Juvenile Life-History
of Fall Chinook Salmon

Understanding Life History Evolution in a Spatially Structured Population

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KENNEDY LAB

- **What are the drivers of life history variation in salmonids?**
- **How does spatial heterogeneity and environment impact survival/reproduction trade-offs throughout the life-cycle?**

OBJECTIVES

Snake River Fall Chinook

- Representation of juvenile yearlings within major spawning areas
- Reconstruct detailed juvenile migratory behavior using otolith microchemistry
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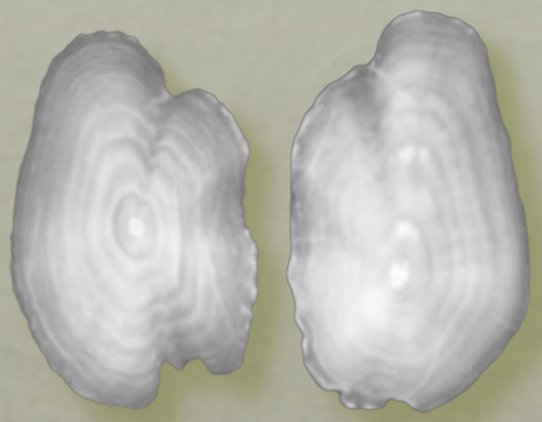
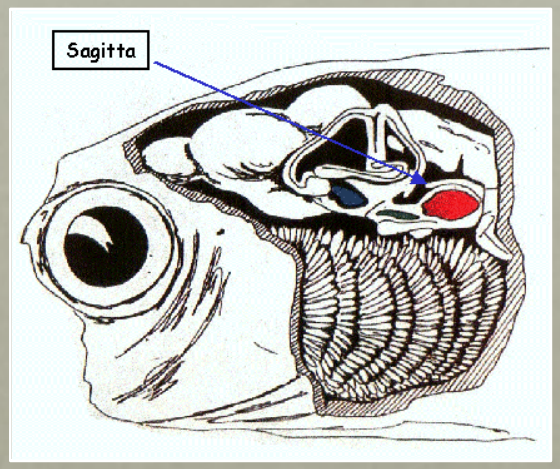
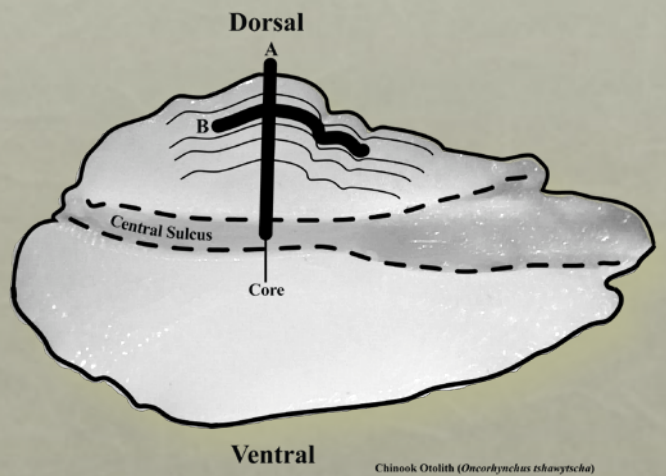
OTOLITH MICROCHEMISTRY





