Towards an understanding of population structure and adaptation by invasive northern pike

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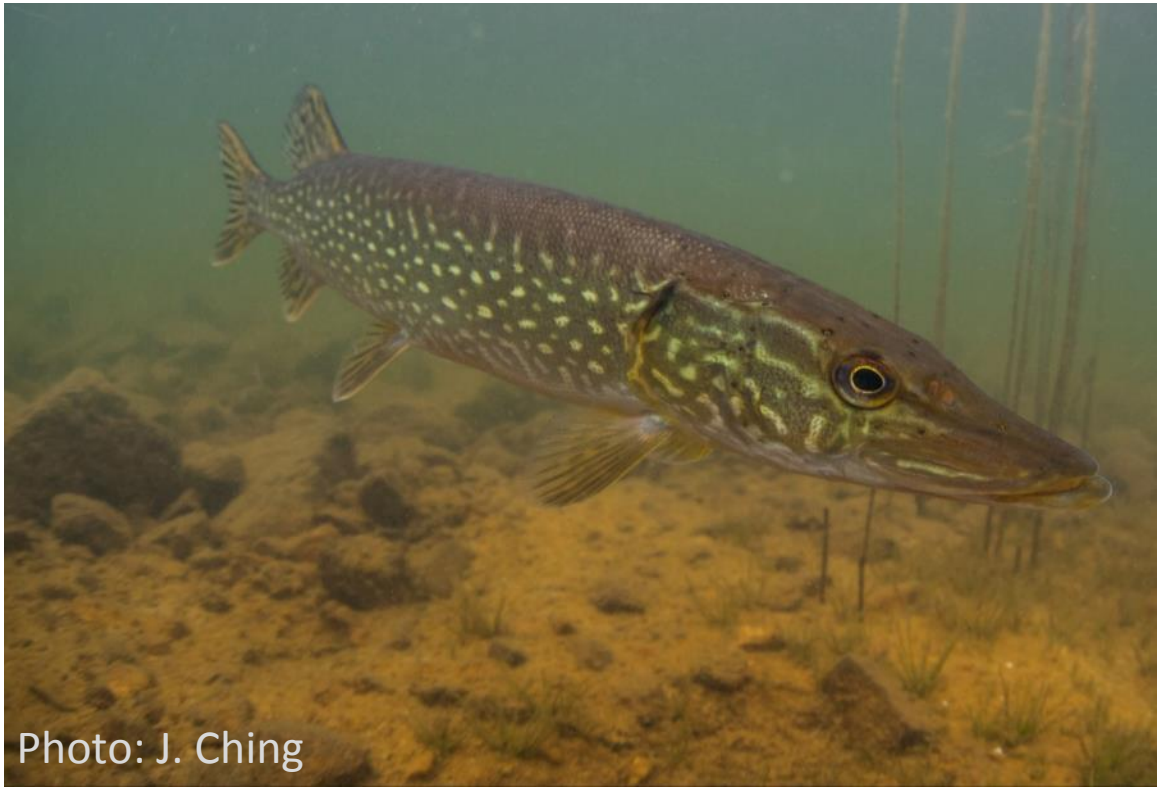
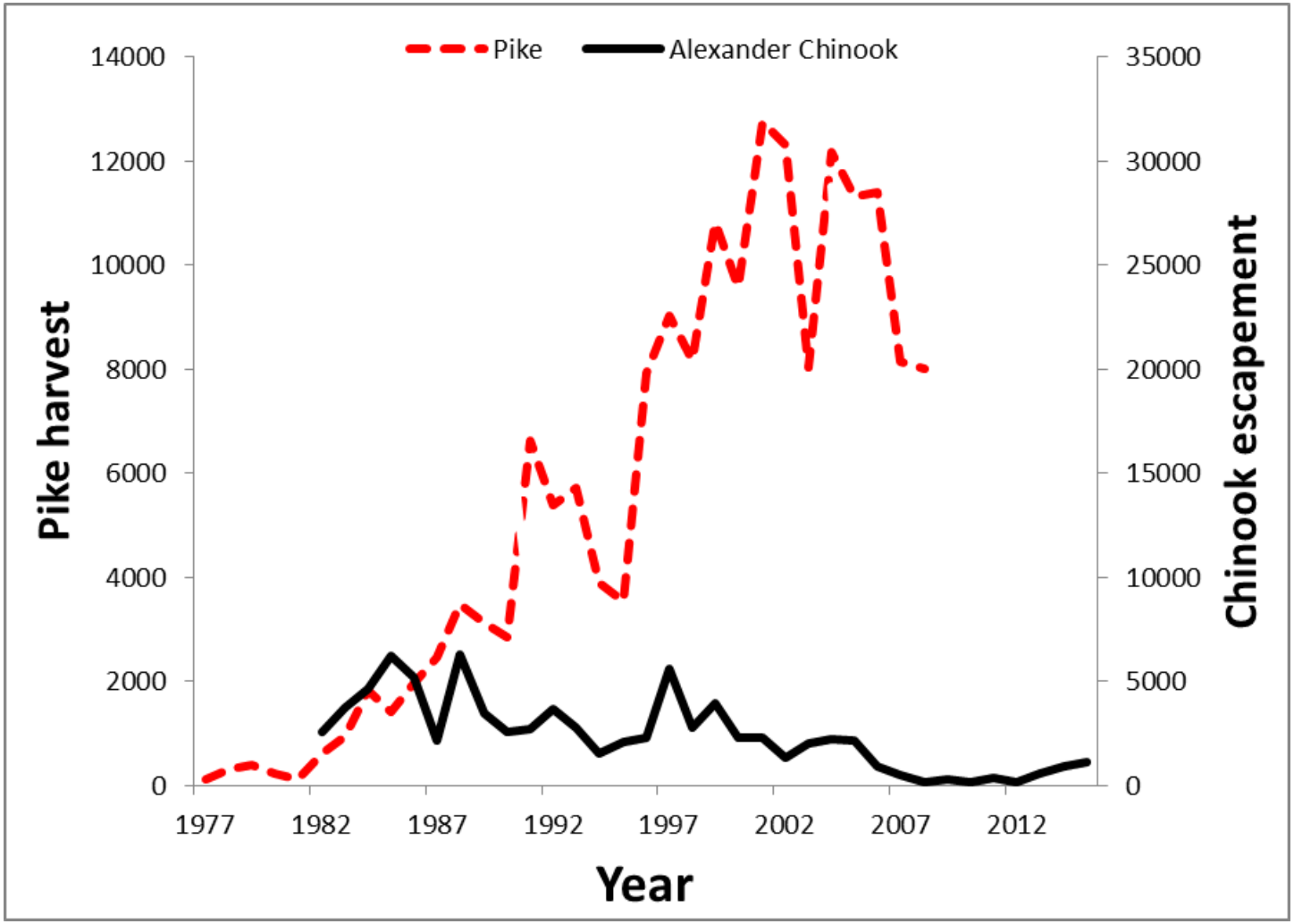
Alaska at the front lines of invasions



