OTOLITH CHEMICAL ANALYSIS

Lake Michigan Steelhead: Where were you hatched?

Nicole Watson[1], Steven Hummel[1], Jory Jonas[2], James Student[1], Kevin Pangle[1]

[1] Central Michigan University

[2] Michigan Department of Natural Resources

Great Lakes Steelhead

Ecologically and economically important species

Strong motivation to manage in an efficient and sustainable fashion

Mixed Stock

- Hatchery-released and wild fish
- Lake population from many different tributaries
- Significant amount of fish are wild, naturally reproducing

Complex Population

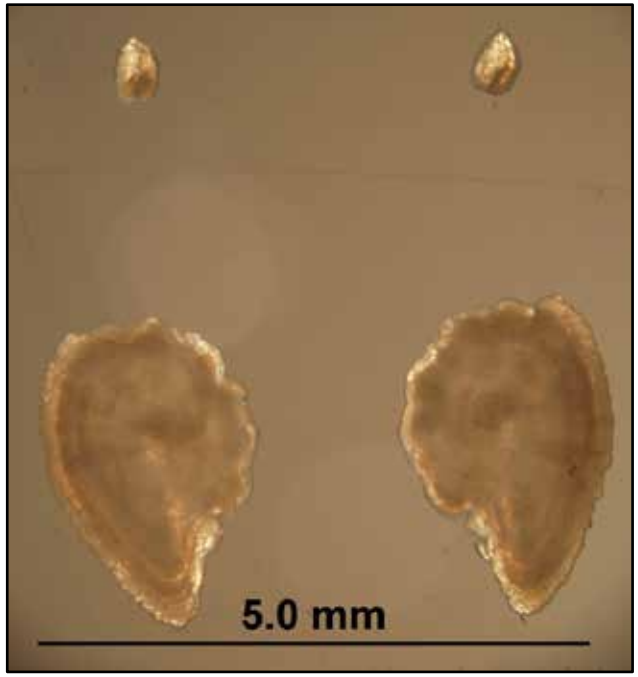
- Unequal contribution of steelhead stocks to total lake population

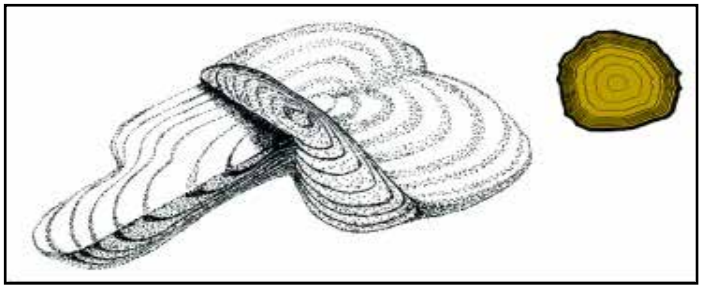
Management

- It's complicated
- Knowledge of natal origin is important
- Target conservation and management to the areas that are the major contributors to the total population

What are Otoliths?

- Hard calcium carbonate structures located behind the brain
- Commonly referred to as “lucky stones”
- Hearing, balance, orientation
- Daily growth

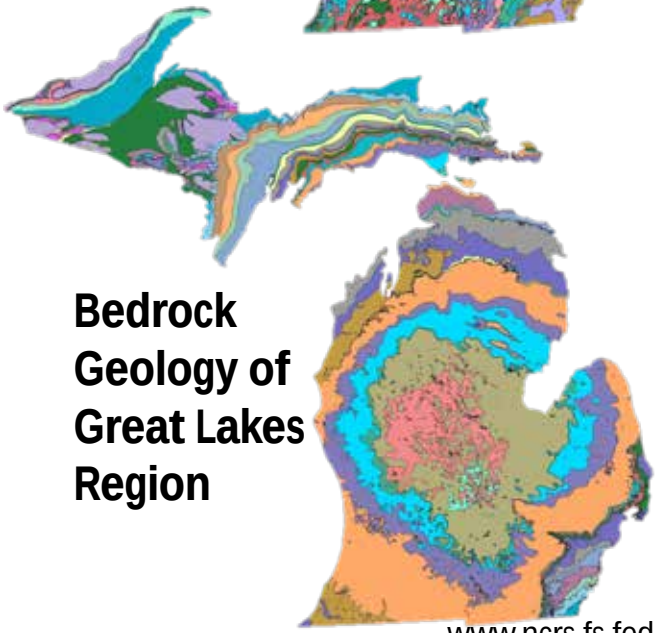




Otolith Chemistry in the Great Lakes

- Otolith chemical analysis can be used to determine natal origins in the Great Lakes
  - Unique geology
- Strontium (Sr)and Barium (Ba)
  - Others of importance: magnesium (Mg), manganese (Mn), iron (Fe), lead (Pb), copper (Cu)

