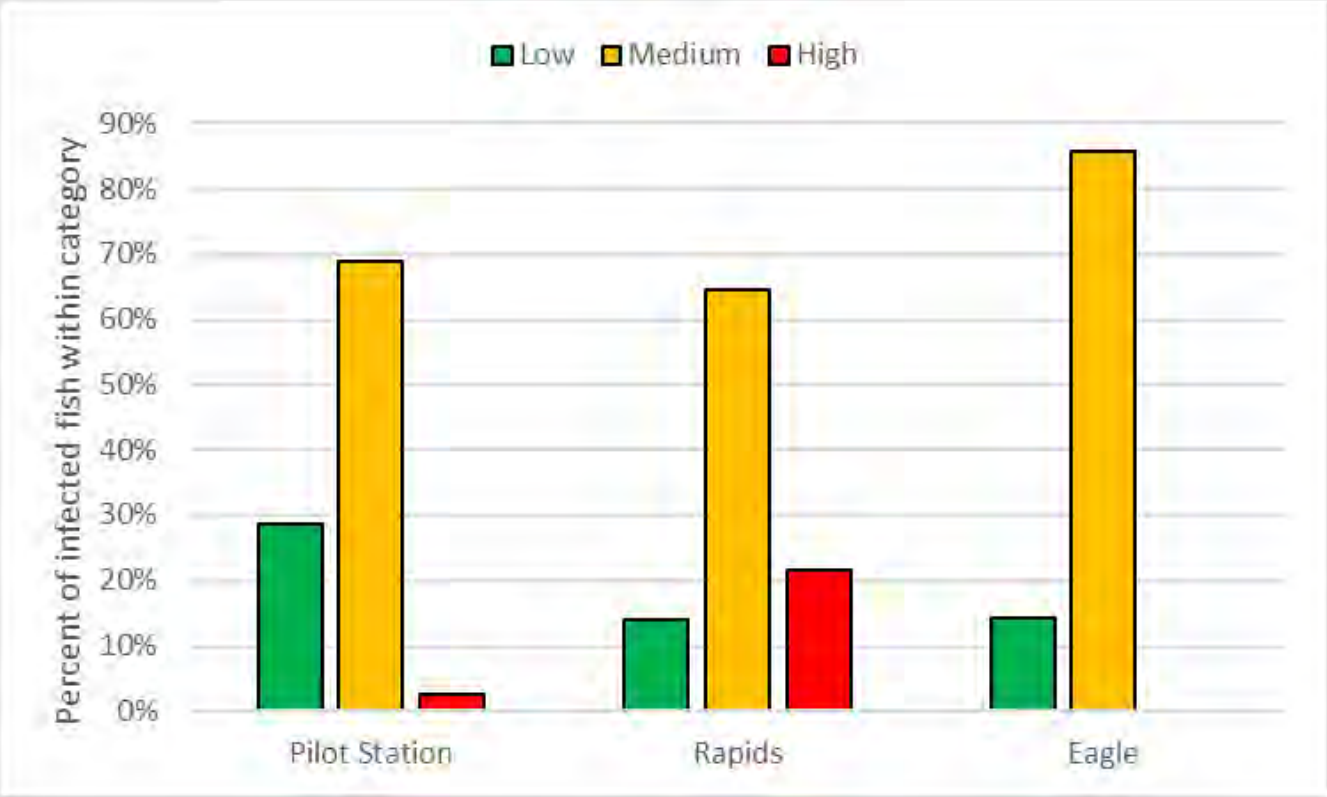
Preliminary Conclusions

- Gross lesions are highly accurate at indicating infection at Rapids but underrepresents infection at lower and upriver locations

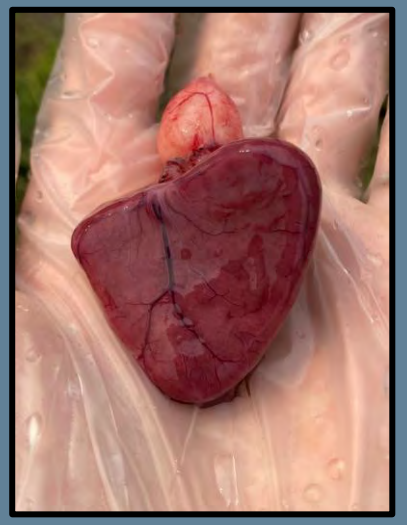
- qPCR and Histology provided similar results, but qPCR appears slightly more sensitive for detecting lightly infected individuals.