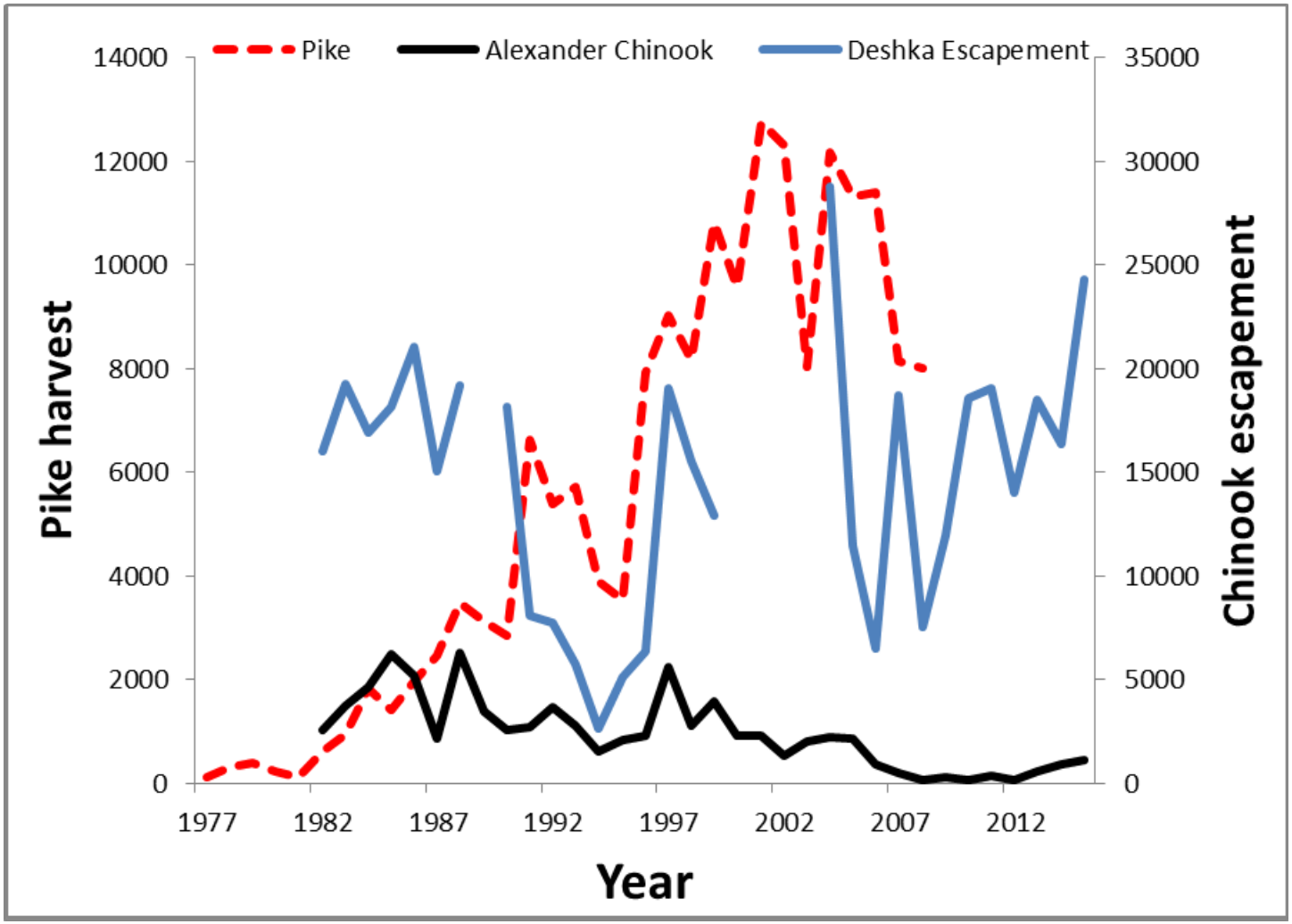
Northern pike have impacted some Chinook salmon populations



Data from Oslund & Ivey 2010; Munro & Volk 2016

Northern pike have impacted some Chinook salmon populations

No obvious impact of northern pike in the Deshka River



Data from Oslund & Ivey 2010; Munro & Volk 2016

An invasion paradox

Northern pike and salmon appear to coexist in Bristol Bay and many interior watersheds (e.g. Chena River), and in at least some watersheds in Southcentral, Alaska

(Google images)

The overarching question

What set of factors determine coexistence or competitive exclusion between salmonids and northern pike?