Surficial Geology of Great Lakes Region



Bedrock Geology of Great Lakes Region

www.ncrs.fs.fed.us

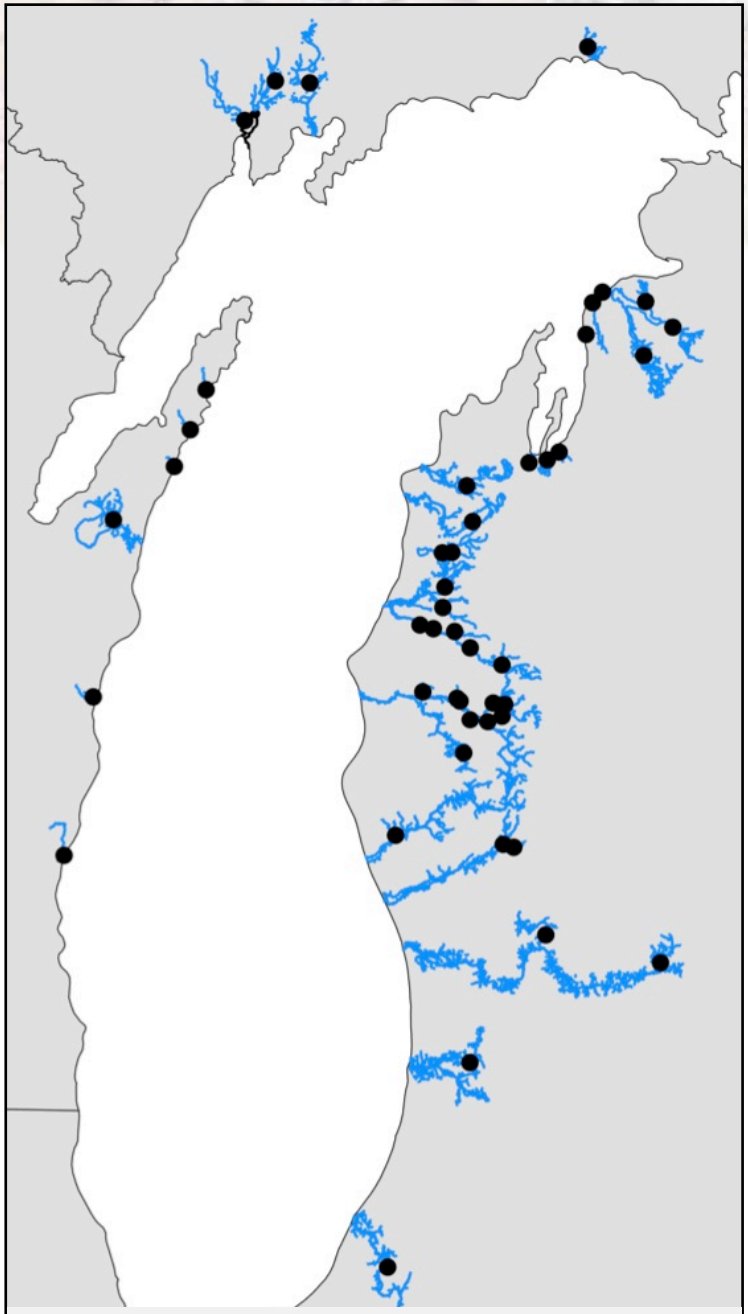
Steelhead Otolith Chemistry

- ***Long-term Goal:*** Determine natal origin of adult fish
- ***Impact:***
  - Identify sources and evaluate the contribution of wild, naturally reproducing steelhead
  - Effective conservation and management of steelhead and natal habitats
- ***This study:*** Utility of otolith chemistry to determine natal origins of young fish of known origin
  - Spatial scale
    - Stream (fine) vs. Regional (coarse)
  - Age class effects:
    - Young-of-year (YOY) vs. Year-one-and-older (YOAO)

Methods: Field Collections

2013-2016

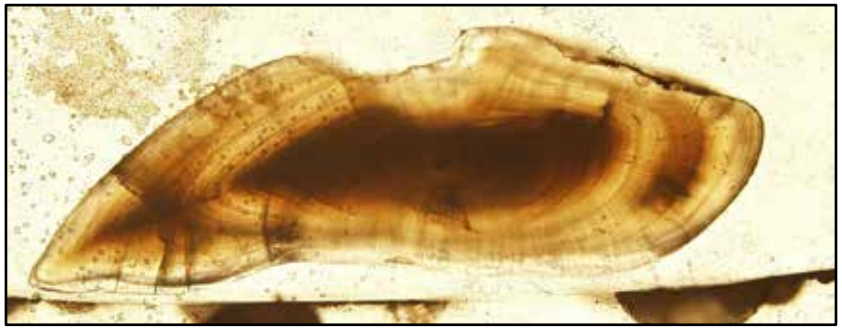
- Spring and Fall
  - Spring: Age 1+ (YOAO)
  - Fall: Age 0 (YOY)
- Comprehensive Sampling
  - Primary contributors to lake population
  - Major watersheds
    - 36 Lower Peninsula (MI)
    - 4 Upper Peninsula (MI)
    - 6 Wisconsin