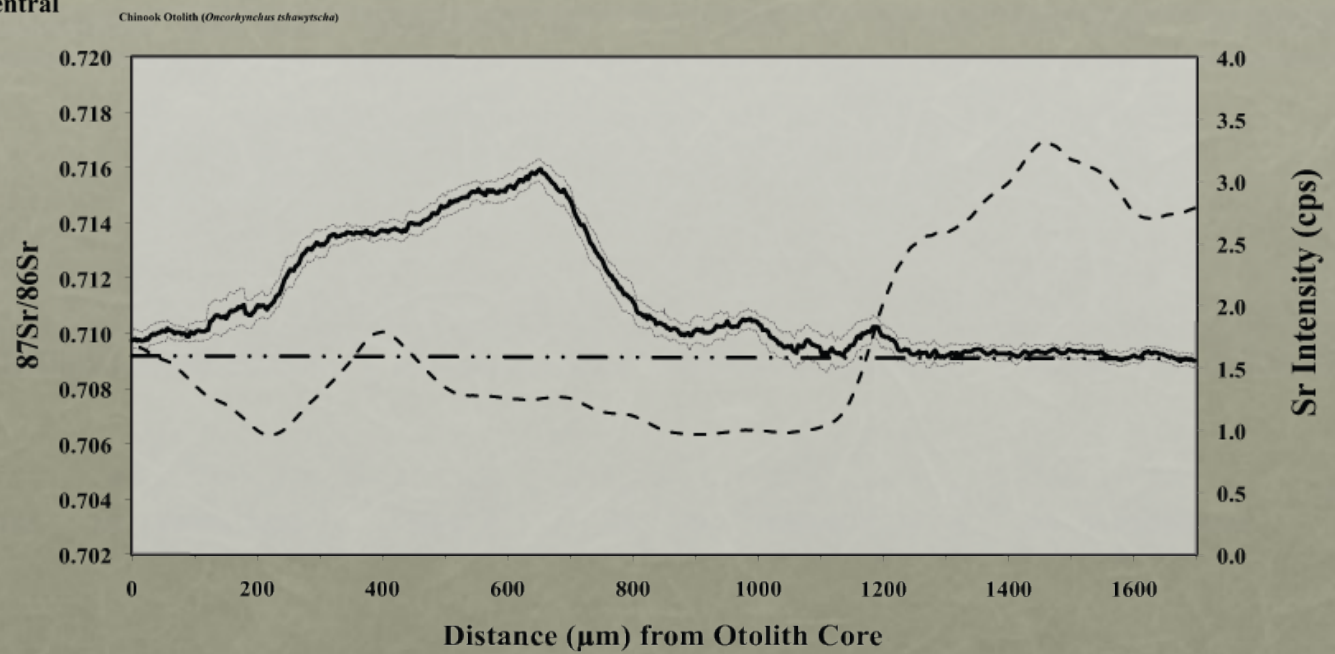
Microchemical Signatures in Otoliths Come From Underlying Rock

MIGRATION RECONSTRUCTION



LA-ICP-MS

- **Natal Signature** (100-250 microns)
- **Rearing Signature** (250-800 microns)
- **Overwintering signature** (>800 microns)
- **Ocean Entry** (increase in strontium intensity)



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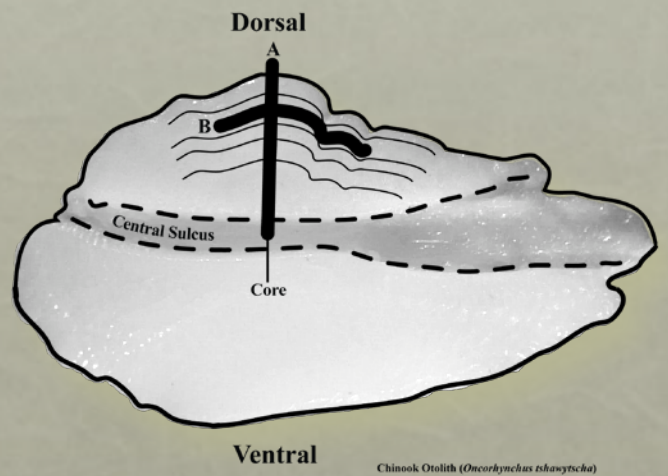

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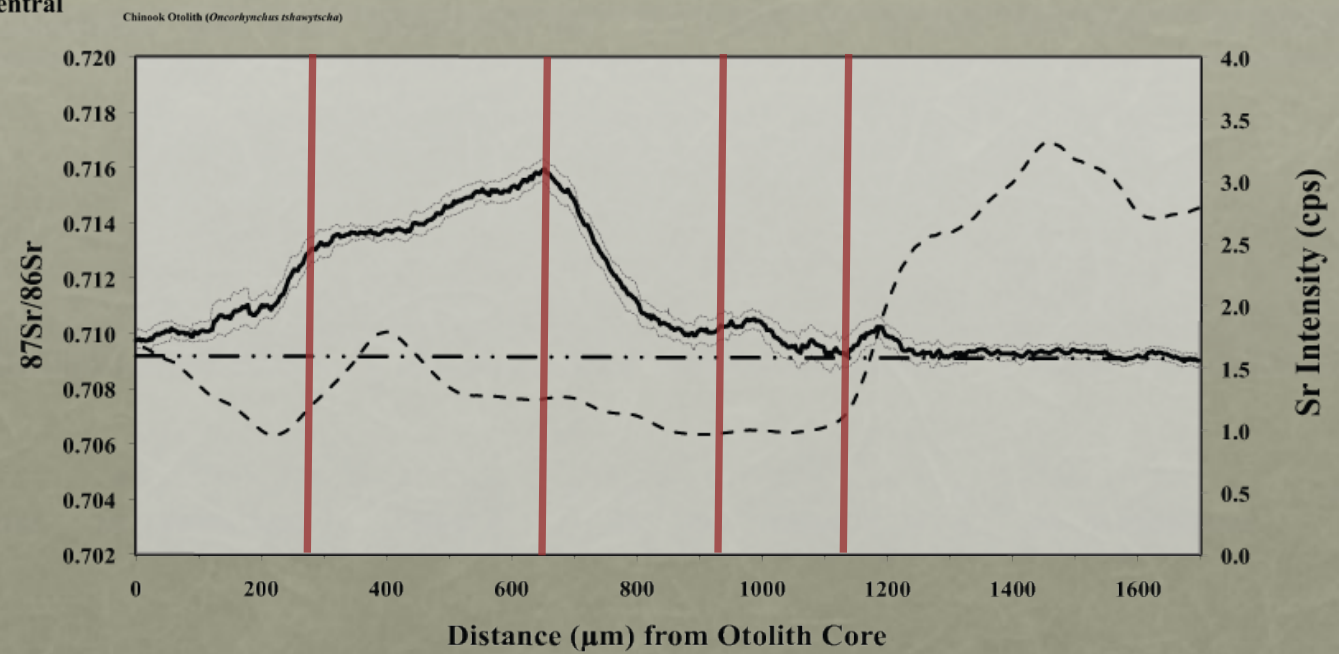