Photo: J. Armstrong


Photo: M. Bond

A lack of understanding of northern pike in the *native* range, impedes our ability to predict impacts in the *invasive* range

Photo: M. Bond

Towards a better understanding

A whirlwind look at three projects:

1. Population structure and adaptive potential
2. Distribution using eDNA
3. Trophic ecology through diet comparisons

Sampling northern pike from Lake Nerka in Bristol Bay, 2016

Population structure and adaptive potential

Objectives:

1. Quantify genetic diversity of invasive populations and place it within the context of the natural diversity of the species

2. Correlate genetic (and potentially phenotypic) diversity with landscape-level environmental features

3. Provide evidence of source population(s) of invasive range: single or multiple sources? Size of founding populations(s)

Kristine Dunker, ADF&G

Jeff Falke, USGS, AKCFWRU, UAF

Andres Lopez, UAF

Adam Sepulveda, NOROCK, USGS

Chase Jalbert, MS student, AKCFWRU, UAF

SOUTHCENTRAL Alaska Science Catalog

Alaska EPSCoR Experimental Program to Stimulate Competitive Research

USGS science for a changing world

Alaska Department of Fish and Game

UAF University of Alaska Fairbanks

Five populations currently being sequenced

http://browse.alaskamapped.org/orthos

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ALASKA DEPARTMENT OF FISH AND GAME

UAF
UNIVERSITY OF ALASKA FAIRBANKS

Quantifying northern pike distribution using eDNA

Objectives:

1. Confirm presence or absence of northern pike in vulnerable west Cook Inlet watersheds

Adam Sepulveda, NOROCK, USGS

Andres Lopez, UAF

Andy Wizik, CIAA

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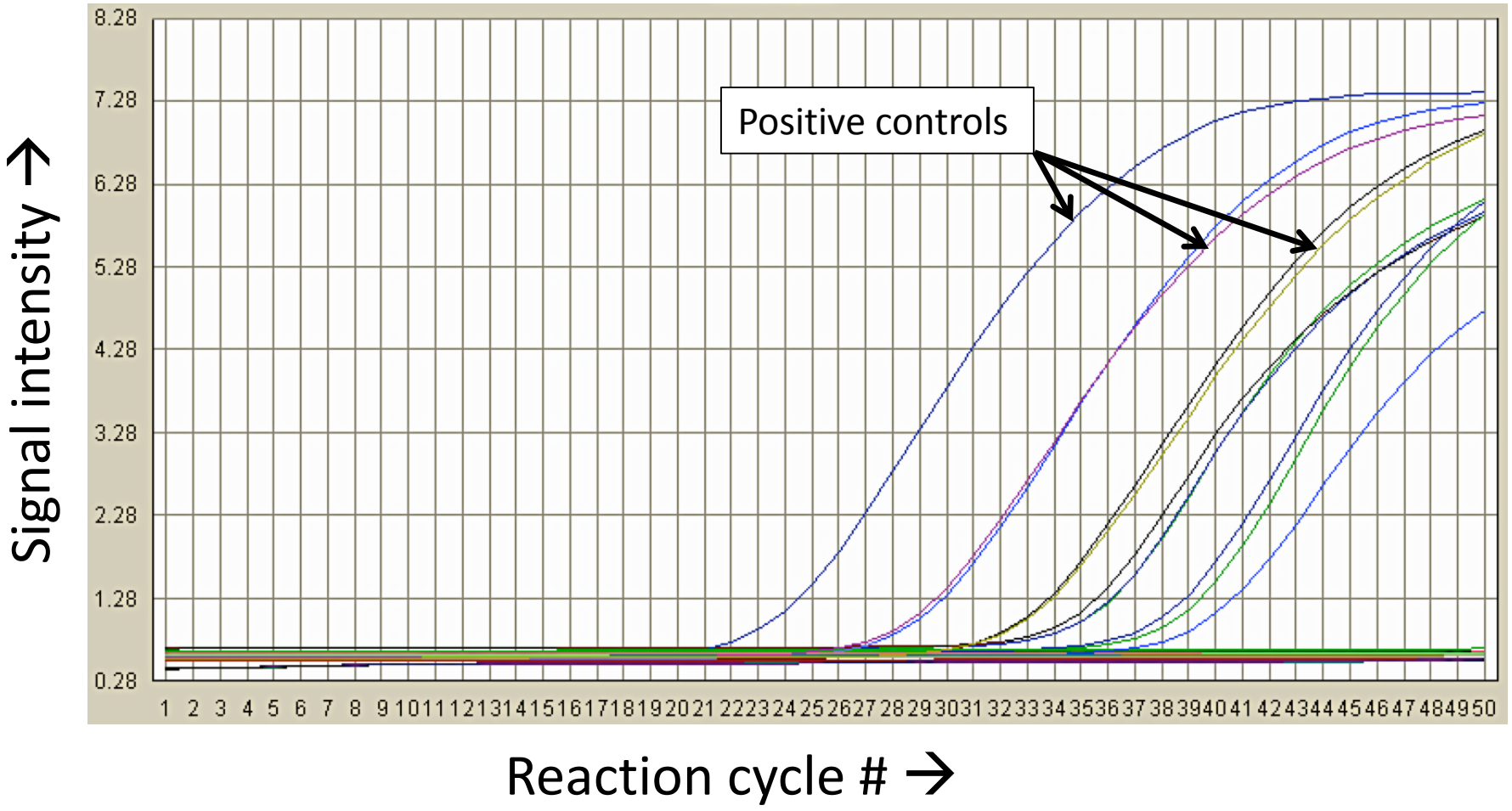
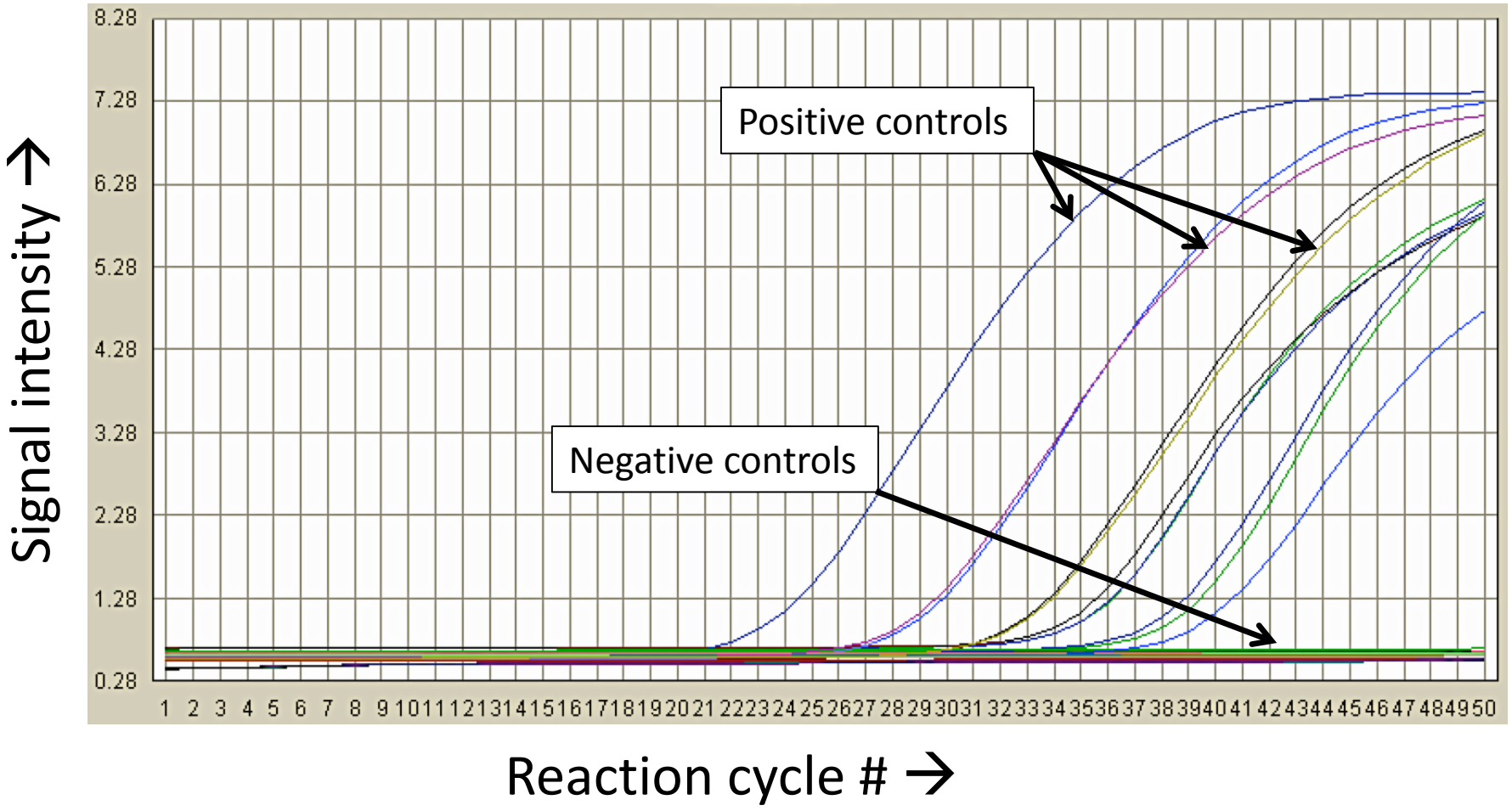
Cook Inlet Aquaculture Association

