Using otoliths to determine connectivity & movements

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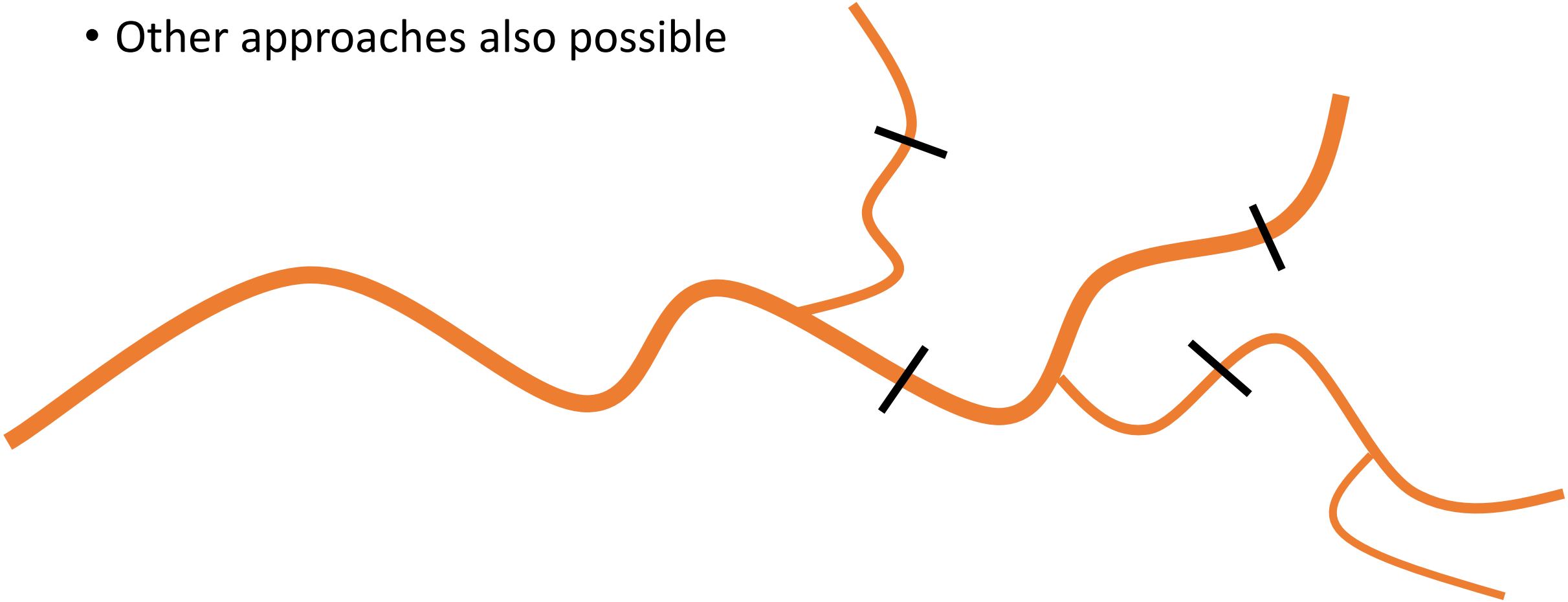
Fish movement
Longitudinal linkages
Lateral (offstream) linkages
Vertical linkages
Spatial & temporal scales

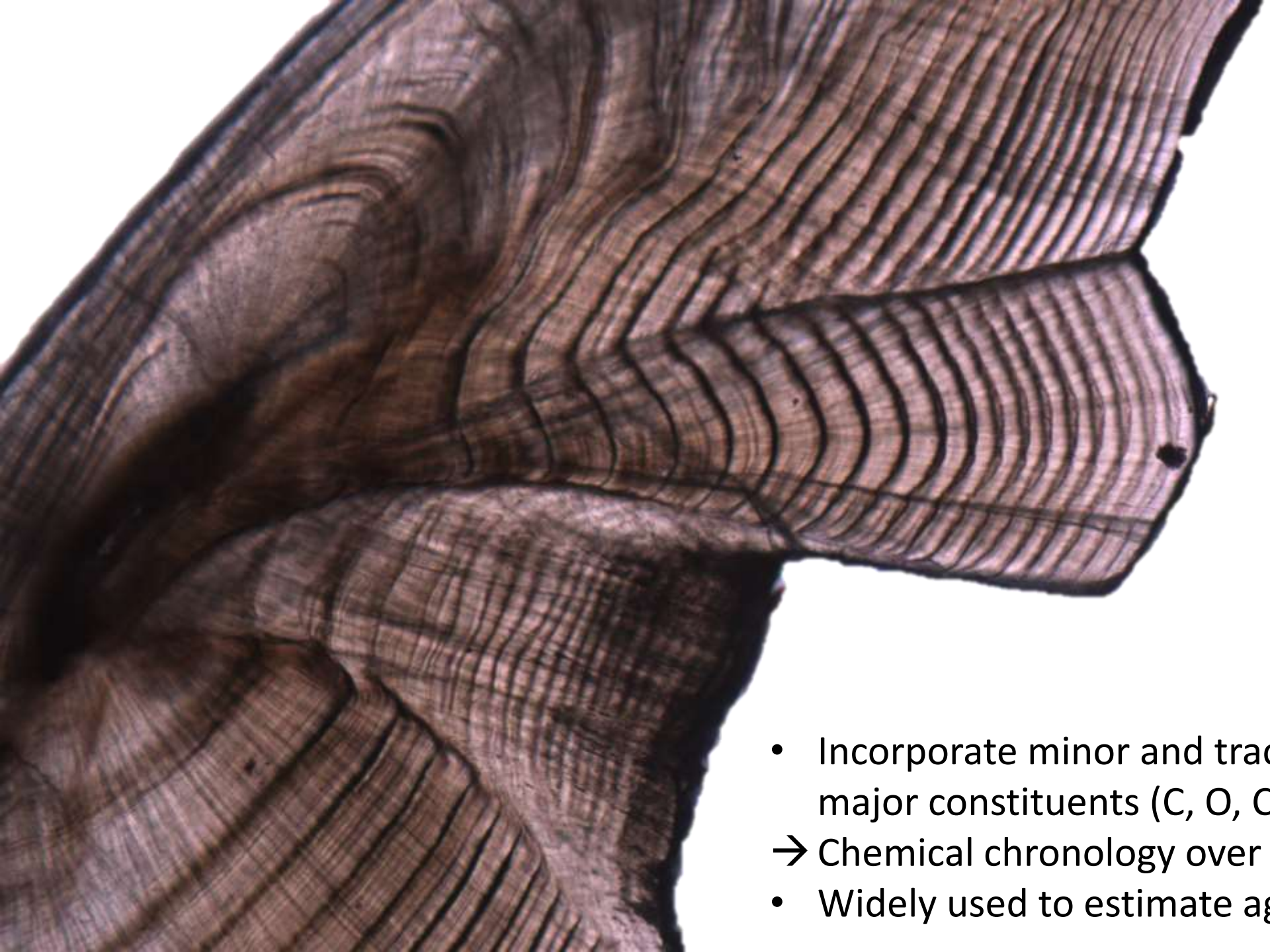
Ecological connectivity

- Movement of organisms vs materials & energy
- Other approaches also possible



Ear bones or otoliths

- Movement & life history information
- Biogenic calcium carbonate
- Usually aragonite on protein matrix
- Inner ear in membrane filled with endolymph fluid
- Accrete material to surface on daily basis



- Incorporate minor and trace elements as well as major constituents (C, O, Ca)

→ Chemical chronology over entire life of fish

- Widely used to estimate age

Otoliths used for more than just age

- Chemical patterns for age determination
- Radiochemical dating to determine longevity
- Population or stock structure
- Connectivity, movements and migration
- Life history behavior and variation
- Reconstructing environmental conditions using chemical tracers
- Combining chemical tracers and fish growth
- Provide information on indigenous fishing practices