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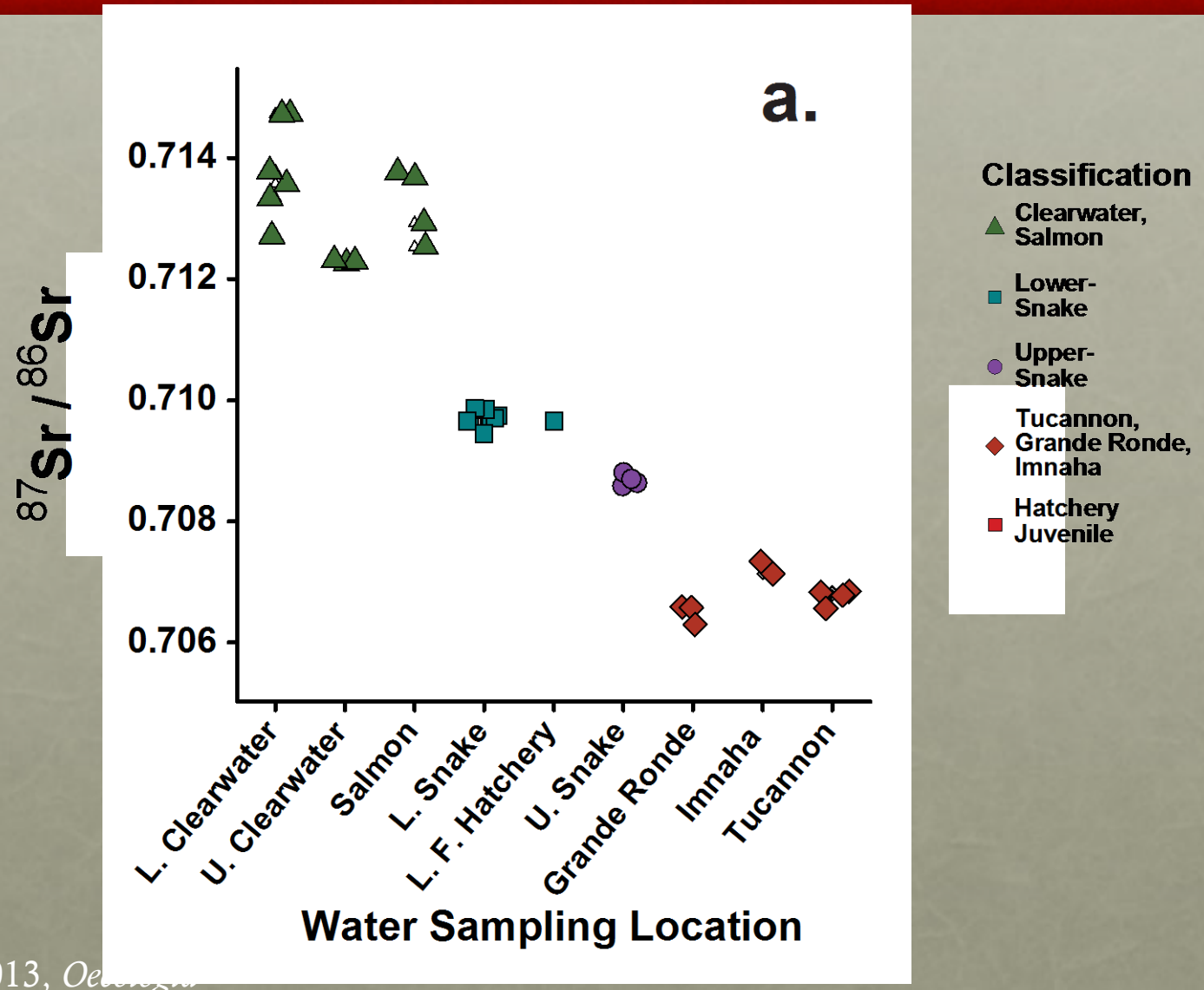