UAF University of Alaska Fairbanks

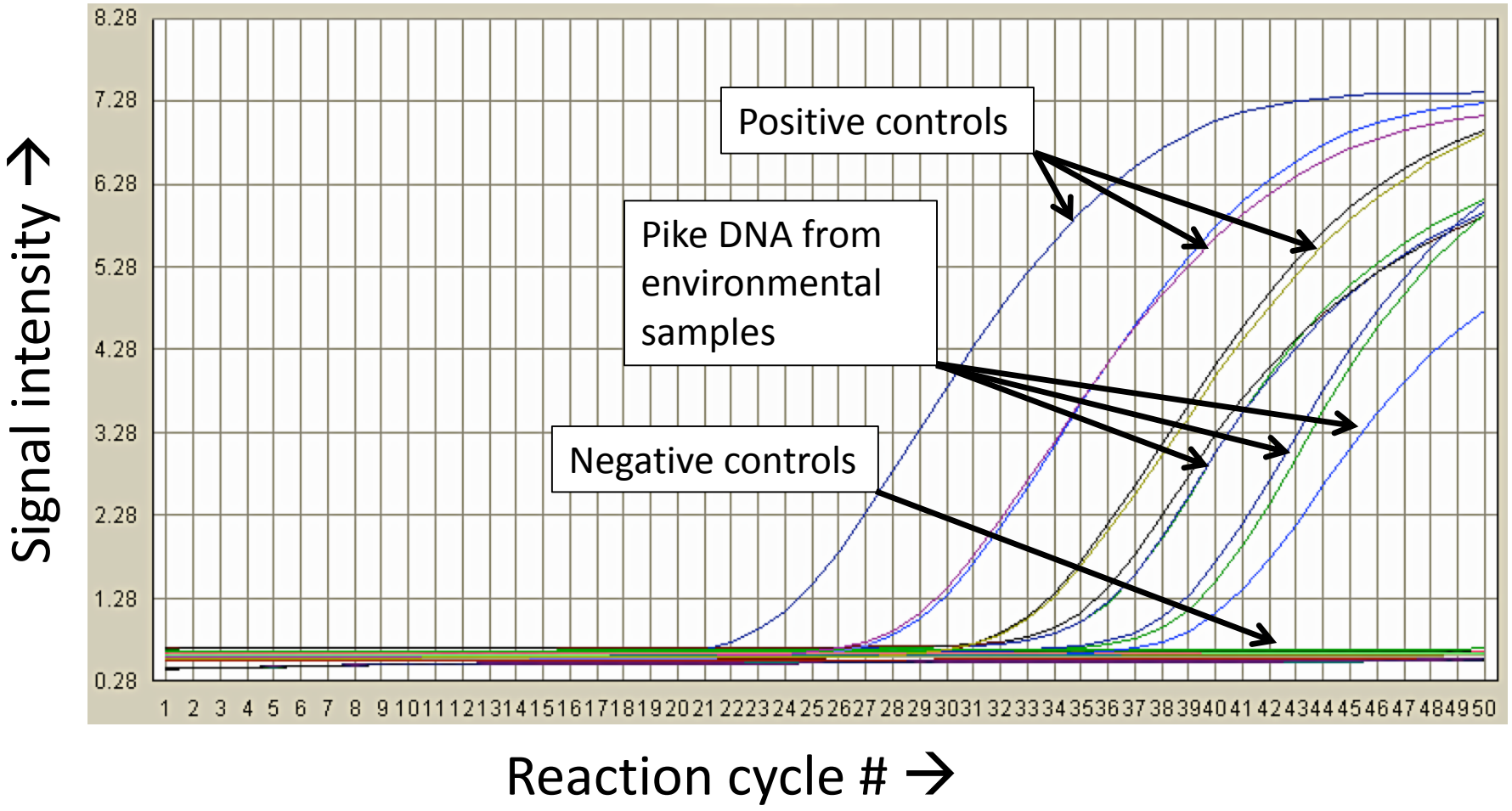
eDNA detection



eDNA detection



eDNA detection



Results suggest northern pike in Chuit Lake and Nikolai Creek

http://akssf.org/default.aspx?id=2461

Results suggest northern pike

Conservation Genet Resour (2015) 7:615–617
DOI 10.1007/s12686-015-0459-x

TECHNICAL NOTE

An evaluation of target specificity and sensitivity of three qPCR assays for detecting environmental DNA from Northern Pike (*Esox lucius*)