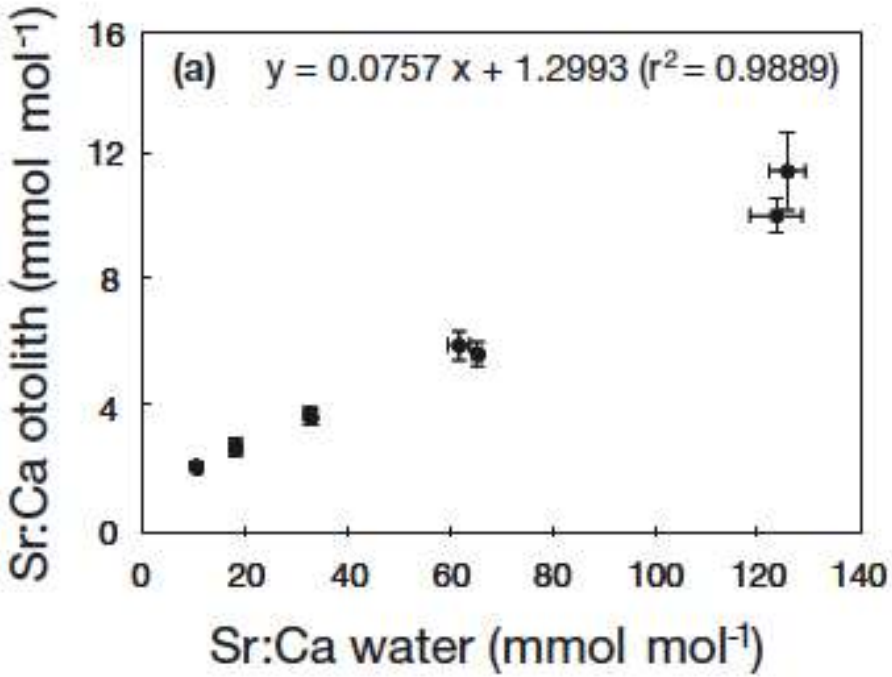
Variation in otolith chemistry can be used to explore life history variation

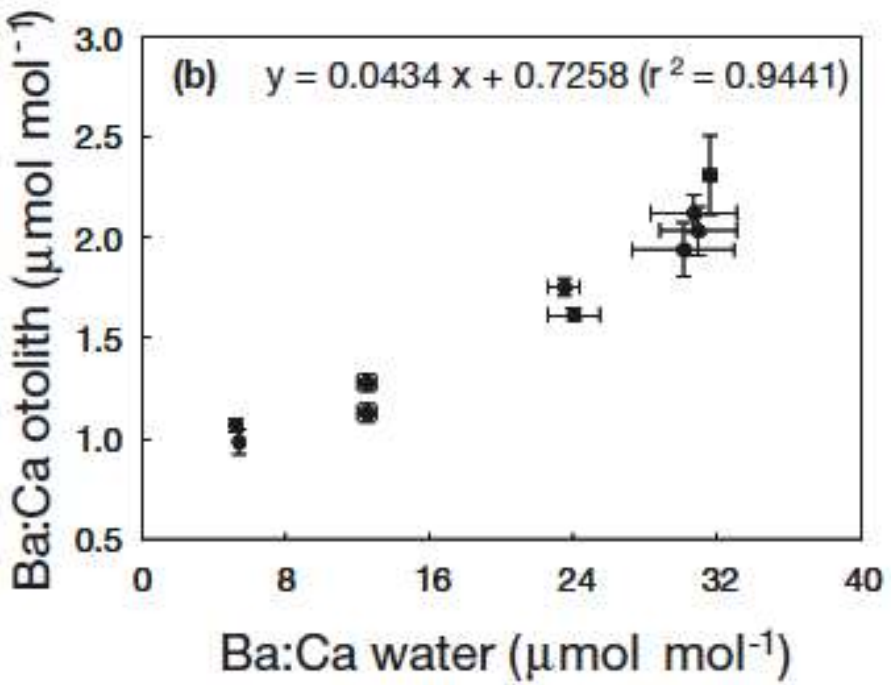
But what does this information tell us?

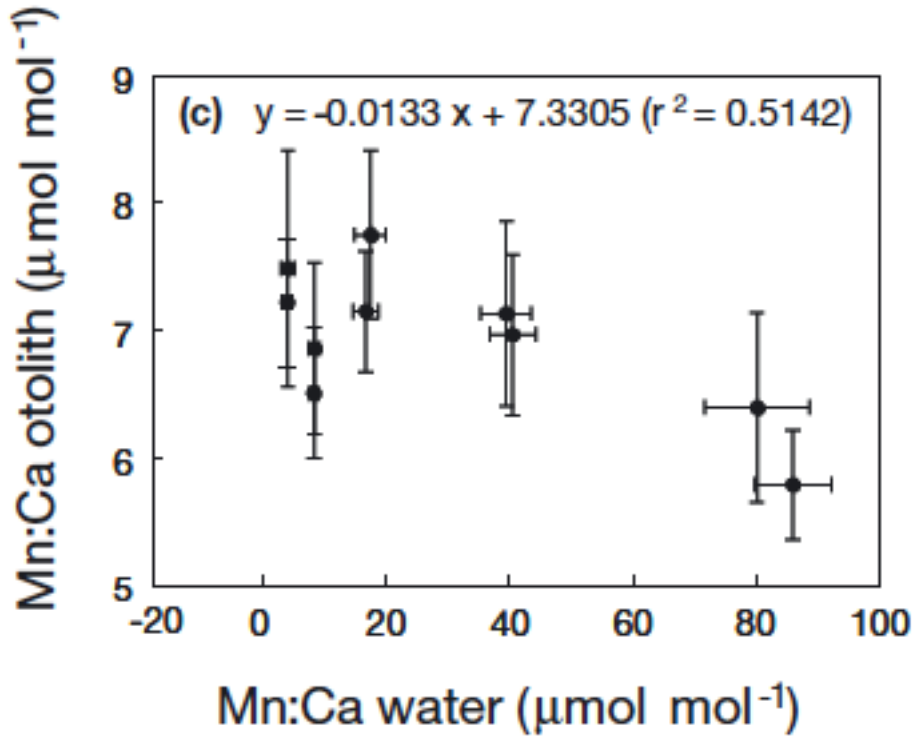
How can we interpret differences in otolith chemistry and infer possible fish movement and life history traits?

Can we use natural and applied tags to study movement in the same manner as we would use other tags?