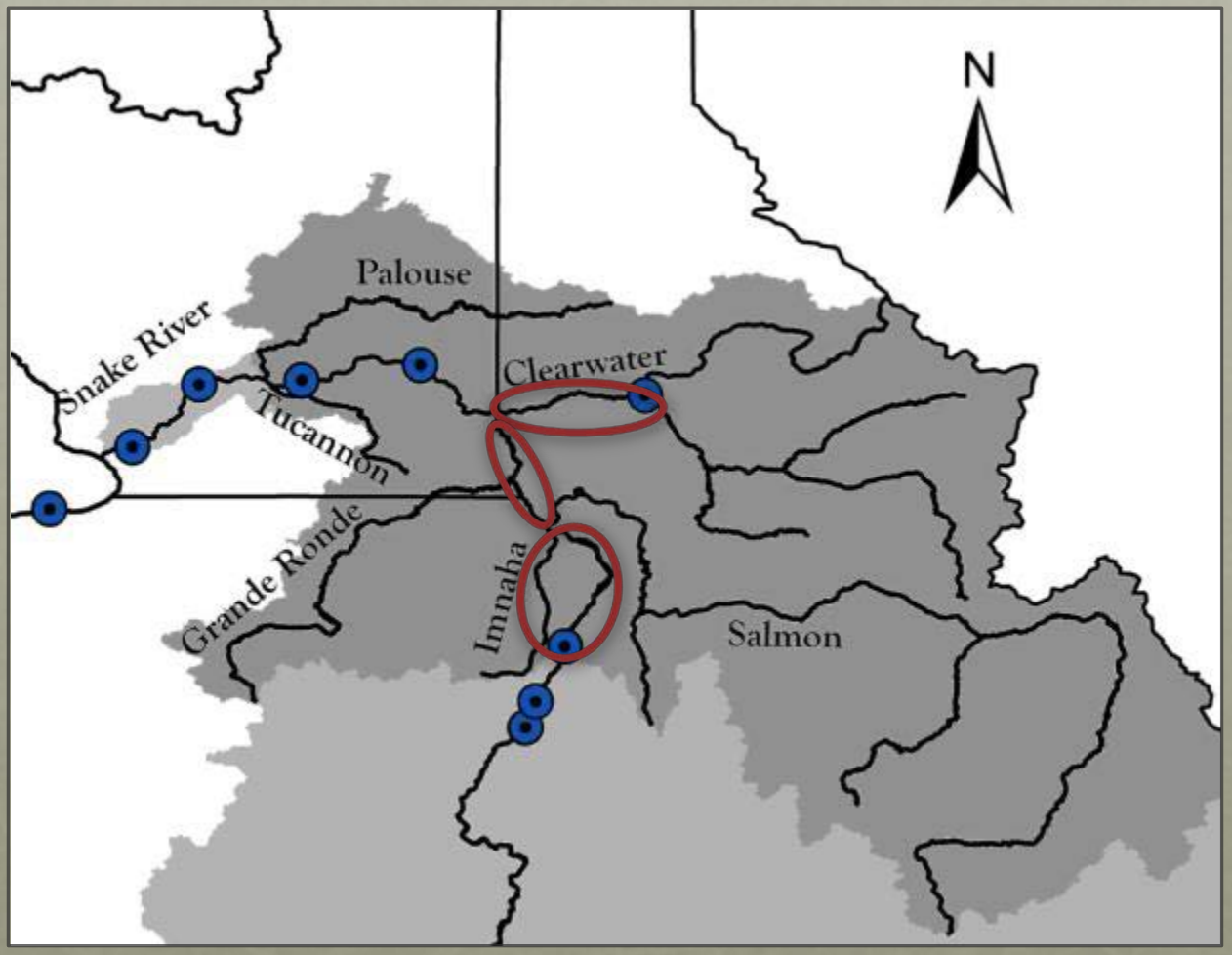
WATER CHEMISTRY