Jeffrey B. Olsen · Cara J. Lewis · Robert L. Massengill · Kristine J. Dunker · John K. Wenburg

Received: 16 May 2014 / Accepted: 26 February 2015 / Published online: 21 March 2015

Abstract We developed and evaluated three qPCR assays for detecting environmental DNA from northern pike (*Esox lucius*). The assays target the cytochrome oxidase 1 (EluCOI), control region (EluCR), and cytochrome b (EluCytB) genes of the mitochondrial DNA. Target specificity, assessed using the fluorescence signal (at 45 cycles) to noise (at 1 cycle) ratio (S/N), showed strong amplification in northern pike (mean S/N = 2.62, 3.52, 2.69 for EluCOI, EluCR, EluCytB). The mean S/N estimates from fifteen non-esocid freshwater fishes were about 1.0, as expected for no amplification. EluCR showed evidence of amplification (mean S/N = 3.16) in muskellunge (*Esox masquinongy*). The sensitivity tests indicated EluCOI has a higher detection probability than EluCR and EluCytB at low (20 copies/reaction) copy number. The results favor using EluCOI although EluCytB and EluCR are viable assays for the detection of northern pike eDNA.

Keywords Northern Pike · *Esox lucius* · Invasive species · eDNA

Northern pike (*Esox lucius*) are a popular freshwater sport fish that has been introduced outside of its native range in the conterminous United States and Alaska (Fuller 2014). In many areas, including southcentral Alaska, non-native northern pike are now a conservation concern given the potential of this apex predator to negatively impact native fish species like salmon and trout (McMahon and Bennett 1996; Sepulveda et al. 2013). The potential for northern pike to cause severe declines in native fish populations has led some management agencies to mount costly species monitoring and control programs (e.g., Massengill 2011).

One of the challenges of monitoring and controlling invasive fish species is that of identifying their presence. Traditional methods such as gillnetting have a number of drawbacks including requiring tremendous allocations of time and effort, possibly impacting non-target species and having questionable effectiveness when fish abundance is low. Therefore, there is interest in the application of environmental DNA (eDNA) analysis to support programs aimed at monitoring and controlling aquatic invasive species (Jerde et al. 2013).

In this study we developed and tested target specificity and sensitivity of three quantitative PCR (qPCR) assays to detect eDNA of invasive northern pike in southcentral Alaska. The assays target 94 base pairs (bp) of the cytochrome oxidase 1 (EluCOI), 64 bp of the control region (EluCR), and 98 bp of the cytochrome b (EluCytB) genes of the mitochondrial DNA. The sequence data was obtained online from the Barcode of Life website (EluCOI) and GeneBank (EluCR, EluCytB). The EluCOI and EluCR assays were designed from 650 base pair and 451 base pair sequences, respectively, using Primer Express software version 3.0.1 (Applied Biosystems Inc). We used Primer Express to modify the EluCytB primers and probe designed by Mike Garvin (pers com.) in order to meet optimum PCR conditions for TaqMan assays (Applied Biosystems Inc). The primer and probe sequences are: EluCOI, F-5′CCTT CCCCCGCATAAATAATATAA3′, R-5′GTGTTGAAGC TGGTGCTGGTAC3′, P-5′CTTCTGACTTCTCCCC3′; EluCR, F-5′AGAACCGACCAACGATTCCA3′, R-5′AT

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PLOS ONE

RESEARCH ARTICLE

Potential of Environmental DNA to Evaluate Northern Pike (*Esox lucius*) Eradication Efforts: An Experimental Test and Case Study

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Abstract

Determining the success of invasive species eradication efforts is challenging because populations at very low abundance are difficult to detect. Environmental DNA (eDNA) sampling has recently emerged as a powerful tool for detecting rare aquatic animals; however, detectable fragments of DNA can persist over time despite absence of the targeted taxa and can therefore complicate eDNA sampling after an eradication event. This complication is a large concern for fish eradication efforts in lakes since killed fish can sink to the bottom and slowly decay. DNA released from these carcasses may remain detectable for long periods. Here, we evaluated the efficacy of eDNA sampling to detect invasive Northern pike (*Esox lucius*) following piscicide eradication efforts in southcentral Alaskan lakes. We used field observations and experiments to test the sensitivity of our Northern pike eDNA assay and to evaluate the persistence of detectable DNA emitted from Northern pike carcasses. We then used eDNA sampling and traditional sampling (i.e., gillnets) to test for presence of Northern pike in four lakes subjected to a piscicide-treatment designed to eradicate this species. We found that our assay could detect an abundant, free-roaming population of Northern pike and could also detect low-densities of Northern pike held in cages. For these caged Northern pike, probability of detection decreased with distance from the cage. We then stocked three lakes with Northern pike carcasses and collected eDNA samples 7, 35 and 70 days post-stocking. We detected DNA at 7 and 35 days, but not at 70 days. Finally, we collected eDNA samples ~ 230 days after four lakes were subjected to piscicide-treatments and detected Northern pike DNA in 3 of 179 samples, with a single detection at each of three lakes, though we did not catch any Northern pike in gillnets. Taken together, we found that eDNA can help to inform eradication efforts if used in conjunction with multiple lines of inquiry and sampling is delayed long enough to allow full degradation of DNA in the water.

