OTOLITH CHEMICAL ANALYSIS

LAKE MICHIGAN STEELHEAD: WHERE WERE YOU HATCHED?

NICOLE WATSON
Graduate Research Assistant
Central Michigan University

A FEW NOTES BEFORE WE BEGIN

- Collaboration between CMU and DNR
- Scientific collection permit for MI and WI
- Minimal catch for analysis
  - ➡ No impact to overall population
- Humane euthanasia of all target fish
- Immediate release of non-target species upon recovery
- Why sacrifice some fish?
  - ➡ Research will benefit conservation of total population

OUTLINE

- Introduction to Great Lakes steelhead
- What are otoliths?
- Steelhead research
    - Otolith Chemistry
    - Diet Analysis & Bioenergetics

GREAT LAKES STEELHEAD

- Introduced in the late 1800’s
- Few self-sustaining populations established by the early 1900’s
- Native range is the Pacific Coast
- Steelhead have been introduced to all continents except Antarctica

STEELHEAD OR RAINBOW TROUT?

- Steelhead are the migratory form of rainbow trout
- Great Lakes steelhead are considered potamodramous (migrating entirely in fresh water)
- Pacific coast steelhead are considered anadromous (migrating from fresh water to ocean)

GREAT LAKES STEELHEAD

- Many strains:
  - Skamania, Michigan, Ganaraska, Chambers, Arlee, Kamloops
- Historical stocking of parr in rivers supporting wild populations provide little contribution to the adult population
- Nearly 15% of all Great Lakes anglers target steelhead, not including stream fishing

GREAT LAKES STEELHEAD

- Juveniles live 1-3 years in stream habitat
- "Smolt" and migrate out to lake to fully mature
  - Smolting: morphological, physiological, and behavioral changes
- Return to natal stream to spawn 1-3 times

A COMPLEX POPULATION

- MIXED STOCK
  - Hatchery-released & wild fish
  - Lake population from many different tributaries

EQUAL OR NOT EQUAL?

- COMPLICATIONS TO CONSERVATION & MANAGEMENT
  - Unequal contribution of steelhead stocks to total population

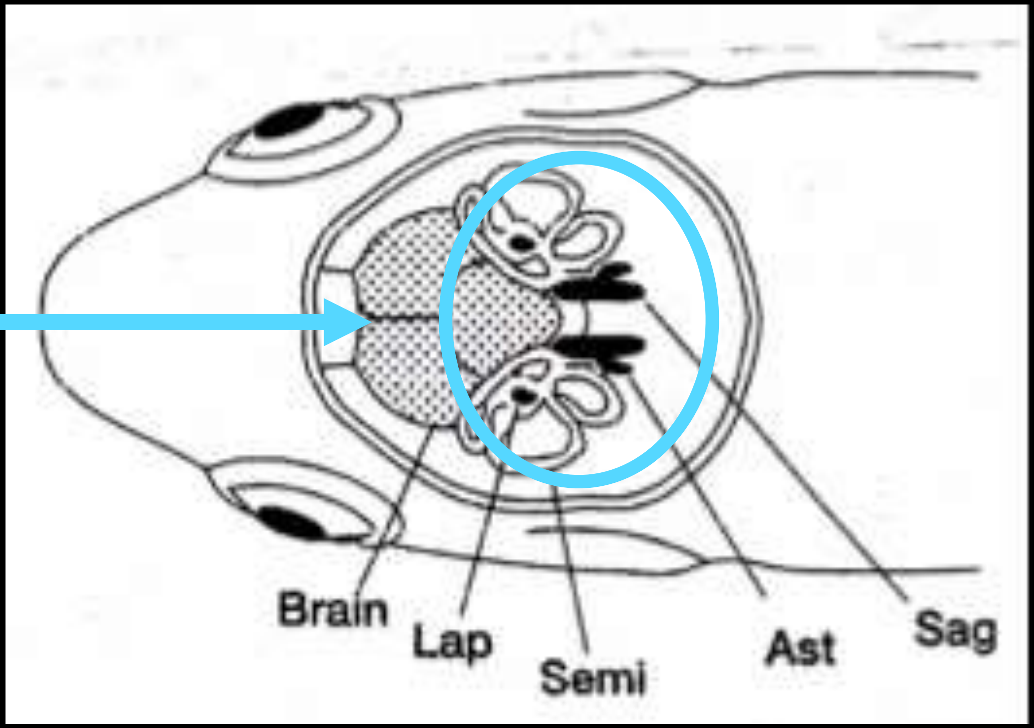
WHO CAME FROM WHERE? HOW?

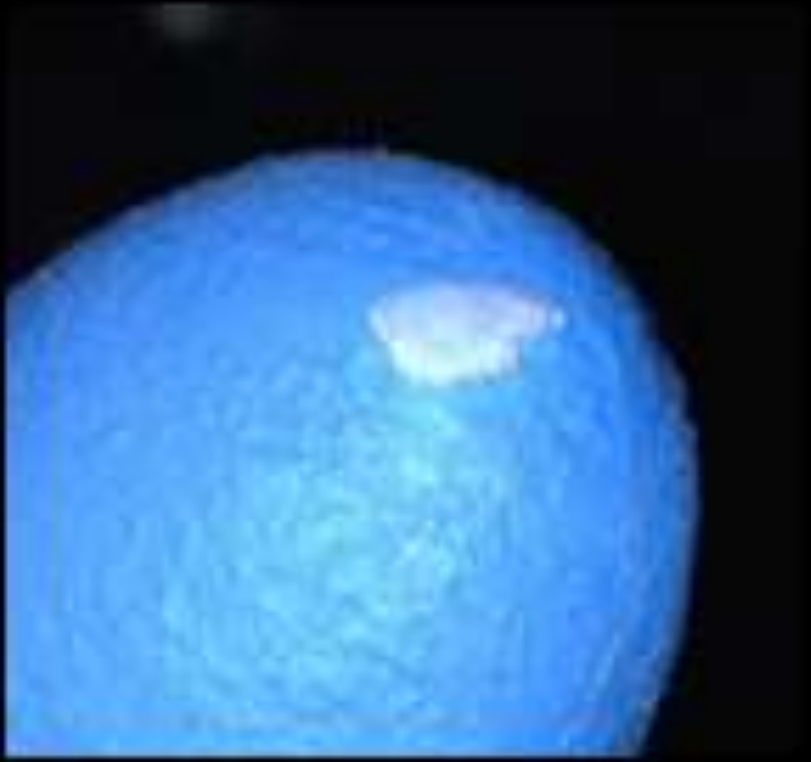
- Knowledge of natal origin important
  - Juveniles depend on cold water habitat
- Target conservation and management to the areas that are the major contributors to the total population

OTOLITH CHEMISTRY HOLDS THE KEY!

WHAT ARE OTOLITHS?

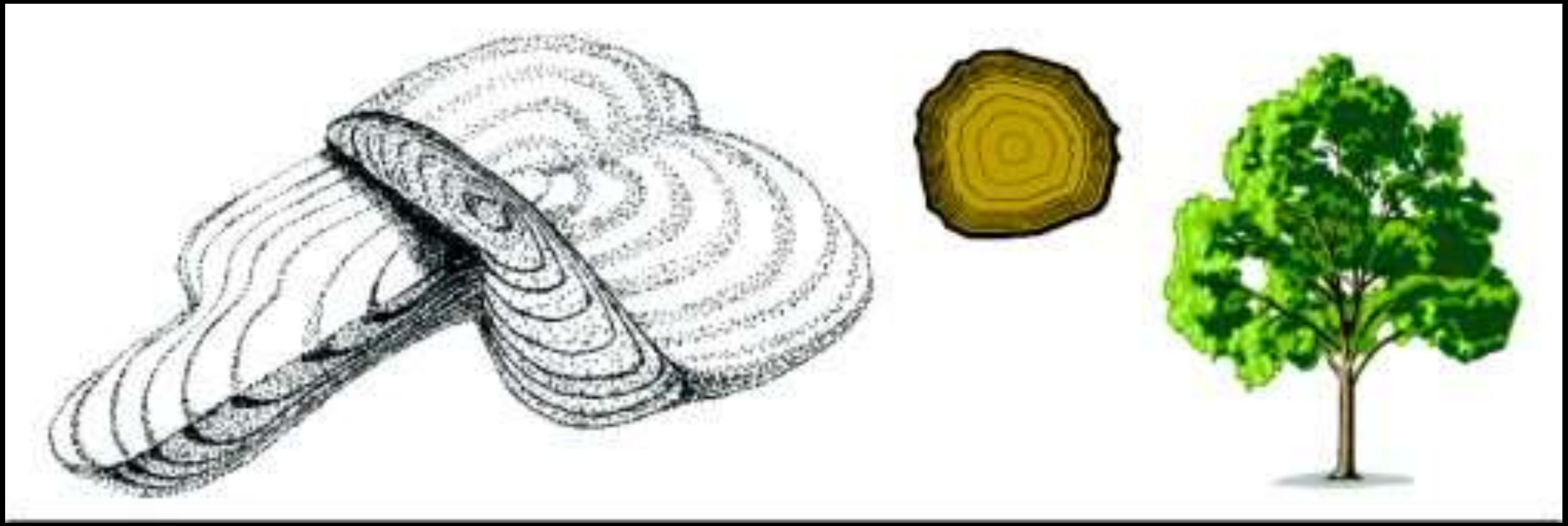
- Hard calcium carbonate structures located behind the brain
- Used for hearing, balance, & orientation
- 3 pairs of otoliths:
  - Lapilli, Astericii, **Sagittae**





