

# **Towards Knowing the Unknowns: Great Lakes Fish Health in the 21<sup>st</sup> Century**

**Dr. Thomas P. Loch**

**Michigan State University – Aquatic Animal Health Laboratory  
Depts of Fisheries & Wildlife & Pathobiology & Diagnostic Investigation  
Michigan State University**

**Email: [lochthom@msu.edu](mailto:lochthom@msu.edu)**





**Sean Burke**

**Amber Johnston**

**Courtney Harrison**

**Steven Sisolak**

**Chris Knupp**

**Michelle Van Deuren**

**MSU-AAHL Crew**

**Dr. Megan Shavaliar**

**Dr. Eileen Henderson, Rachel London, Hannah Augustyniak, Matt Misewicz, Jenna Darling**





# Great Lakes Fisheries

---

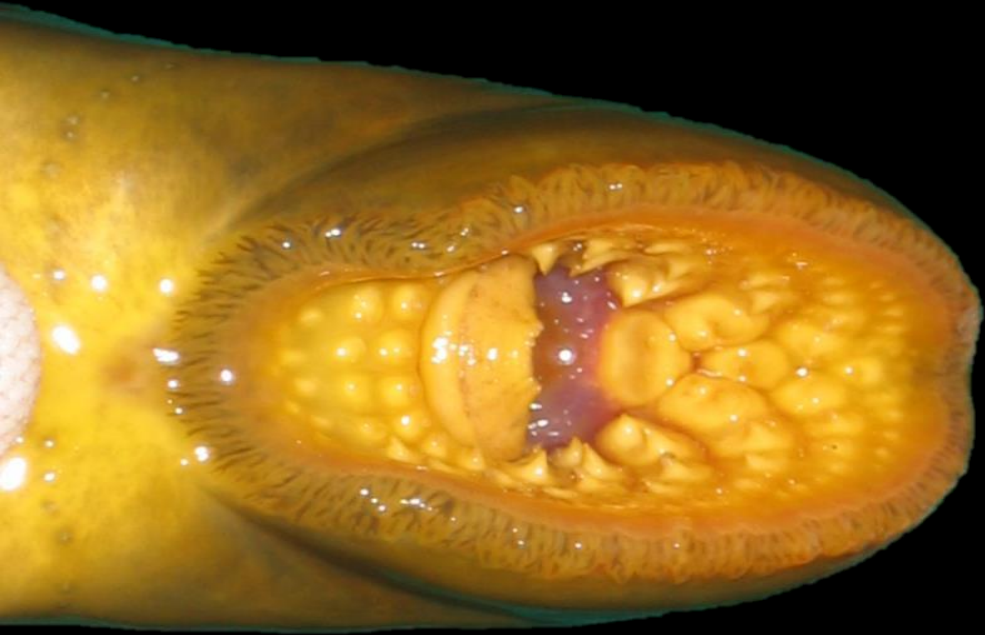


# Challenges to Great Lakes Fisheries



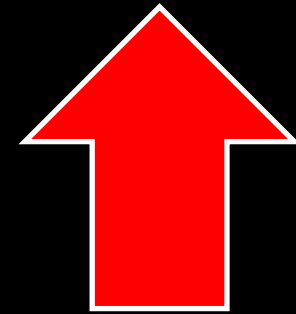
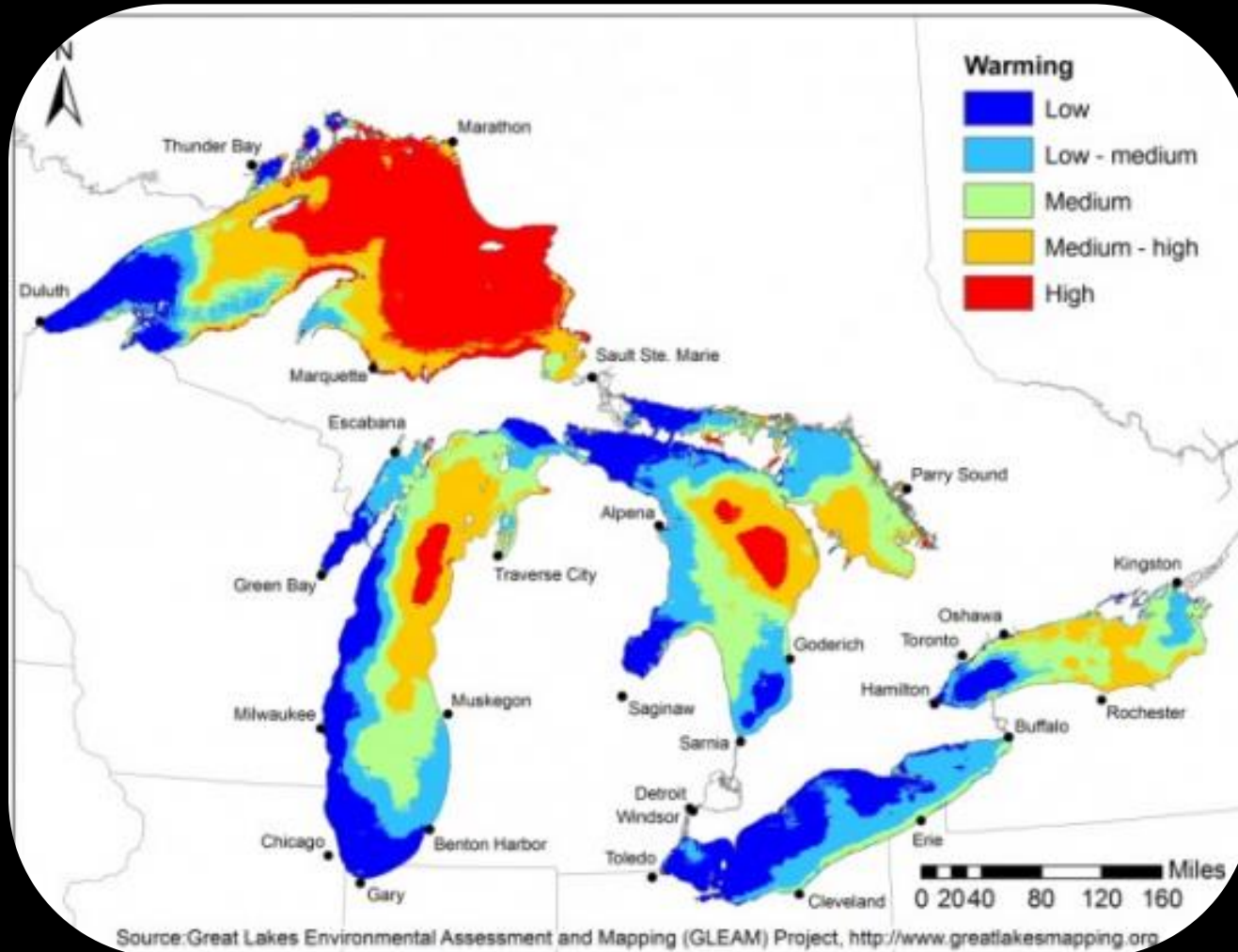
- **Environmental contaminants (e.g., PFAS, EDRs, etc.)**

# Challenges to Great Lakes Fisheries





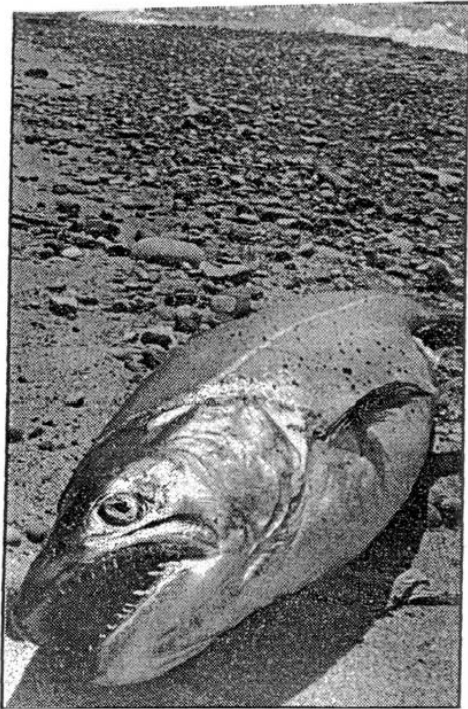
# Challenges to Great Lakes Fisheries



**Projected  
Surface Water  
Temps: 6 °C (?)**

# Challenges to Great Lakes Fisheries

Kalamazoo Gazette  
April 20, 1989



GAZETTE PHOTO / RICK CAMPBELL

Part of the salmon die-off along Lake Michigan.

## Dead salmon found on beaches

JOHN BLOCK  
GAZETTE OUTDOOR WRITER

LAKE MICHIGAN — While some fishermen are having a banner spring taking young coho salmon in Lake Michigan from New Buffalo north to Saugatuck, others are concerned about a salmon die-off.

Dead Chinook salmon and a few steelhead are being found in the lake and washed up on beaches. The fish range in age from 1 to 4 years and weigh from two to 12 pounds.

"It's a continuation of the die-off we had last summer," says Jim Copeland, manager of the Wolf Lake State Fish Hatchery in Mattawan. "It started about three weeks ago."

Dave Johnson, chief fish biologist at the Plainwell district office, said he hasn't received reports of dead fish in the lake from any boat anglers recently.

"The only reports we've had have been of fish found on beaches or by piers," Johnson says.

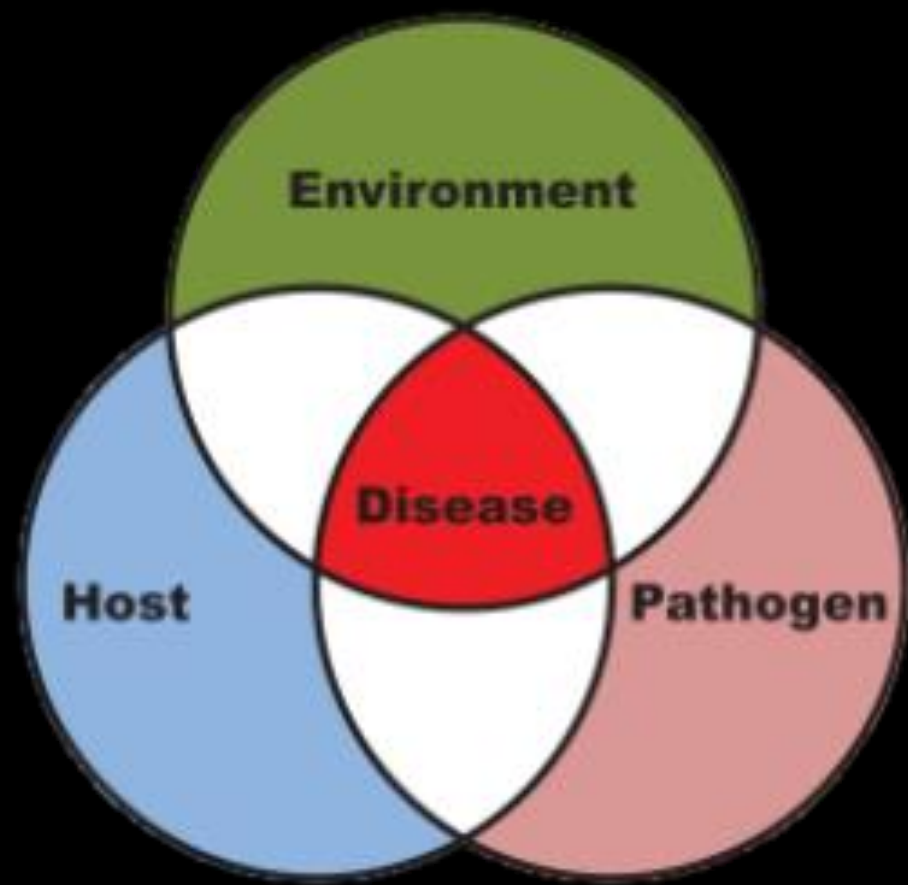
A bacterial kidney disease was deemed responsible for the fish deaths last summer. Copeland says that the fish are being checked for that this spring, but a viral problem is also being considered.

"The bacteria in the fish dying now is not what you'd find in a hatchery die-off," Copeland points out. "John Hnath, our pathologist here, has checked and tested over 20 fish this spring. He's also sent samples

Please see FISH, B2









# Great Lakes Fishery Conservation

```
graph TD; A[Great Lakes Fishery Conservation] --> B[Hatchery-Based]; A --> C[Management of Wild Fisheries]; A --> D[Aquaculture]; E[Infectious Disease] --> B; E --> C; E --> D;
```

The diagram is a flowchart on a black background. At the top is a white rounded rectangle containing the text 'Great Lakes Fishery Conservation'. Three white arrows point downwards from this box to three separate white rounded rectangles below it. The left one is labeled 'Hatchery-Based', the middle one is labeled 'Management of Wild Fisheries', and the right one is labeled 'Aquaculture'. The middle box has a red glow effect. Below these three boxes is a larger white rounded rectangle containing the text 'Infectious Disease' in red. Three red arrows point upwards from this bottom box to the three boxes above it.