Element incorporation in otoliths

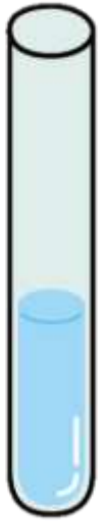




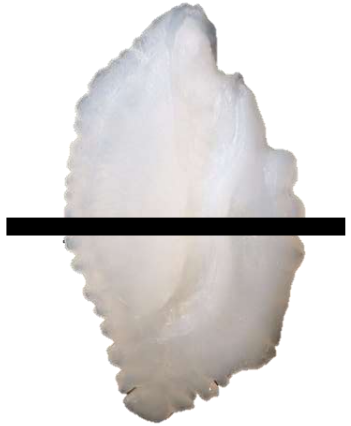


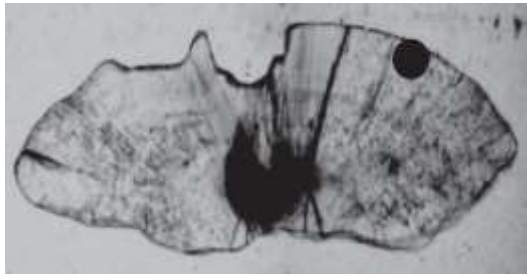
Elsdon & Gillanders (2003) MEPS

Otolith sampling approach influences spatial resolution



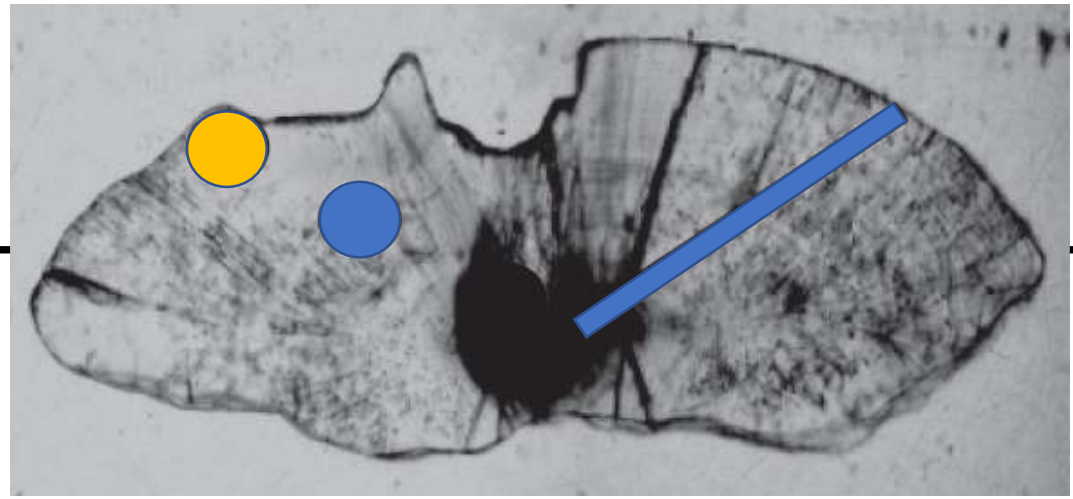
Integrated signature – one value per element/isotope