GROWTH & OTOLITHS

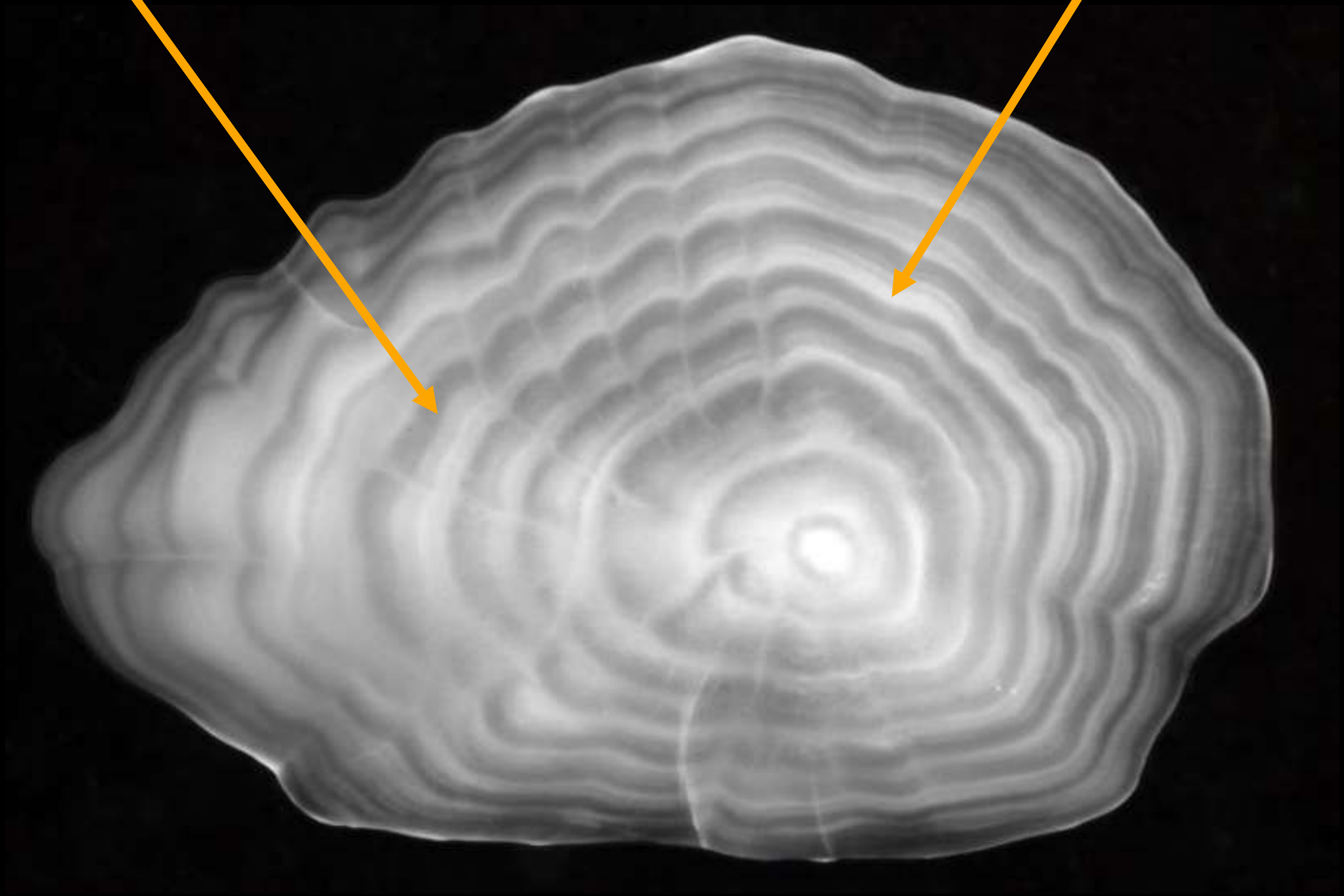
- Close resemblance to tree rings & layers of an onion
- Daily growth increments