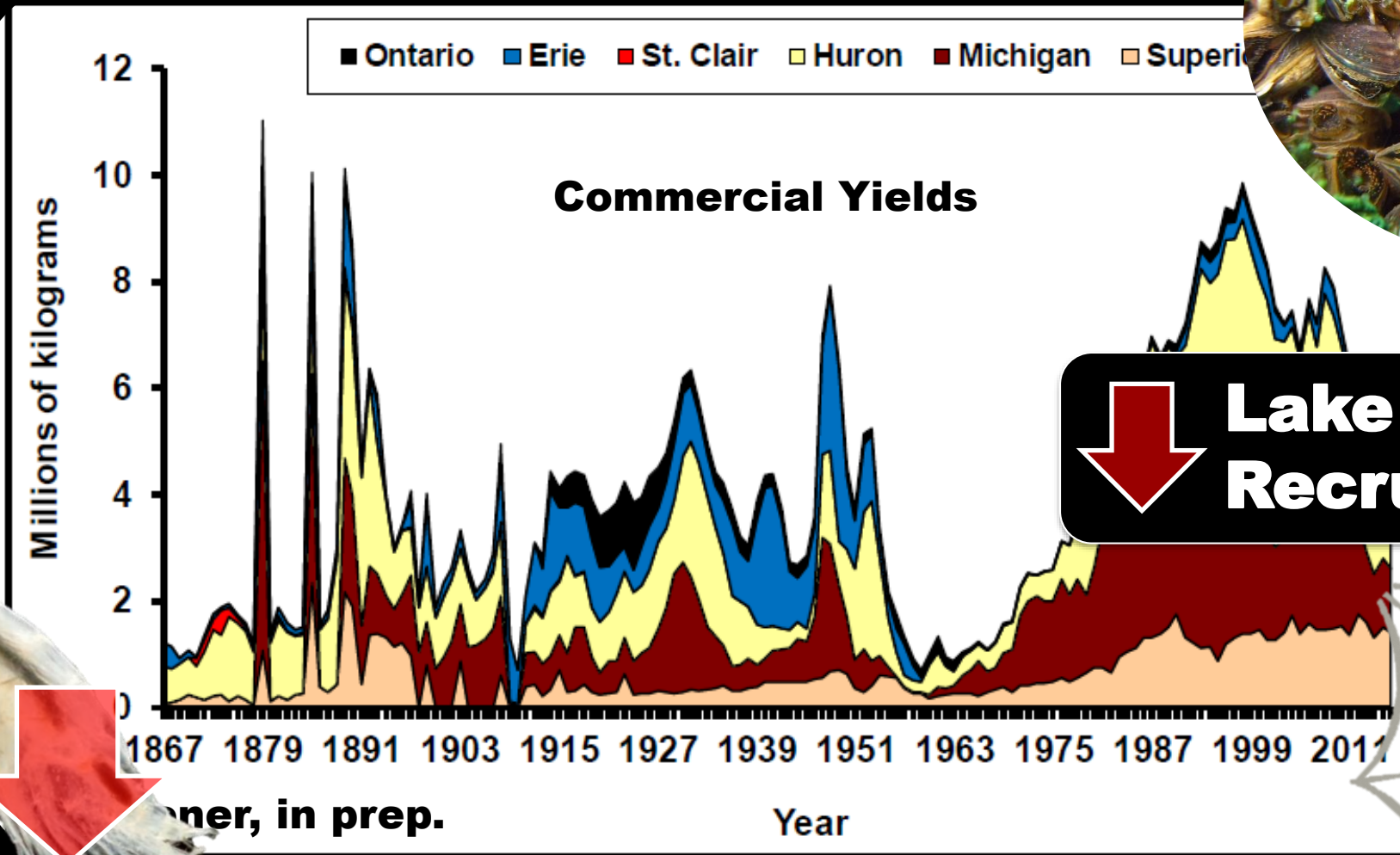
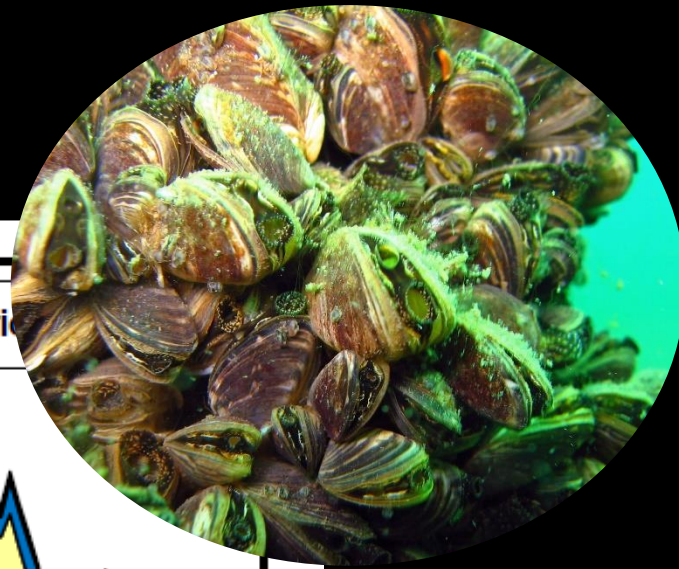
**Hatchery-  
Based**

**Management of  
Wild Fisheries**

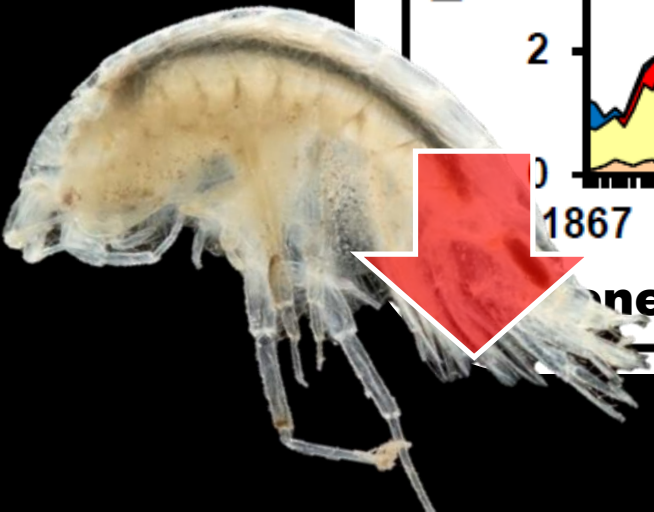
**Aquaculture**

**Infectious  
Disease**

# Lake Whitefish



**↓ Lake Whitefish Recruitment**



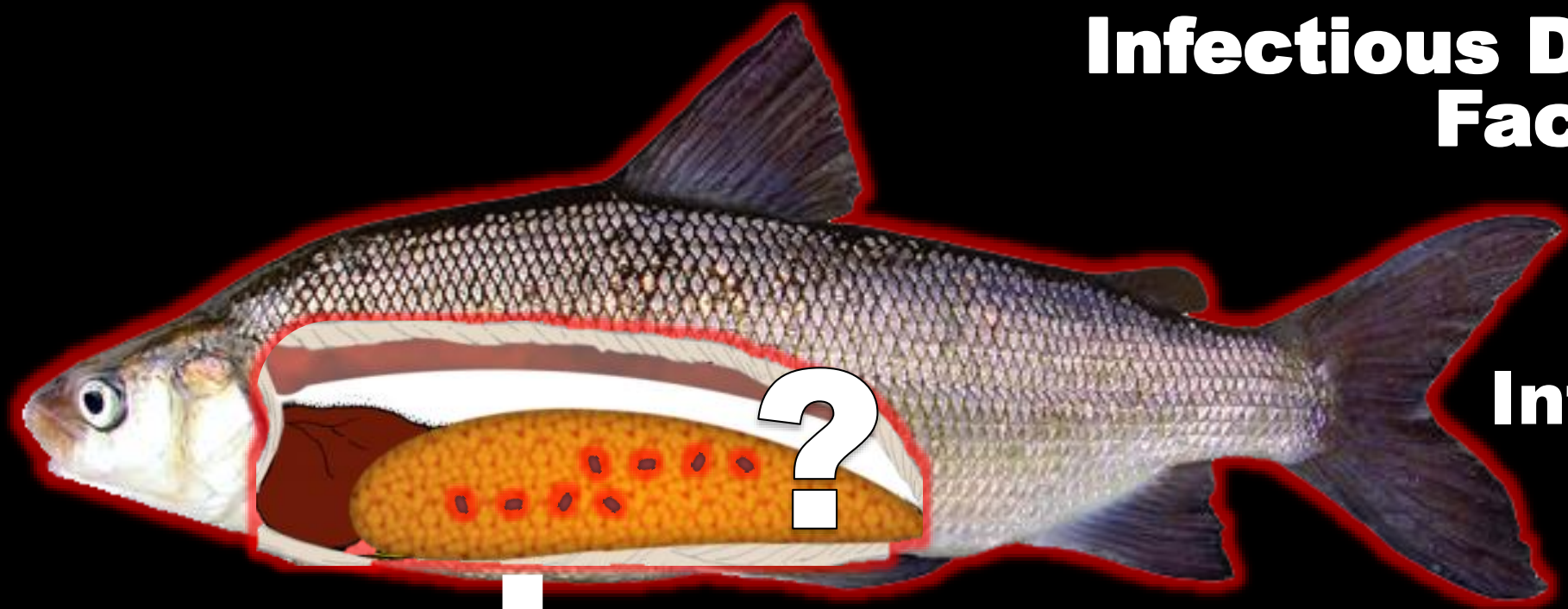
ner, in prep.

Year

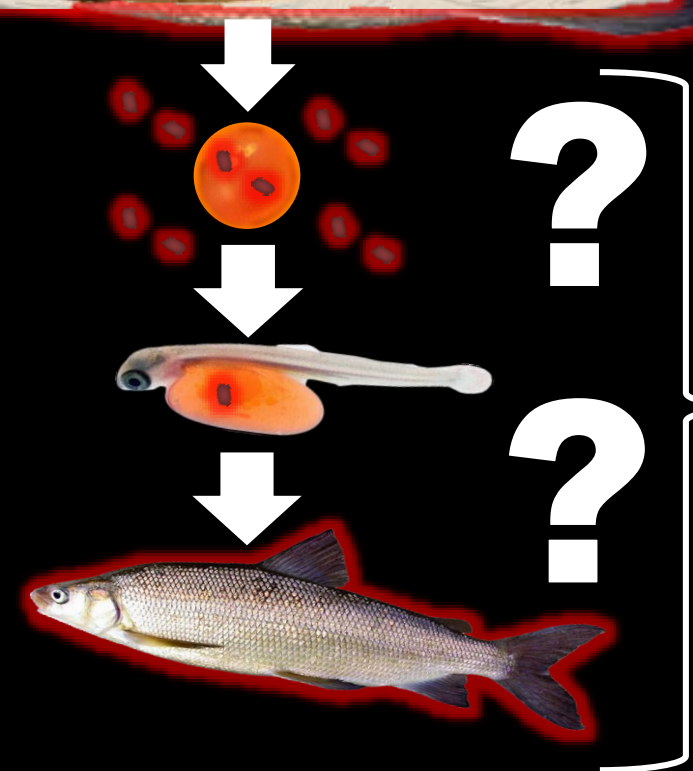




# Infectious Diseases as a Factor?



Infection(s) = ?



Infection(s) = ?