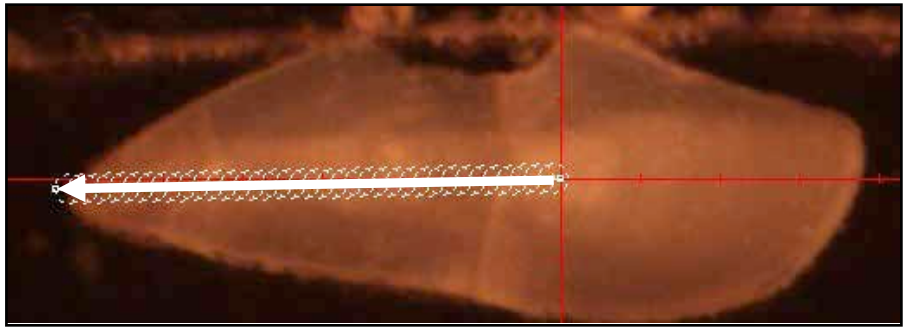


Each black dot is a site

Methods: Otoliths

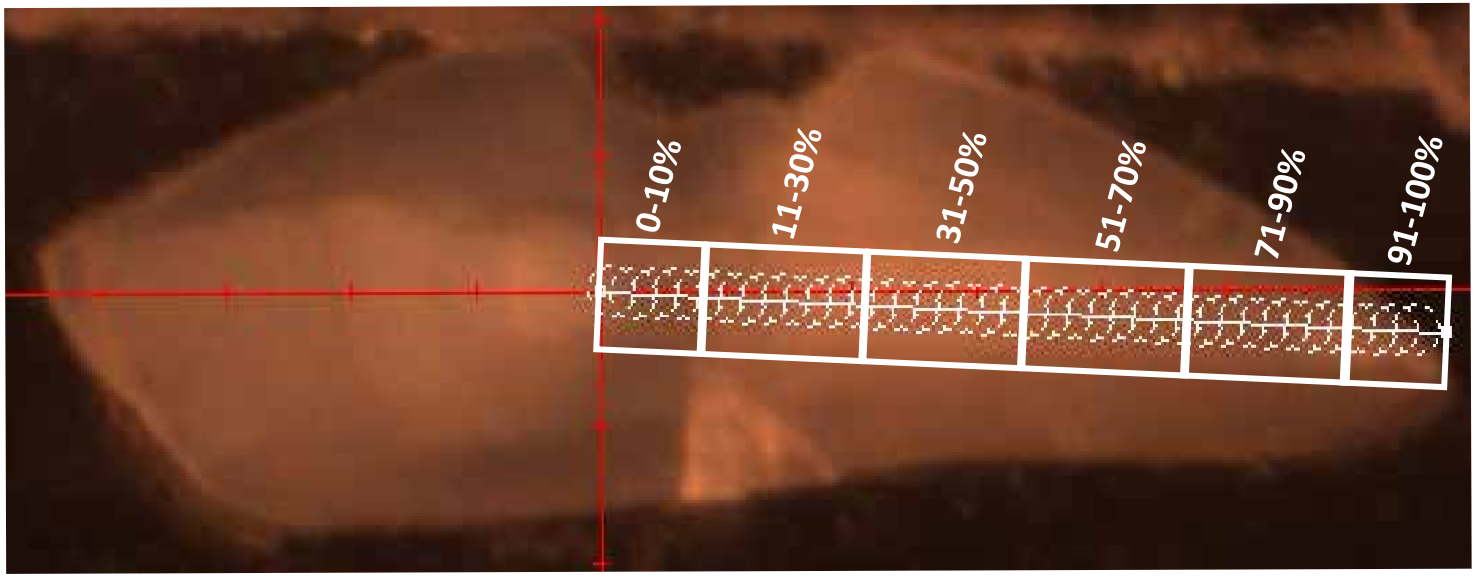
- Otoliths are removed, embedded in epoxy, sectioned to 300µm, and polished until the core is visible
- Laser-ablation inductively coupled plasma mass spectrometry (LA-ICP-MS)
  - Core to edge transect
  - Pulse rate: 8-12Hz
  - Circular spot size: 40µm
  - Pass rate: 6µm/s





