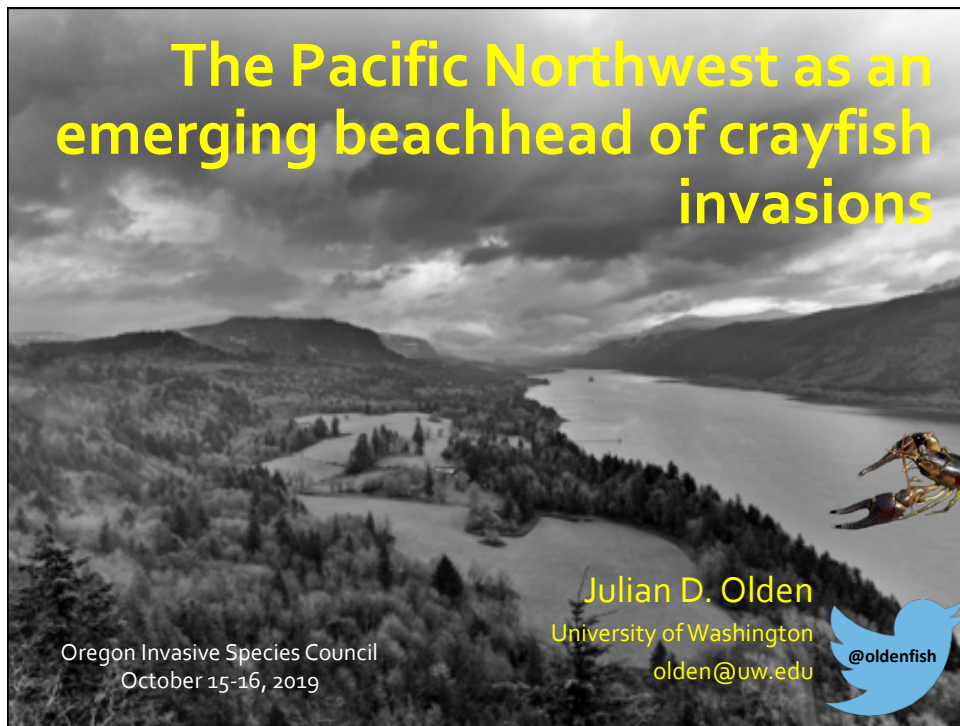


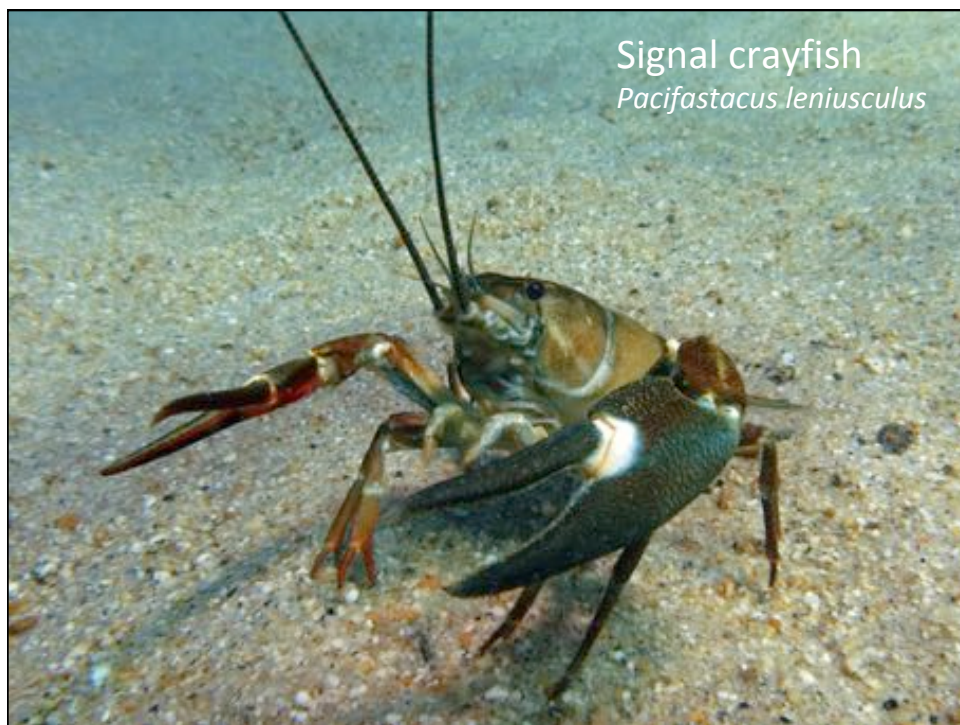
The Pacific Northwest as an emerging beachhead of crayfish invasions



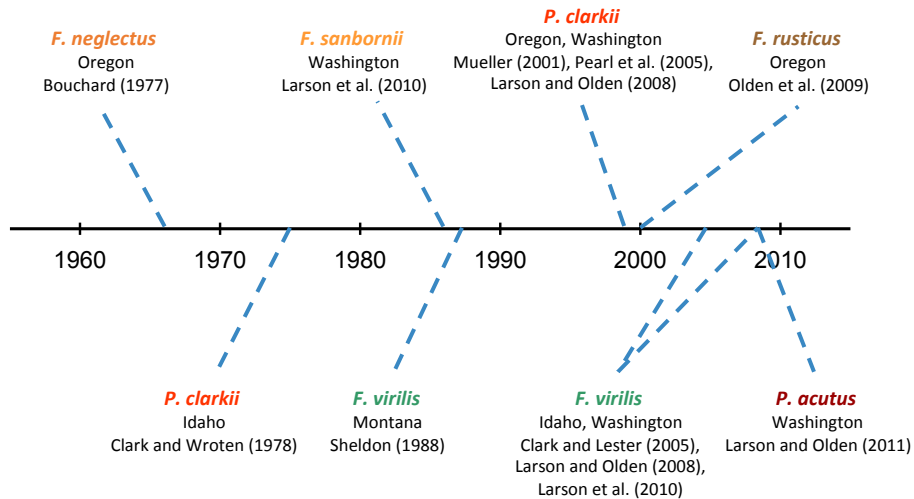
Oregon Invasive Species Council
October 15-16, 2019

Julian D. Olden
University of Washington
olden@uw.edu

@oldenfish



Chronology of crayfish invasions in the western U.S.