Preliminary Conclusions

- Average density of infection (i.e., severity) increased significantly between Pilot Station and Rapids, and there was insufficient power to detect a change between Rapids and Eagle.
- The percentage of heavily infected fish increased significantly between Pilot Station and Rapids, and no heavily infected fish were detected at Eagle.



Percentage of infected fish by qPCR severity category



Vs.

No visible infection

Visible infection

General Impressions based on preliminary findings

- Ichthyophonus infection and disease impacted the 2022 run of Yukon River Chinook salmon.
- Prevalence of infection is one of the highest recorded for Yukon River Chinook salmon.
- Disease progression followed expected patterns between Pilot Station and Rampart.
- Inseason changes to sample sizes at Eagle did impact our ability to draw meaningful conclusions about en route mortality of Canadian-origin Chinook salmon.
- It is premature to conclude that the observed “difference between estimates” in 2022 was caused by Ichthyophonus-associated en route mortality, but it remains a leading hypothesis.

Plans Moving Forward

Additional analysis of 2022 data

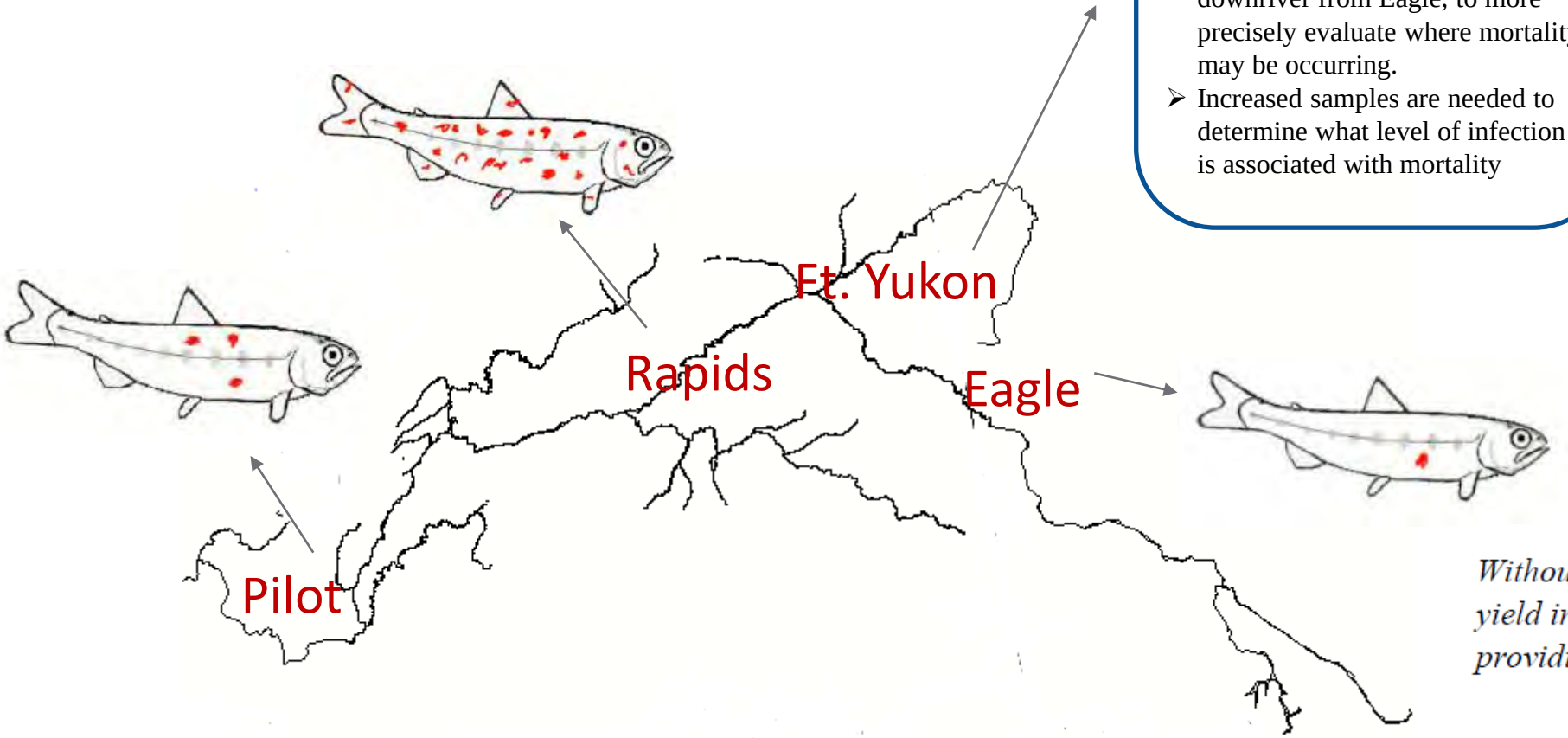
- Genetic analysis to assign individual samples to stock of origin and conduct stock-specific analyses.
- Engagement with biometric and disease pathology modeling partners to develop framework for estimating parameters required to estimate disease-associated mortality.
- Reporting results through a range of publication and **community outreach** venues.