Methods: Data Analysis

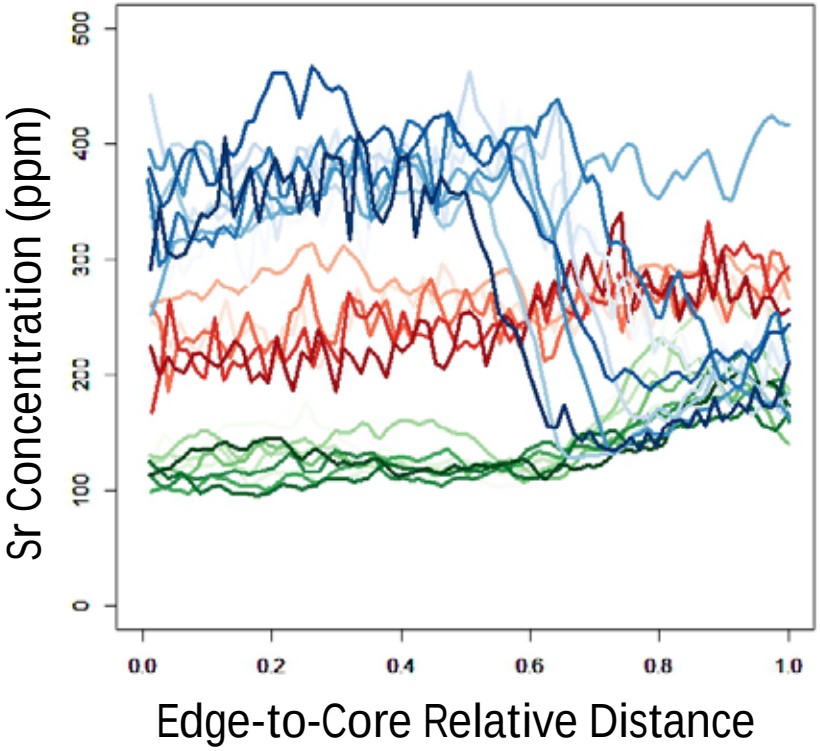
- Classification accuracies are based on random forest analysis
  - Transects are divided into regions for data analysis
  - Groupings are based on spatial resolution

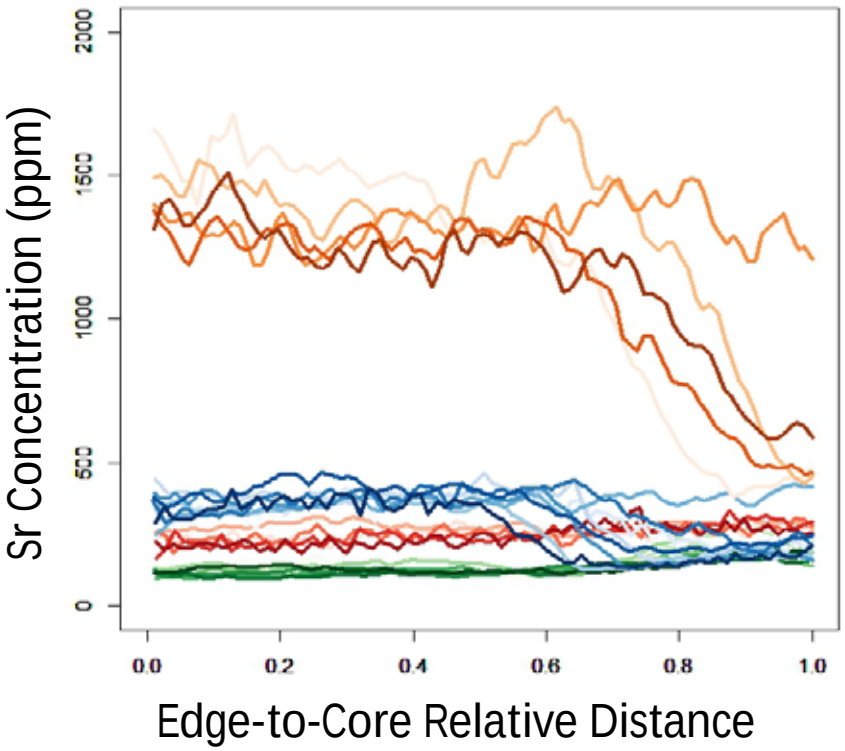


Results: Unique Signatures

Streams with unique geology or anthropogenic effects result in unique otolith signatures