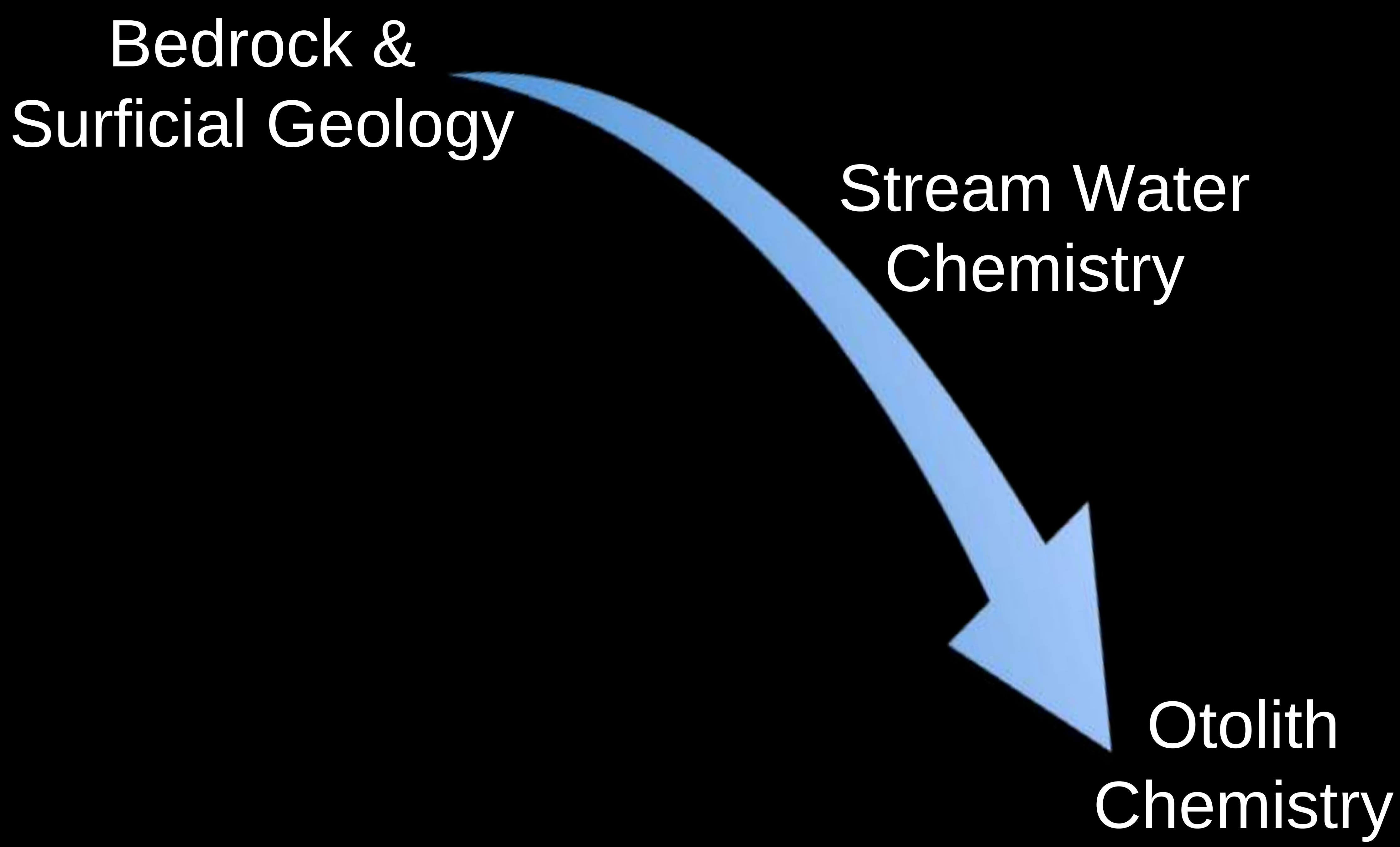
GROWTH & OTOLITHS

Dark (opaque): slow growth

Light (translucent): fast growth

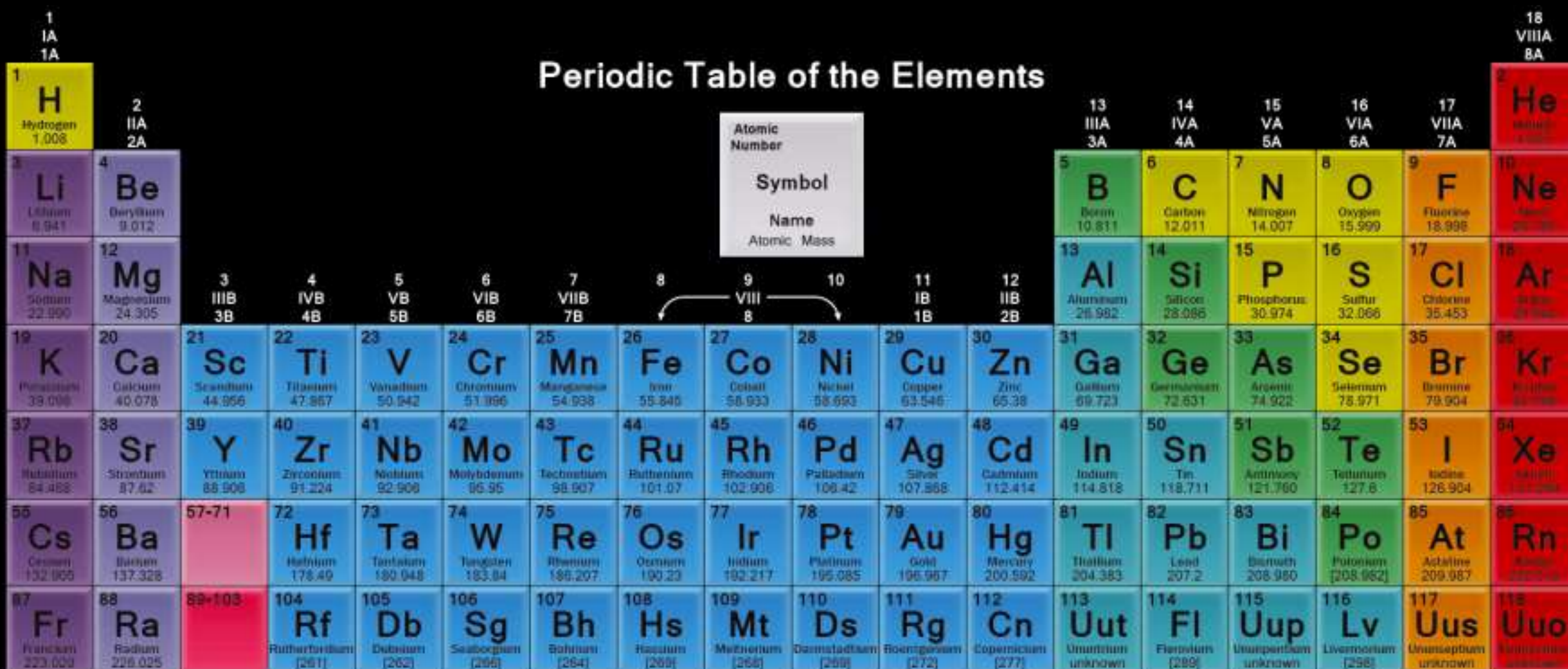


INFLUENCES OF OTOLITH CHEMISTRY



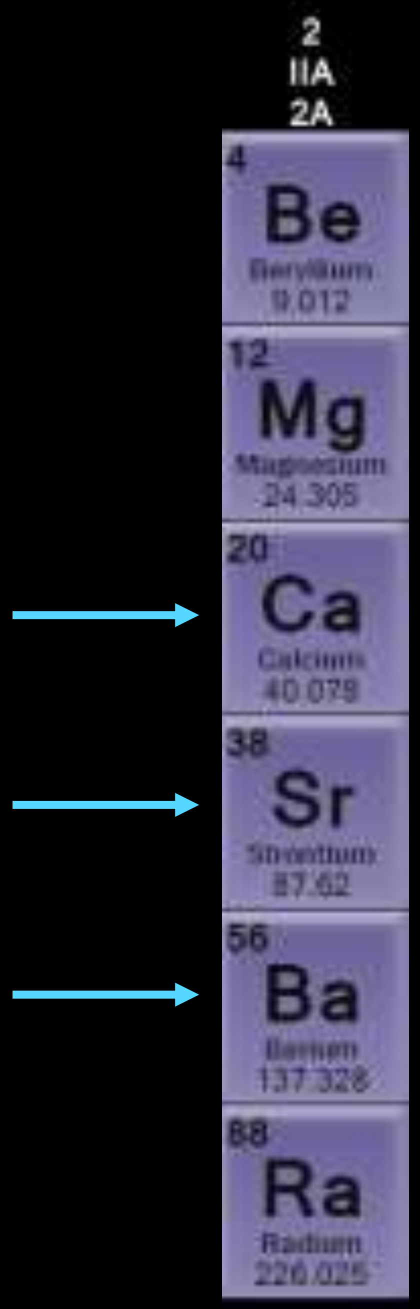
CHEMISTRY

- Columns (groups) of the periodic table have the same number of valence electrons
- Valence electrons are involved in bonding



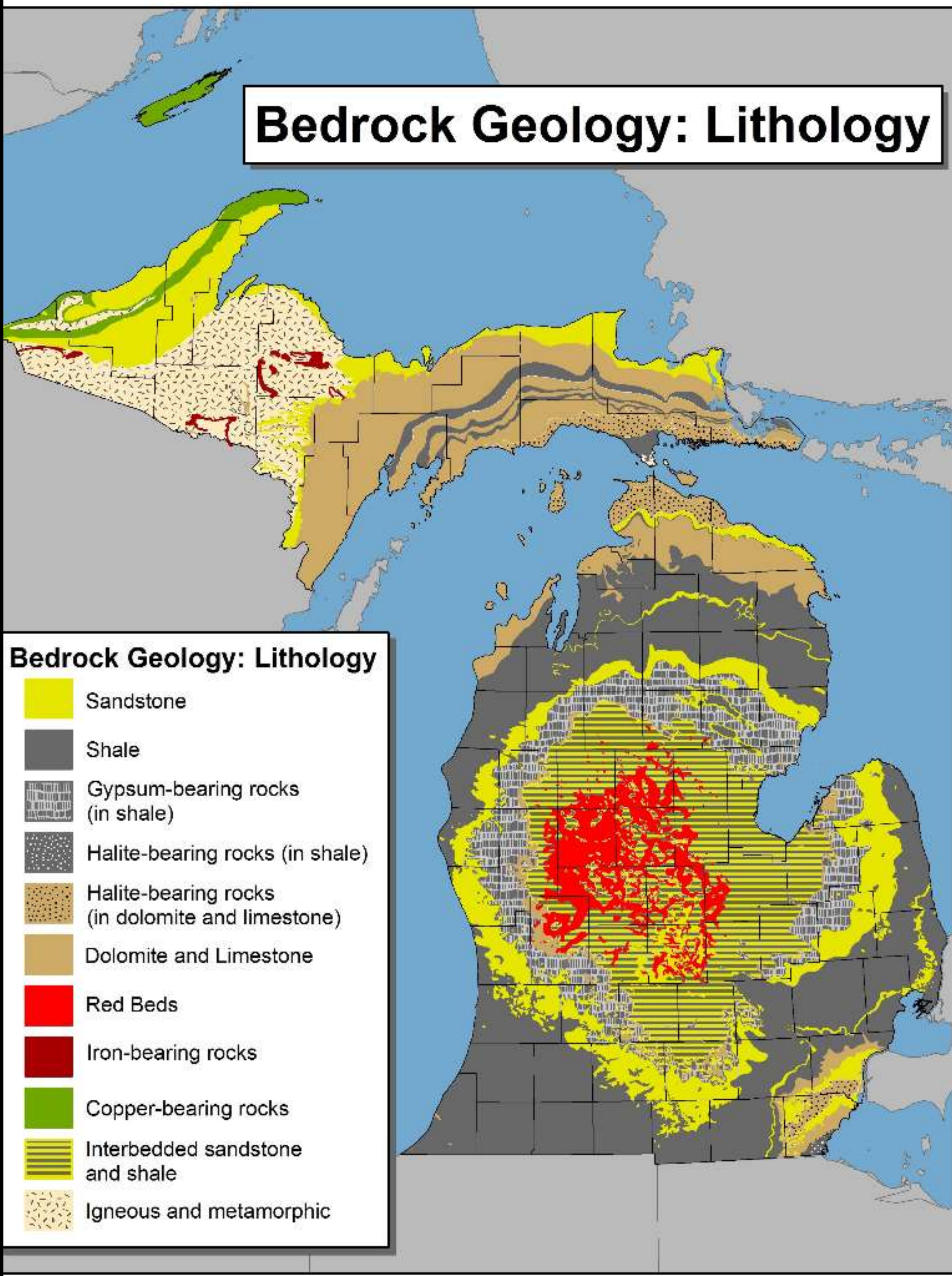
A BIT MORE CHEMISTRY

- Calcium (Ca), Strontium (Sr), Barium (Ba) are all in the the second group of the periodic table
- Ca, Sr, and Ba all have two valence electrons
- This allows Sr and Ba to easily substitute with Ca in the crystalline matrix of the otolith
- Elements of highest concern are Sr and Ba, others are important as well (Mg, Mn, Fe, Rb)



UNIQUE FINGERPRINT

- Unique geology gives way to unique otolith chemical fingerprint
- Different geologic layers have different Sr & Ba concentrations
- Each color on the map represents a different bedrock composition



STEELHEAD RESEARCH

HYPOTHESIS & CONSIDERATIONS

- Individual stocks can be determined through otolith chemical analysis when the chemical composition of the otolith is unique

→ Considerations:

- Various spatial scales
- Inter-annual variations
- Age class & classification accuracy

GOALS

DETERMINE NATAL ORIGIN OF JUVENILE STEELHEAD USING OTOLITH CHEMISTRY

LONG-TERM:

- Determine natal origin of adult steelhead captured from Lake Michigan

HOLD ON…

We already know where juvenile steelhead come from

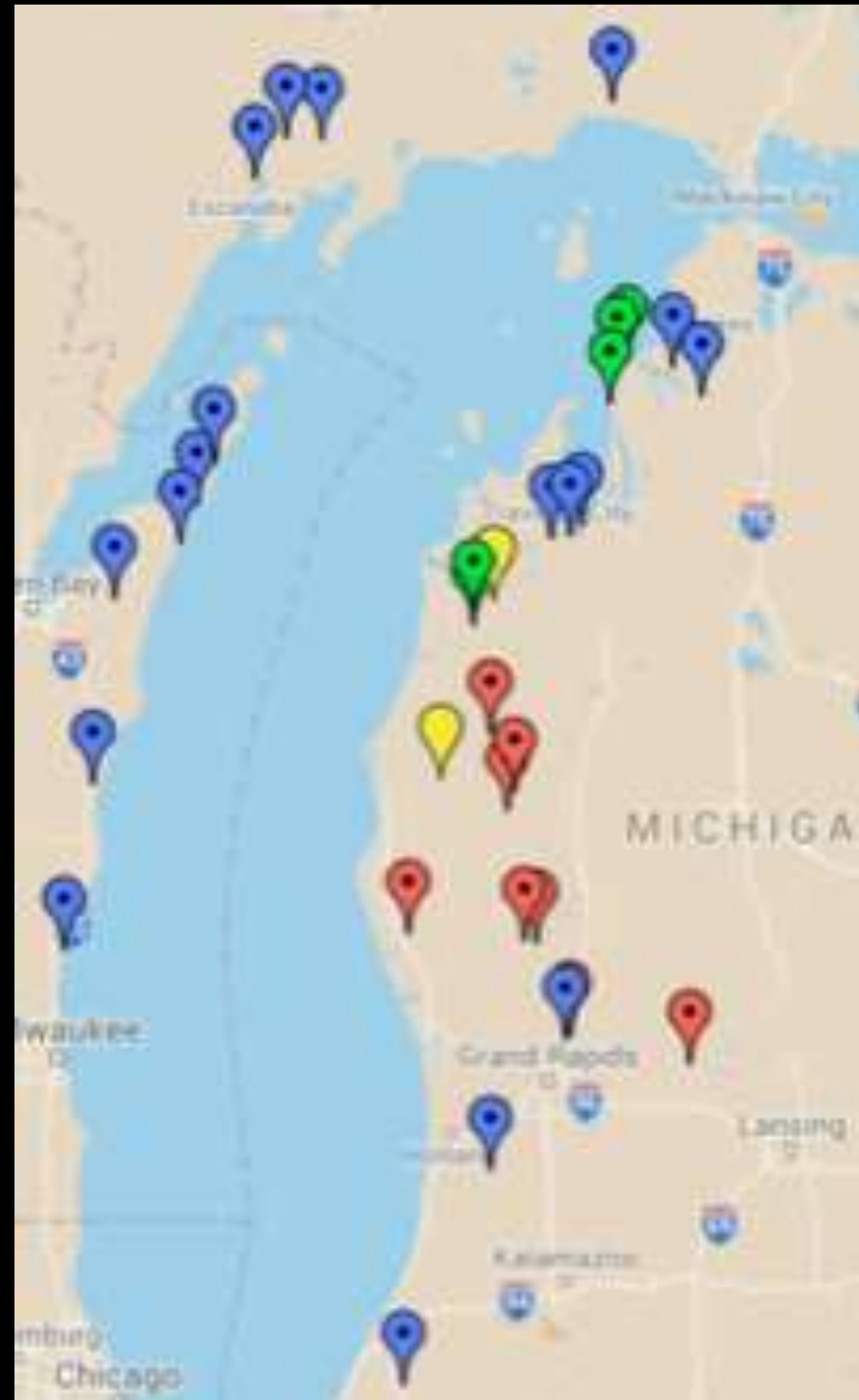
- The computer doesn't know this. That is needed for the long-term goal
- Wouldn't it be nice to know which streams contribute the most to the adult population?