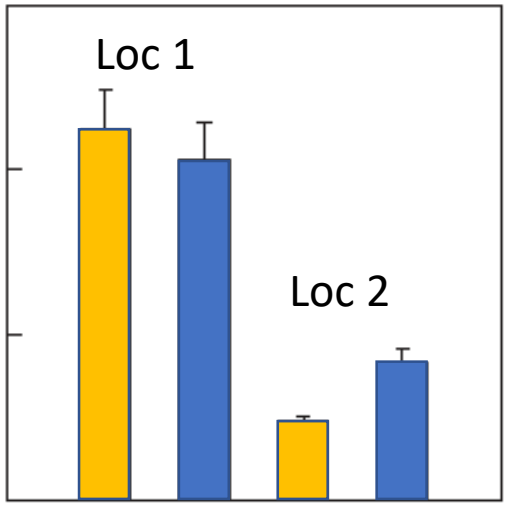


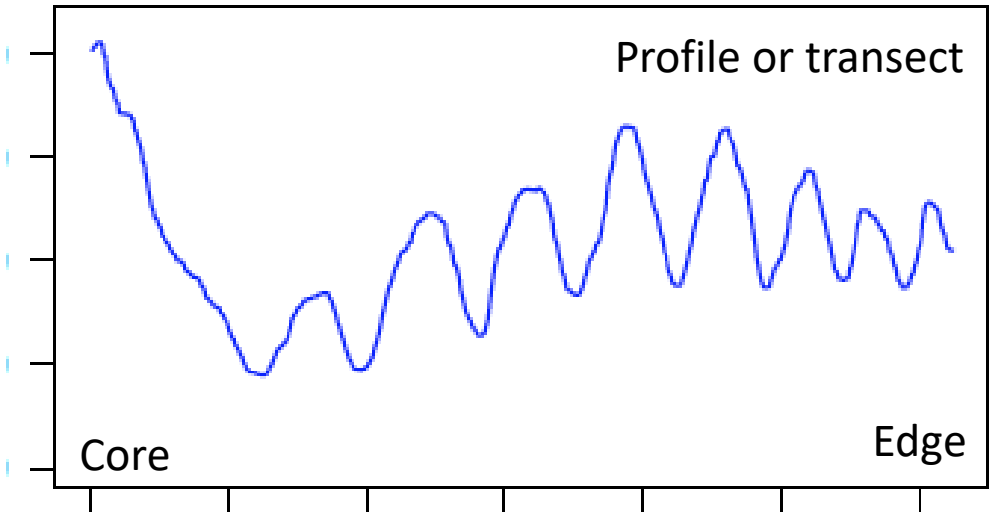


Signature reflecting specific life period – one value per element/isotope

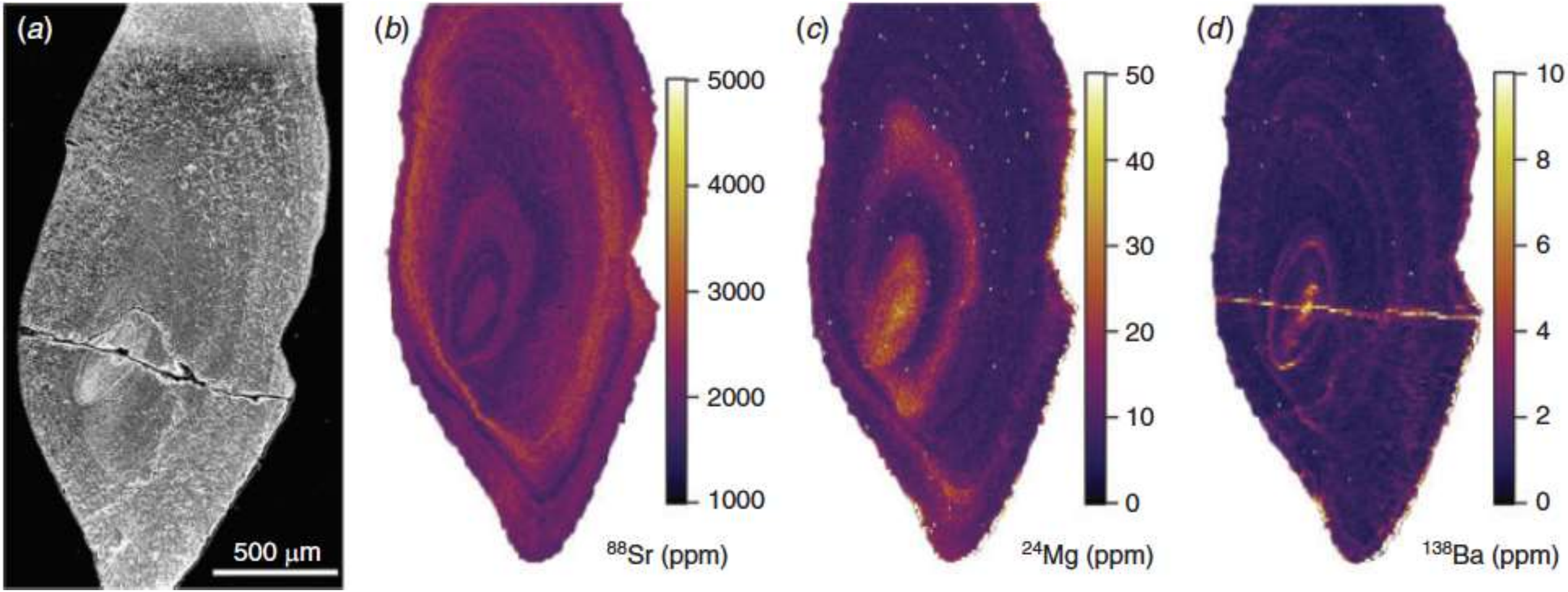
Otolith sampling approaches continued







Otolith sampling approaches continued

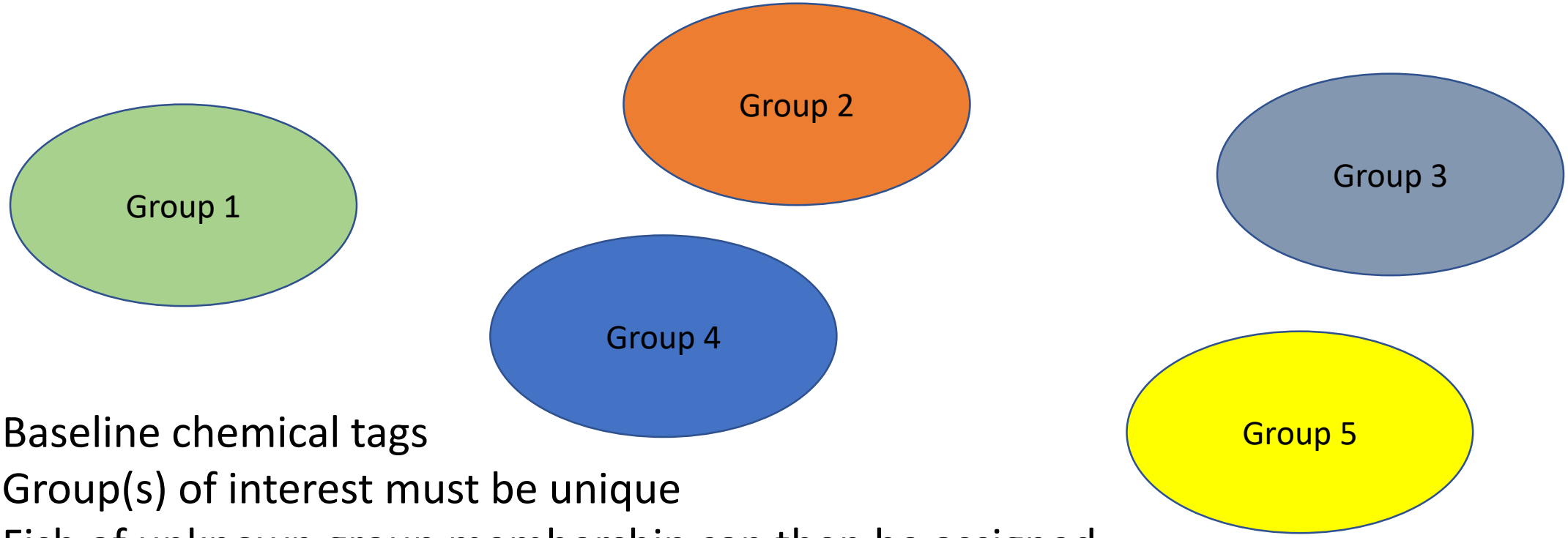


McFadden, Wade, Izzo, Gillanders, Lenehan, Pring (2016) MFR

Movements and life-history information

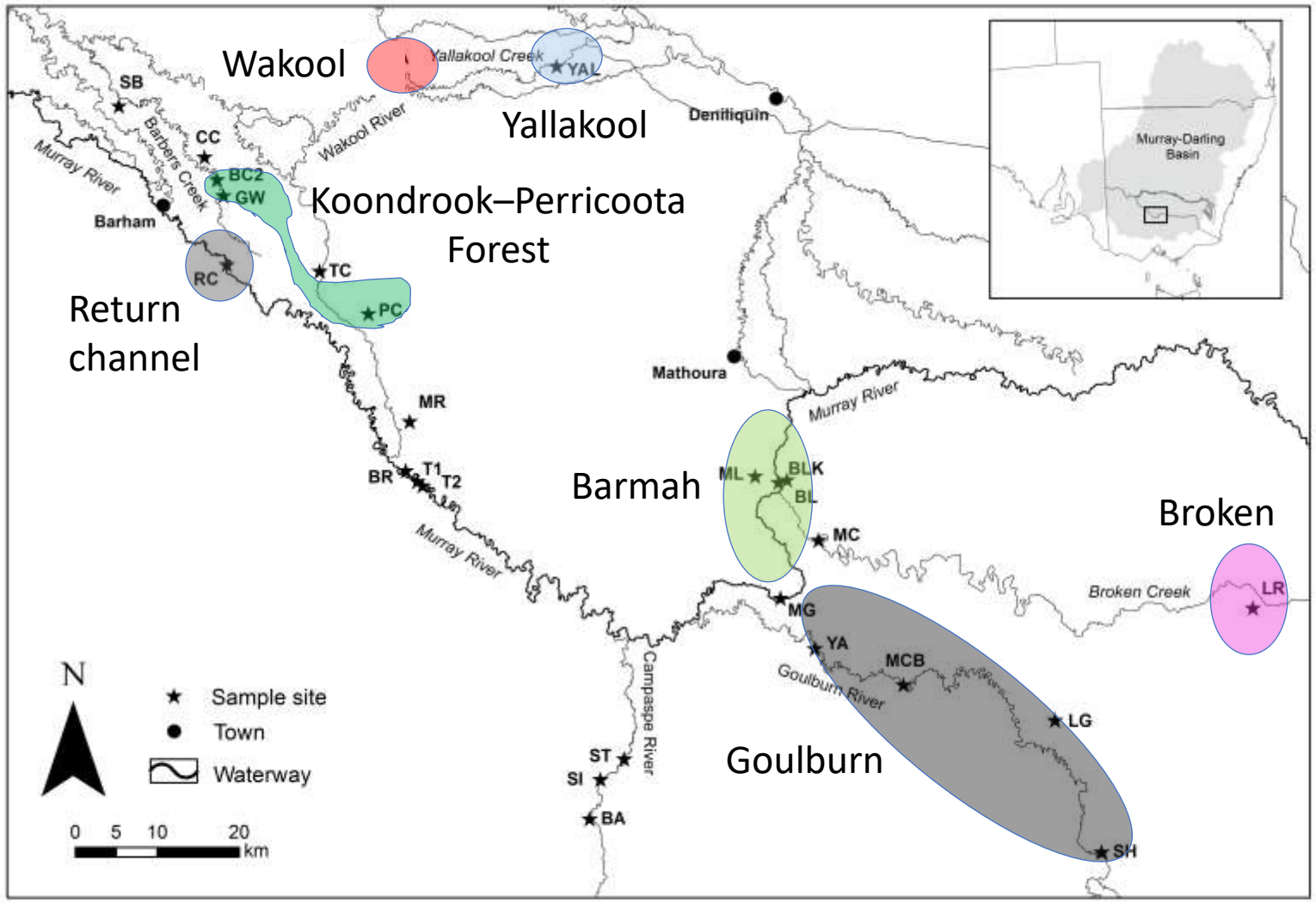
1. Estimates of movement & life-history traits of a single fish group
2. Assessing connectivity among groups using natural chemical tags in otoliths
3. Transgenerational marks to determine parentage & natal origins
4. Profile analysis to define life-history variation within a population
5. Profile analysis to describe movements through different environments

Assessing connectivity among groups using chemical tags in otoliths



- Baseline chemical tags
- Group(s) of interest must be unique
- Fish of unknown group membership can then be assigned
- Natural or applied tags can be used
- Determine contribution of each group to mixed population
- Group mixing, movement among groups, natal homing

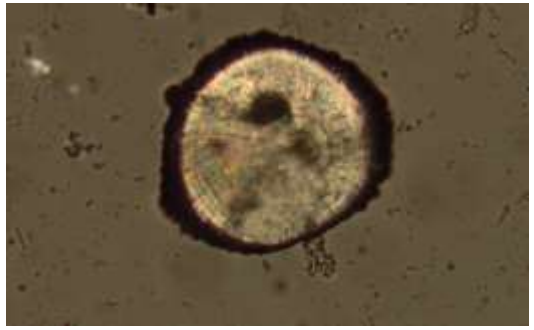
Connectivity among groups – MDB carp

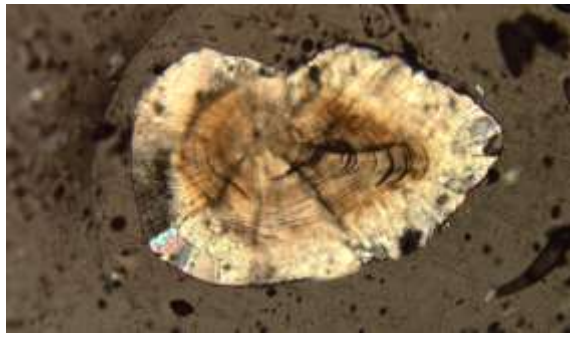


- KPF is a living Murray icon site
- Environmental works enable watering of forest without overbank flood
- Does inundation allow carp to colonise River Murray?
- Sampled 7 areas