Revisions to Study Design

NEW Fort Yukon

Hope to add a new sampling location between Rapids and Eagle to:

- Increase the statistical rigor of our study design.
- This proposed site is far enough up river from Rapids, yet downriver from Eagle, to more precisely evaluate where mortality may be occurring.
- Increased samples are needed to determine what level of infection is associated with mortality



Eagle Samples are Critical

Without Eagle samples all other samples will yield inconclusive results and fall short of providing actionable information.

Secure funding for project years 2023 and 2024

Alaska Department of Fish and Game

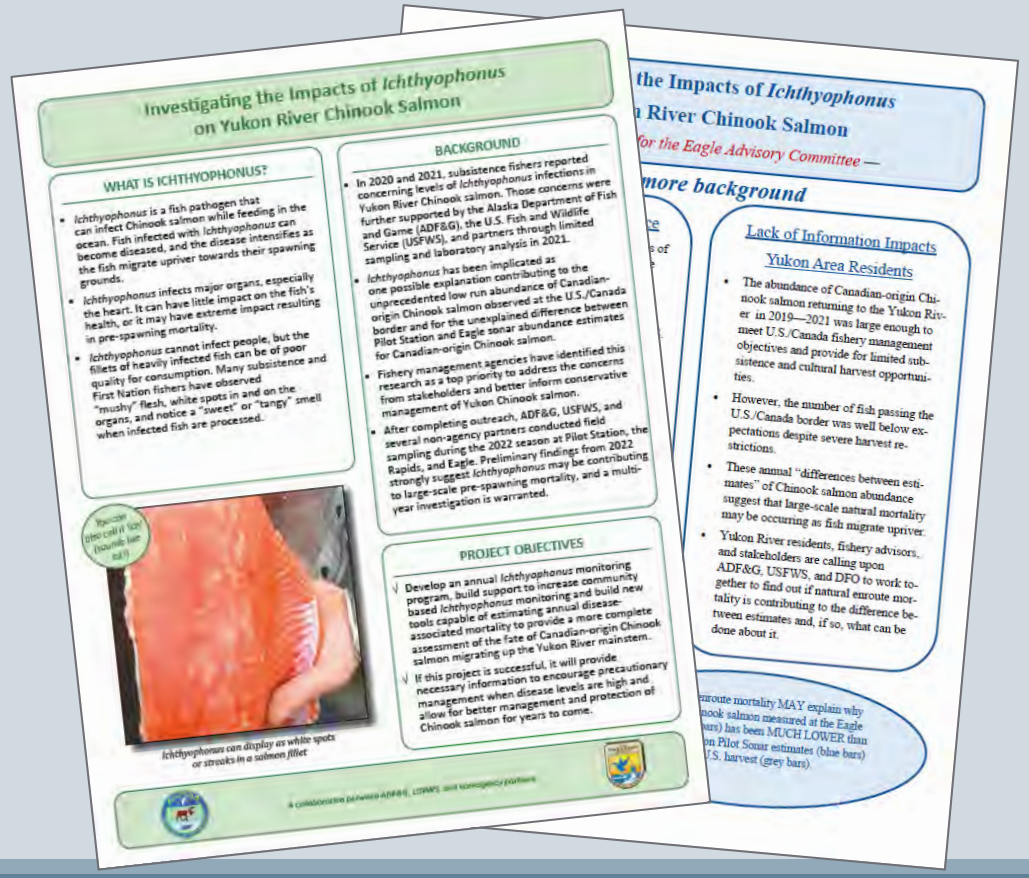
Alaska Sustainable Salmon Fund
Calls for Proposals