Citation: Dunker KJ, Sepulveda AJ, Massengill RL, Olsen JB, Russ OL, Wenburg JK, et al. (2016) Potential of Environmental DNA to Evaluate Northern Pike (*Esox lucius*) Eradication Efforts: An Experimental Test and Case Study. PLoS ONE 11(9): e0162277. doi:10.1371/journal.pone.0162277

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Competing Interests: The authors have declared that no competing interests exist.

Trophic ecology of northern pike

Objectives:

1. Quantify diet variation within and among locations (native and invasive range)

2. Quantify the occurrence and importance of salmonids in northern pike diets

Adam Sepulveda, NOROCK, USGS

Frank von Hippel, Northern Arizona University

Nate Cathcart, research scientist, UAF

Stormy Haught, ADF&G

Tom Quinn, SAFS, UW

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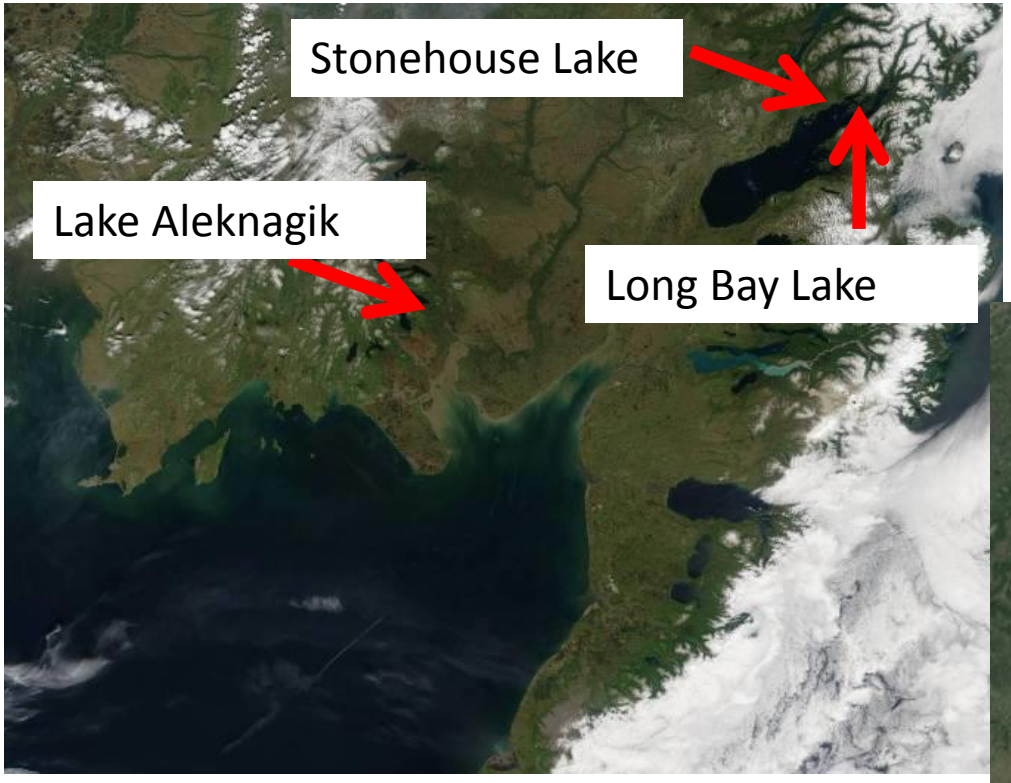
Diet comparisons

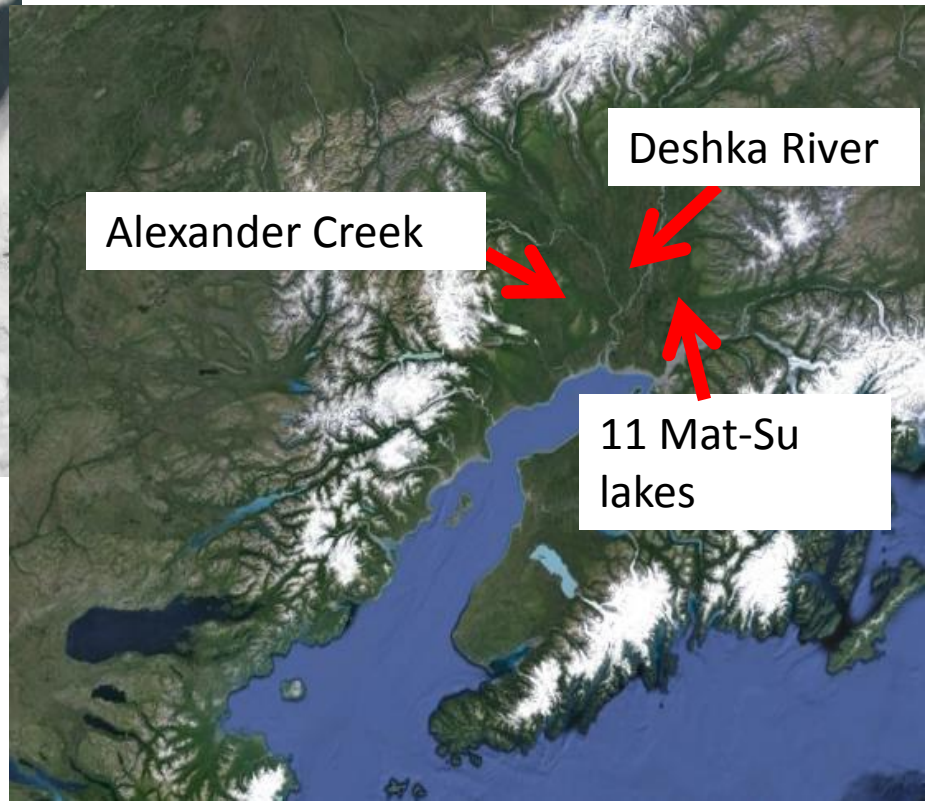
Bristol Bay (Native range)