Non-native Crayfish in the PNW

Red swamp crayfish
Procambarus clarkii



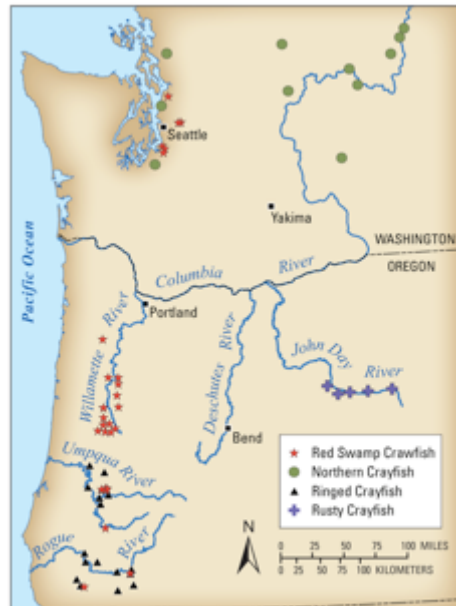
Northern crayfish
Faxonius virilis



Ringed crayfish
Faxonius rusticus



Rusty crayfish
Faxonius rusticus

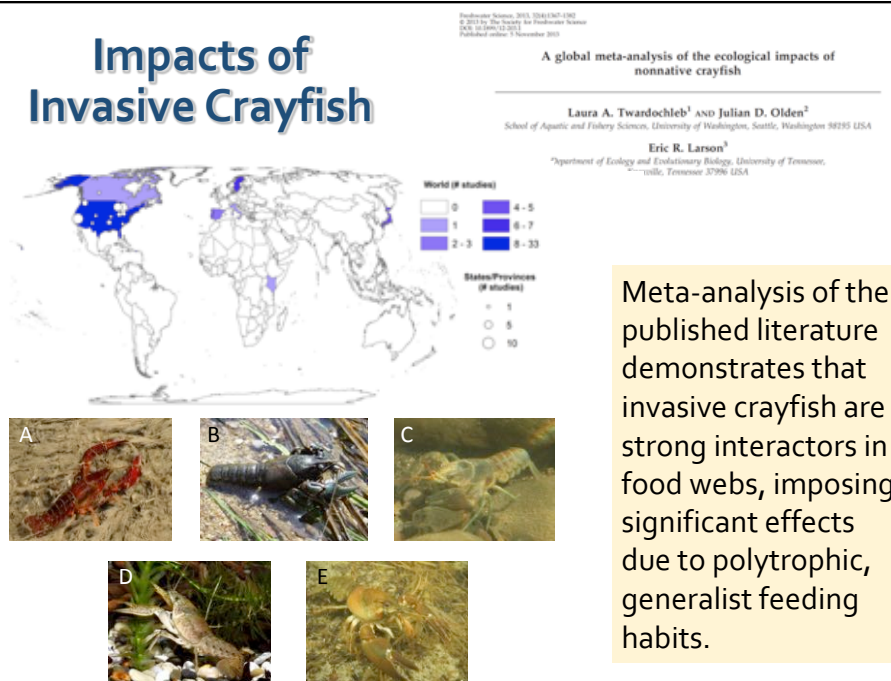


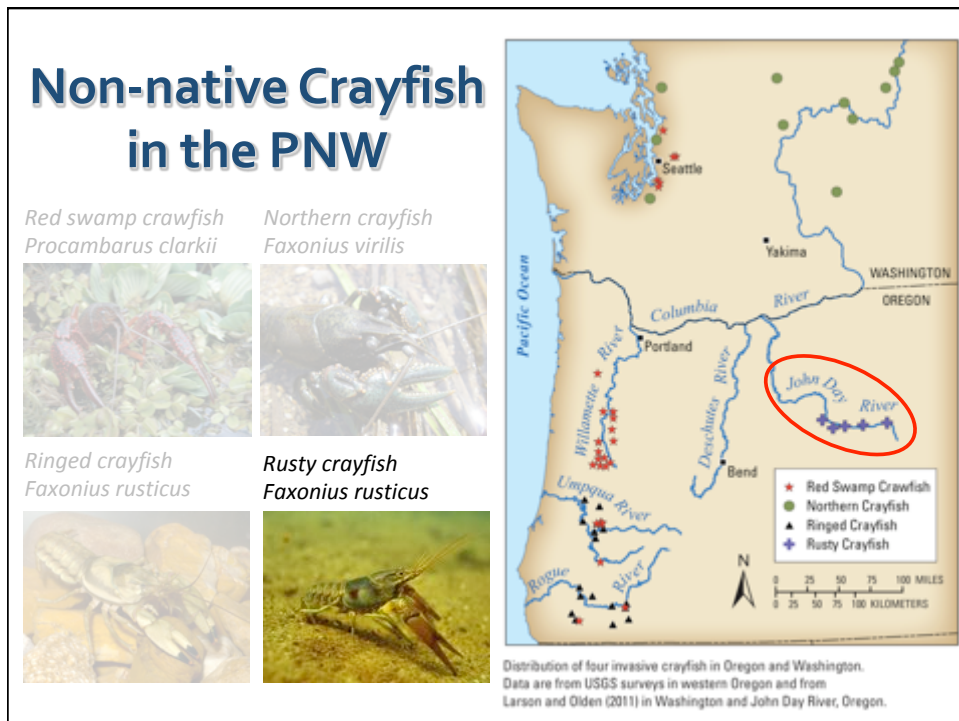
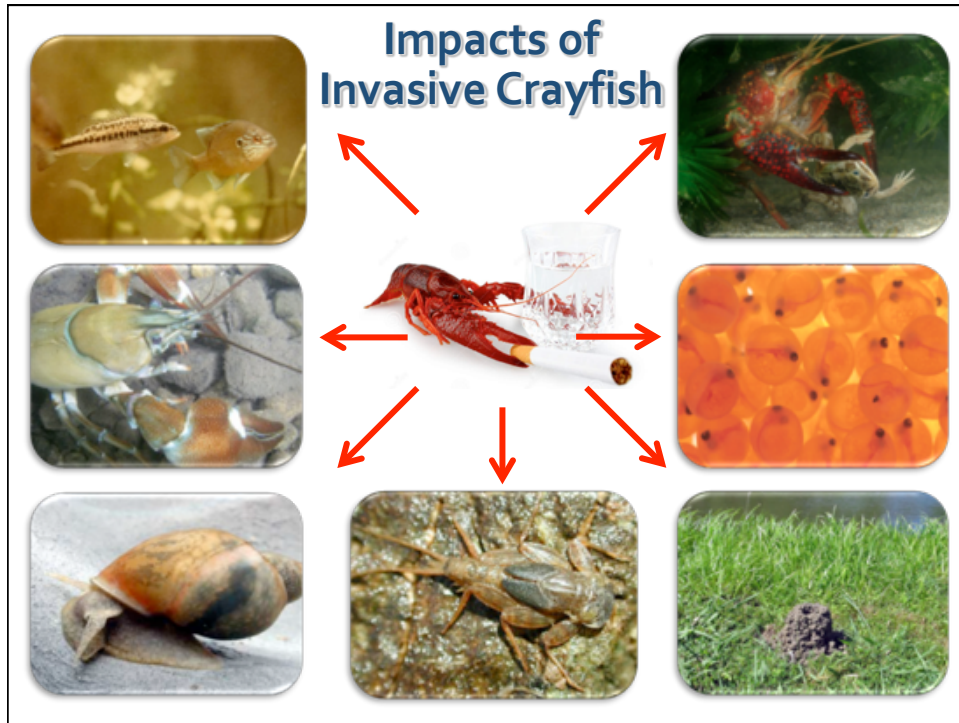
Distribution of four invasive crayfish in Oregon and Washington. Data are from USGS surveys in western Oregon and from Larson and Olden (2011) in Washington and John Day River, Oregon.