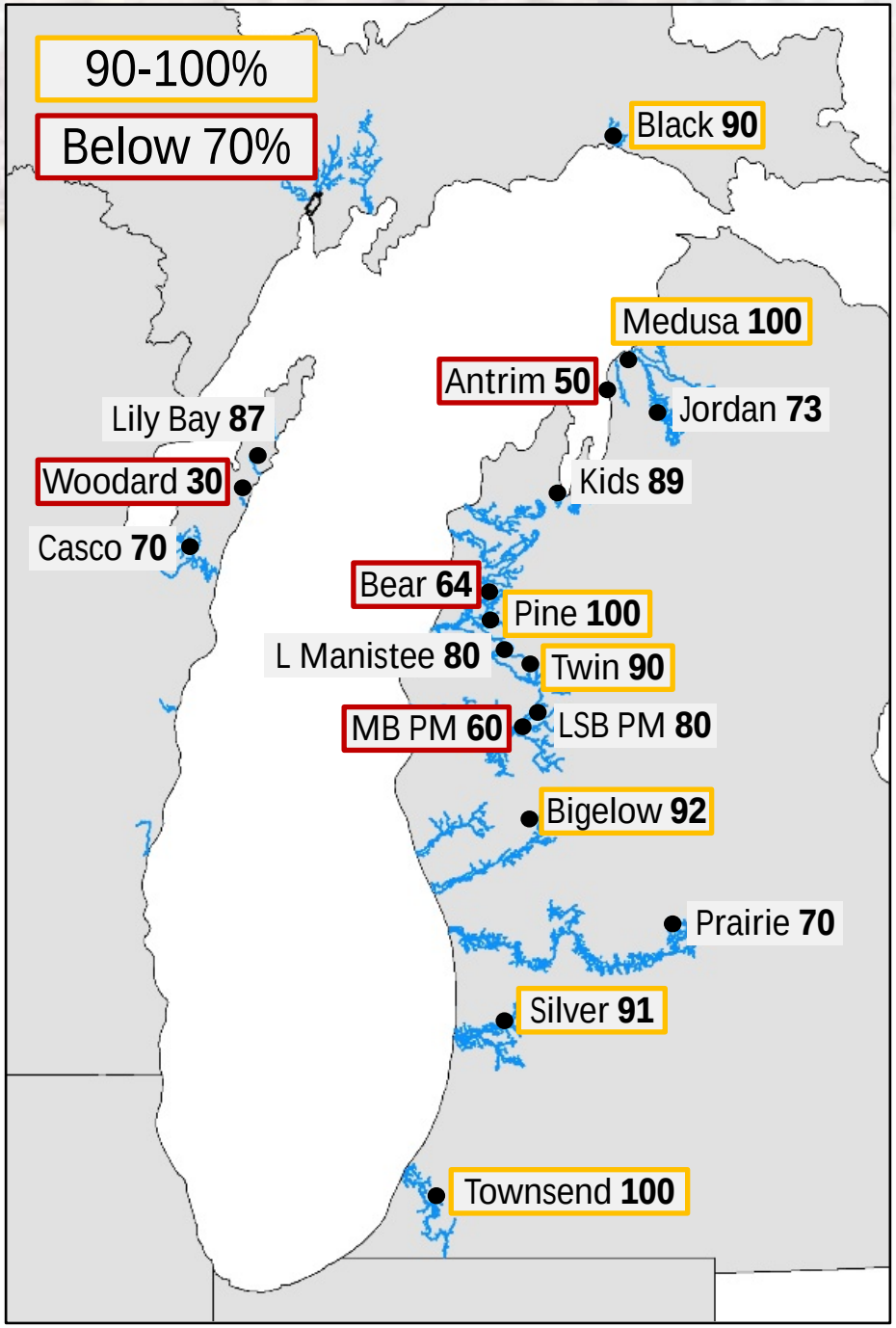
- Medusa Creek
- Little Manistee
- Silver Creek
- Townsend Creek





Spatial Discrimination: YOY Individual Stream

- Mean Accuracy: 80%
- Many important tributaries have +90% accuracy
- Streams with poor accuracy often misclassified into a neighboring stream