# Investigating Infectious Diseases As A “Bottleneck” To Lake Whitefish Recruitment

**Courtney E. Harrison, Travis O. Brenden, Mark P. Ebener,  
Chris K. Knupp, Michelle R. Van Deuren, Amber E. Johnston,  
Megan A. Shavalier, & Thomas P. Loch**

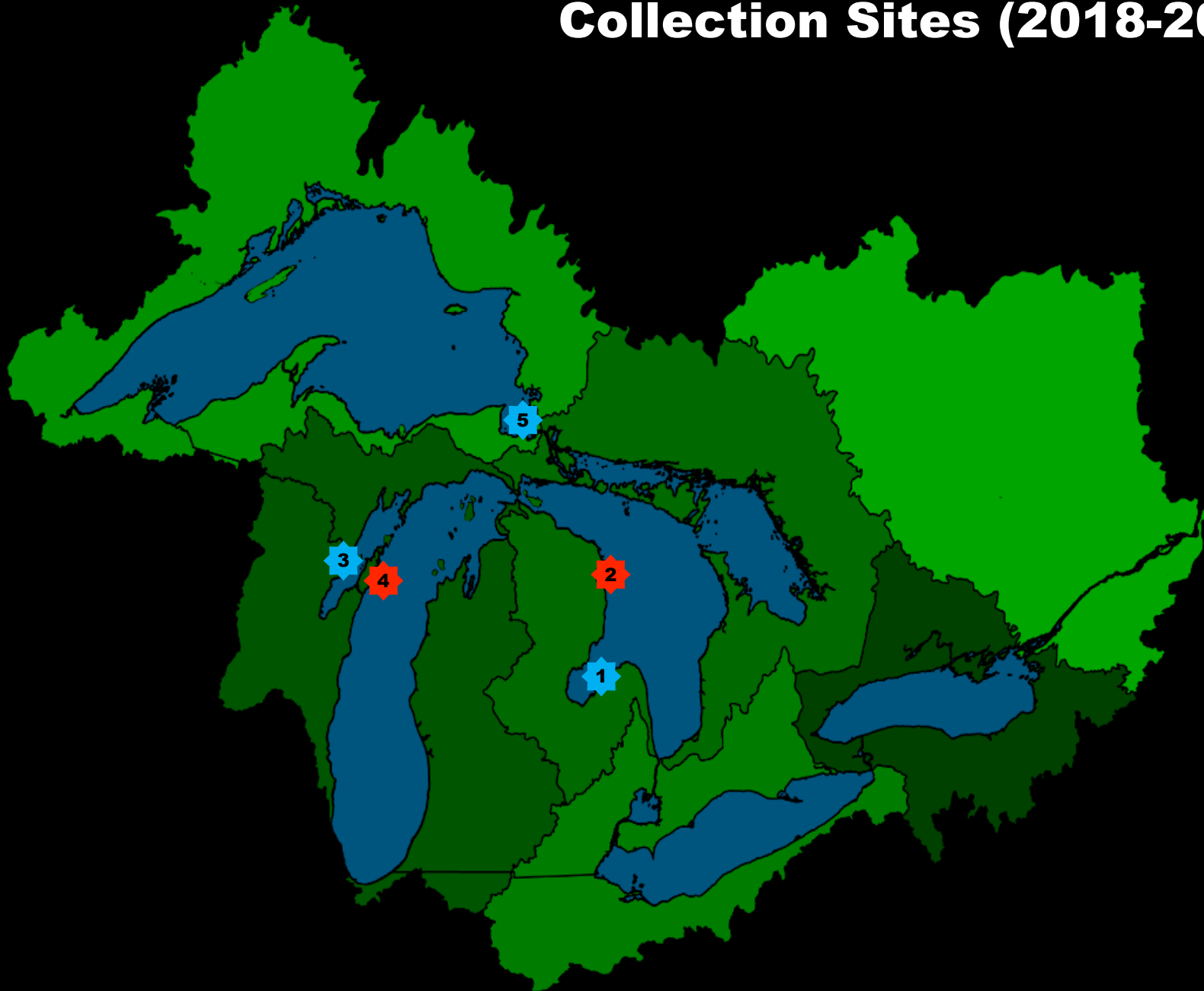


**Courtney Harrison,  
Masters Student**





# Spawning Phase Adult Lake Whitefish Collection Sites (2018-2019)



## “Good Recruitment”

- 1** Lake Huron  
Caseville, Saginaw Bay,  
MI
- 3** Lake Michigan  
Menominee River, WI
- 5** Lake Superior  
Whitefish Bay, MI

## “Poor Recruitment”

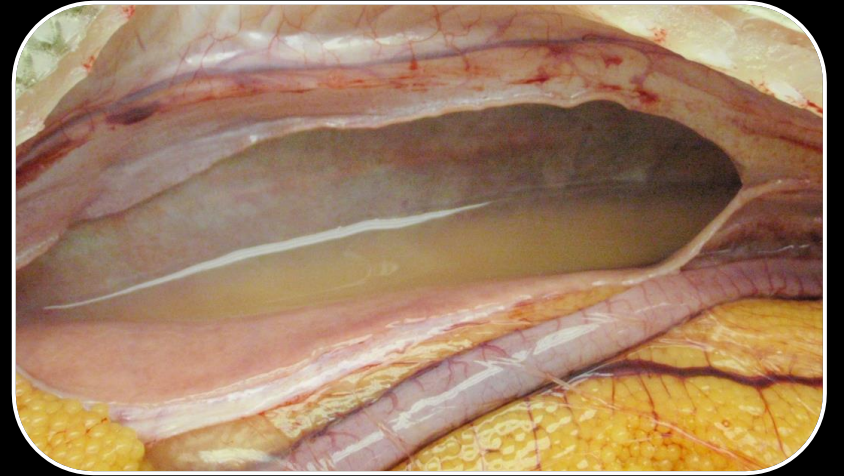
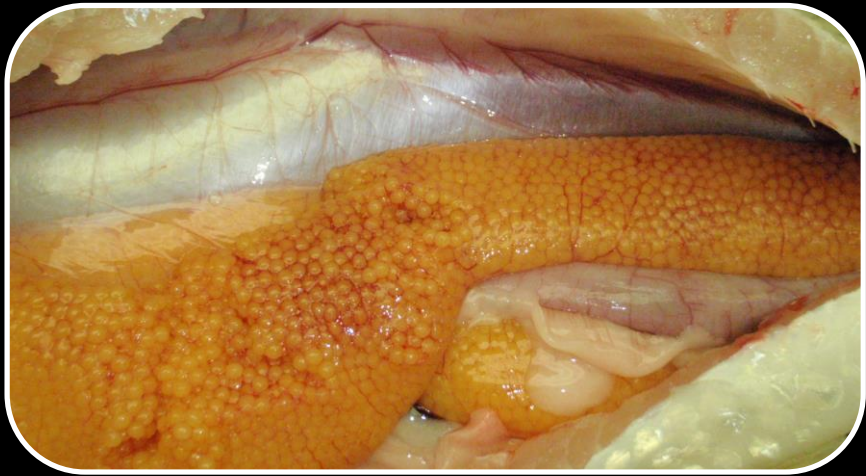
- 2** Lake Huron  
Alpena, MI
- 4** Lake  
Michigan  
Baileys Harbor,  
WI



# Fish Collection

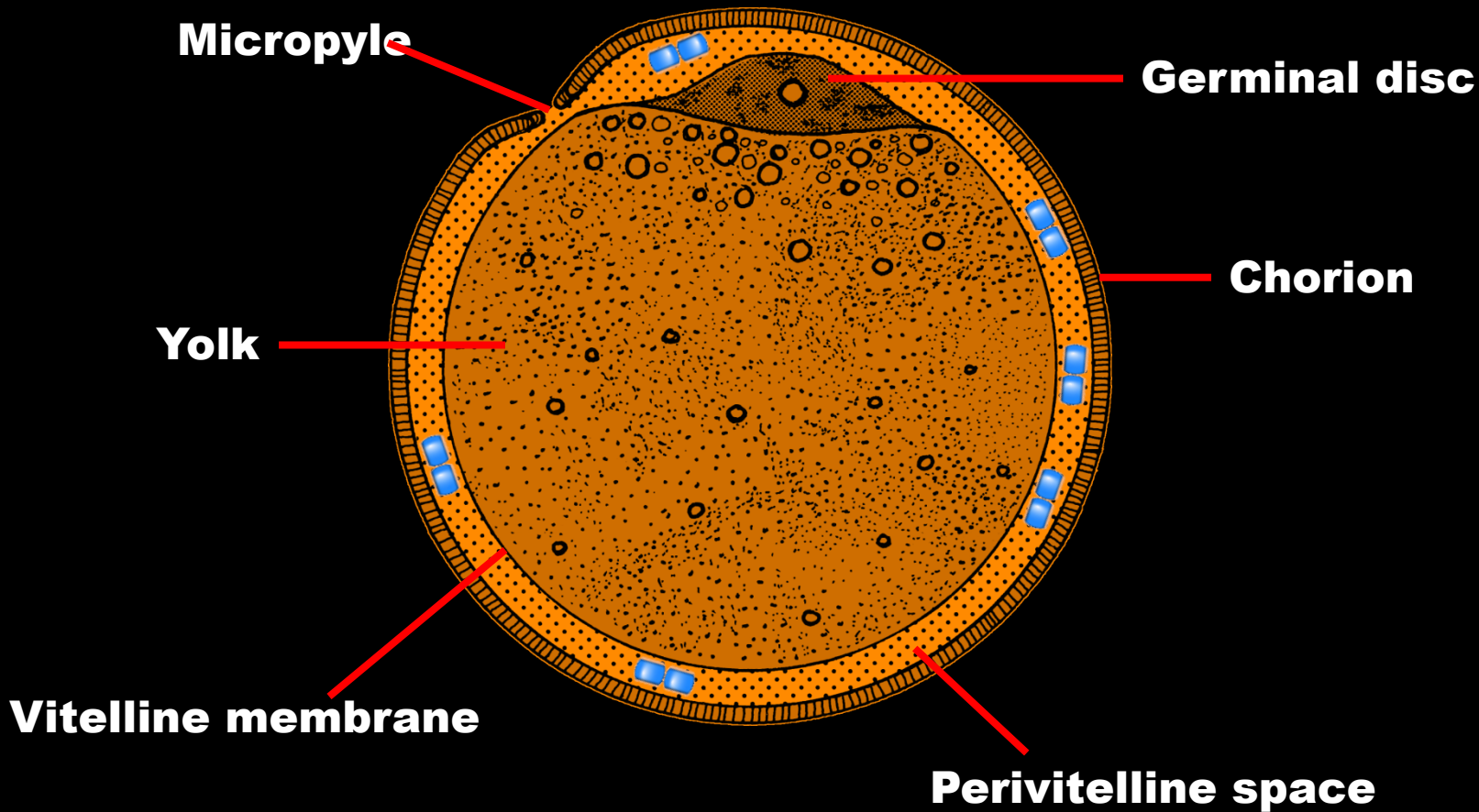






**Virological, bacteriological, histopathological, serological, and molecular analyses**

# Quick Detour: *Intra Ova* Bacterial Transmission



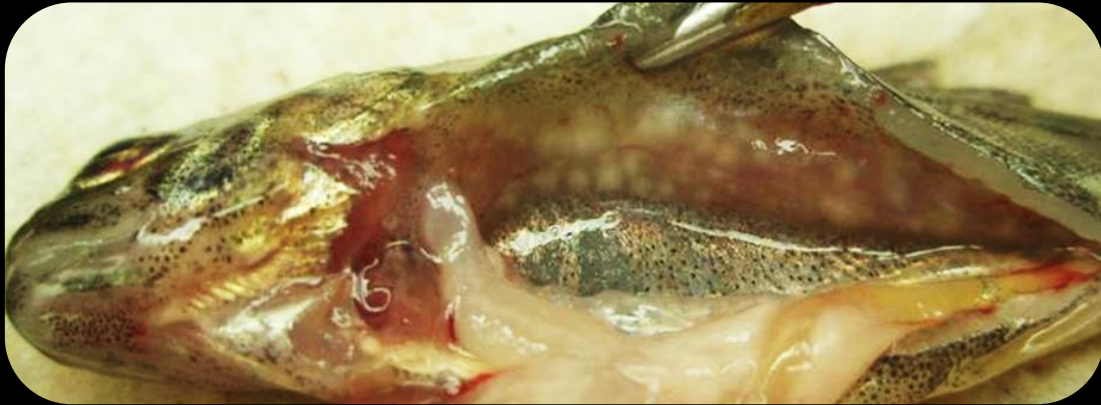
*Renibacterium salmoninarum*

*Flavobacterium psychrophilum*



# R. salmoninarum

- Bacterial Kidney Disease**



Kalamazoo Gazette  
April 13, 1991

## DNR waging battle against salmon-killing disease

HOWARD MEYERSON  
GAZETTE NEWS SERVICE

LANSING — Bacterial kidney disease is taking a far greater toll on Lake Michigan salmon than previously thought, Department of Natural Resources officials said recently while unveiling a new strategy to eradicate the problem.

New research shows 40 percent to 50 percent of the 5 million chinook planted annually in Lake Michigan die from the disease before they are 3 years old.

Other findings indicate that BKD exists throughout Michigan's chinook hatchery stock; BKD is prevalent in Illinois, Wisconsin and Indiana waters; and young fish are highly susceptible, becoming sick at year one and dying by year three.

"We are now spearheading an effort to have all of the chinook and coho we stock in Lake Michigan come from non-BKD sources and raised on BKD-free water supplies," said DNR fish chief John Robertson.