WHY IS THIS IMPORTANT?

- This research provides a new tool for fisheries research
- The results of this study will pave the way for future research that attempts to determine the natal origins of adult steelhead collected from Lake Michigan
- This will allow for more effective conservation and management of both steelhead themselves and their natal habitats

SPATIAL VARIATION

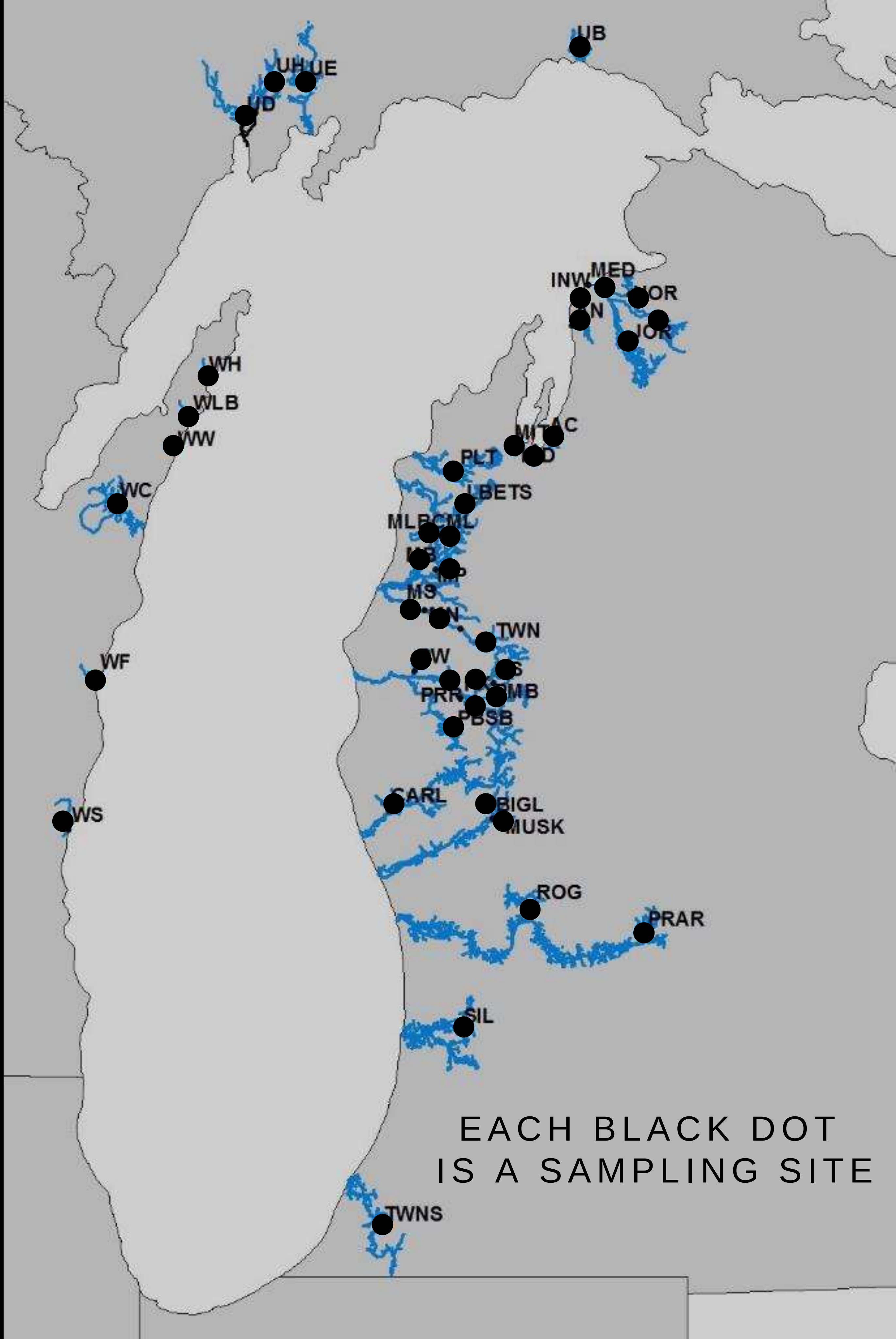
- How specific can we get?
- Watershed A, B, C?
  - ➞Manistee
  - ➞K-zoo
  - ➞St. Joe



CAN WE GET MORE SPECIFIC?

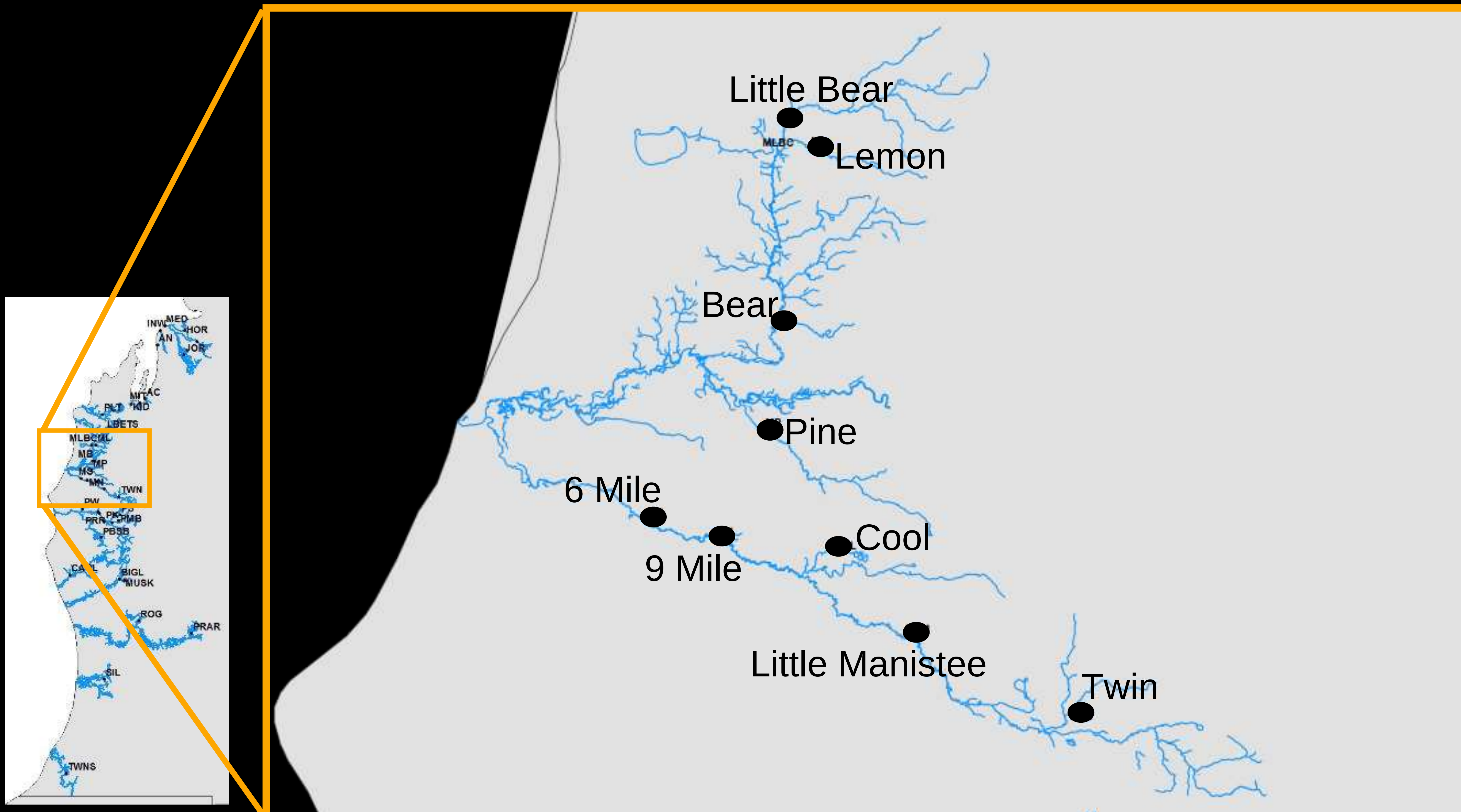
2014 FIELD SAMPLING

- Spring: June-July
- Fall: August-November
- Total sites:
  - → 36 Lower Peninsula
  - → 4 Upper Peninsula
  - → 6 Wisconsin
- All sites will be revisited in spring and fall 2015