Duncan, Martin, Rogers & Gillanders (2017) report

Connectivity among groups - approach



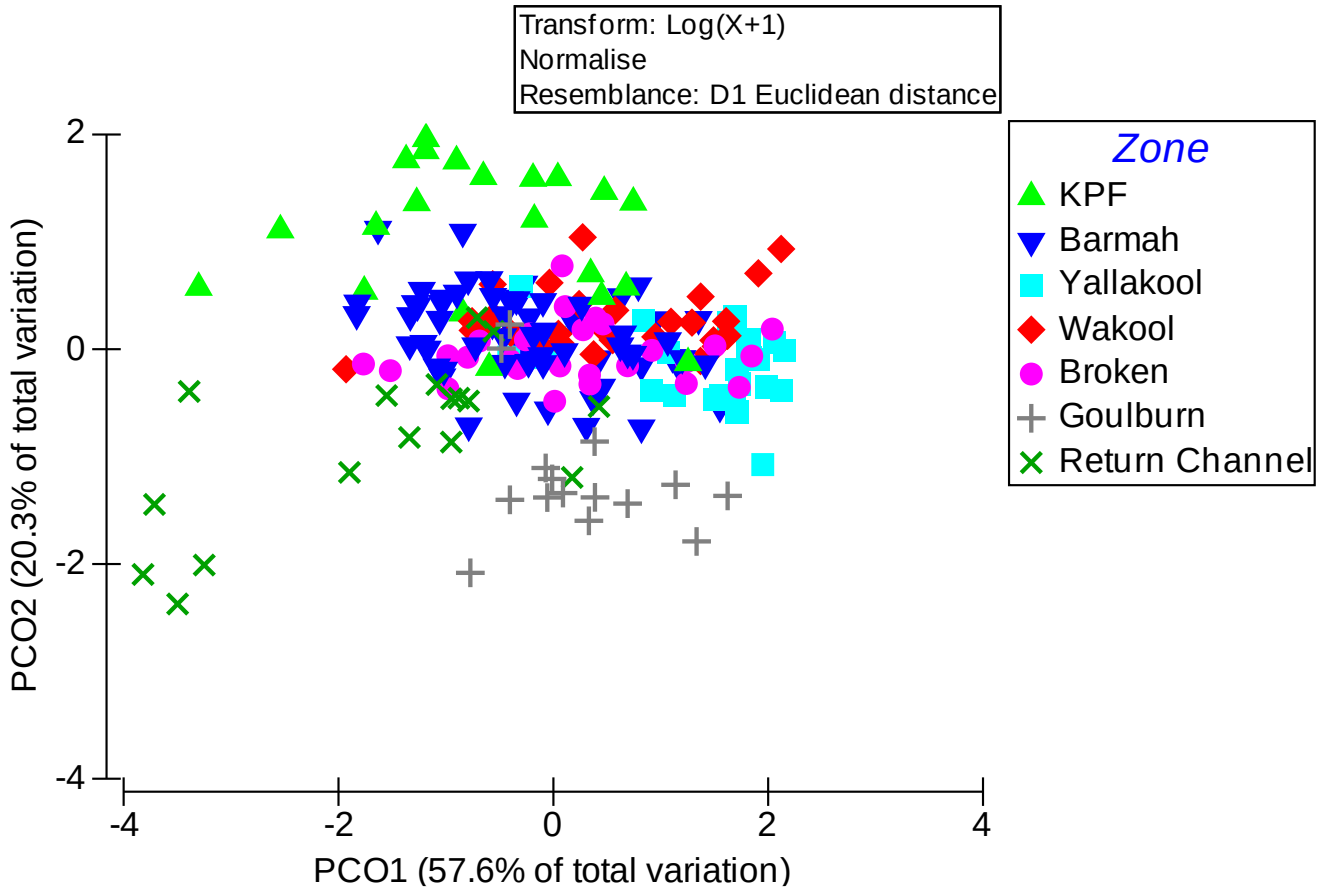


- Sampled seven areas
- Larval signatures = baseline data
- YoY collected later
- Proportion of YoY from each place

- Actual connectivity requires estimates of number of fish in each group

Duncan, Martin, Rogers & Gillanders (2017) report

Connectivity among groups – larval signatures

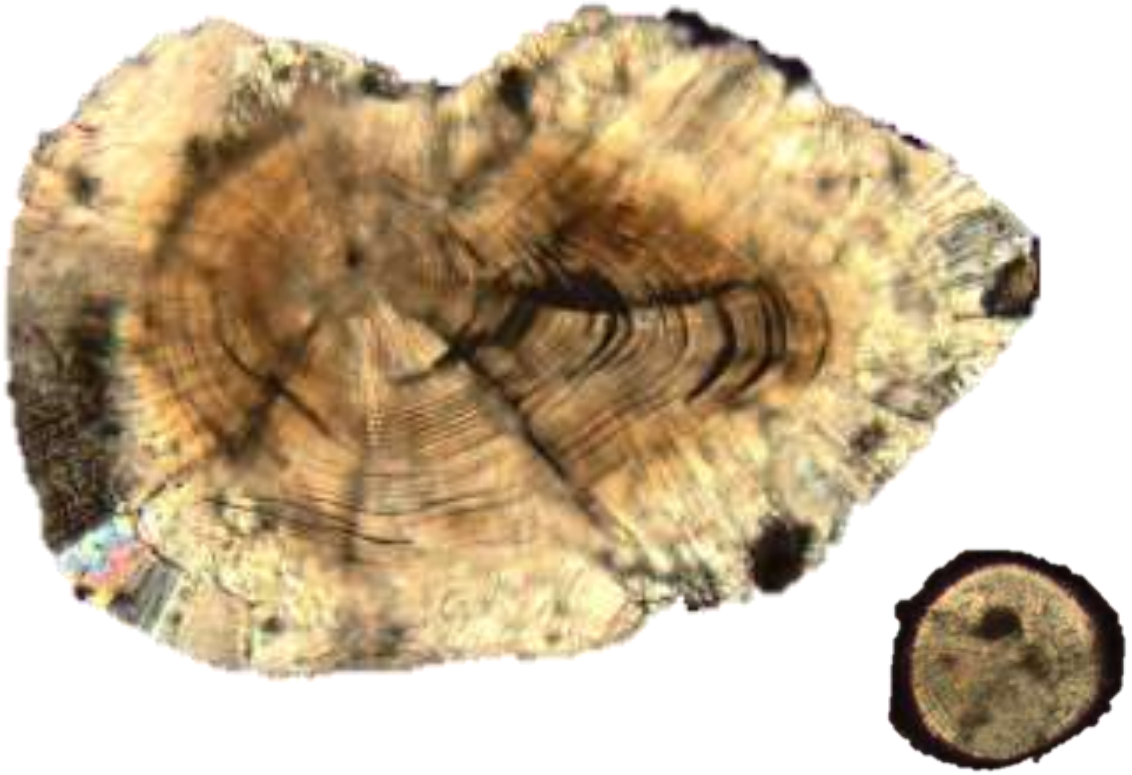


- Multielement signature
- Overall classification success was 62%
- Range 39-80%
- KPF – 76%