The new BKD control strategy involves getting 16 million salmon eggs from New York. Robertson called the plan "a big-time initiative" when he apprised the Lake Michigan Salmonid Task Force of the latest BKD findings. The task force was formed three years ago to address the issue of a declining Lake Michigan salmon fishery.

Robertson said the effects are far greater than previously thought.

along with angler's reports confirmed the idea. As such, BKD was considered one of many factors contributing to the decline.

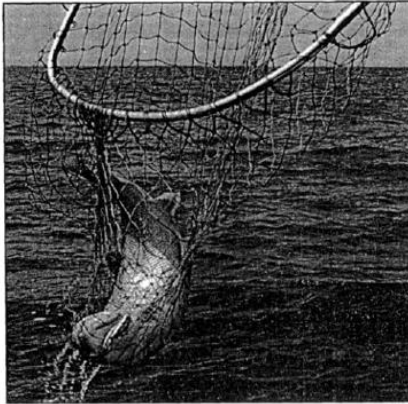
"We have been very misled by what we have seen on the beach," Robertson said, adding that when young fish die and surface they are often eaten by seagulls and cormorants, and depending on season and prevailing winds, dead and dying fish may sink to the bottom.

Denny Grinold, the Michigan Charter Boat Association representative on the task force, says that confirms what anglers have reported as far back as 1977. Reports of dead fish on the bottom were investigated by DNR staff but never confirmed.

"I'd be the last one to say I told you so," Grinold said, "but back when fish started washing up on the beaches of Illinois and Indiana, and the airplane trips over beaches to count dead fish emphasized a few hundred fish, we thought there had to be much more dead salmon going to the bottom and pointed that out three years ago."

Robertson said the agency's new research is limited, offering only one year of information and will be fleshed out in time. But the laboratory and open-water studies proved significant, providing the first data about the adult life history of the salmon and shedding light on the BKD problem.

Studies at the DNR's Wolf Lake Hatch-



ed to result in a steadily diminishing population of infected fish and an increasing population of healthy ones, Smith said.

Preliminary findings of open-water research on Lake Michigan, where 850 salmon smolts were settled along the beach, gave no indication of BKD occurring in wild, naturally reproducing fish, Robertson explained. It was clearly the young hatchery fish that were affected.

"We need two to four years of data to really home in on the mortality rate, but our estimates were that 40 to 50 percent are being knocked out before they reach their third year," Smith said.

Grinold of the Michigan Charter Boat Association said when you add natural mortality rates to those BKD mortality rates, the fishing situation starts to make sense. At its peak in 1986, Lake Michigan's chinook catch rate was 103 fish per 100 angler hours. At low ebb in 1985 and 1990, it was 3.4 fish per 100 hours.

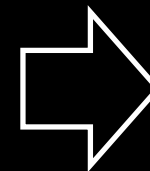
"It jibes," Grinold said. "Fishing is different these days as much as it is poor with new habits for feeding, so catch rates are down. If you add in natural mortality at 10 to 15 percent, you are now into a 60 to 70 percent decline."

Grinold believes the DNR "is on the right track" in fighting the BKD problem, calling the New York egg program "an excellent approach."

"Nothing will happen to resolve the sport fishing problem until the BKD problem is solved," he said.

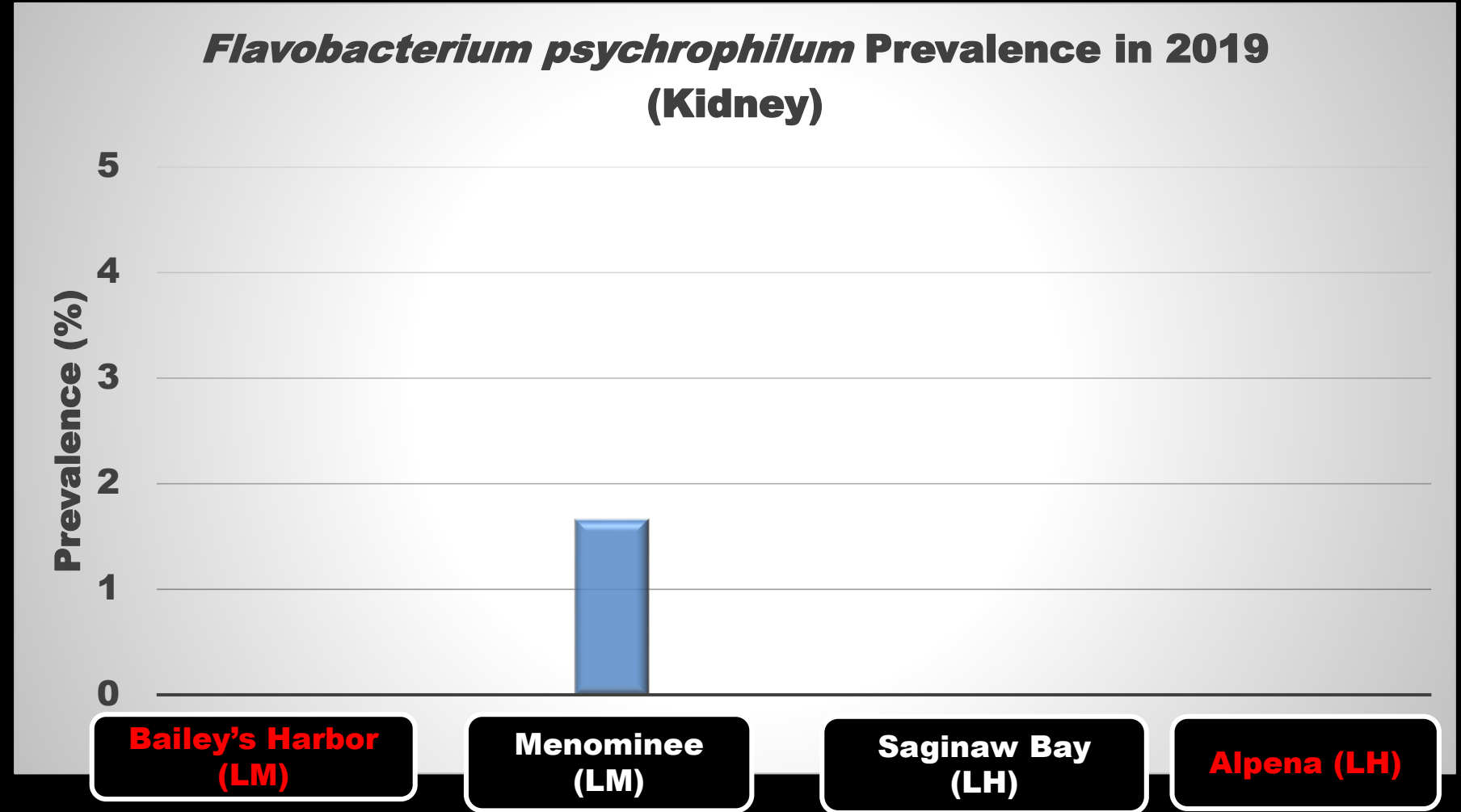
# F. psychrophilum

- Bacterial Coldwater Disease**



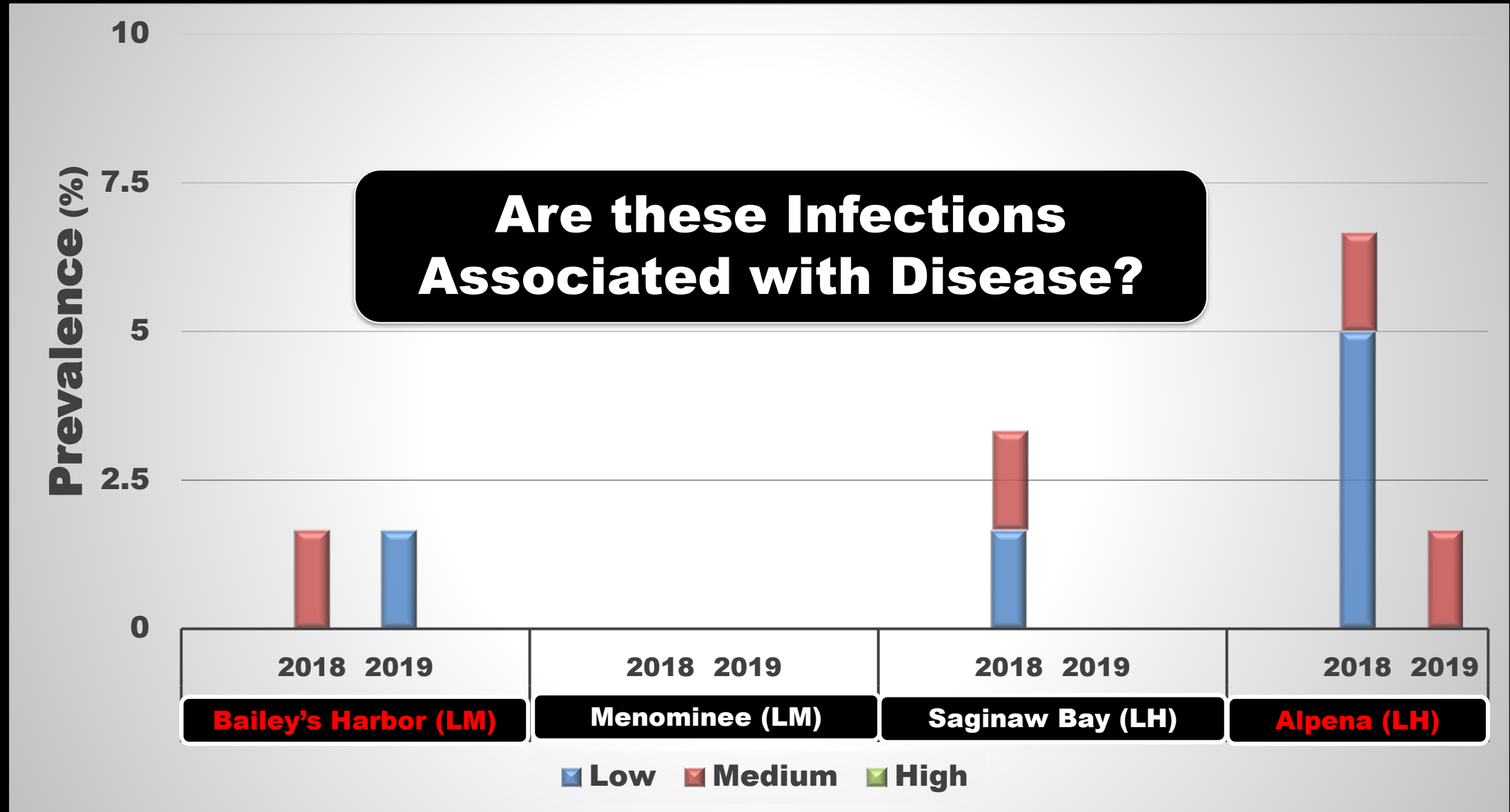
**Top 5  
Impediment  
to  
Aquaculture  
Globally**