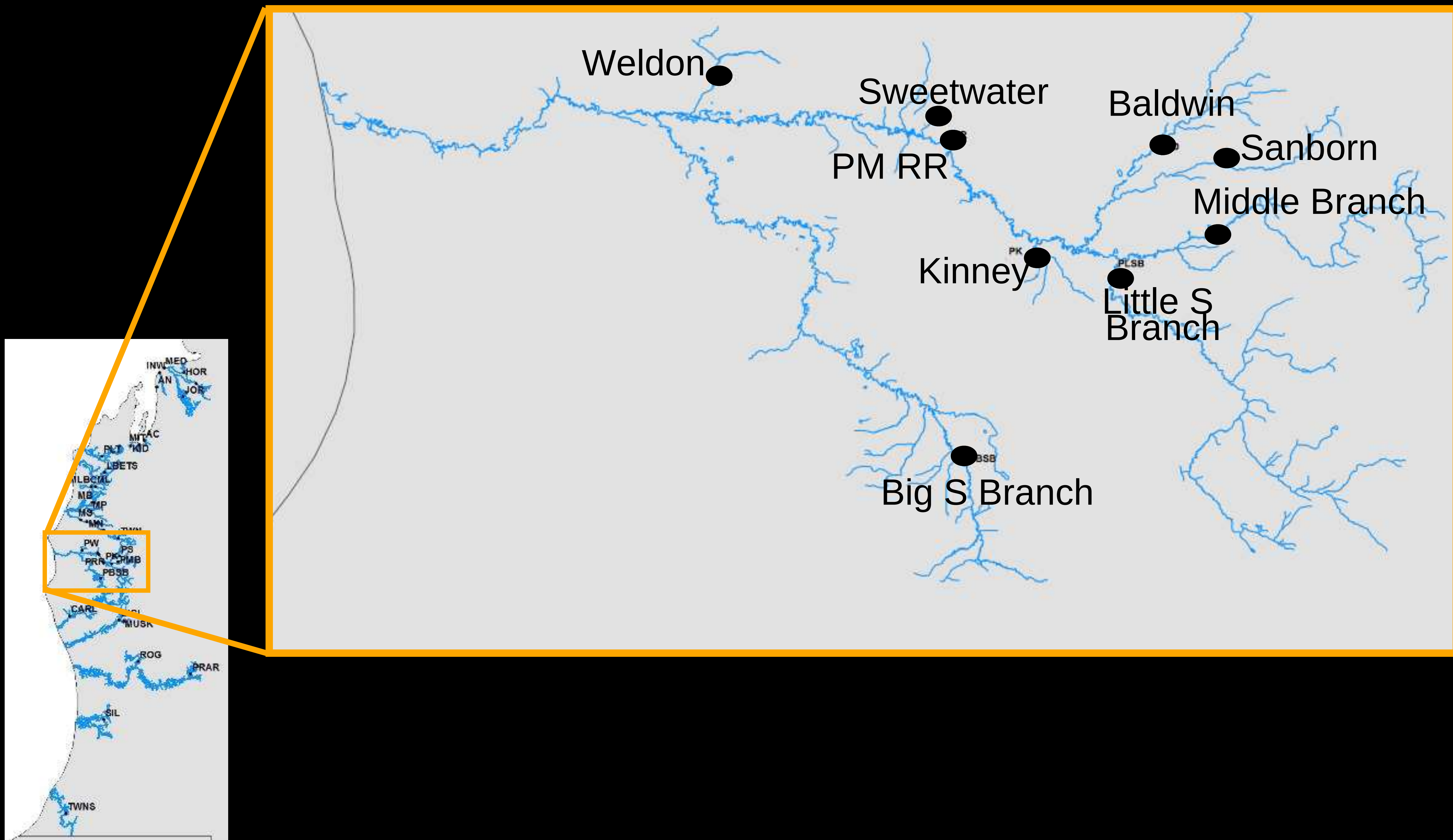
MANISTEE & LITTLE MANISTEE

INTENSIVE SAMPLING



PERE MARQUETTE

INTENSIVE SAMPLING



FIELD COLLECTIONS

- Electro-fishing
- Electrical current induced by closing circuit
- Temporarily stuns fish
- Non-target species released
- Target species collected

NEW FOR 2015

“Unnamed Creek”

Tributary of the Dowagiac

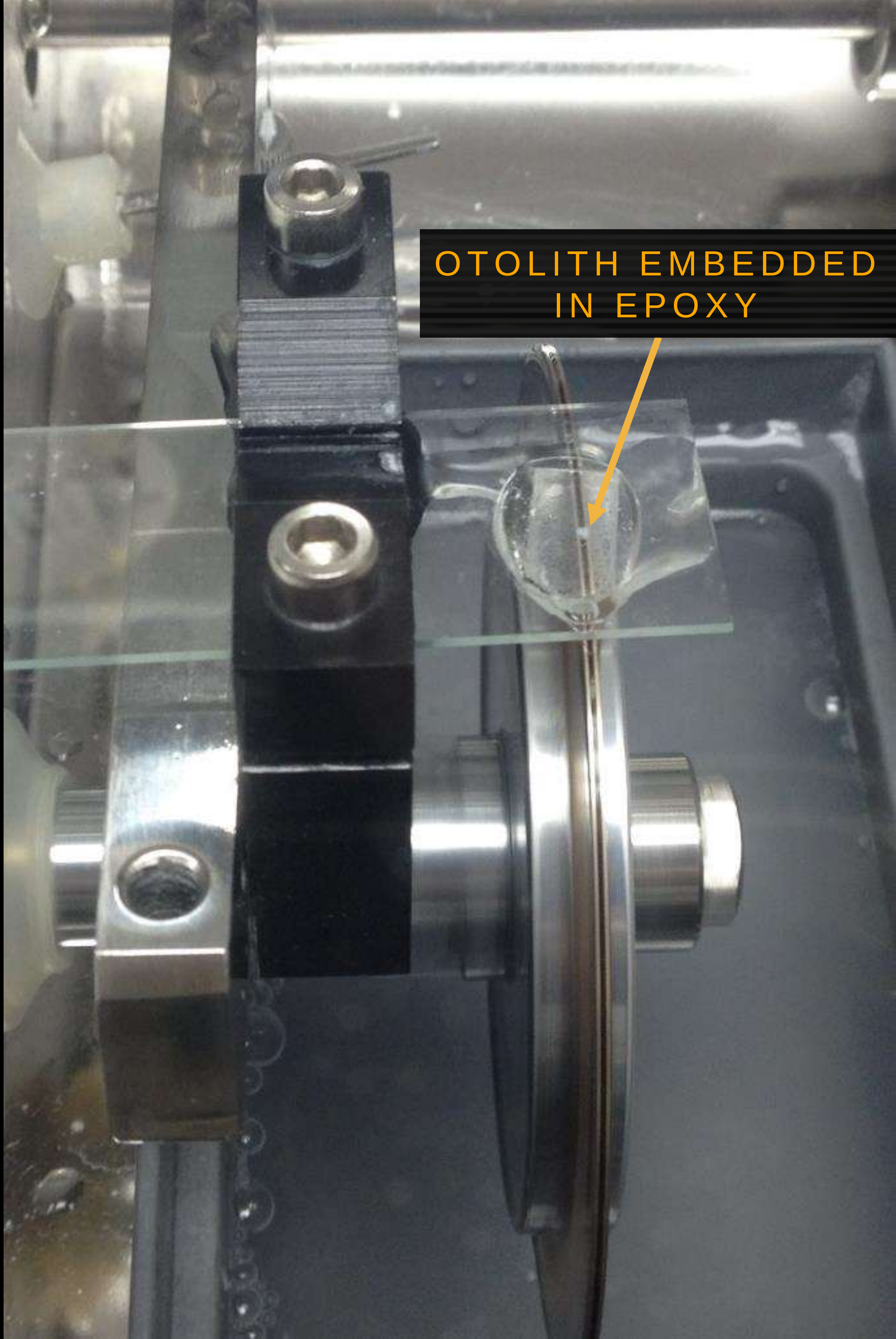
Sampled 14-May-15

LABORATORY WORK

- Over 700 fish excised:
  - → Length & weight
  - → Otoliths removed
  - → Scale sample
  - → Stomach removed