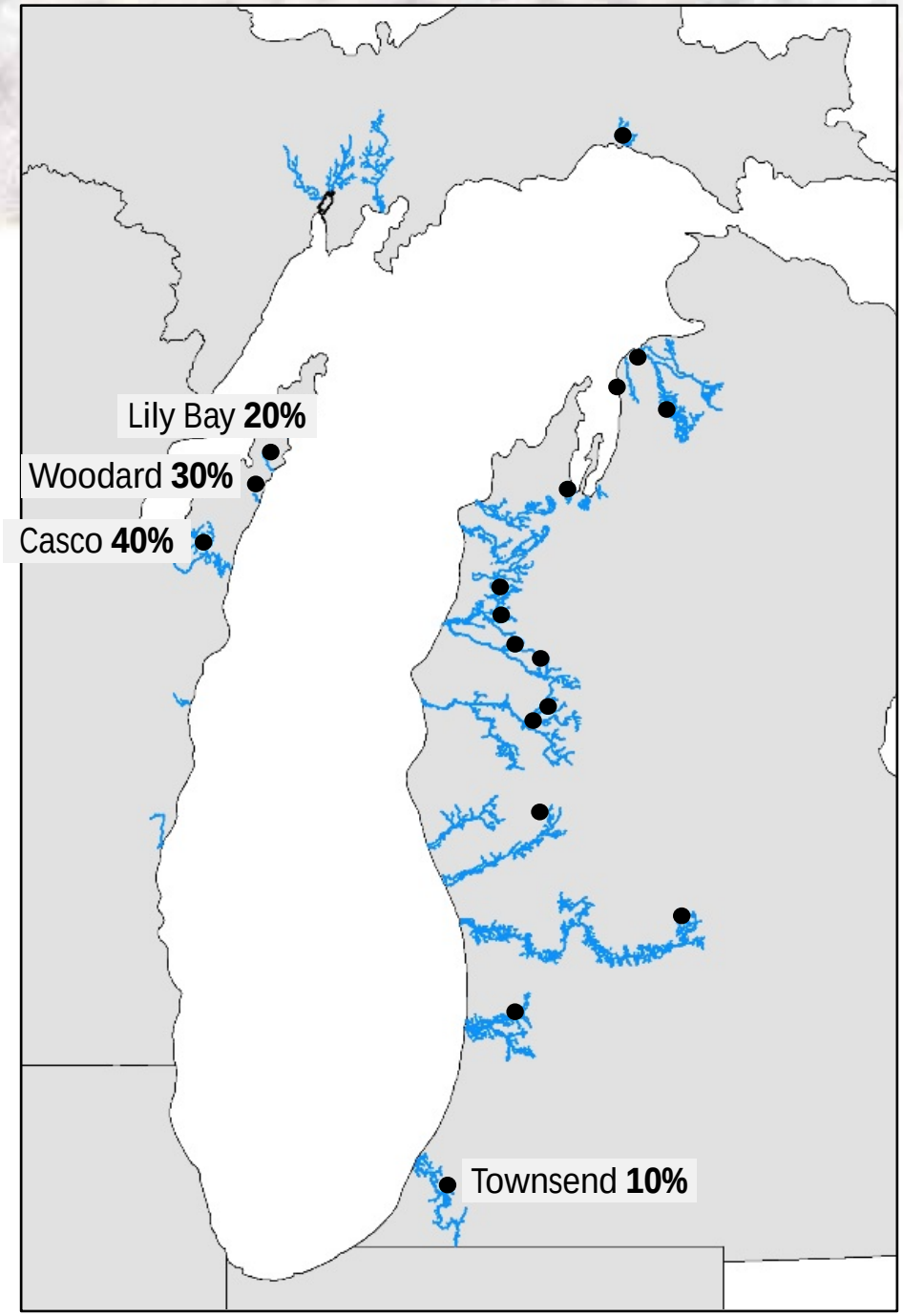


Spatial Discrimination: YOY Individual Stream

Woodard: 30% accuracy

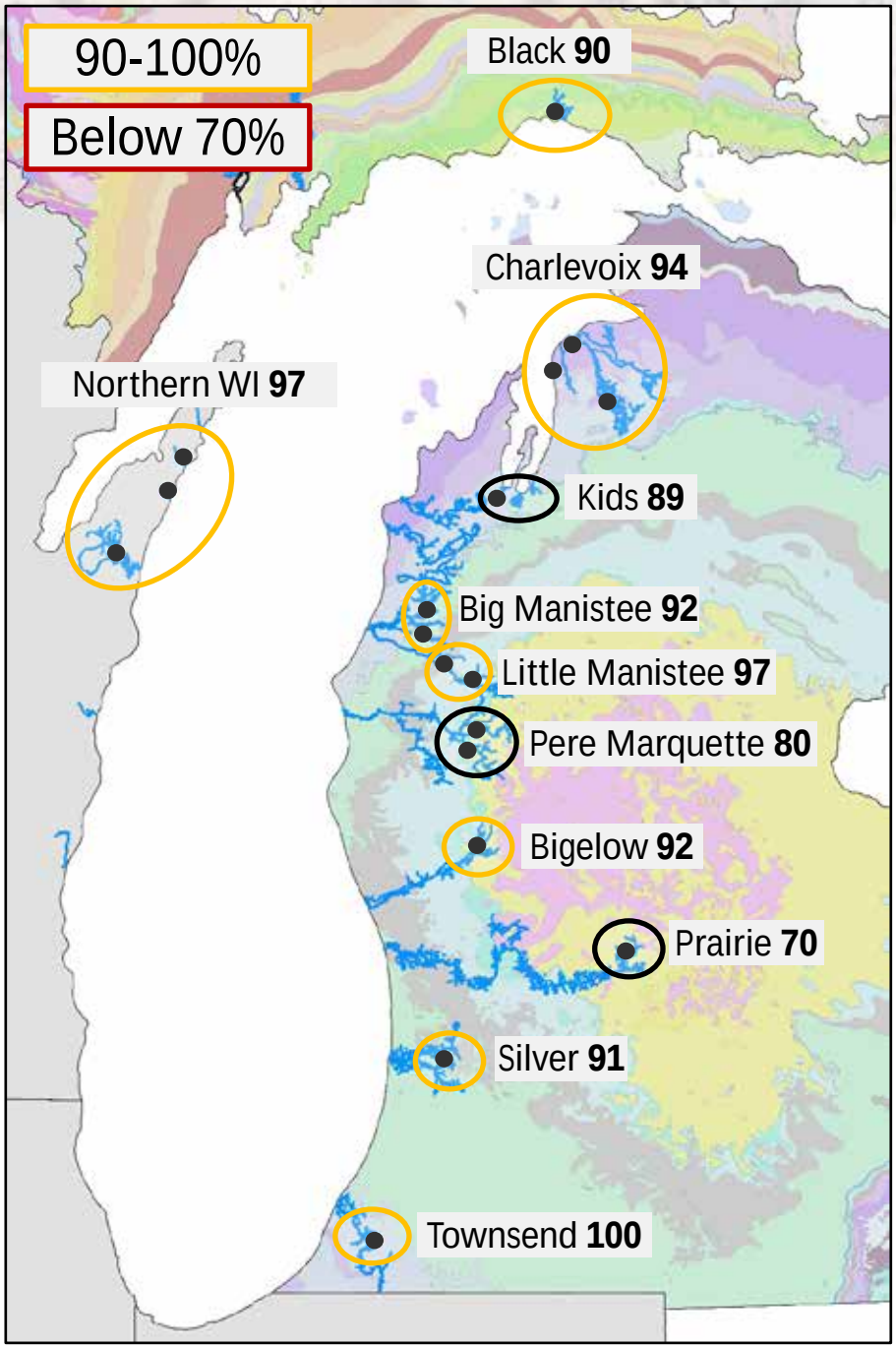
- 20% as Lily Bay Creek
- 40% as Casco Creek
- 10% as Townsend Creek