2022 Yukon River Salmon Research and Management Assistance – US

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

Community outreach

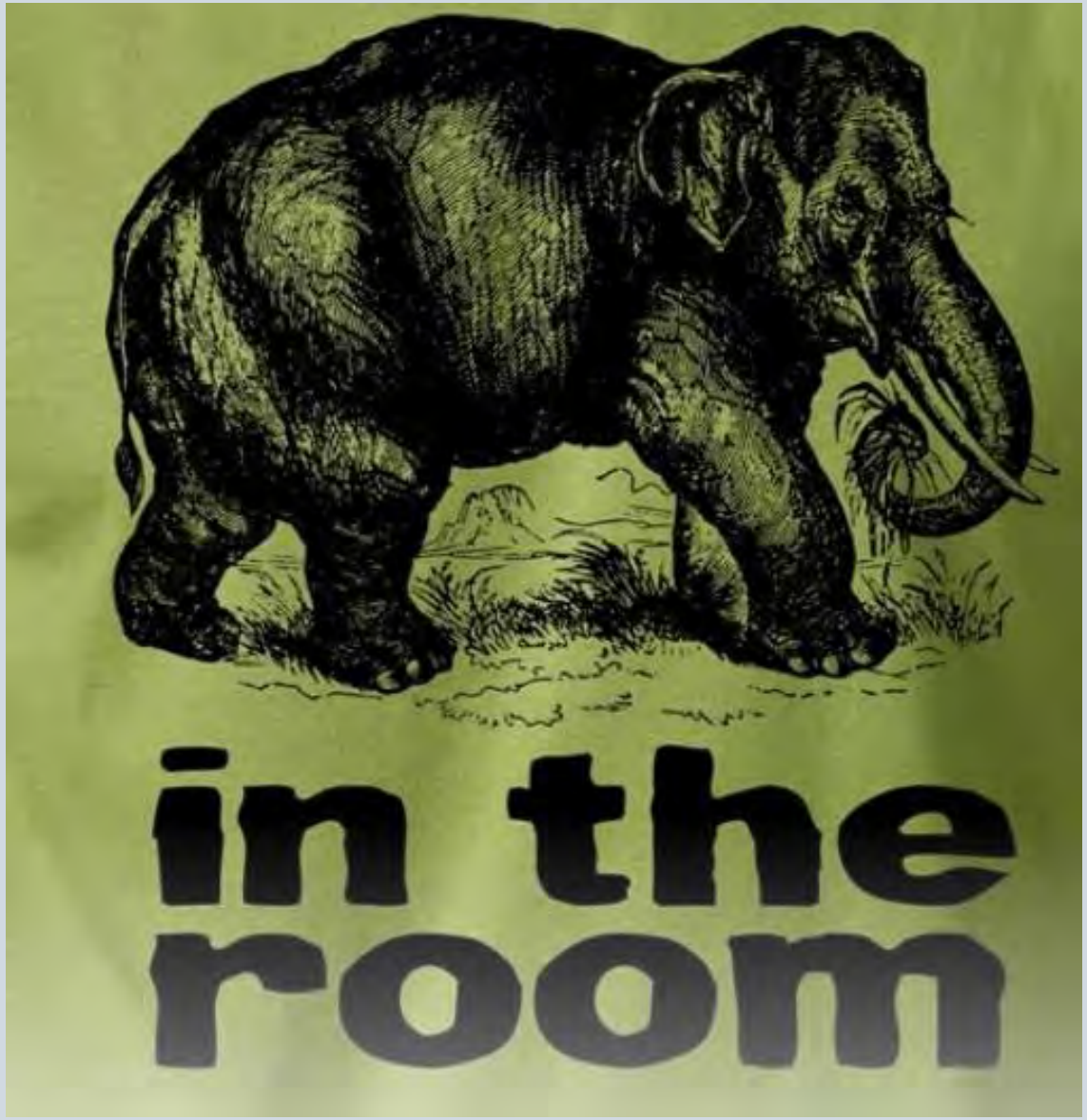
Informational Flyers



Meeting Presentations

- SOA Advisory Committees
- Federal Regional Advisory Committees
- Yukon River Panel, Joint Tech Committee
- Yukon River Panel
- Alaska Board of Fisheries
- YRDFA
- Other venues upon request..

Closing Thought



We acknowledge there is a broad range of support for this work

- Lethal sampling when run sizes are at record low levels and fisheries are closed is unpopular and often controversial.
- The decision to undertake this study was made thoughtfully and intentionally.
- We believe this project is vital so we can quantify the biological impact of this disease and provide responsible and actionable advice to fishery managers.
- Conservation of the Yukon River Chinook salmon resource and your fisheries is our highest priority.

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Project leaders

ADF&G:

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- Fred West
- Zachary Liller

USFWS:

- Holly Carroll
- Keith Ivy
- Scott Walter

Project partners

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- Eagle Tribe

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Contact us if you have any comments or questions!

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Questions

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