- Classify YoY using core chemistry

Duncan, Martin, Rogers & Gillanders (2017) report

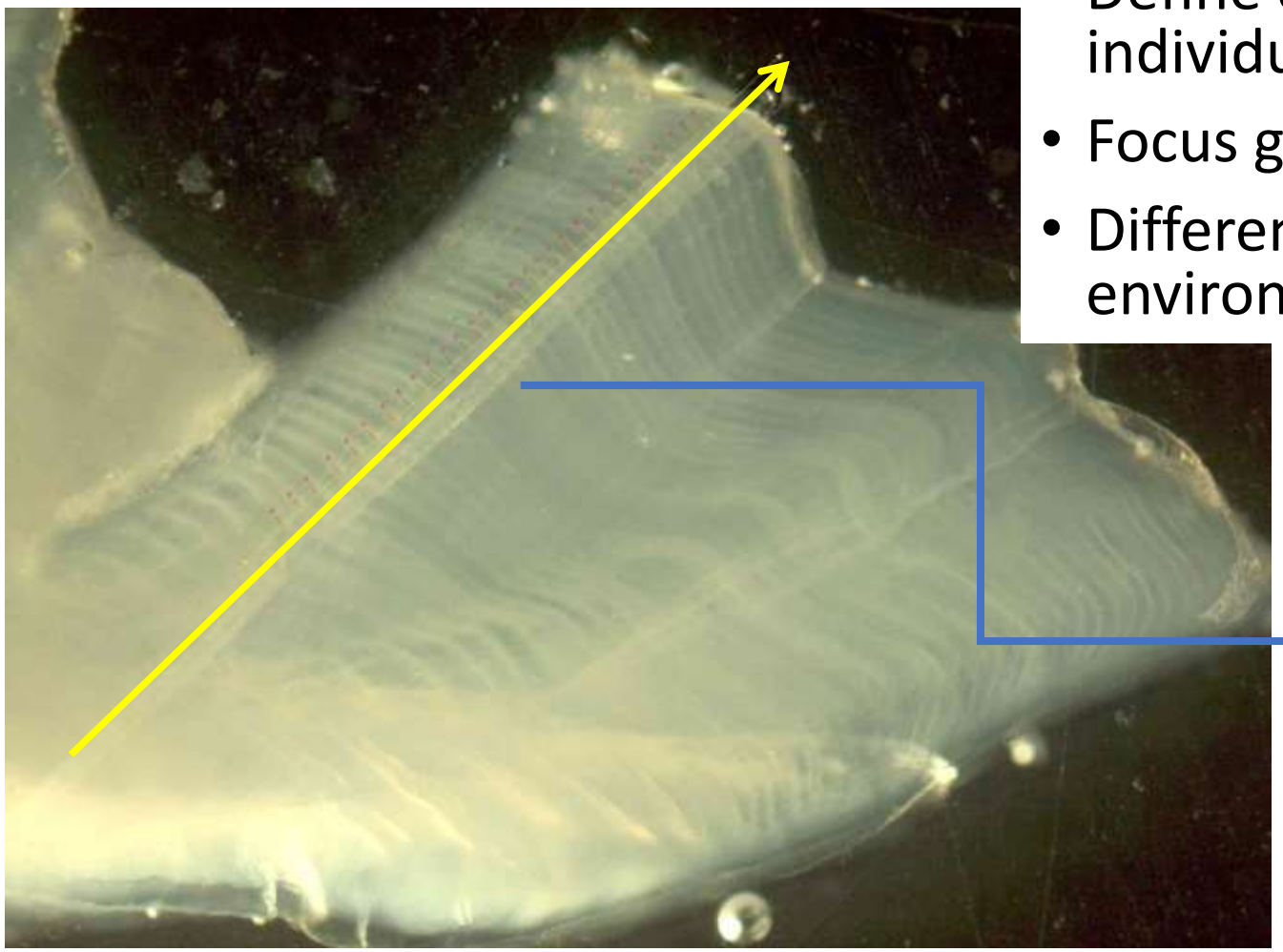
Connectivity among groups – YoY fish

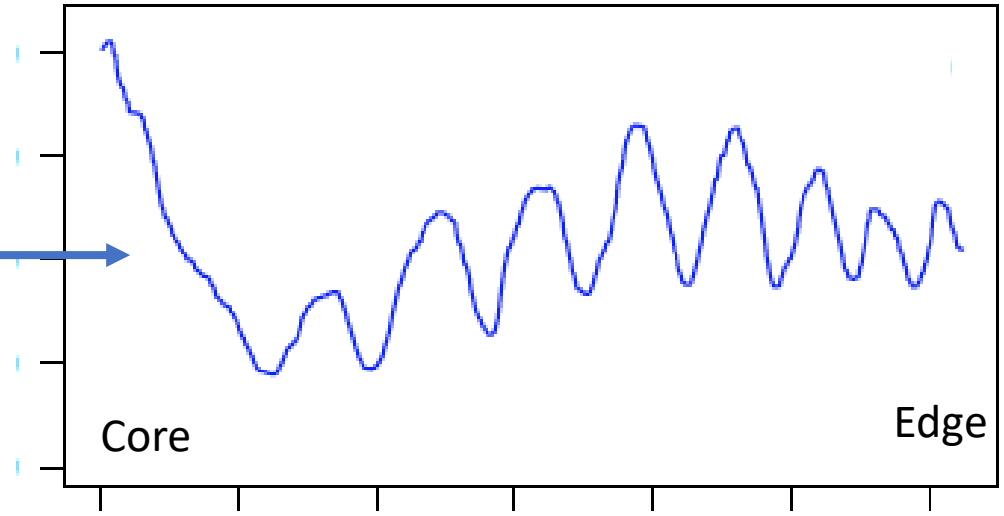


- Some fish not from region sampled
- Treat YoY as unknowns
- Murray River YoY mostly from Goulburn & Yallakool
- KPF YoY also mostly from Goulburn & Yallakool
- One KPF YoY from forest
- Carp colonizing river not from forest

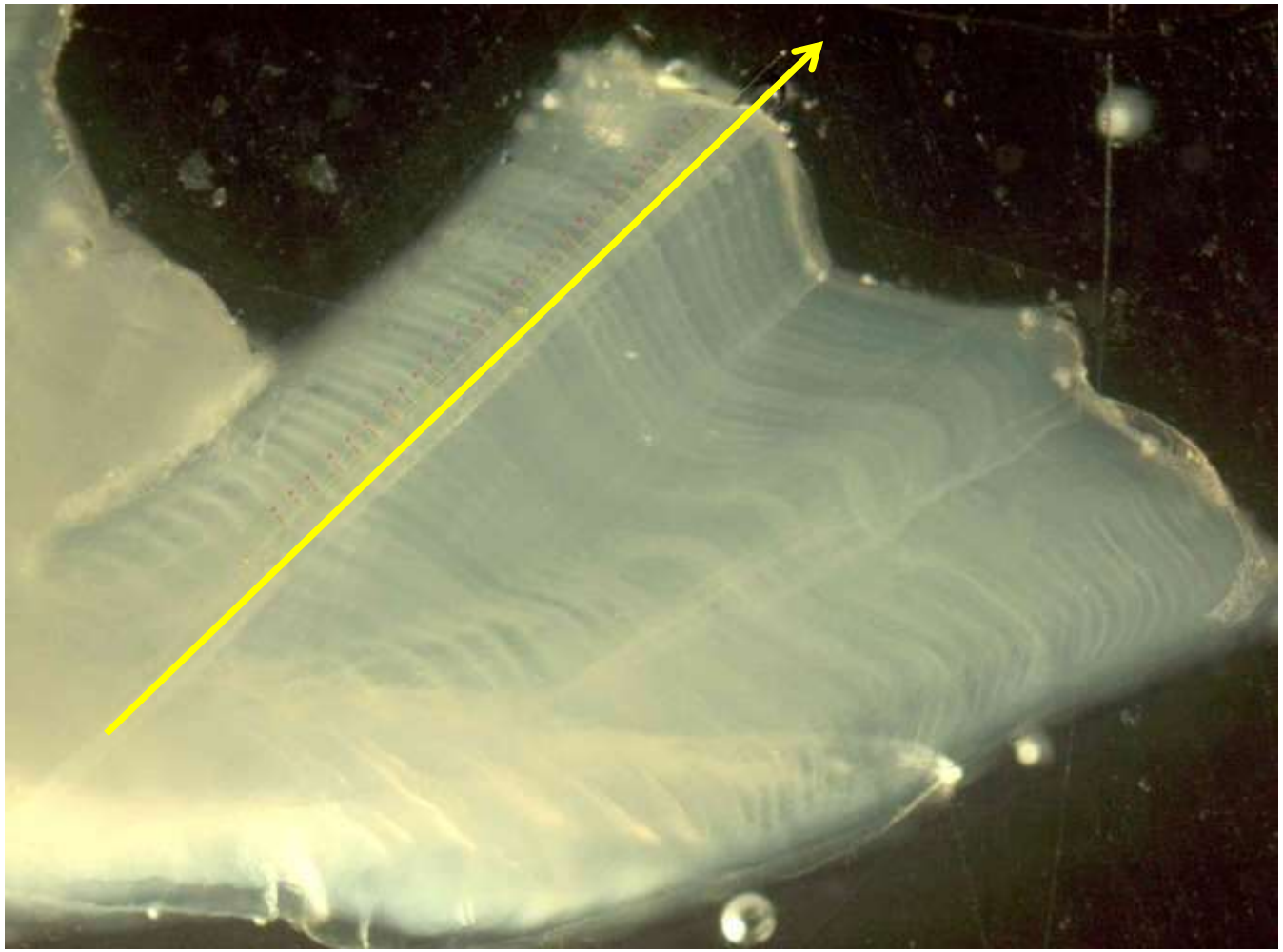
Life-history variation within a population – profile analysis