Woodard

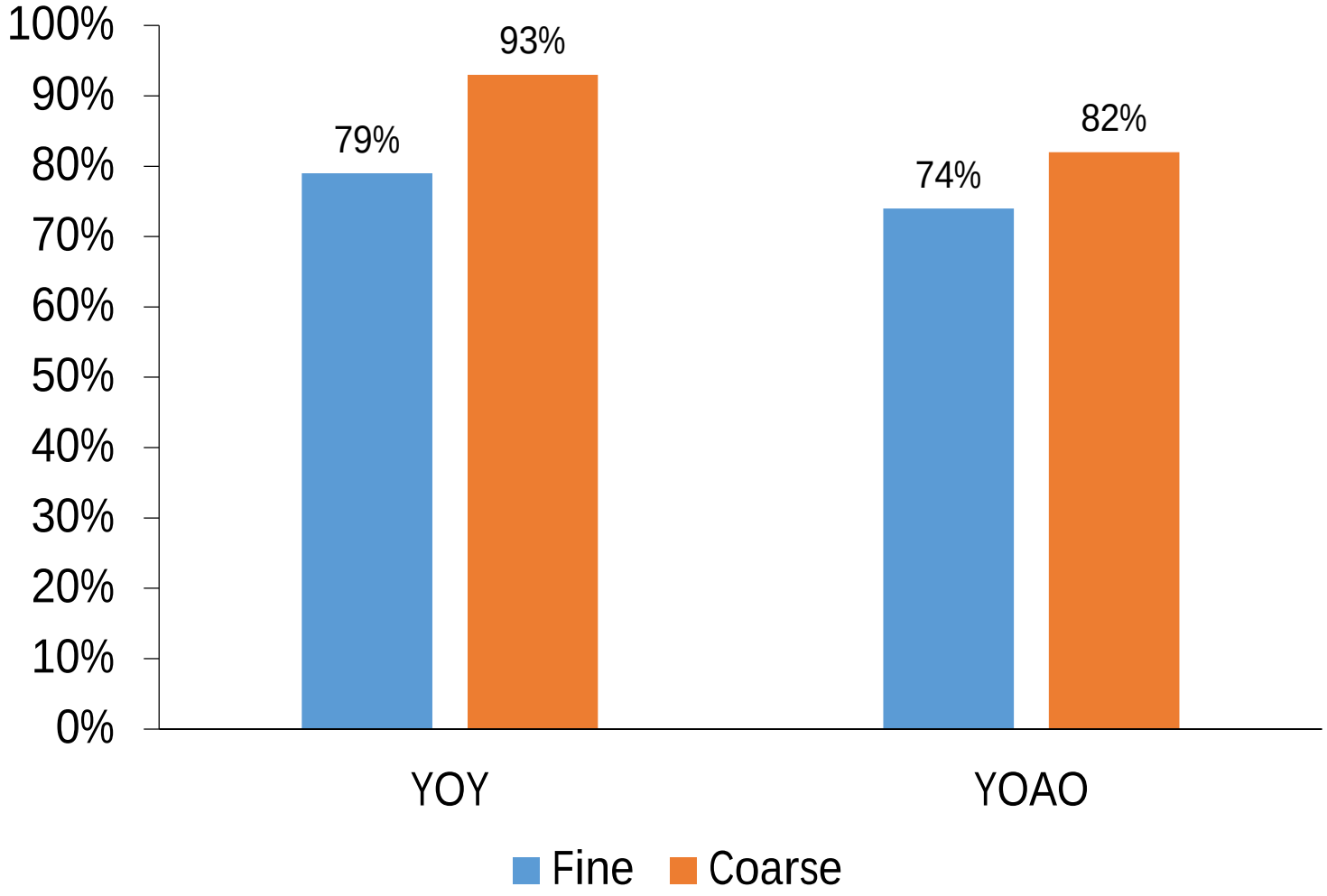


Spatial Discrimination: YOY Regional Stream

- Mean Accuracy: 91%
- Majority of important regional zones have +90% accuracy
- Misclassifications typically were to neighboring region
- Many regional groups are in similar bedrock layers