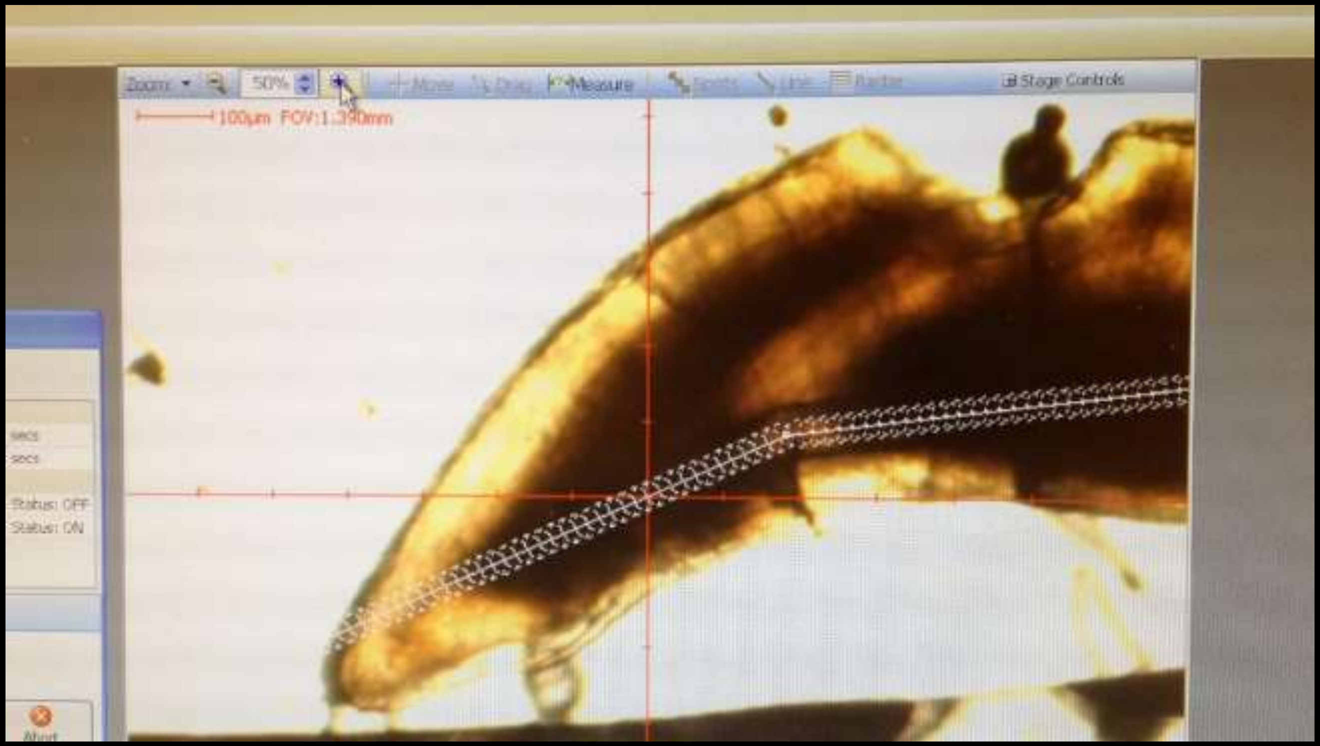
OTOLITH PREP

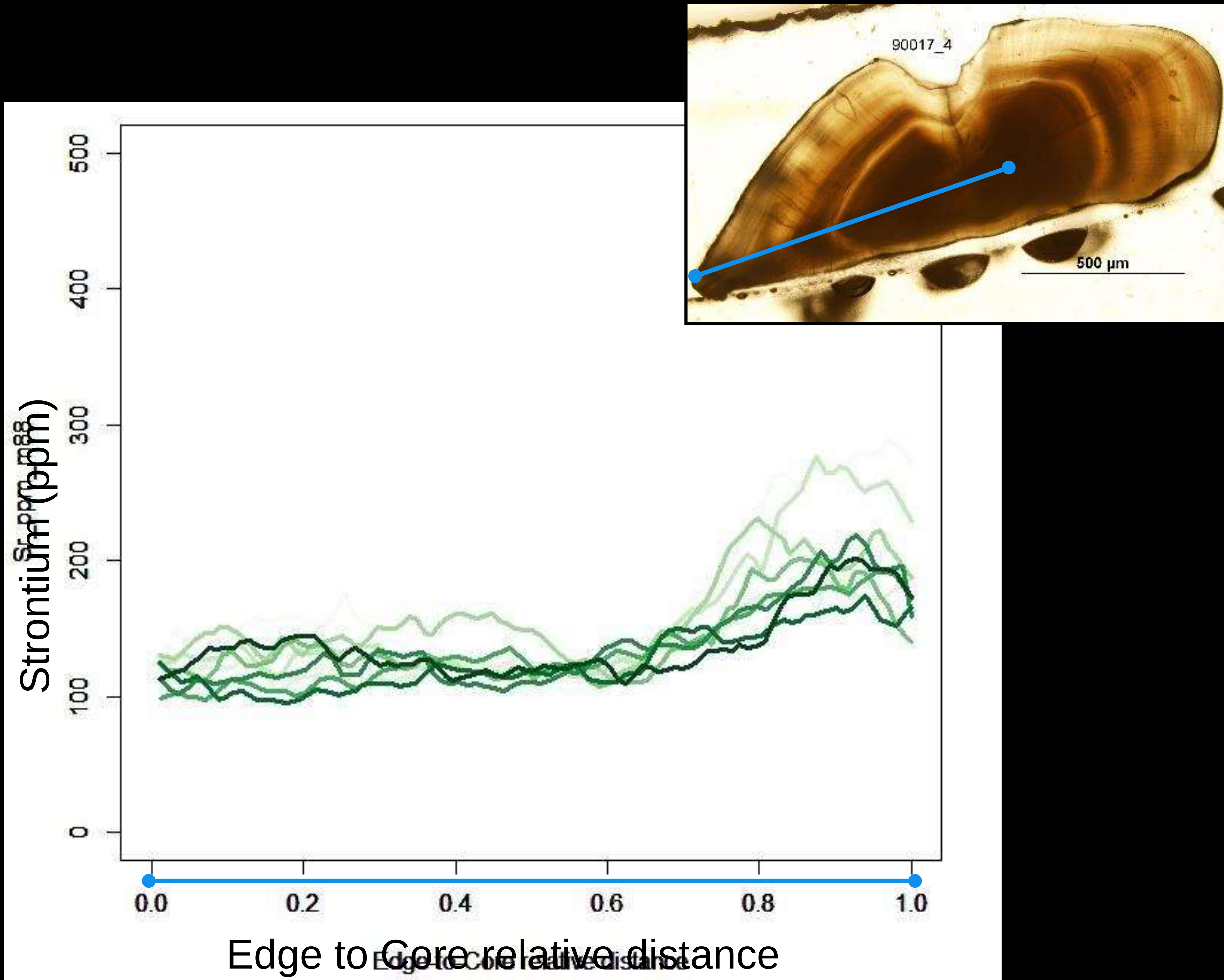
- Remove
- Dry
- Embed
- Section
- Polish, polish, polish, check under microscope, polish more
- Ablate