# First Detection of *F. psychrophilum* in GL LWF



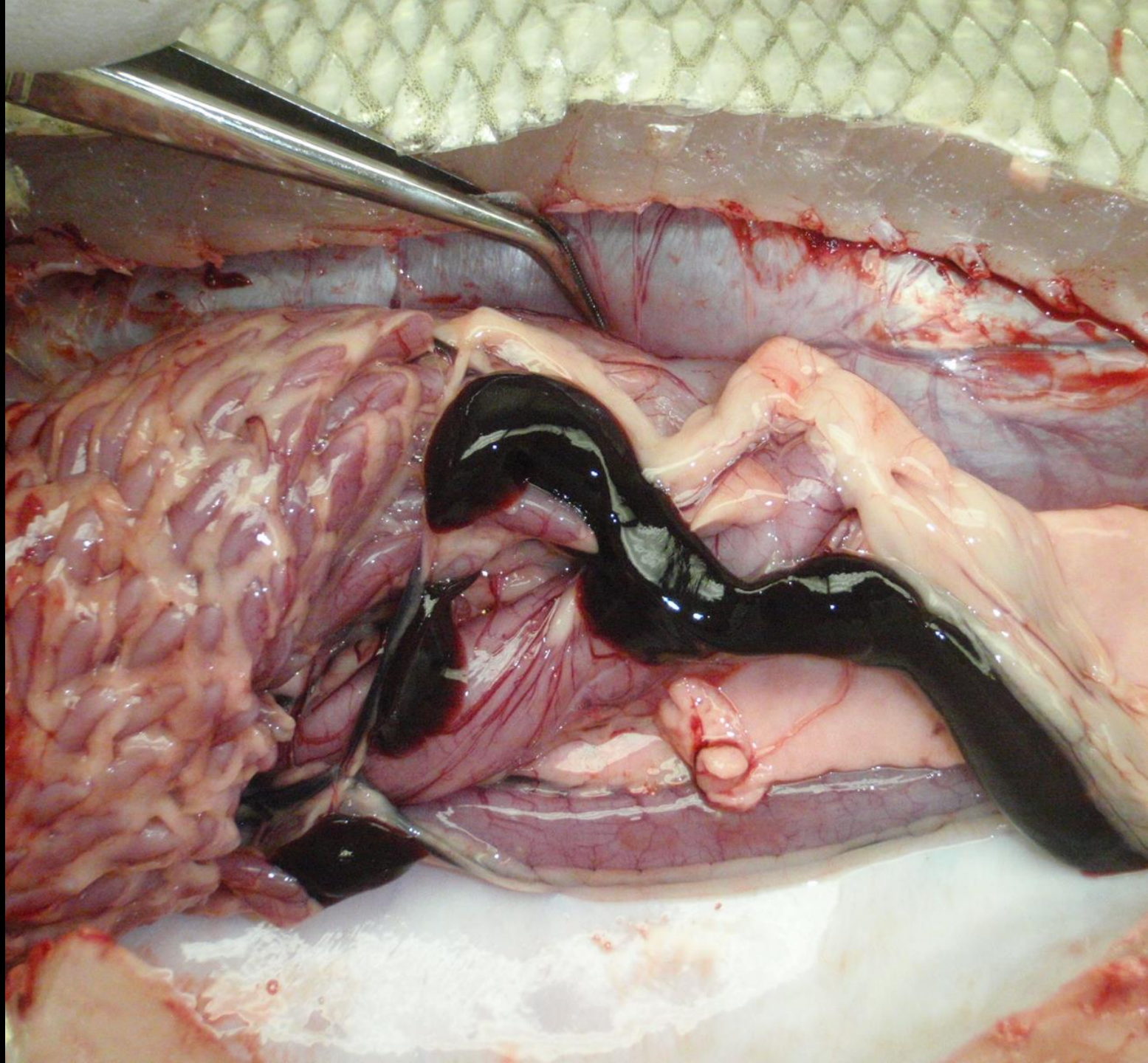


# *R. salmoninarum* Infection Prevalence (KSH)



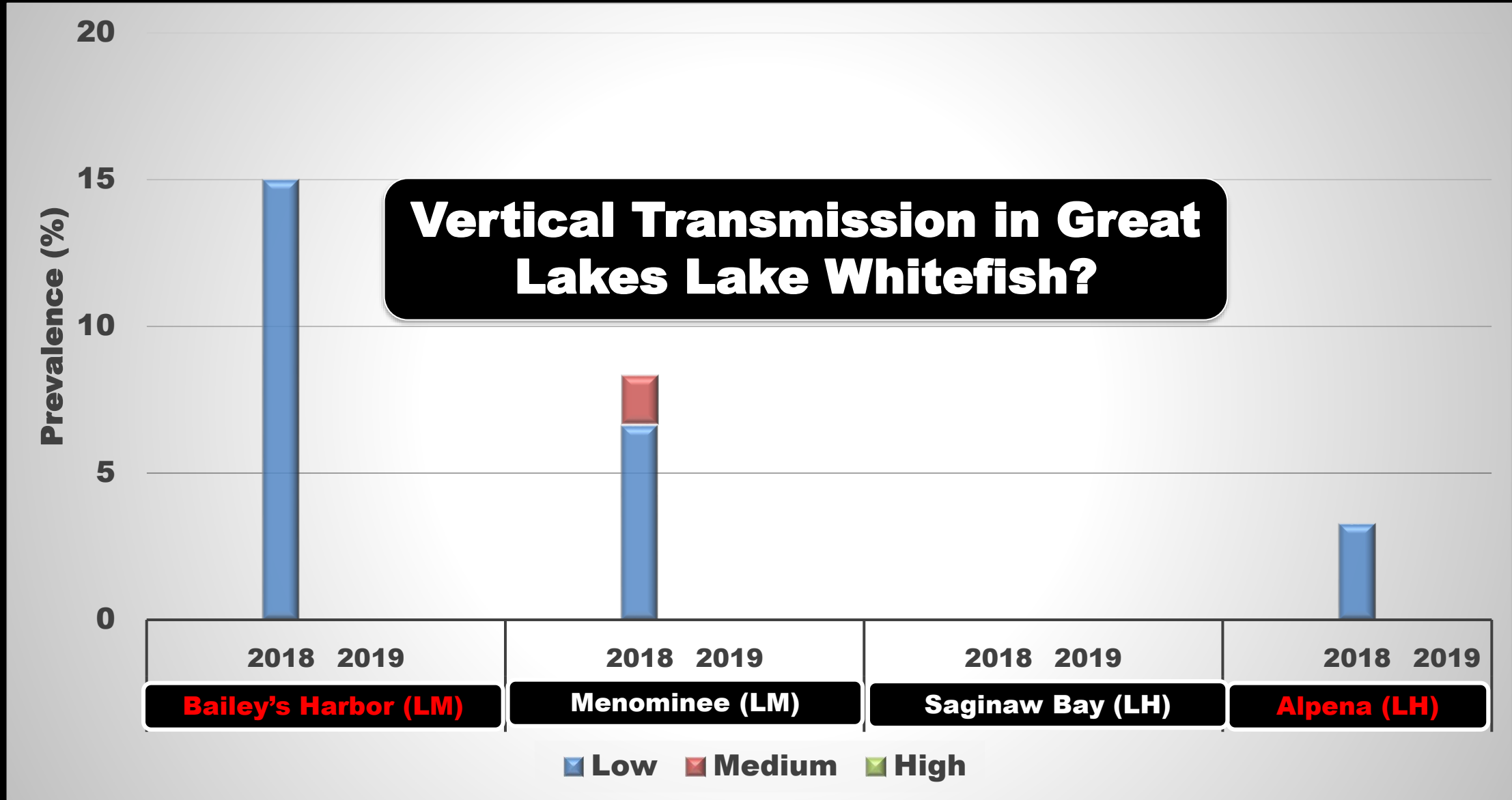
Detection via semi-quantitative ELISA







# *R. salmoninarum* Infection Prevalence (Gonads)



Detection via semi-quantitative ELISA

# Infectious Diseases in Juvenile LWF?



## 2019 Age-0 LWF Collections

- **Bailey's Harbor (LM), n=150**
- **Thunder Bay, Alpena (LH), n=150**
- **Whitefish Bay (LS), n=24**
- **Caseville, Saginaw Bay (LH), n=1**
- **Menominee (LM), n=0**



**What are their effects  
on juvenile LWF  
health?**

**Will climate change  
exacerbate any such  
effects?**



# Conclusions Thus Far

- **Well-known fish pathogens recovered from reproductive tissues of GL LWF for the first time**
- **Some infections were associated with severe signs of disease in the affected host**
- **Is there evidence for transmission between generations, and what effect can these infections have during the early life stages?**

# Great Lakes Fishery Conservation

```
graph TD; A[Great Lakes Fishery Conservation] --> B[Hatchery-Based]; A --> C[Management of Wild Fisheries]; A --> D[Aquaculture]; E[Infectious Disease] --> B; E --> C; E --> D;
```

**Hatchery-  
Based**

**Management of  
Wild Fisheries**

**Aquaculture**

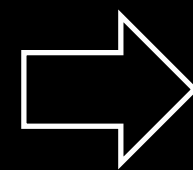
**Infectious  
Disease**



# Great Lakes Lake Sturgeon



**Infectious Diseases of  
GL Lake Sturgeon**



**???**

# Streamside Rearing of GL Lake Sturgeon



**Mortality Events of Unknown Cause(s)**

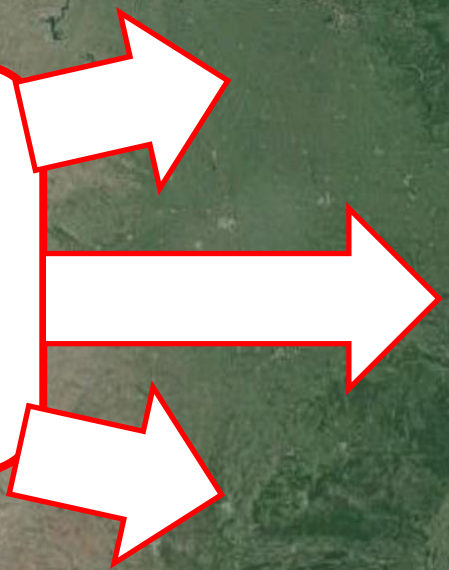


**Sturgeon Pathogenic  
Microbes**



**???**

**Sturgeon  
Pathogenic  
Microbes**



# Assessing the risk of emergent and endemic fish pathogens to Great Lakes lake sturgeon



**Amber E. Johnston, Megan A. Shavalier, Kim T. Scribner, Esteban Soto, Edward A. Baker, Douglas Larson, Thomas P. Loch**



# Adults GL Lake Sturgeon Sampling Sites



<b>Site</b>	<b># Sampled (2019)</b>
<b>Black River</b>	<b>137</b>
<b>St. Clair River</b>	<b>76</b>
<b>Peshtigo River</b>	<b>19</b>