Pathways of Crayfish Introductions

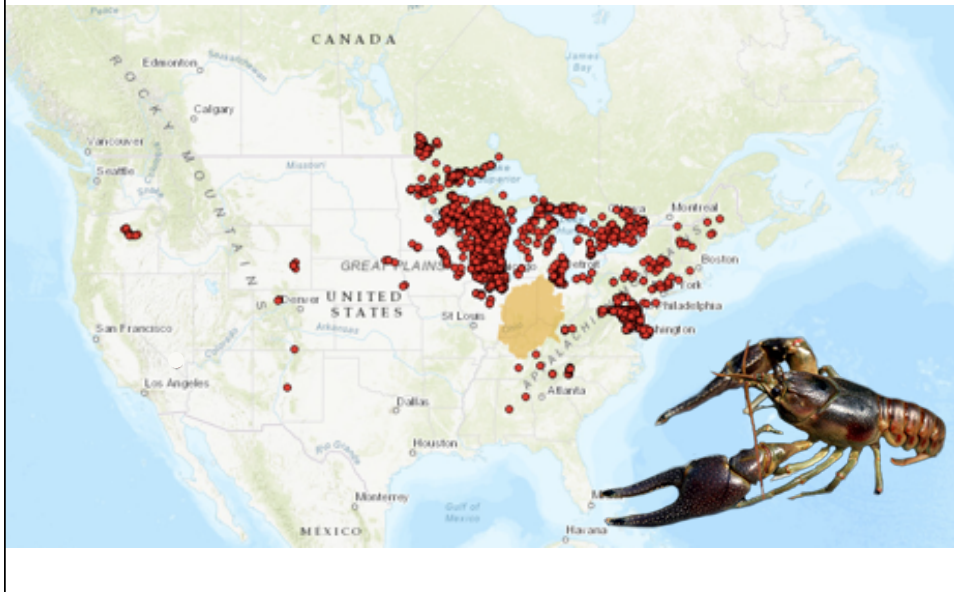
- Release as live bait associated with angling
- Release after educational use in classroom
- Release associated with pet aquariums
- Intentional introduction as forage for sportfish
- Intentional introduction to golf course ponds
- Intentional introduction to create harvest opportunities
- Secondary spread from existing populations

Impacts of Invasive Crayfish





Rusty Crayfish Distribution



Diverse pathways of introduction

- Bait bucket
- Schools



Diverse ecological impacts

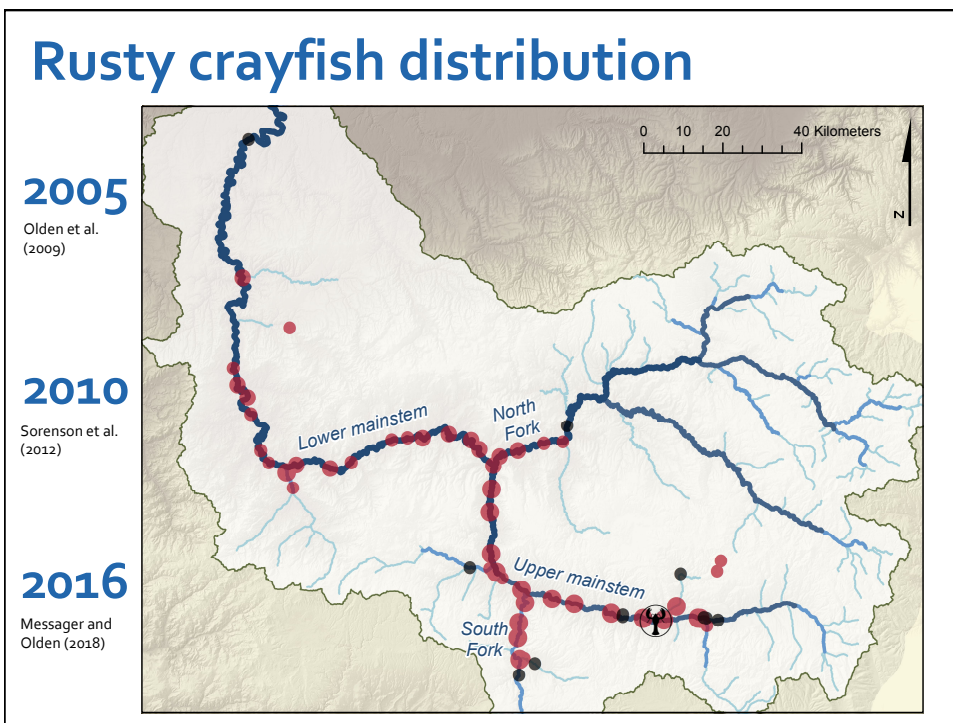
- Polytrophic diet
- Extremely high densities