T. Quinn (*yet* unpublished diet data)
2006-2008

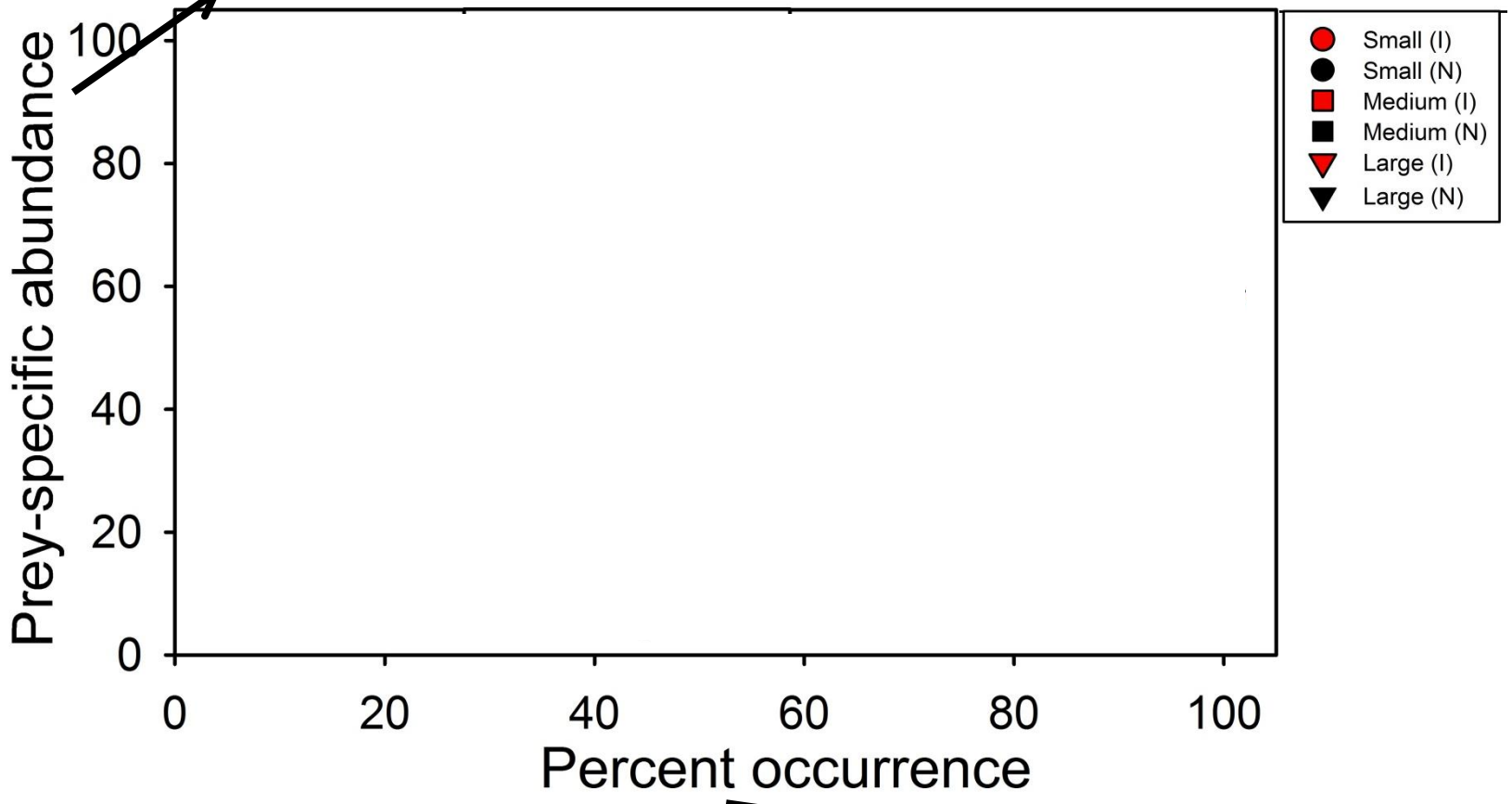
Mat-Su watersheds (invaded range)

Data from Sepulveda et al. (2013,2014) and Haught and von Hippel 2011



Visualizing northern pike diets

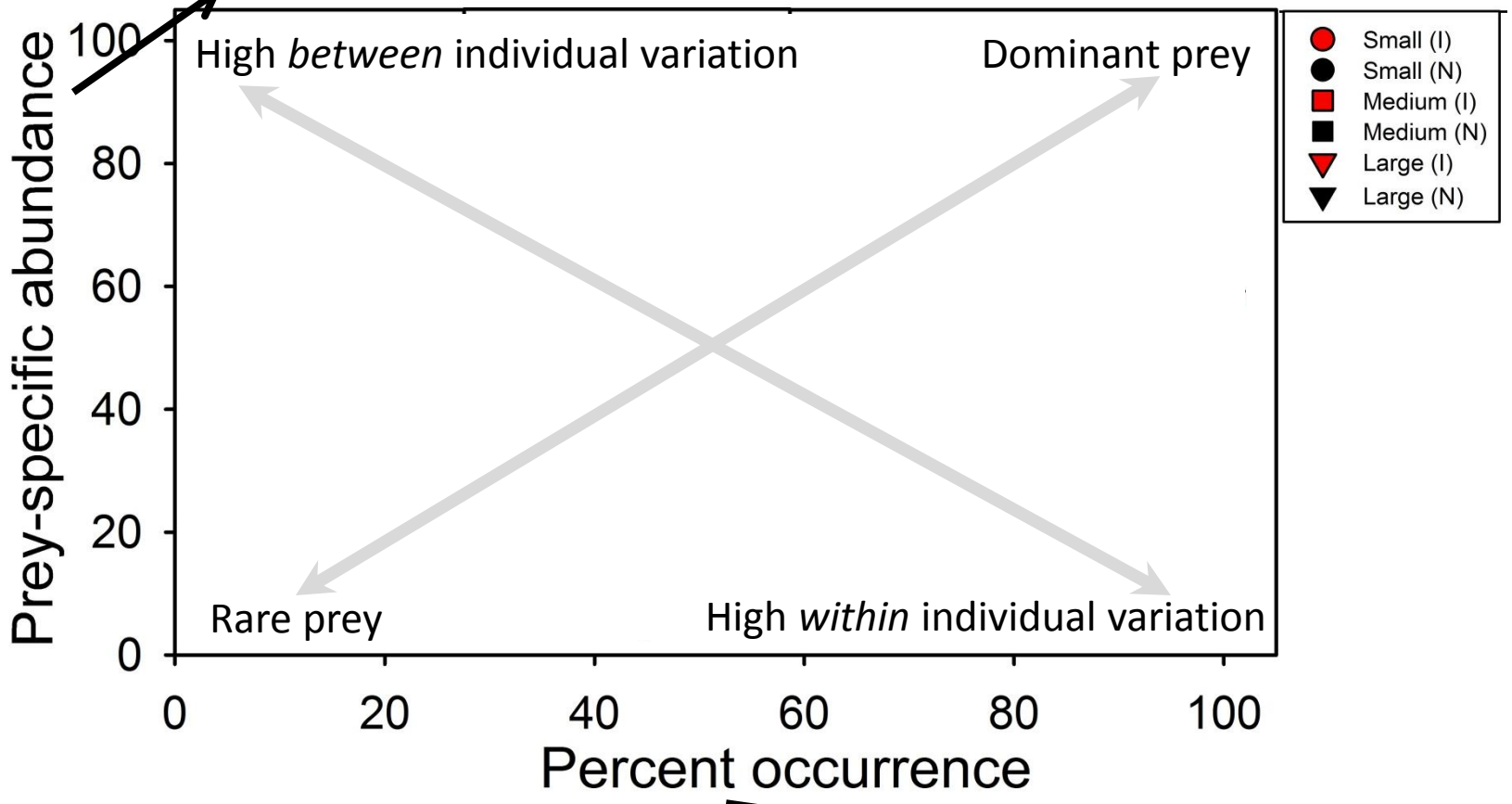
Proportion salmonids constitute in total diet of predators that consume salmonids