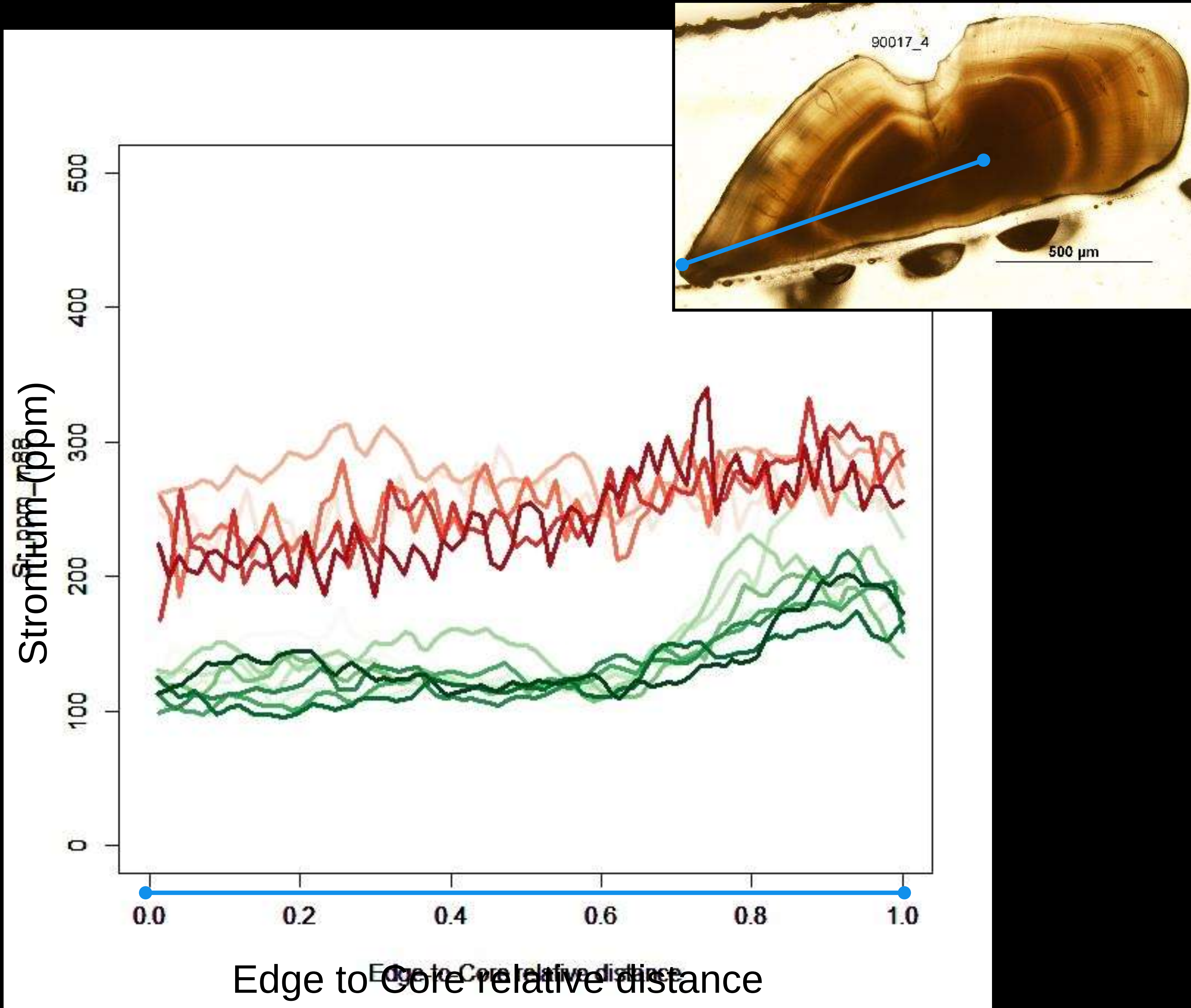


LASER ABLATION INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY

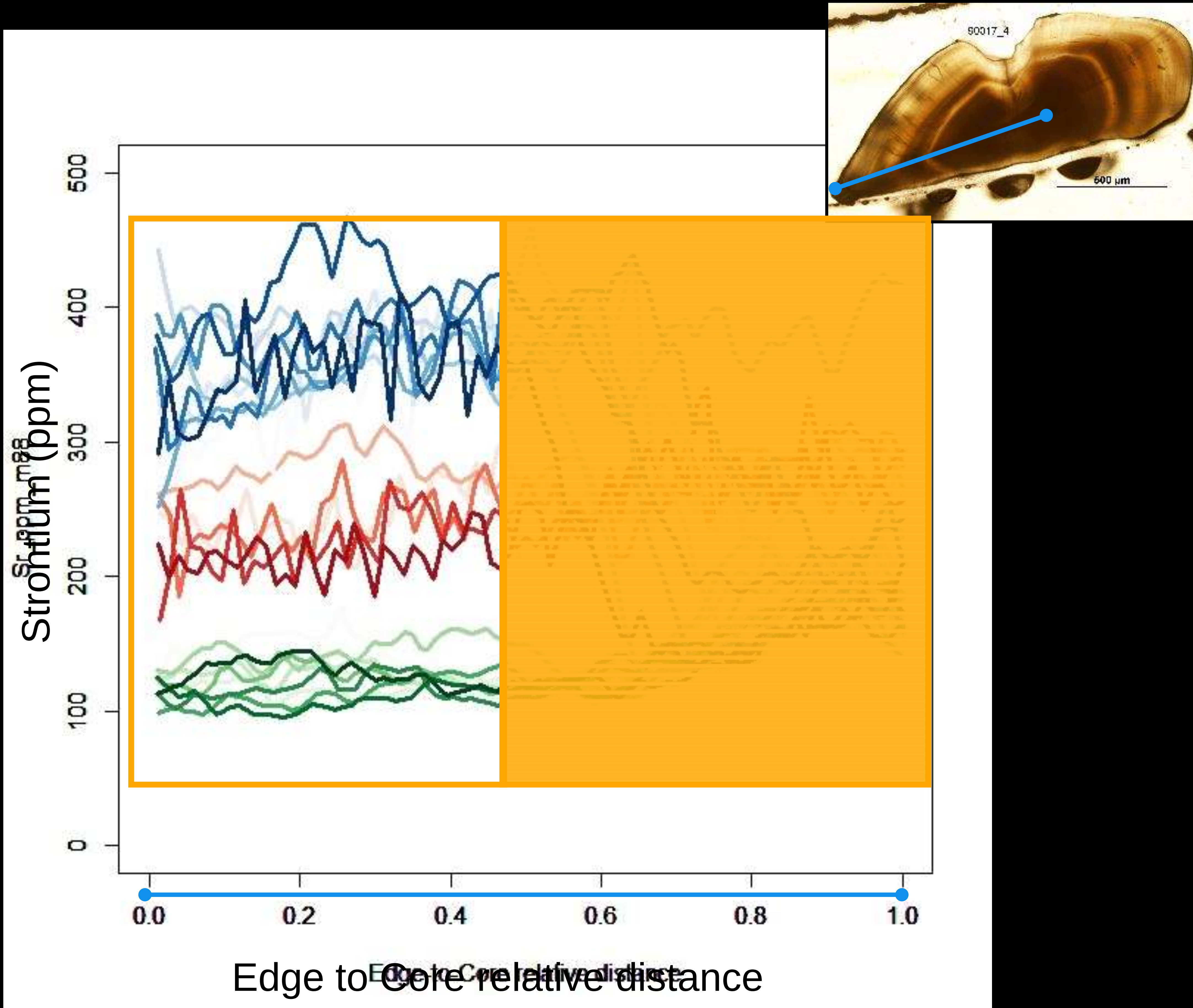
LA-ICP-MS: LASER ABLATIONS

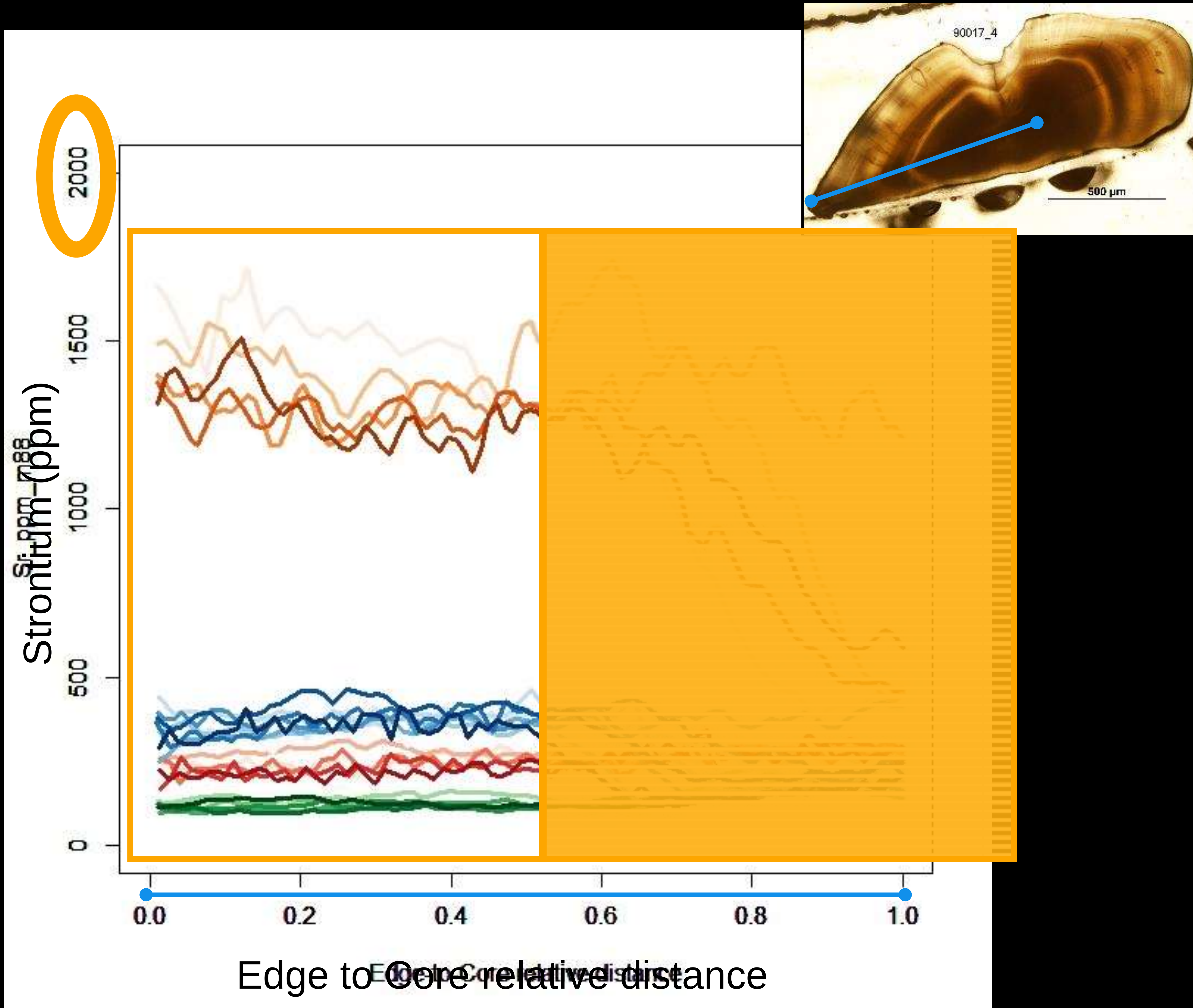



90017_4
500 µm
Strontium (ppm)
0
100
200
300
400
500
0.0
0.2
0.4
0.6
0.8
1.0
Edge to Core relative distance



90017_4
500 µm
500
400
300
200
100
0
0.0
0.2
0.4
0.6
0.8
1.0
Strontium (ppm)
Edge to Core relative distance


Strontium (ppm)
Sr_ppm_m88
500
400
300
200
100
0
0.0
0.2
0.4
0.6
0.8
1.0
Edge to Core relative distance
Edge-to-Core relative distance
90017_4
500 µm


Strontium (ppm)
Edge to Core relative distance
0
500
1000
1500
2000
0.0
0.2
0.4
0.6
0.8
1.0
90017_4
500 µm