Twardochleb et al. 2013, Hansen et al. 2017

John Day River, OR



Rusty crayfish distribution

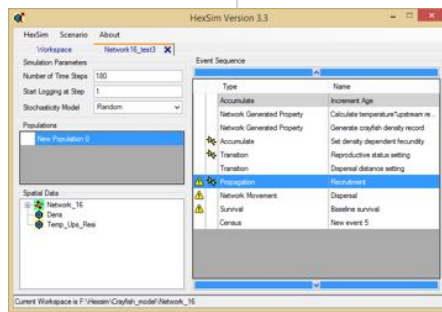


Approach

Spatially-explicit individual-based model

HexSim

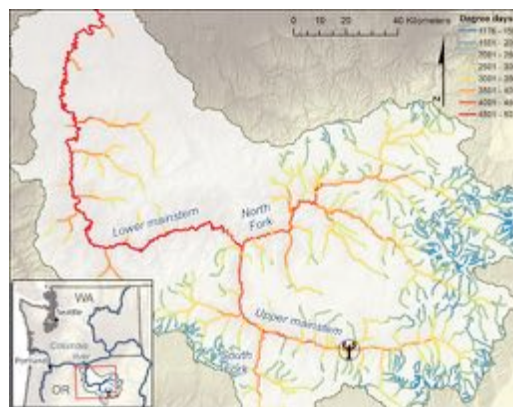
- Sequential event architecture
- Network structure



Approach

Environmental Context

- **Hydrography (NHD+ v2)**
 - Flow direction
 - Reach gradient
 - Estimated mean monthly discharge
 - August flow > 0.25 ft³/s
- **Wetted width**
- **Water temperature**
 - Daily land surface temperature
 - Watershed area
 - Elevation
 - Calendar day



Water temperature expressed as degree days > 6° C

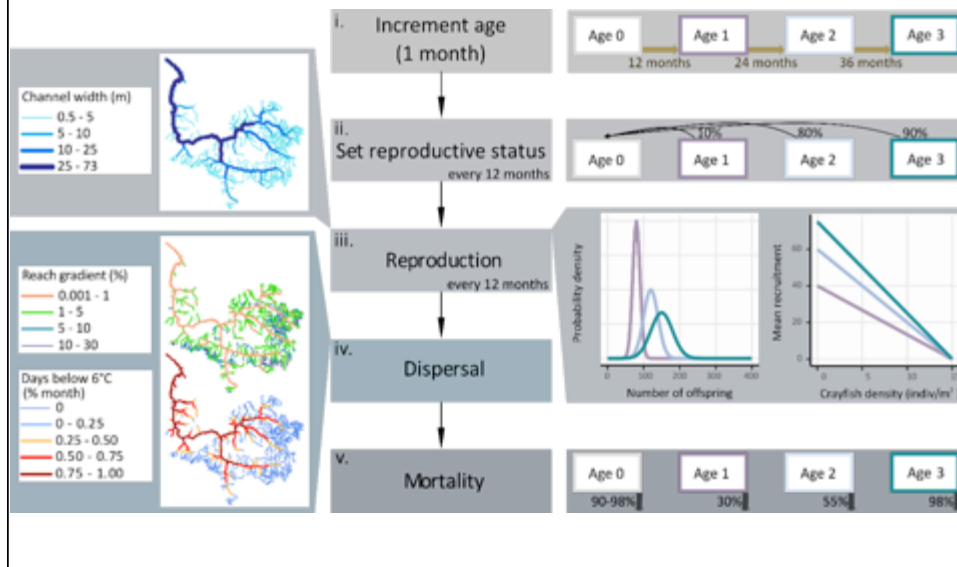
McNyset et al. 2015, Data from ISEMP

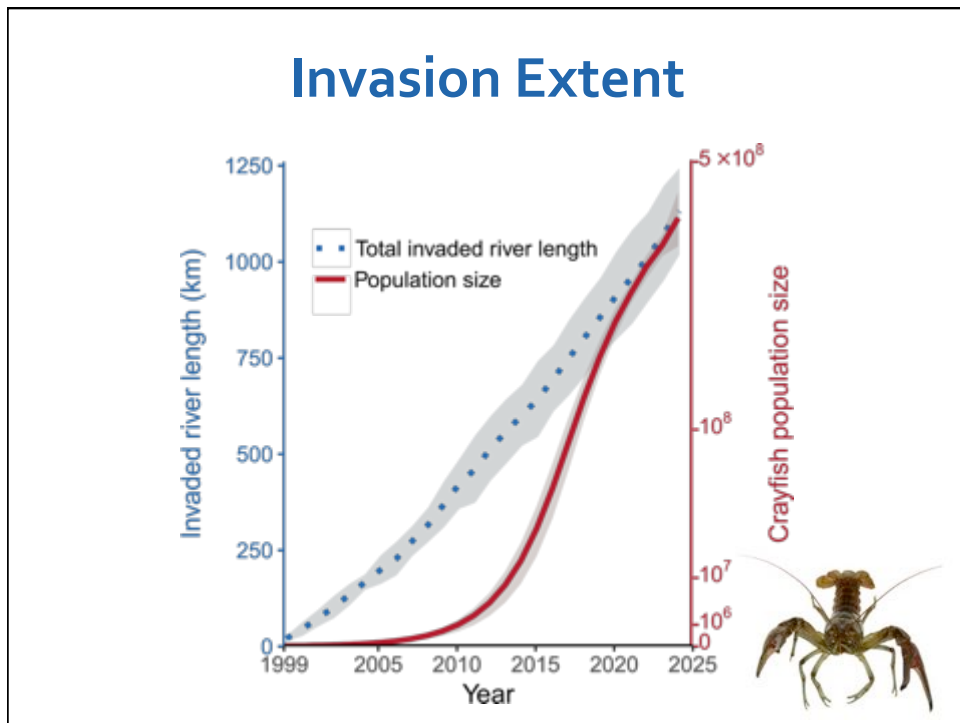
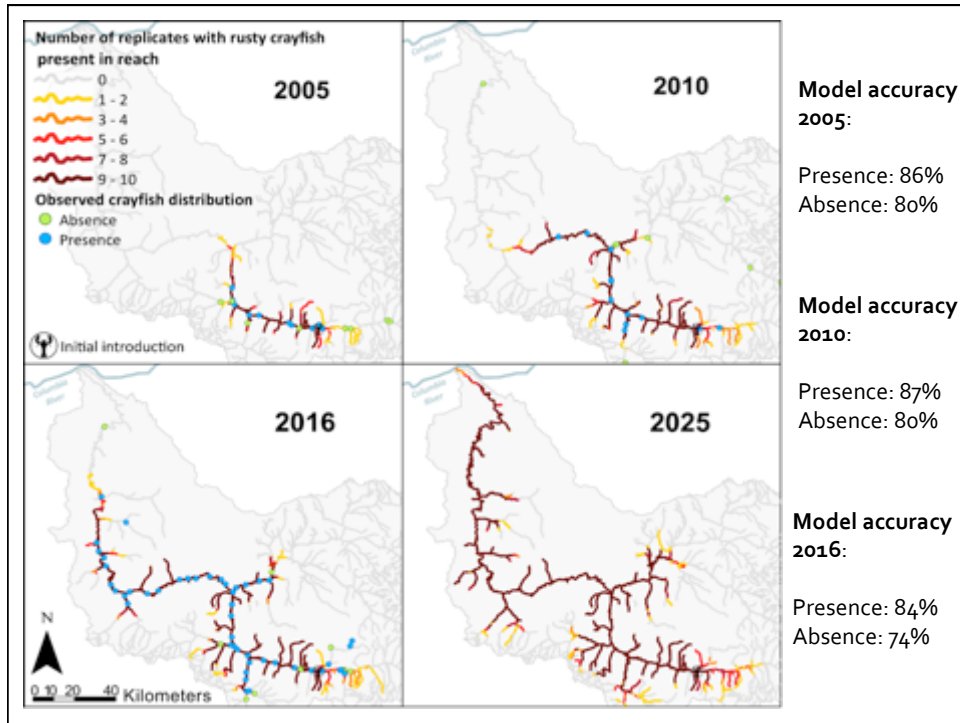
Approach Modeling Process