# Blood & Tissue Biopsy Collection (Adults)



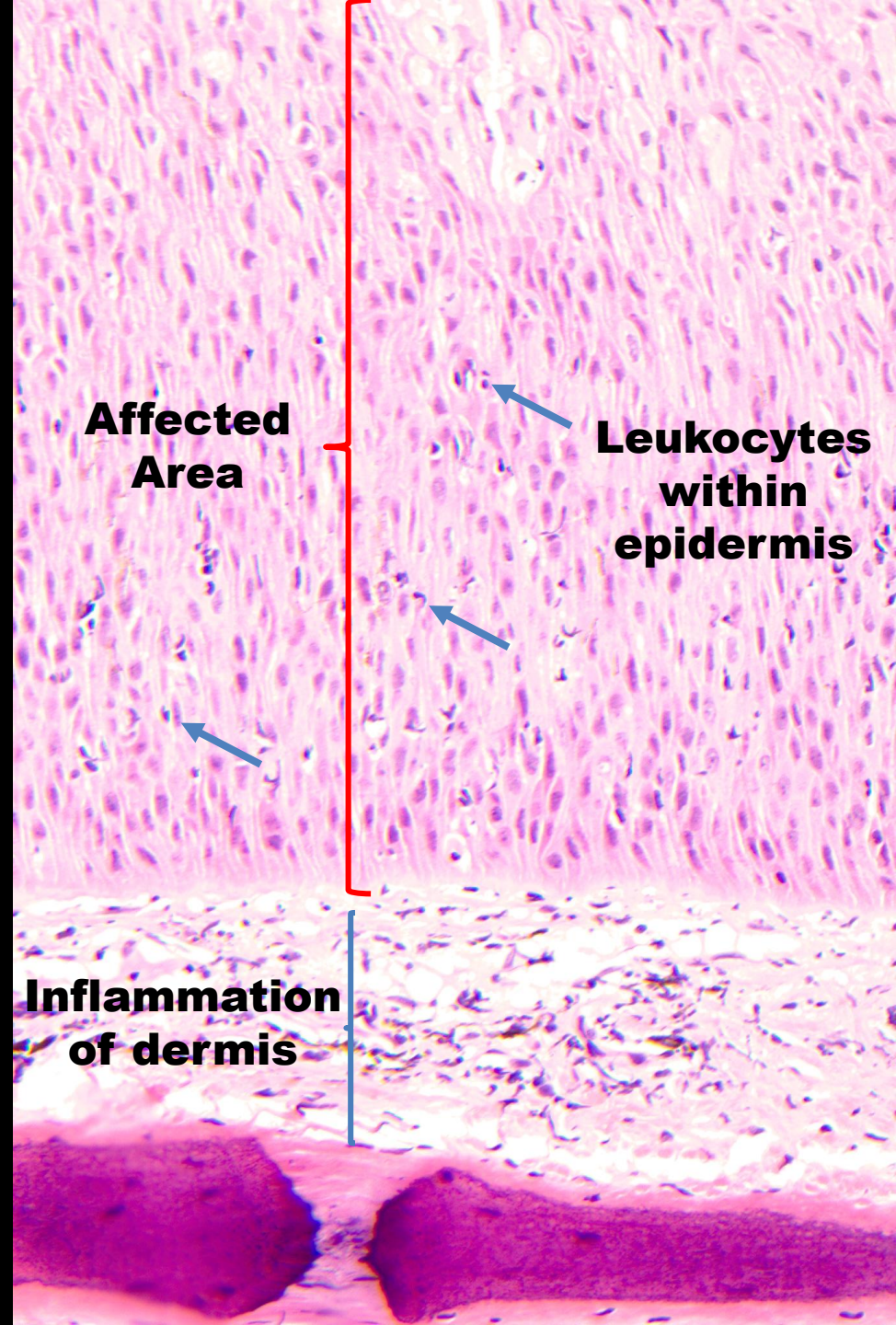
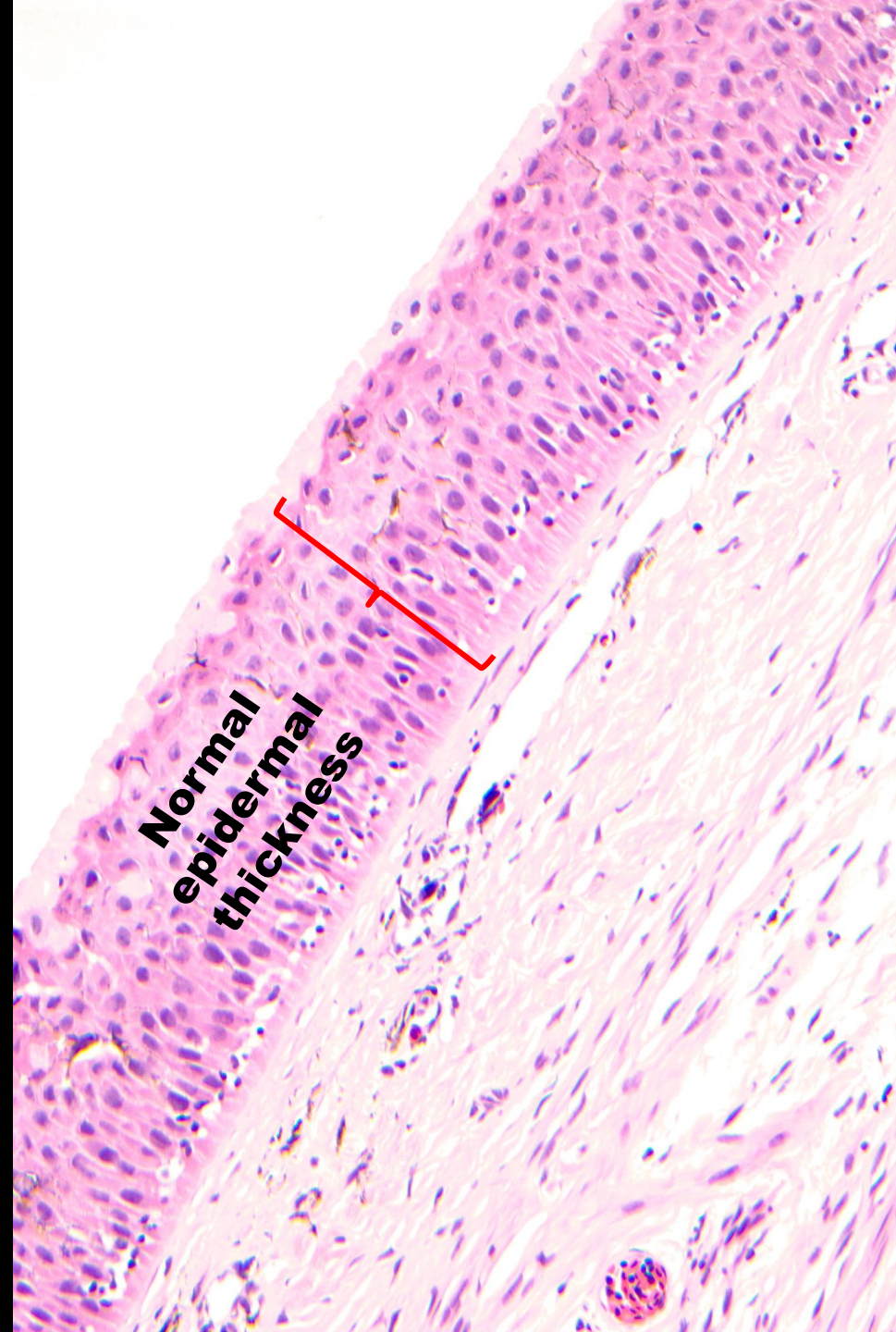
**Virological, bacteriological, histopathological, molecular, hematological analyses**



**Thus Far (2019)...**  
**~5% (Black River)**  
**~1% (St. Clair River)**  
**0% (Peshtigo River)**









# Acipenserid Herpesviruses

## Isolation of an epitheliotropic herpesvirus from white sturgeon *Acipenser transmontanus*

R. P. Hedrick<sup>1,\*</sup>, T. S. McDowell<sup>1</sup>, J. M. Groff<sup>1</sup>, S. Yun<sup>1</sup>, W. H. Wingfield<sup>2</sup>

<sup>1</sup> Department of Medicine, University of California, Davis, California 95616, USA

<sup>2</sup> California Department of Fish and Game, Fish Disease Laboratory, Rancho Cordova, California 95670, USA

## Case report: concurrent herpesviral and presumptive iridoviral infection associated with disease in cultured shortnose sturgeon, *Acipenser brevirostrum* (L.), from the Atlantic coast of Canada

S E LaPatra<sup>1</sup>, J M Groff<sup>2</sup>, I Keith<sup>3</sup>, W E Hogans<sup>4</sup> and D Groman<sup>5</sup>

<sup>1</sup> Research Division, Clear Springs Foods, Inc., Buhl, ID, USA

<sup>2</sup> Department of Pathology, Microbiology and Immunology, School of Veterinary Medicine, University of Califor-

## Characteristics and pathogenicity of a novel herpesvirus isolated from adult and subadult white sturgeon *Acipenser transmontanus*

L. R. Watson, S. C. Yun, J. M. Groff, R. P. Hedrick\*

Department of Medicine and Epidemiology, School of Veterinary Medicine, University of California, Davis,  
California 95616, USA

# Molecular Analysis

**Nucleic  
acid  
extraction**



**PCR Amp. of  
DNA  
polymerase  
gene**



**Sequencing  
of Viral DNA**

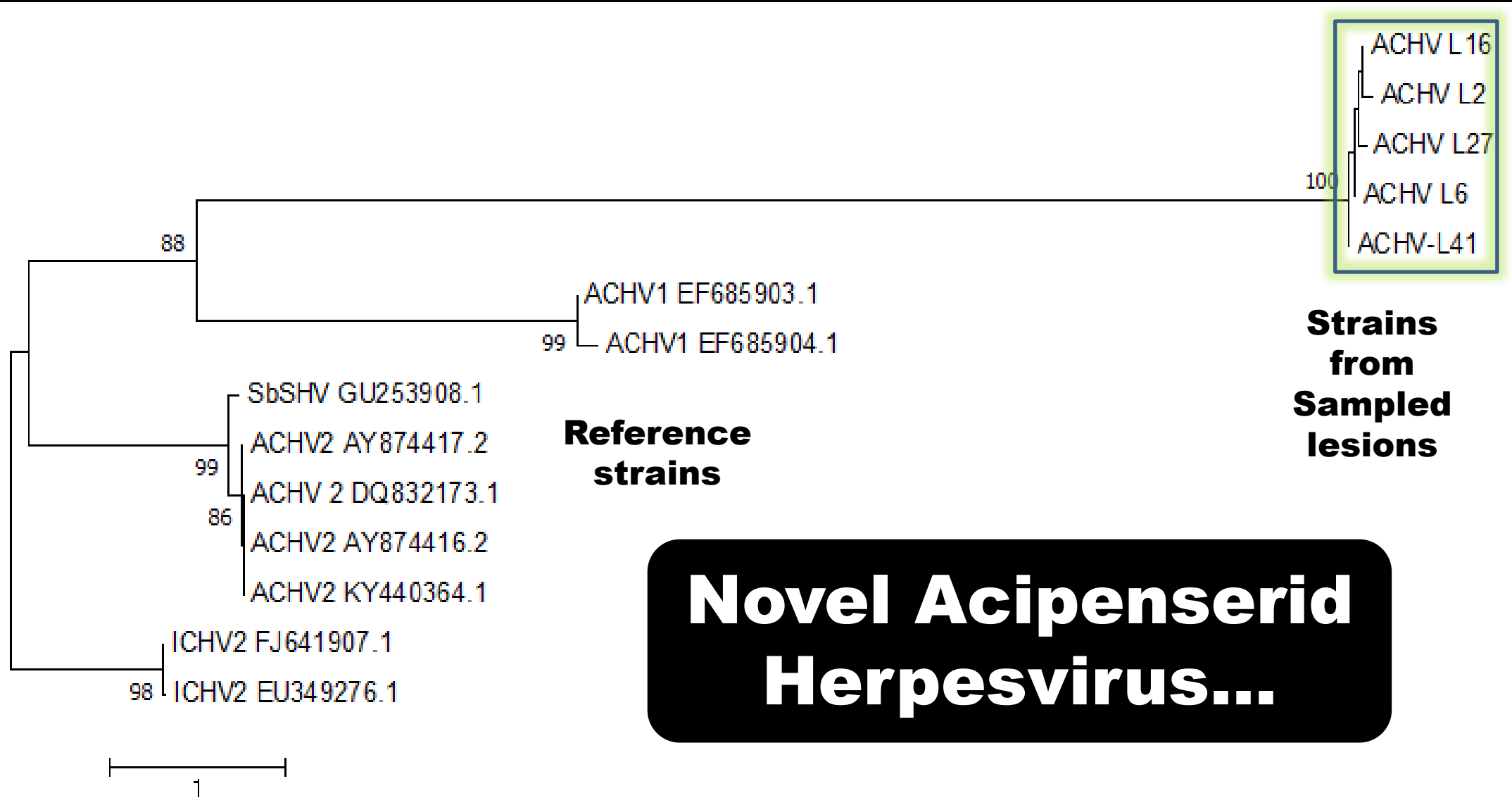


**Phylogenetic  
Analysis**





# Phylogenetic Analyses



**Parent to  
offspring  
transmission  
?**

**Any role in  
unexplained  
hatchery  
mortality  
events?**

**Any role in  
Great Lakes  
lake  
sturgeon  
declines?**

**Will  
environmental  
“challenges”  
exacerbate  
effects?**

**Susceptible  
to current  
hatchery  
disinfectants  
?**

**Future  
disease  
prevention?**



# Great Lakes Fishery Conservation

```
graph TD; A[Great Lakes Fishery Conservation] --> B[Hatchery-Based]; A --> C[Management of Wild Fisheries]; A --> D[Aquaculture]; E[Infectious Disease] --> B; E --> C; E --> D;
```

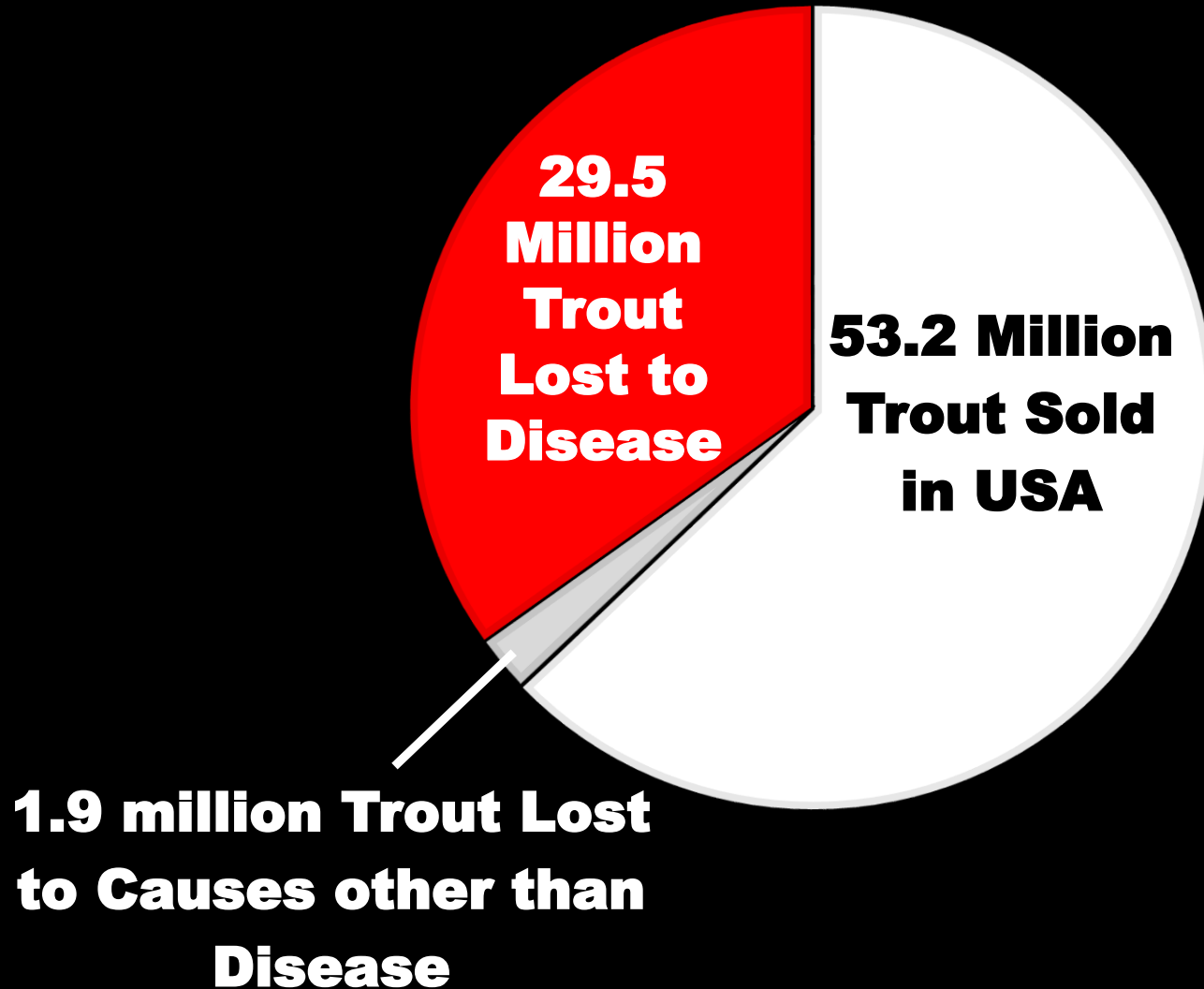
**Hatchery-  
Based**

**Management of  
Wild Fisheries**

**Aquaculture**

**Infectious  
Disease**

# Aquaculture & Fish Disease (2017)



Source: USDA – National Agriculture Statistics Service (2018)