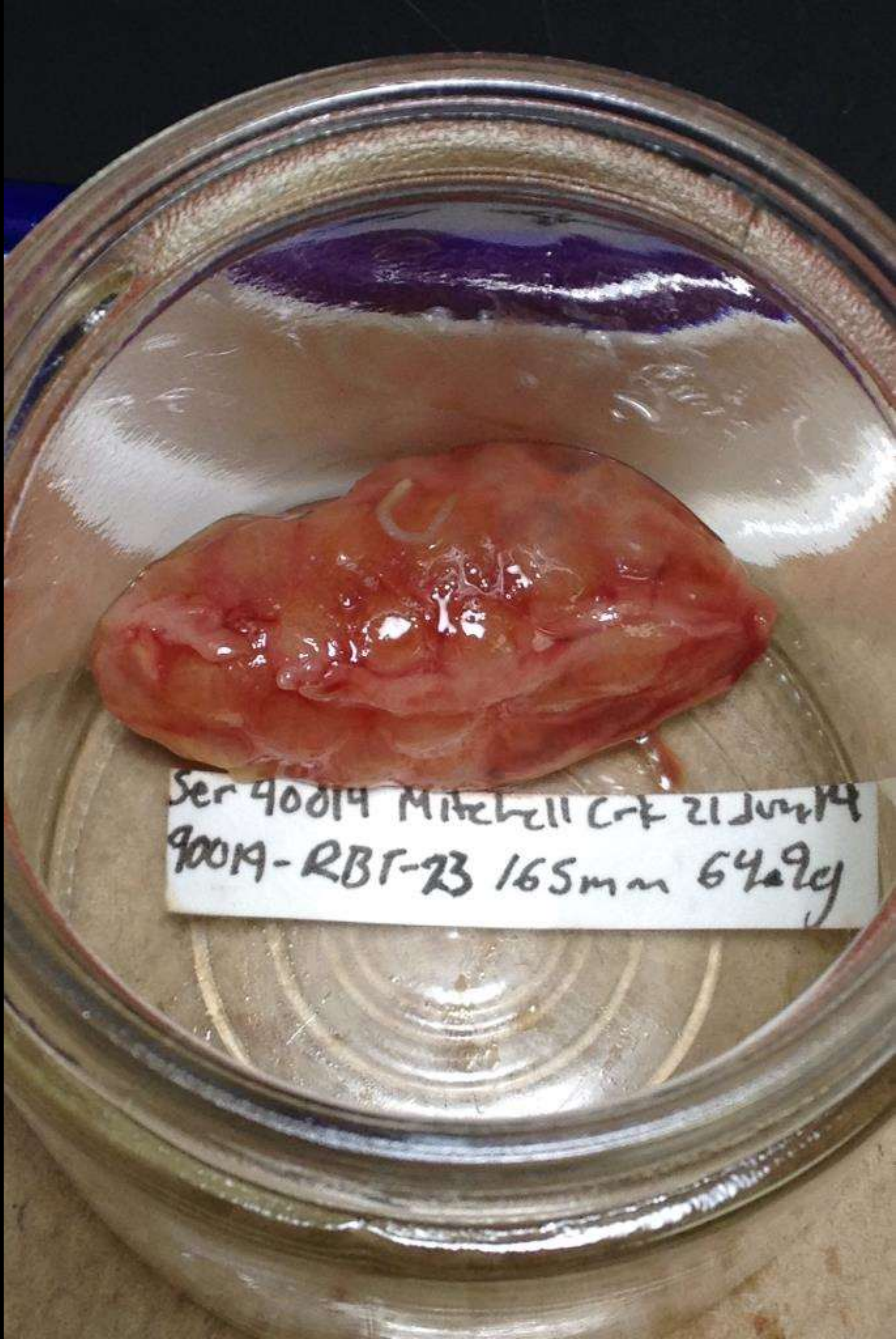
WHY IS THIS IMPORTANT?

Knowing which streams contribute to the surviving and reproducing population of steelhead in Lake Michigan will allow for more effective conservation and management of both steelhead themselves and their natal habitats

OTOLITH CHEMISTRY HOLDS THE KEY!

DIET ANALYSIS

- Previous studies have only concentrated on very few streams
- Data from 46 streams in the Lake MI basin
- Land use impacts, spatial variation, TOD, season
- Funding recently awarded



BIOENERGETICS MODEL

- Determine how diet composition influences growth of juvenile steelhead
- Fill the gap of a basin-wide diet analysis
- Compare actual growth & diet with model

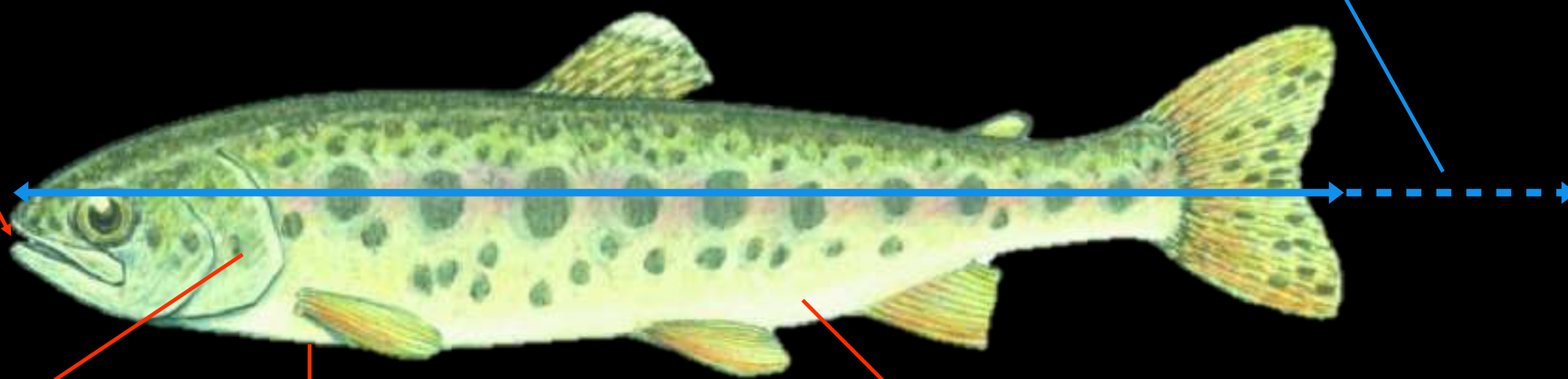




$$G = C - R - S - F - U$$

C = Consumption

G = Growth



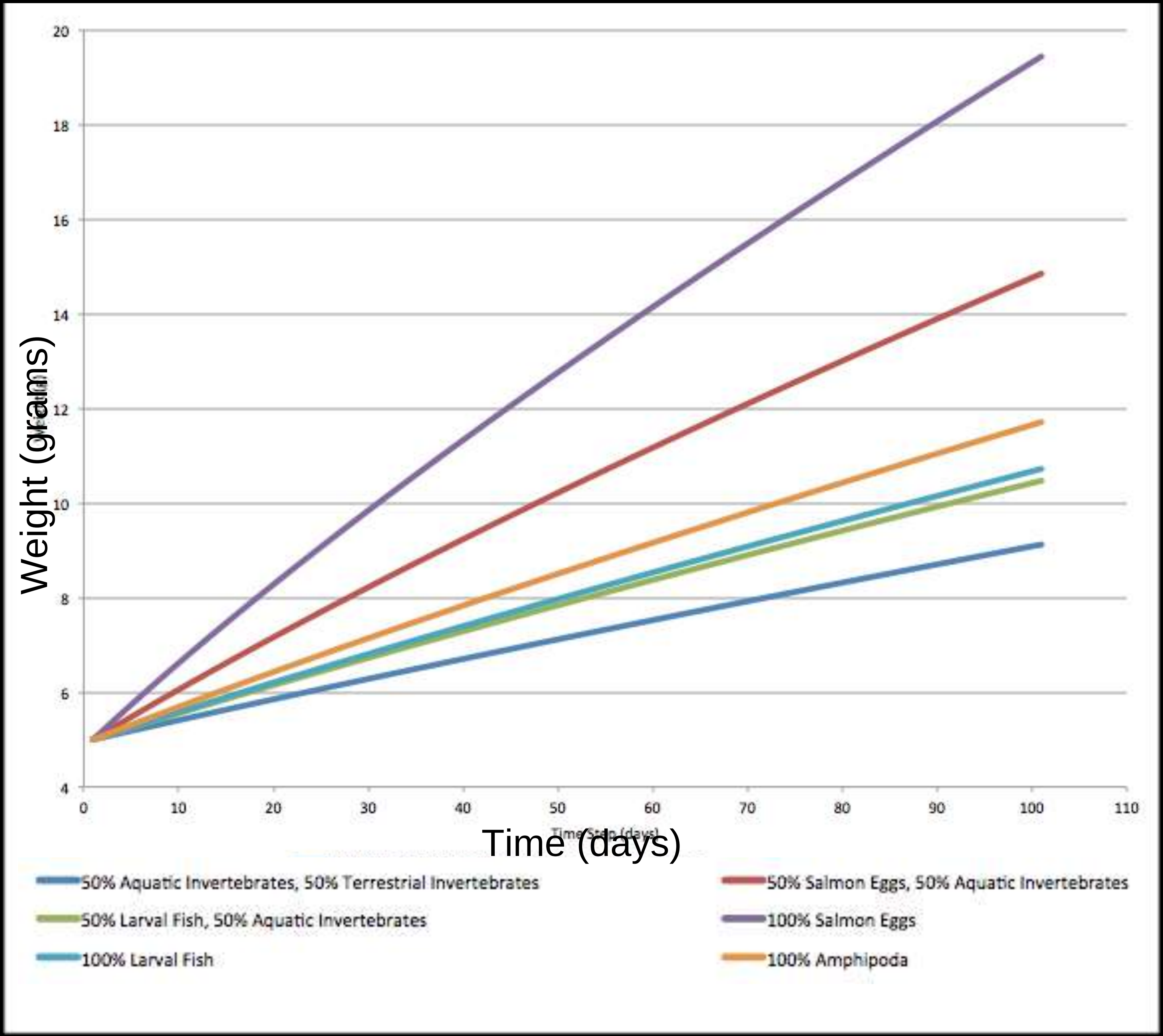
R = Respiration

S = Specific Dynamic Action
(cost of digestion)

U = Excretion

F = Egestion

Change in growth due to differences in diet composition



BIOENERGETICS

FUTURE DIRECTIONS

- Model can be modified to simulate seasonal changes
  - Temperature
  - Diet composition
  - Stream velocity
- Potential to aid in stream restorations to provide adequate, high quality food for juvenile steelhead

WHAT NEXT?

- Spring field sampling has begun
- Fall sampling in August-October
- Otolith data will be presented at IAGLR & AFS in ’15 & ’16
- Continue to work on diet analysis & bioenergetics model

ACKNOWLEDGEMENTS & THANKS

- GLFT
- MDNR
- WDNR
- CMU
- Kalamazoo TU
- SJRVFF
- SJRBC
- Dr. Kevin Pangle

THE SMALL ARMY
CMU UNDERGRADUATE STEELHEAD PROJECT VOLUNTEERS

Arica Andrews
Kyle Brumm
Pete Corp
Joe Decaussin
Jameson Farinosi
Chantelle Fortier
Kynzie House
Halley Love
Alan McTaggart
Carlie Money
Brittany Santure
Lee Scheffler
Dave Thumser

SPECIAL THANKS
FAMILY AND FRIENDS

Tom Watson
Patty Armenio