- Model development based on literature review and rusty crayfish distribution in 2005 (Olden et al. 2009) and 2010 (Sorenson et al. 2012)
- Forecast to 2016 and model validation test
- Re-calibrate and forecast to 2025
- Assess management scenarios




Model structure HexSim





Preventing New Introductions




Shellfish/Seafood Species Rules

CRAB: All crabs must be cooked and served within 24 hours of capture. All crabs must be cooked and served within 24 hours of capture.

CLAM: All clams must be cooked and served within 24 hours of capture. All clams must be cooked and served within 24 hours of capture.

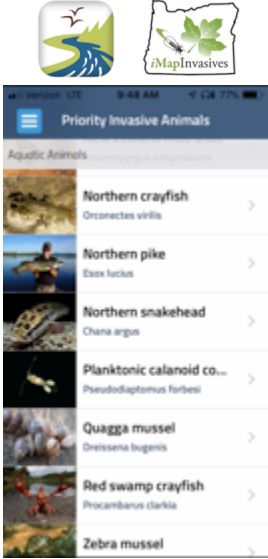
SCALLOP: All scallops must be cooked and served within 24 hours of capture. All scallops must be cooked and served within 24 hours of capture.



ALERT!!
These waters are closed to the public.

PROHIBITED
All live aquatic animals and plants.


• Remove ALL aquatic plants and animals.
• Drain ALL water.
• NEVER empty aquariums or tubs.



iMapInvasives

Priority Invasive Animals

- Northern crayfish
- Northern pike
- Northern snakehead
- Planktonic calanoid co...
- Quagga mussel
- Red swamp crayfish
- Zebra mussel



State of Washington
DEPARTMENT OF FISH AND WILDLIFE

Mailing Address: P.O. Box 43201, Olympia, WA 98504-3200 • (360) 902-2200 • TDD (360) 902-2207
Main Office Location: Natural Resources Building, 5111 Washington Street SE, Olympia, WA

Aquatic Invasive Species (AIS) Permit

Limited Use of Live Prohibited and Native Crayfish
By
The Washington State Office of the Superintendent for Public Instruction (OSPI)
For
2018-2019 K-12 School Science Curriculum

Controlling or Eradicating Existing Populations

Methods	Population size	Area size	Applicability	Species-specificity	Selectivity	Impact	Time	Cost	Efficacy
Mechanical									
Trap	Low	Low	High	High	High	High	High	High	High
Electrofishing	Low	Low	High	High	High	High	High	High	High
By hand	Low	Low	High	High	High	High	High	High	High
Physical									
Drainage	=	Low	High	High	High	High	High	High	High
Diversion of rivers	=	Low	High	High	High	High	High	High	High
Barriers	=	Low	High	High	High	High	High	High	High
Biological									
Predators	Low	Low	High	High	High	High	High	High	High
Pathogens	=	=	High	High	High	High	High	High	High
Biocides									
Chemical	=	Low	High	High	High	High	High	High	High
Natural	=	Low	High	High	High	High	High	High	High
Autocidal									
SMRT									?
Sex pheromones	=	Low	High	High	High	High	High	High	High

Low Medium High - irrelevant ? unknown

Modified from Gherardi et al. (2011)

Physical Removal

The Fisheries and Aquaculture Sciences, 2019

Control of Nuisance Populations of Crayfish with Traps and Toxicants

T. D. BEALS AND L. E. MARGINA
 U.S. Fish and Wildlife Service
 National Fisheries Research Center
 First Office Area 419
 La Crosse, Wisconsin 54602, USA

Abstract—Crayfish have long been a nuisance in fish-rearing ponds in fish hatcheries. The rusty crayfish (*Decapoda rustica*) has displaced endemic species and caused serious declines of aquatic plants in some ponds and lakes in the midwestern U.S.A. We attempted to evaluate the effects of intensive trapping on a crayfish population and to identify a selective chemical control agent and evaluate its effectiveness under field conditions. A crayfish population in a small pond was suppressed but not eliminated by trapping; adults were effectively harvested but efficiency diminished sharply as the population declined. 0.1% thiodiazinon proved a possible control agent for crayfish, a selective piscicide (altho' it was not for the main issue, 75 mg/L produced a complete kill of crayfish in the pond and was also the most effective for crayfish in laboratory tests.

Crayfish are a nuisance in fish hatchery rearing ponds in several midwestern states. The Wisconsin Department of Natural Resources (DNR) reported that crayfish often become so numerous in rearing ponds that they eat the eggs of forage fish species and injure or kill young muskellunge (*Esox*

masquinongy) during harvest (Jacobson 1981; Koch and Bills 1987). In the past 10 years, the rusty crayfish (*Decapoda rustica*), a nonnative species, became established in lakes of Wisconsin and adjacent states. This crayfish has displaced endemic species (Cappell 1982). It is an aggressive feeder (Edgar et al. 1993); in some lakes, it has caused serious declines of aquatic plants (Norman and Magnuson 1978), which has led to declines in the quality of sport fisheries.