# Flavobacteria



# Bacterial Coldwater Disease



**<90% Mortality in  
Affected Captive Fish  
Stocks**

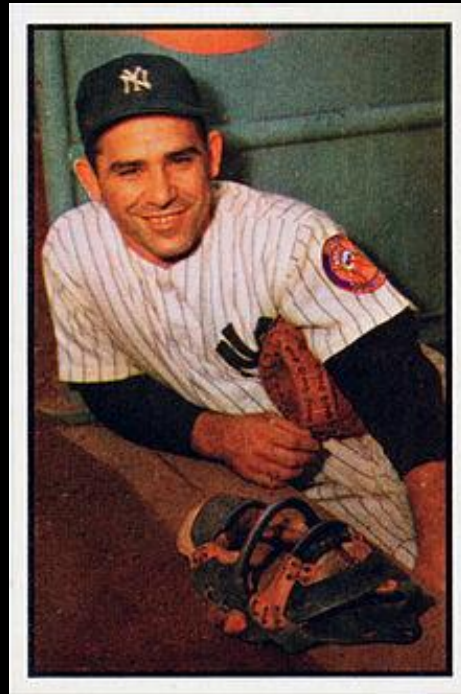


# CARE AND DISEASES OF TROUT

---

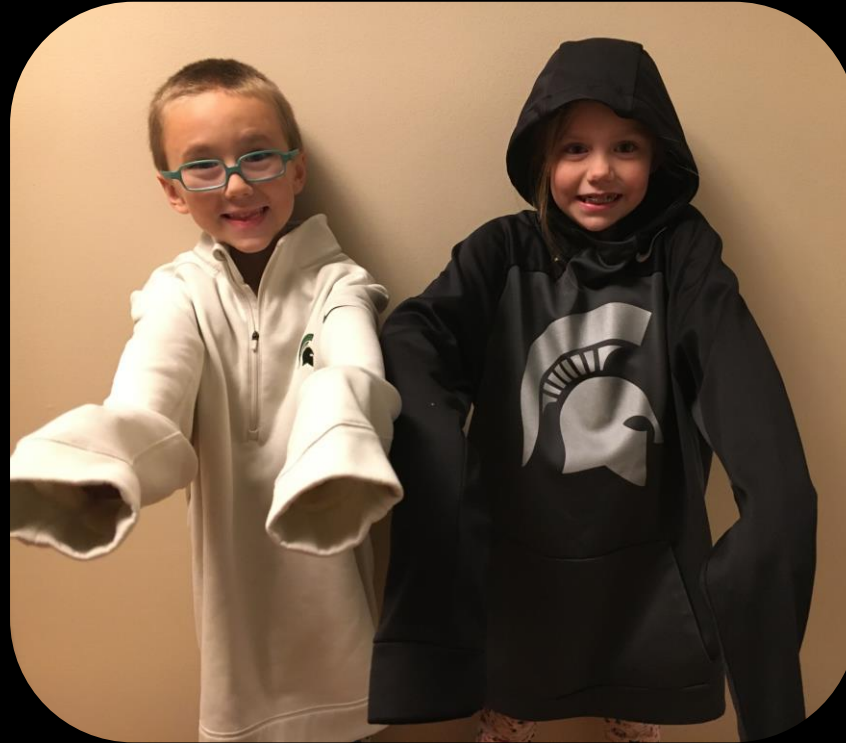
By H. S. DAVIS

Revised edition, 1946



# Why Have Adequate BCWD Prevention & Control Measures Yet to be Realized?

**Virulence?**



**Vaccination?**

**Antibiotic  
Susceptibility?**



# Flavobacterial Diversity and its Effect on Disease in Aquaculture

**C. Knupp<sup>1</sup>, D. Call<sup>3</sup>, K. Cain<sup>4</sup>, G. Wiens<sup>5</sup>, T.J. Bruce<sup>4</sup>, J. Ma<sup>4</sup>, M. Faisal<sup>1,2</sup>, T.P. Loch<sup>1,2</sup>**

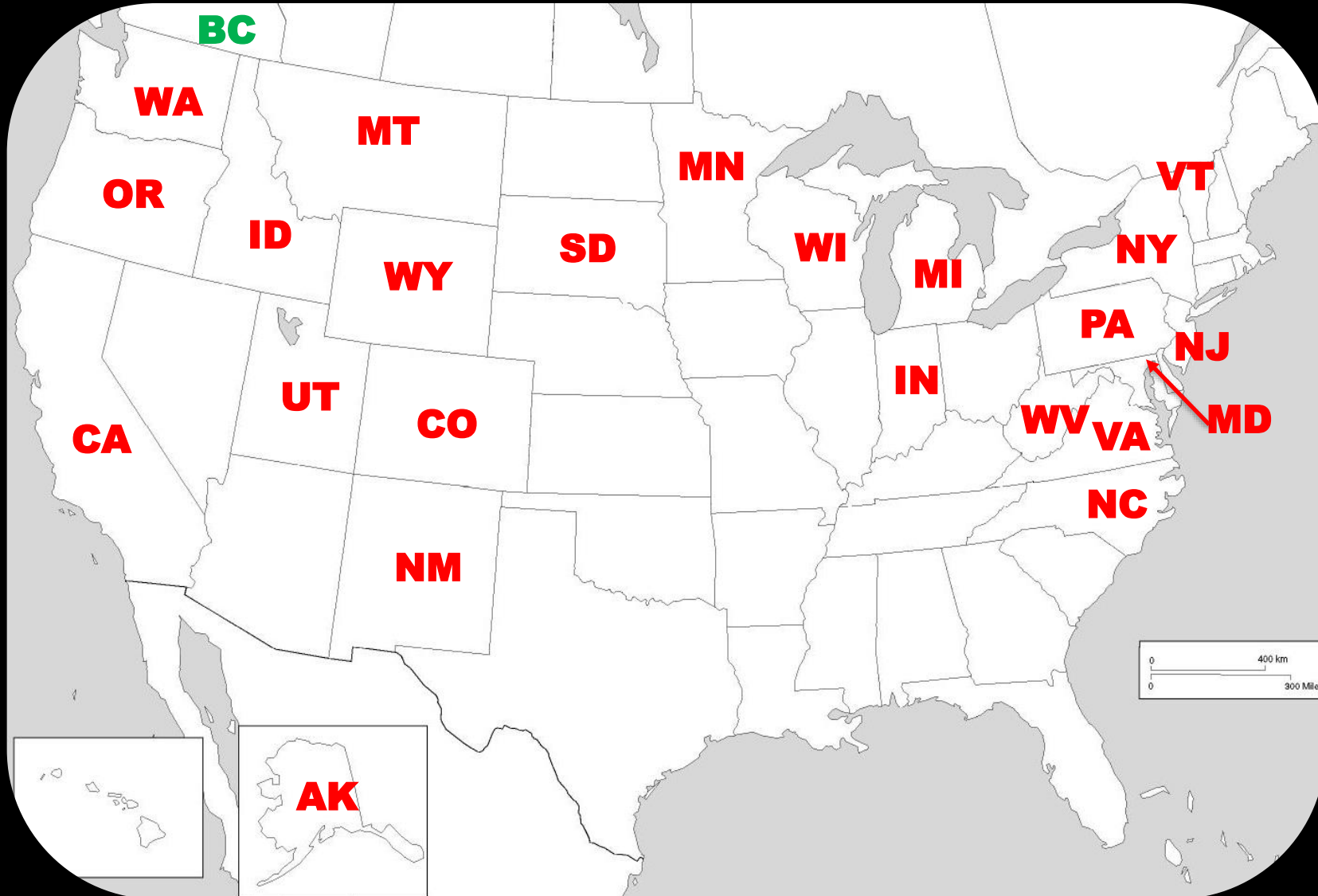
<sup>1</sup>Department of Fisheries & Wildlife, Michigan State University, East Lansing MI; <sup>2</sup>Department of Pathobiology & Diagnostic Investigation, Michigan State University, East Lansing, MI; <sup>3</sup>Department of Veterinary Microbiology and Pathology, Washington State University, Pullman, WA; <sup>4</sup>Department of Fish and Wildlife Sciences, University of Idaho, Moscow, ID; <sup>5</sup>United States Department of Agriculture – Agricultural Research Service, Kearneysville, WV 25430

**USDA**



**Chris  
Knupp,  
PhD  
Student**

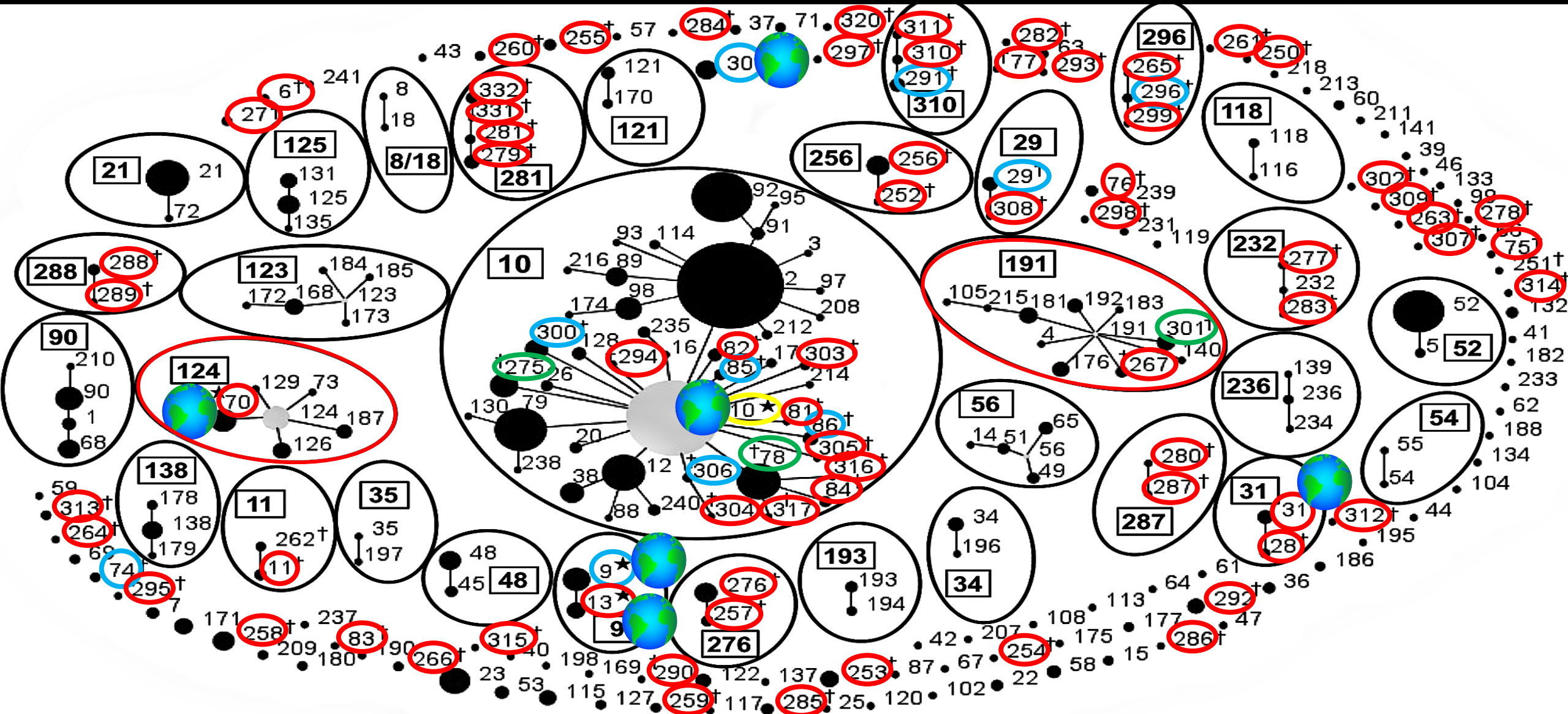
# *F. psychrophilum* from Across the USA