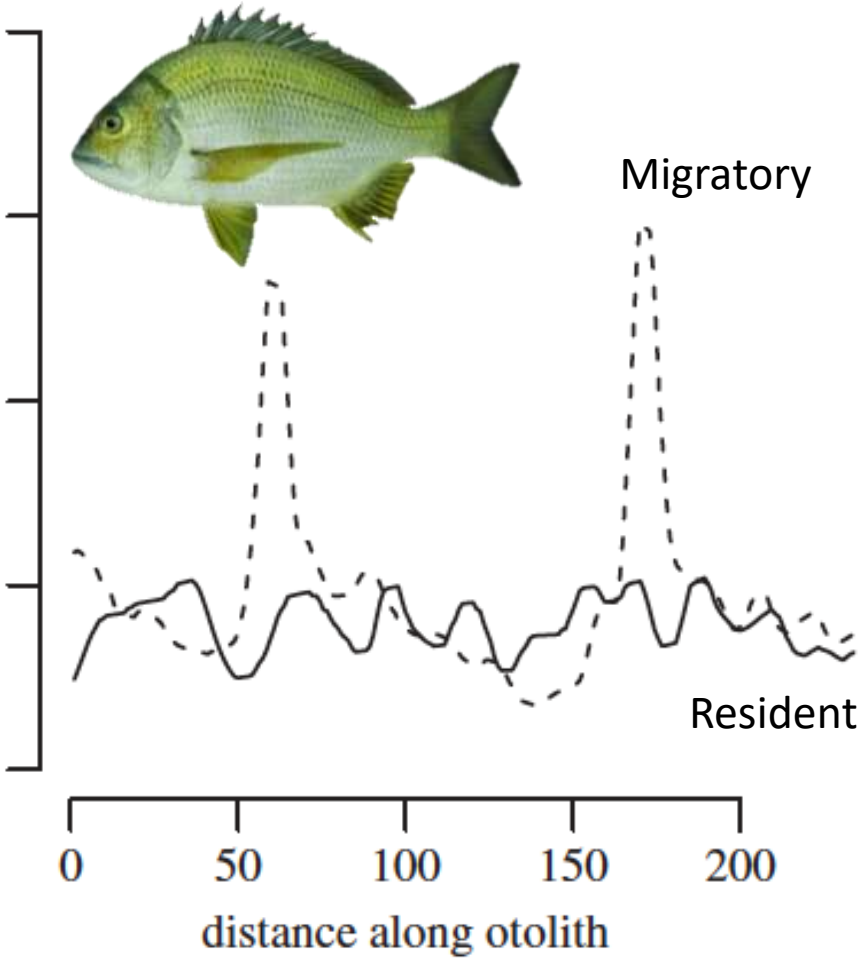
- Define differences in movement patterns of individuals within a population
- Focus generally on large scale movements
- Different environments but location of environments unknown