The rusty crayfish is native to streams in Illinois, Indiana, and Ohio. Fishery biologists suspect that it may have been introduced into Wisconsin waters through release of surplus bait or through deliberate stockings by crayfish trappers who wished to expand their operations. Resource managers are concerned about the impact of this invasion on angling, its potential for spreading to other waters, and its possible destruction of aquatic plants. Measures suggested for its control include the imposition of stricter controls on bait sales, the use of more efficient trapping methods and toxicants, and the introduction of diseases to natural predators.

In an attempt to help identify and evaluate methods for controlling these populations, we conducted studies at the National Fisheries Re-

Freshwater Biology (2007) 48, 1134–1146

doi:10.1111/j.1565-2478.2007.01741.x

APPLIED ISSUES

Intensive trapping and increased fish predation cause massive population decline of an invasive crayfish

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¹Center for Limnology, University of Wisconsin, Madison, WI, U.S.A.
²Department of Plant and Soil Science, Utah State University, Logan, UT, U.S.A.

SUMMARY

1. Invasive species frequently have adverse impacts on native communities and ecosystems. Management options are often limited. Our goal is to evaluate the effect of intensive trapping and fish predation on the population dynamics of an invasive crayfish.
2. From 2001 to 2005, we removed invasive rusty crayfish (*Decapoda rustica*) by trapping in Sparkling Lake in northern WI. In addition, the Wisconsin Department of Natural Resources restricted harvest of fish species known to consume crayfish, thereby increasing predation on crayfish that are too small to trap.
3. After an initial increase, catch rates of rusty crayfish declined by approximately 95%, from 13 crayfish per trap per day in 2002 to 0.65 in 2004. The catch rate in 2005 remained low at 0.5 crayfish per trap. Females comprised nearly 80% of the catch from 2002 to 2004. Unlike rusty crayfish in Sparkling Lake, catch rates of *D. rustica* and *Cherax caryinatus* in three nearby lakes increased or remained relatively constant over the 5-year removal period.
4. We also examined the influence of habitat and temperature on crayfish catch rates. Catch rates were highest at water temperatures between 20 and 25 °C and on cobbles, log or macrophyte habitats that may serve as refuge from fish predation.
5. Five summers of intensive trapping and fisheries management practices reduced abundances, but did not extirpate rusty crayfish in Sparkling Lake. To determine the potential of trapping as a management option for invasive crayfishes, these methods must be tested in other systems.

Keywords: control, crayfish, invasive species, management, *Cherax caryinatus*

Introduction

Invasive species are a leading threat to aquatic ecosystems and biodiversity fields (Chapin & Hubert-Samuel 2005), and there is a need to rapidly develop management strategies to reduce adverse impacts. Prevention of future invasions should be the cornerstone of management efforts (Vander Zanden et al. 2006), but control and eradication are often required because many invaders already have established populations and adversely impacted native

communities. Control can also be effective at curbing the spread of newly established invader populations (Myers et al. 2003). Eradication or control of invasive species has been used successfully as a restoration strategy on islands (Gardner et al. 2003; Cruz et al. 2005), in lakes (Knepp & Matthews, 1996), in marine areas (Culler & Kirtz, 2000) and other systems (Mack et al. 2000; Myers et al. 2003).

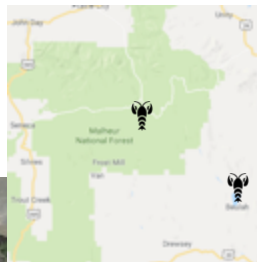
The rusty crayfish (*Decapoda rustica*, Hessel), native to the Ohio River valley, has invaded large areas of the United States and Canada (Hobbs, Jass & Hunter, 1999; Taylor et al., 1996; Lodge et al., 2000). Rusty crayfish were introduced beyond their native range primarily as live bait, but other vectors of dispersal such as stocking for macrophyte control

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Additional infestations of rusty crayfish