YOY vs. YOAO
Fine and Coarse Classification Accuracy

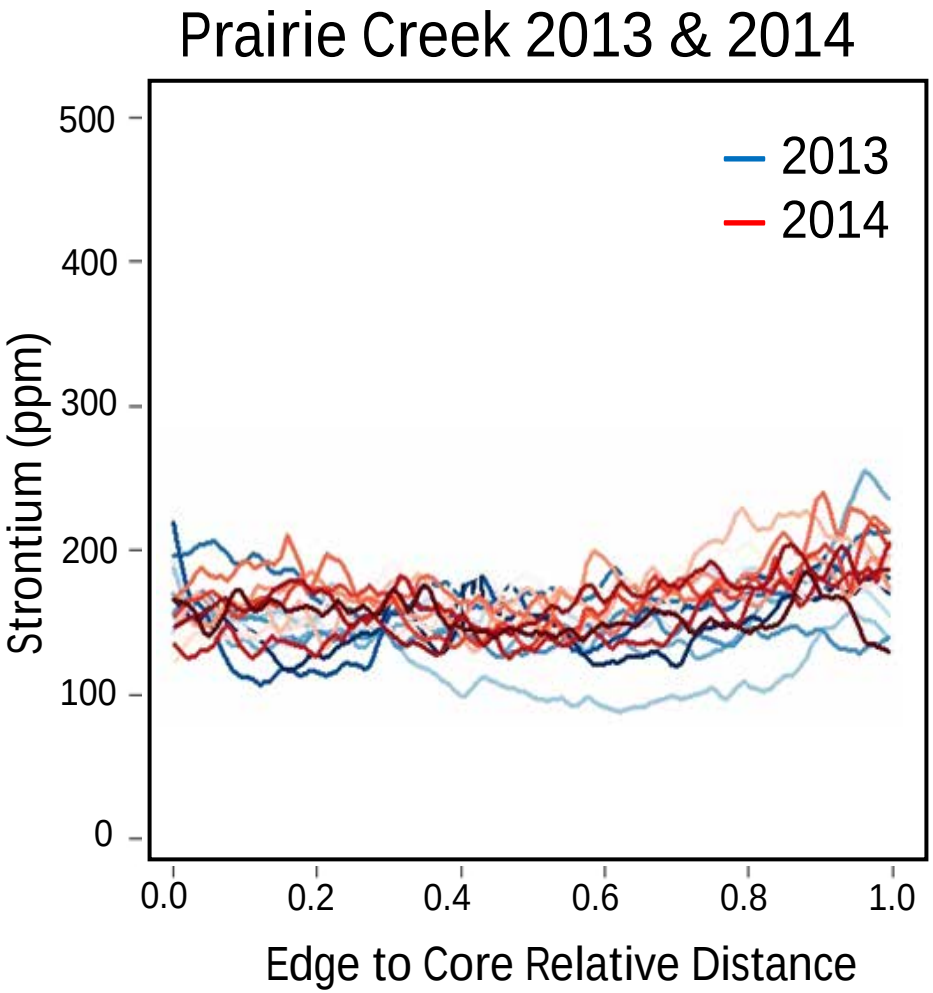


Discussion: Spatial Analysis

- Otolith chemistry can be used to classify fish to natal origin
  - Sites with high classification accuracy are known producers of wild fish
  - Sr and Ba: elements of most importance in analysis
  - Little difference with age
  - Unique signatures: natural and anthropogenic
- Results consistent with Marklevitz et al. (2011) which tested utilization of otolith chemistry to discriminate natal origins of chinook salmon in the Great Lakes
  - Our results show the ability to classify to a finer scale
  - May be due to steelhead residing in natal streams for a longer period of time than chinook

Discussion: Temporal Variation

- Otolith signatures can change annually
  - Previous research found evidence of annual variation in chemical signatures of yellow perch in Lake Erie tributaries
- Preliminary evidence shows low annual variation
  - Can be problematic at fine resolution
- May be due to steelhead residing in groundwater fed streams providing a more chemically stable environment



Conclusion

- Otolith chemical analysis can be used to identify sources of natural reproduction of steelhead
- Pave the way in determining natal origin of adult fish
- Results from this study will allow for more effective conservation and management of both steelhead themselves and their natal habitats

Acknowledgements & Thanks

GLFT

MDNR

WDNR

CMU

Kalamazoo TU

SJRVFF

SJRBC

Carlie Money

THE SMALL ARMY

CMU UNDERGRADUATE STEELHEAD PROJECT VOLUNTEERS

Miranda Andrews
Arica Andrews
Kyle Brumm
Joseph Burger
Jacob Butler
Pete Corp
Joe Decaussin
Kieran Elder
Jameson Farinosi
Chantelle Fortier
Kallan Green
Kynzie House
Halley Love
Alan McTaggart
Brittany Santure
Lee Scheffler
Nicole Strickland
Dave Thumser
Courtney Weldon

SPECIAL THANKS

FAMILY AND FRIENDS

Tom Watson
Patty Armenio
John Law
Ann Miller
Jen Ripple
Nome Buckman

QUESTIONS?