Life history variation within a population – Migrant & resident Ba:Ca profiles

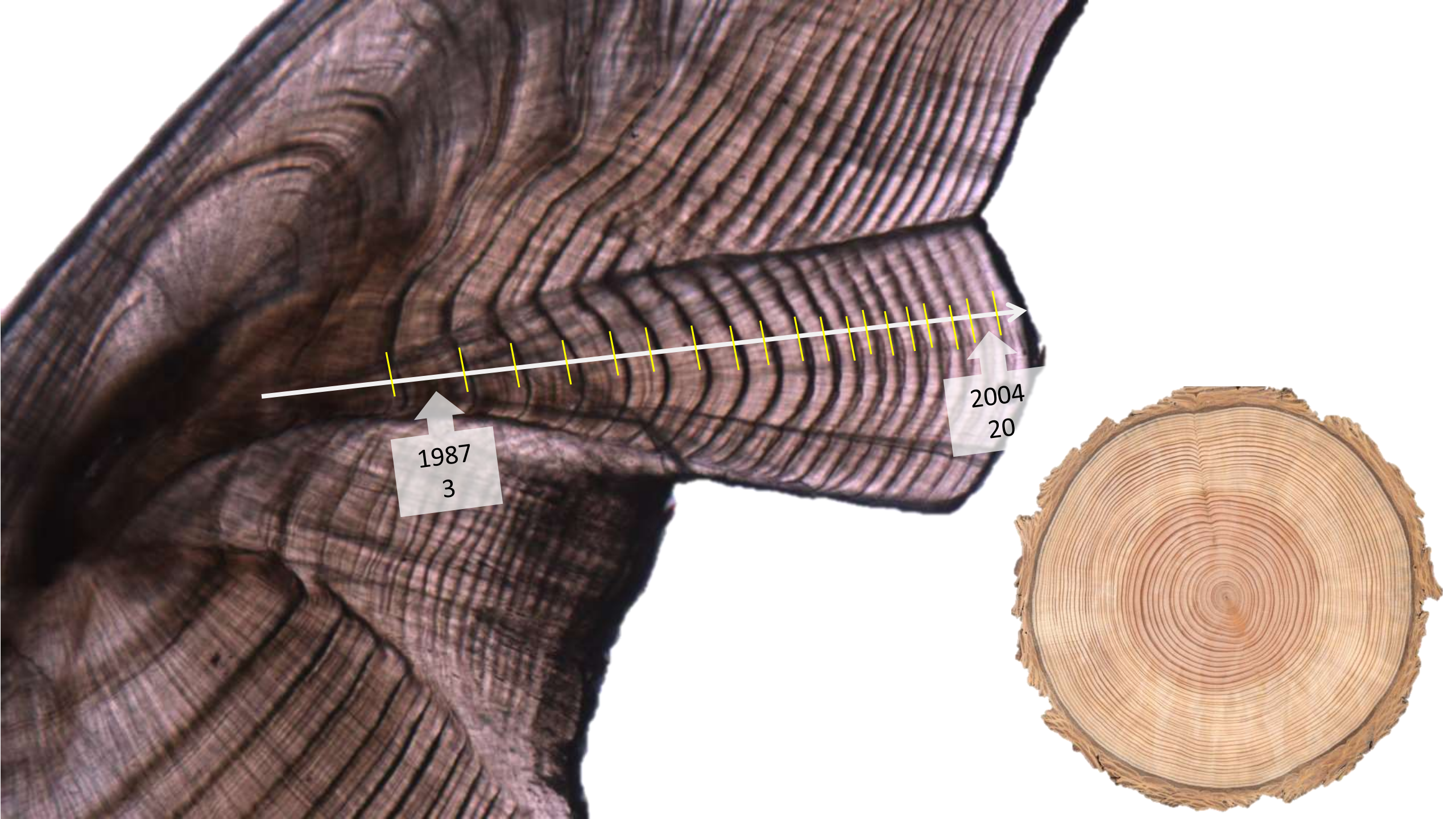




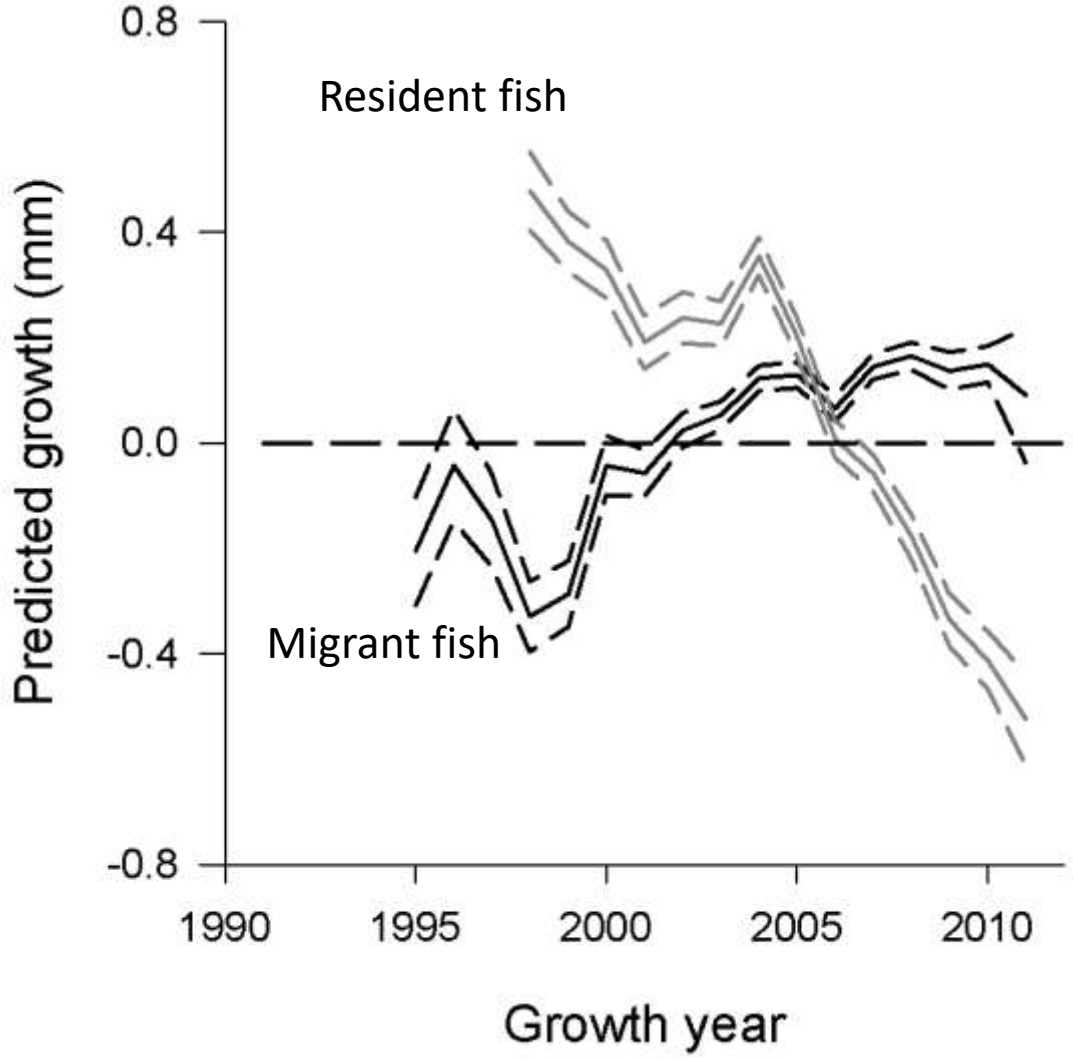
Biochronologies to reconstruct growth histories

And determine possible drivers of growth variation

- One or more environmental variables limit growth
- Environmental variability induces synchronous growth among individuals over time


1987
3
2004
20

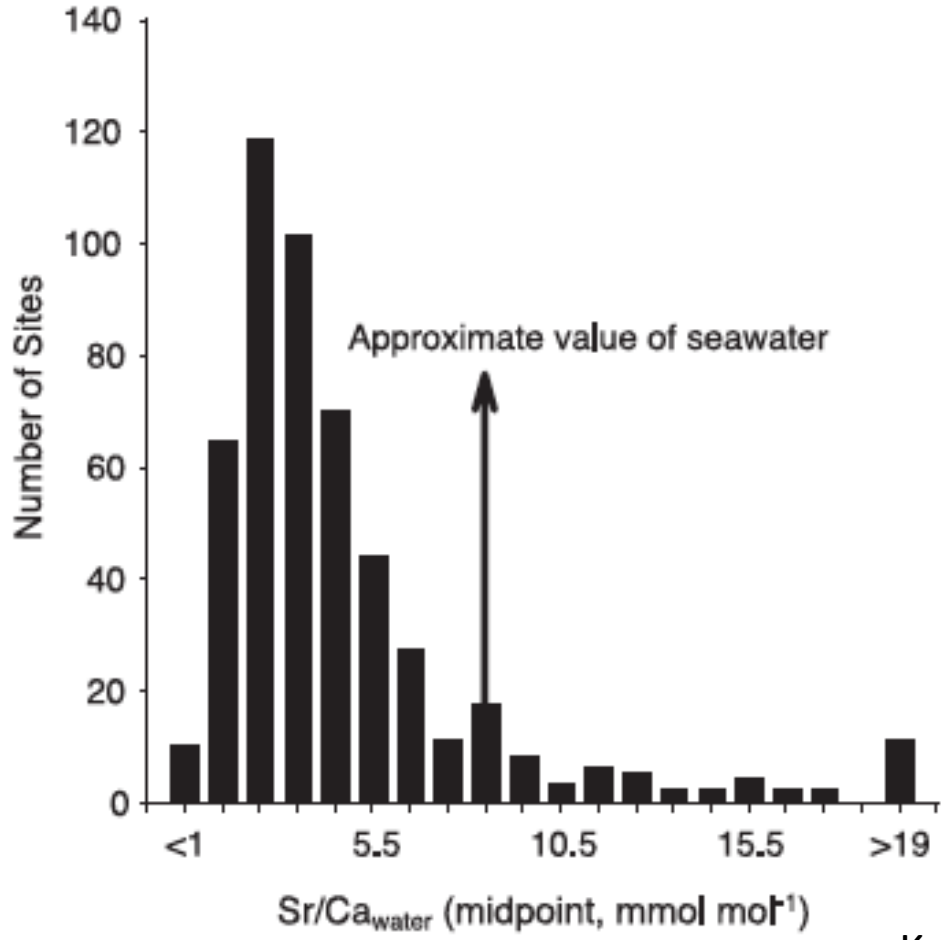
Life history variation within a population – application



Gillanders, Izzo, Doubleday, Ye (2015) Biology Letters

Movement through different environments

- Need established link between environment and otolith chemistry
- Requires water sampling



Kraus & Secor (2004) JEMBE

Summary

- Otolith chemistry can be used to demonstrate movement and connectivity in a system
  - Understanding of spatial and temporal scales of variability in water and environmental parameters aids interpretation
  - Further research on factors influencing otolith chemistry required

- Only one approach to determining movement and connectivity