Summit Prairie Pond



Beulah Reservoir

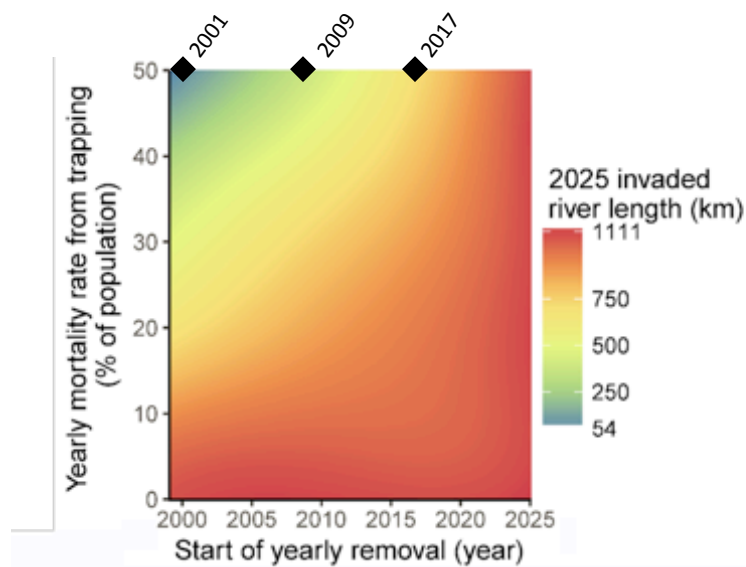


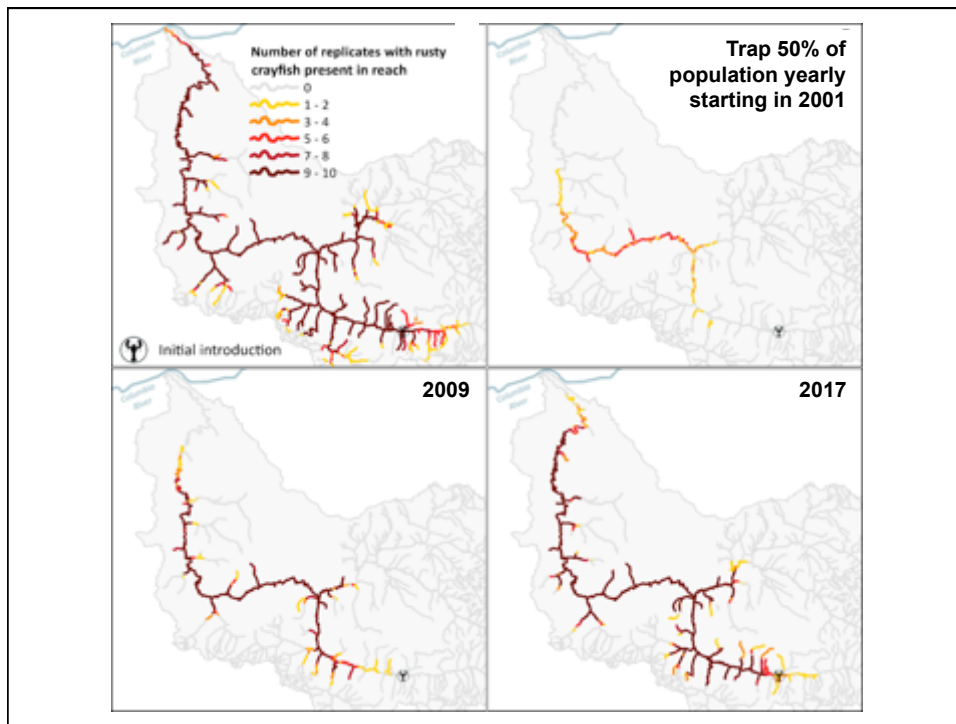
Management strategies

- Explored different control strategies that involved varying levels of crayfish removal occurring at different starting years
- Estimated required trapping effort to achieve management outcomes