fish with salmonids in diet/
fish with food in their stomachs

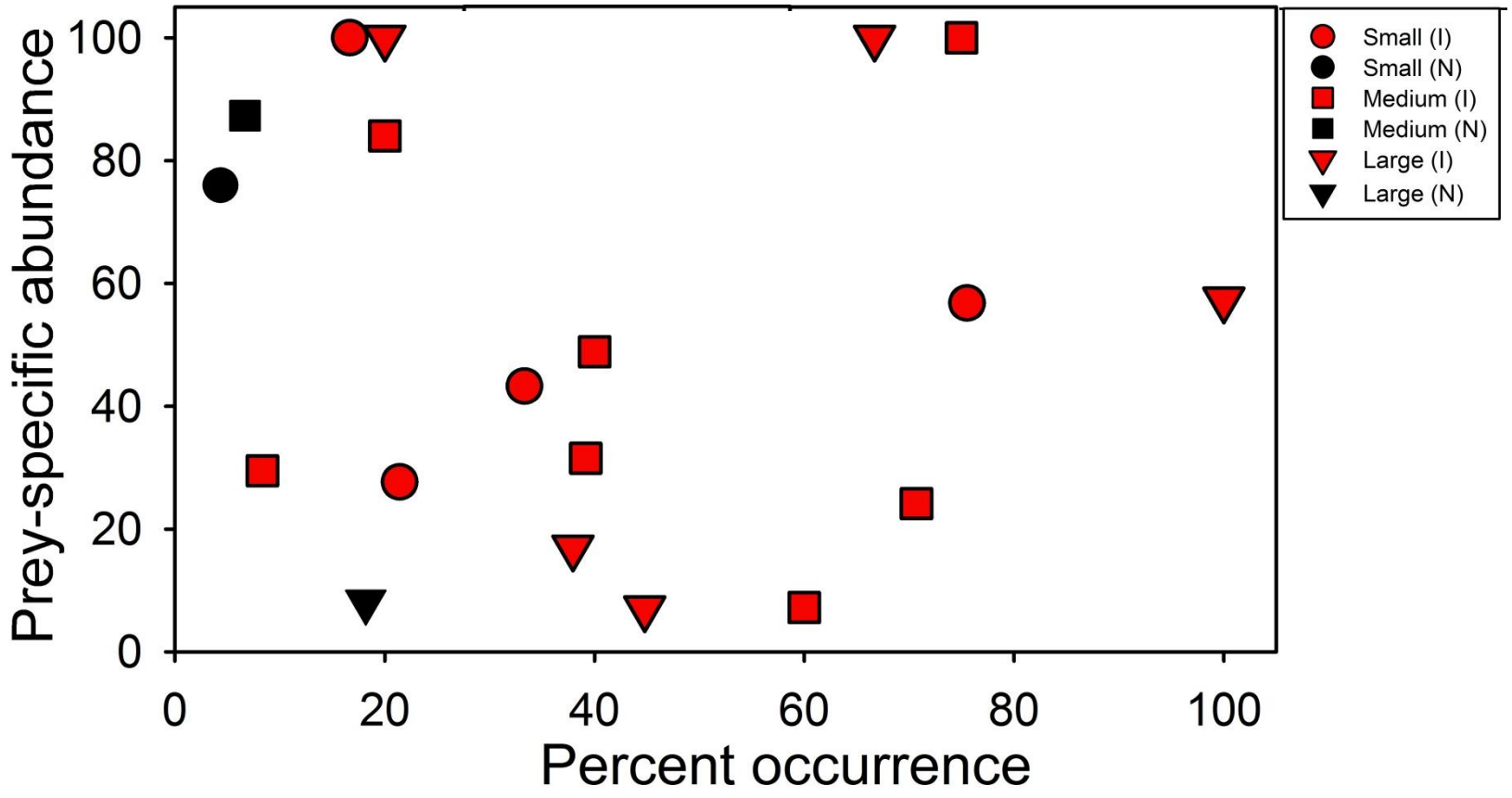
Visualizing northern pike diets

Proportion salmonids constitute in total diet of predators that consume salmonids



fish with salmonids in diet/
fish with food in their stomachs

More salmonids on menu in the invasive range than native range



More salmonids on menu in the invasive range than native range

More to come…

A lack of understanding of northern pike in the *native* range, impedes our ability to predict impacts in the *invasive* range

Photo: M. Bond

Coexistence or extinction?

Acknowledgements

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Kasaan Brandel
Eric Hollerback
Don Reeves
Matt Wamke

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