- **>470 *Fp* isolates (& growing!)**
- **23 States, 1 Province**
- **4 decades (1981-2019)**

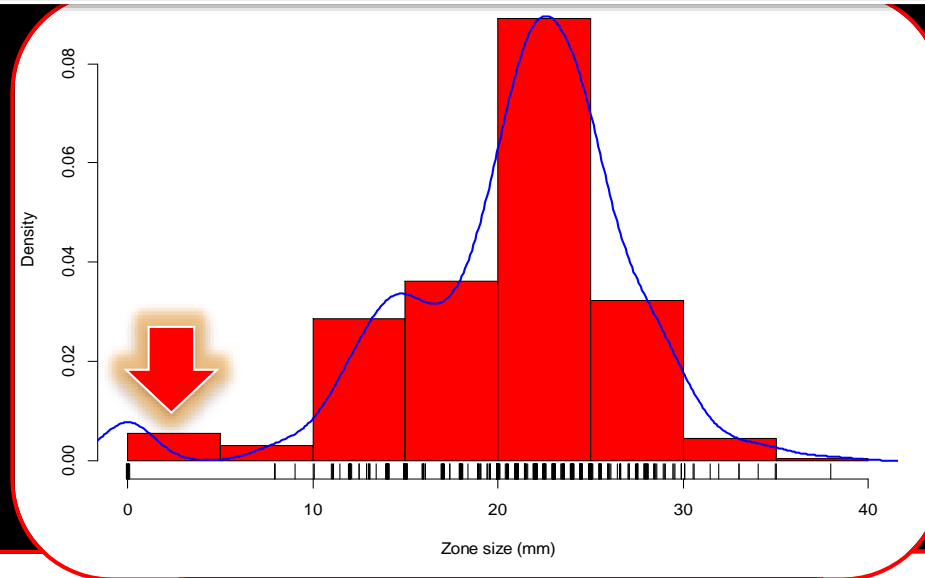


# *F. psychrophilum* Genetic Diversity (Multilocus sequence typing)



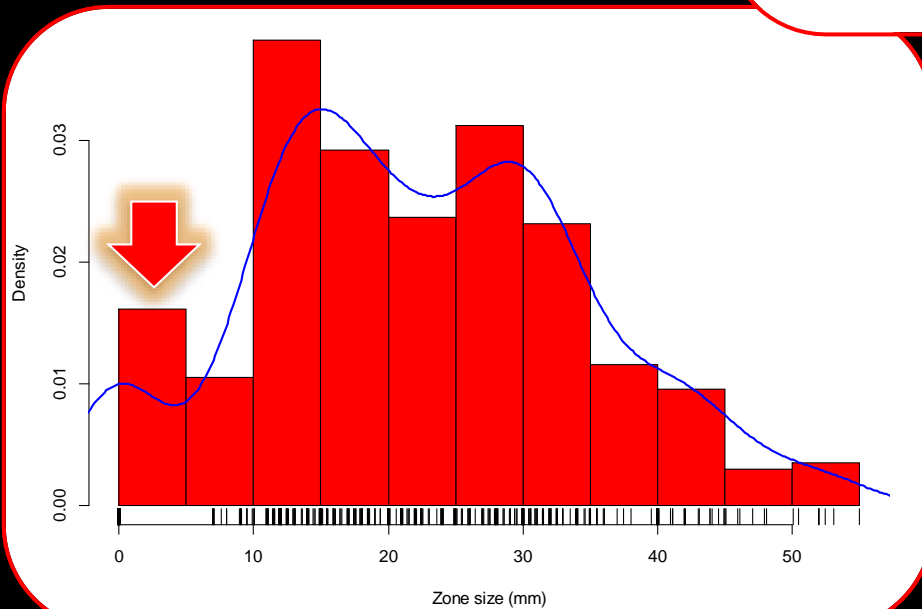
# *F. psychrophilum* Antibiotic “Susceptibility” (USA)

Distribution of Zone Sizes for Florfenicol (1 µg)

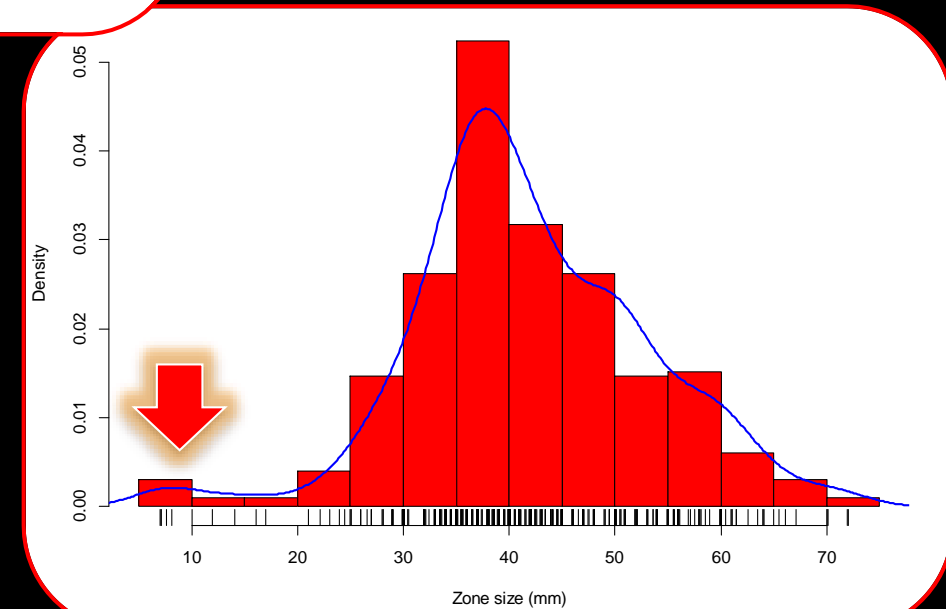


WASHINGTON STATE  
UNIVERSITY

n=>390

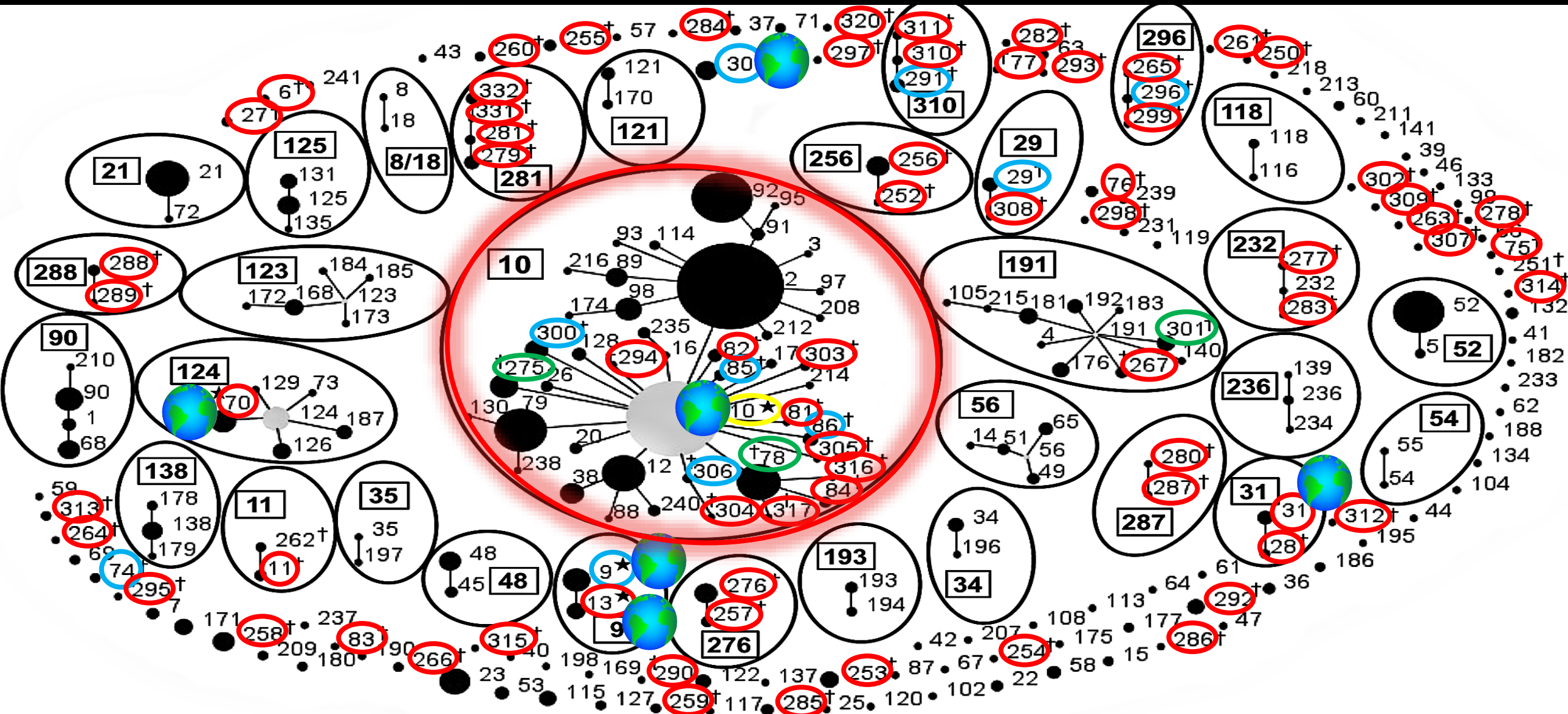


Dist. of Zone Sizes for Sulfa-Trimethoprim (3.75/1.25 µg)



Distribution of Zone Sizes for Oxytetracycline (30 µg)

# *F. psychrophilum* Genetic Diversity (Multilocus sequence typing)





# Conclusions

- **Intraspecific *F. psychrophilum* diversity is substantial, but top “troublemakers” in the USA (& GL) identified**
- **Evidence for transmission via egg trade**
- **“Troublemakers” more likely to “resist” approved antibiotics (mechanism(s) = ???)**
- **Ongoing studies: vaccine development, improved egg disinfection, and elucidating *F. psychrophilum* disease ecology in hatcheries/aquaculture**

# **Great Lakes Fish Health in the 21<sup>st</sup> Century**

- **The “unknowns” we need to know are many...**
- **The challenges facing Great Lakes fishes, as well as the agencies that manage them, are many...**
- **Need to ensure that resources and effort to address such challenges thru science-based decision-making are equally numerous...**
- **Thank goodness dedicated and intelligent people like yourselves are likewise numerous!**

# Acknowledgements

## Funding Agencies:

- MDNR Fisheries Division
- USDA - NIFA (2016-67015-24891, 2016-70007-25756)
- USFWS - GLFWRA (F19AP00229)
- GLFT (2018.1806)

Gary Whelan, Martha VanAmberg, Ed Eisch, Jan VanAmberg, Aaron Switzer, Jim Aho, Randy Espinoza, Dan Sampson, Paul Stowe, Jon Jackoviak, Matt Hughes, Roger Greil, Seth Herbst, many others from MDNR Fisheries Div.!

Kim Scribner, Esteban Soto, Ed Baker, Doug Larson, Todd Wills, Jon Bauman, Michael Donofrio, Henry Quinlan, Glenn Miller, Andrew Briggs, Brad Utrup, Roy Beasley, Jeremy Maranowski

Pierre Nicolas, Claudia Deobald, Keira Osbourn, Danielle Van Vliet, Coja Yamashita, Jayde Ferguson, Dave Meuninck, Hui-Min Hsu, Bridget Baker, Ling Shen, Geoff Grocock, Carl Smith, Danielle Godard



- Travis Brendan, Mark Ebener, Todd Williams, Sam McMurry, Tony LeBlanc, Ralph Wilcox, Todd Stuth
- Little Traverse Bay Bands of Odawa Indians
- Michelle Van Deuren, Dr. Megan Shavalier, & other past and present MSU – AAHL Colleagues