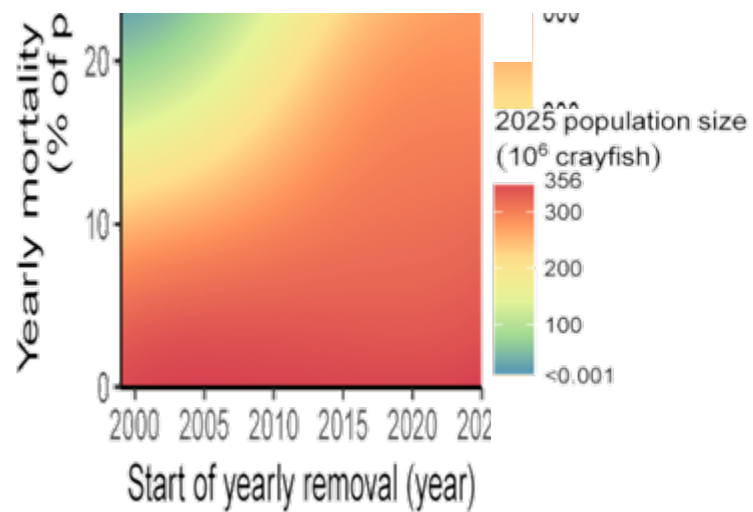


Controlling rusty crayfish spread





Controlling population size

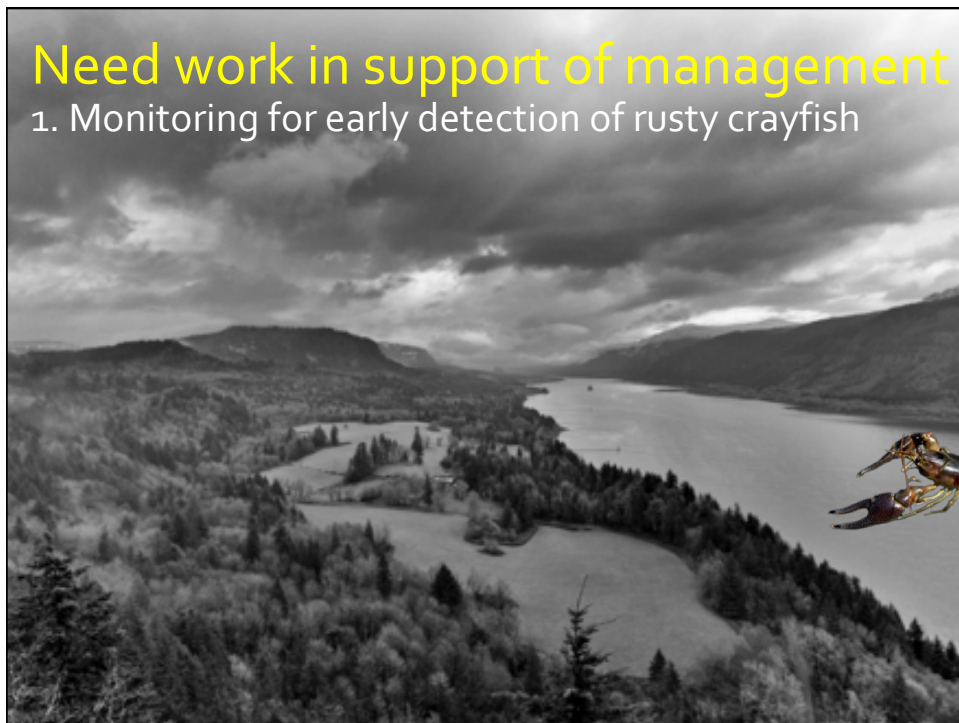


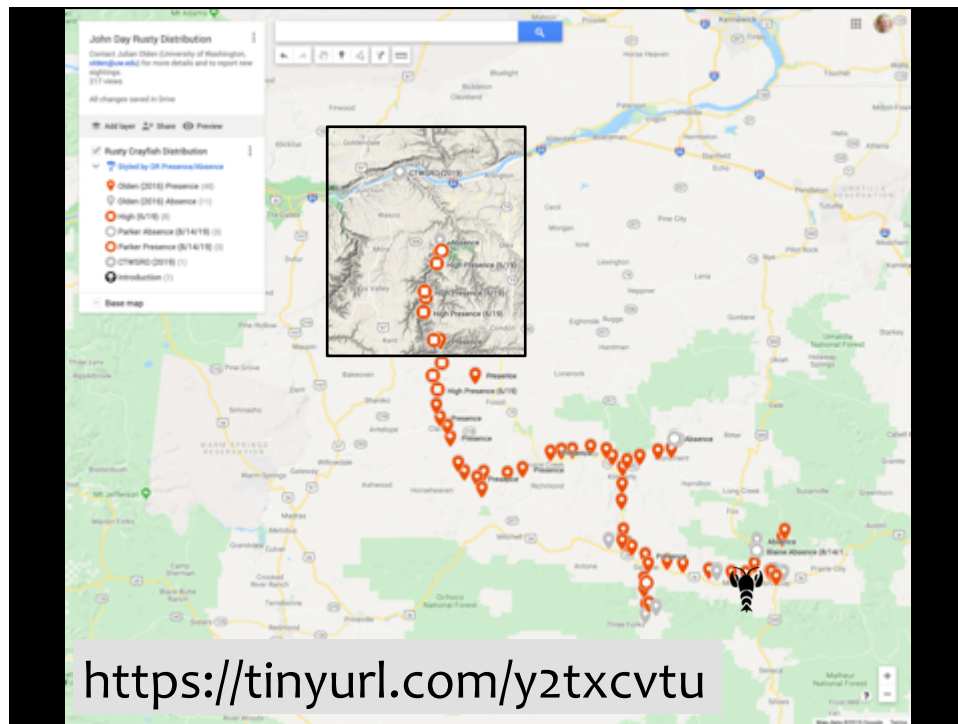
Conclusion

- Invasive crayfish represent a significant, yet largely overlooked, threat to freshwater ecosystems of PNW
- New populations of invasive crayfish are discovered constantly, and the rate of secondary spread can be rapid
- Early response remains critical, but strong management actions could still substantially decrease densities and future spread of existing populations
- Greater partnerships between scientists and natural resource managers is need to tackle this challenge

Need work in support of management

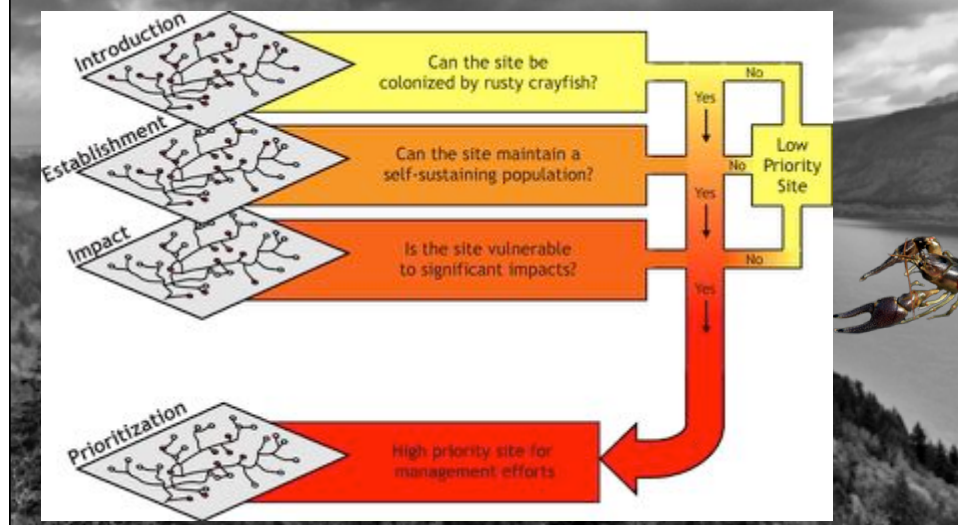
1. Monitoring for early detection of rusty crayfish





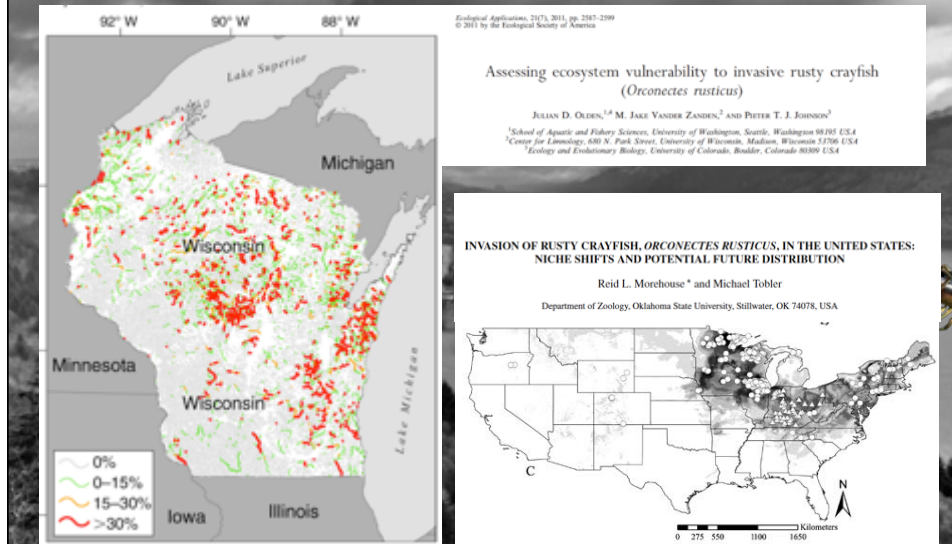
Needed work in support of management

1. Monitoring for early detection of rusty crayfish
2. Assessing risk to rusty crayfish invasion



Need work in support of management

1. Monitoring for early detection of rusty crayfish
2. Assessing risk to rusty crayfish invasion



Need work in support of management

1. Monitoring for early detection of rusty crayfish
2. Assessing risk to rusty crayfish invasion
3. Quantify food-web impacts



Need work in support of management

1. Monitoring for early detection of rusty crayfish
2. Assessing risk to rusty crayfish invasion
3. Quantify food-web impacts
4. Test effectiveness of local-scale control



Need work in support of management

1. Monitoring for early detection of rusty crayfish
2. Assessing risk to rusty crayfish invasion
3. Quantify food-web impacts
4. Test effectiveness of local-scale control
5. Complete an Invasive Species Action Plan

Eager to collaborate!!!!



Thank you

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206-616-3112

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- Mathis Messenger

Crayfish data

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- Keith Sorenson and Steve Bollens (Washington State University)
- Keith DeHart (ODFW)

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- Grant County Assessor's office
- John Day Fossil Beds National Monument staff
- Landowners
- Burns Paiute Tribe
- Western Rivers Conservancy

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- Mark Armour (EPA)
- Chris Jordan (NOAA)
- Kristina McNyset (South Fork Research)

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- Ethen Whattam (SAFS)

**Mason Keeler
Endowed Professorship**