From Hegg et al. 2013, *Oecologia*

STUDY AREA


N
Palouse
Snake River
Clearwater
Tucannon
Grande Ronde
Imnaha
Salmon

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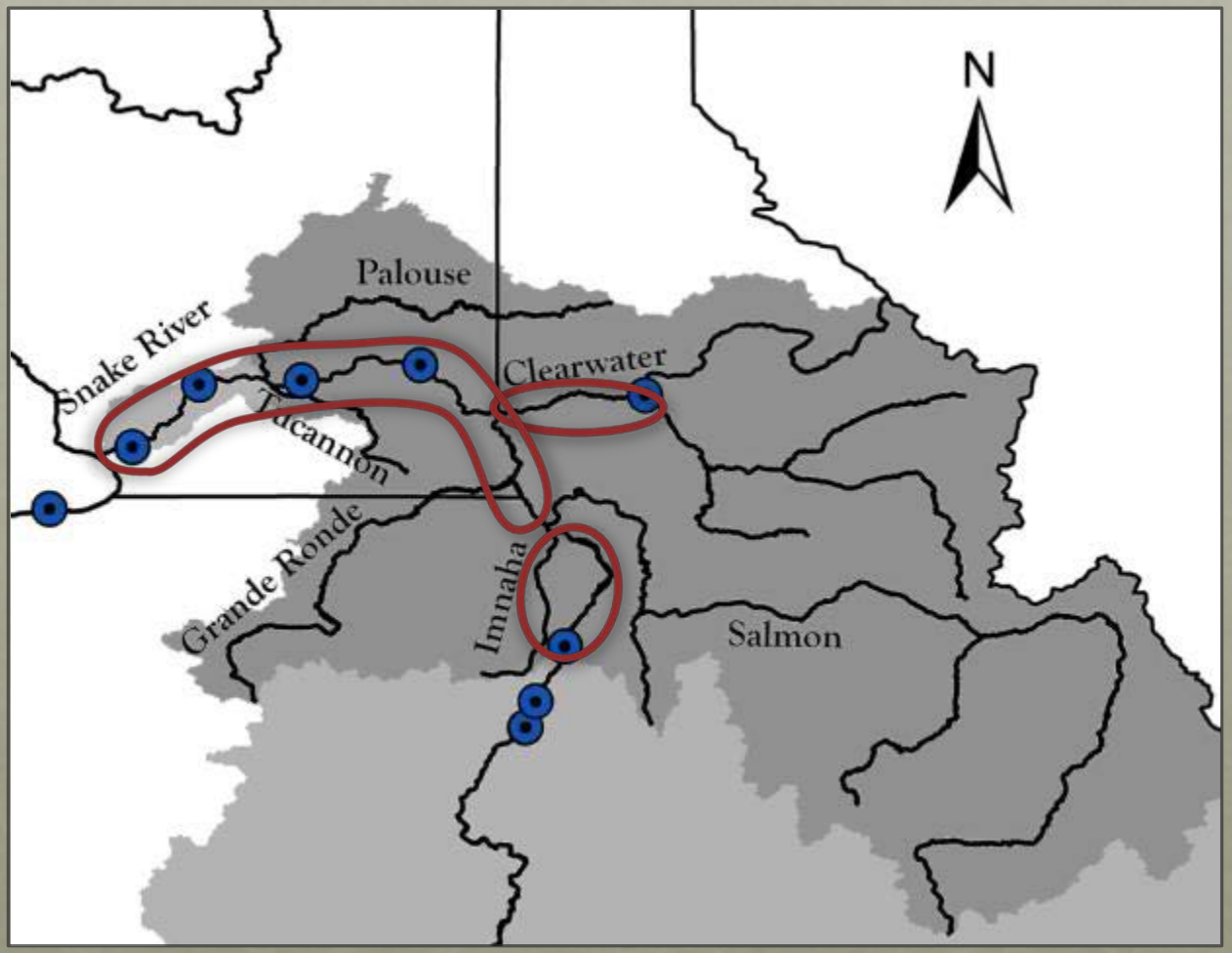
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YEARLING REPRESENTATION

- **Determining Yearling Representation**

Natal Stream	Subyearling	Yearling	% Yearling
Upper Snake	12	2	13% *
Clearwater/Salmon	10	34	77% *
Lower Snake	22	36	62%
Grande Ronde/Tucannon/Imnaha	1	1	50%
Total	45	71	
Percentage	39%	61%	

N = 120

From Hegg et al. 2013, *Oecologia*

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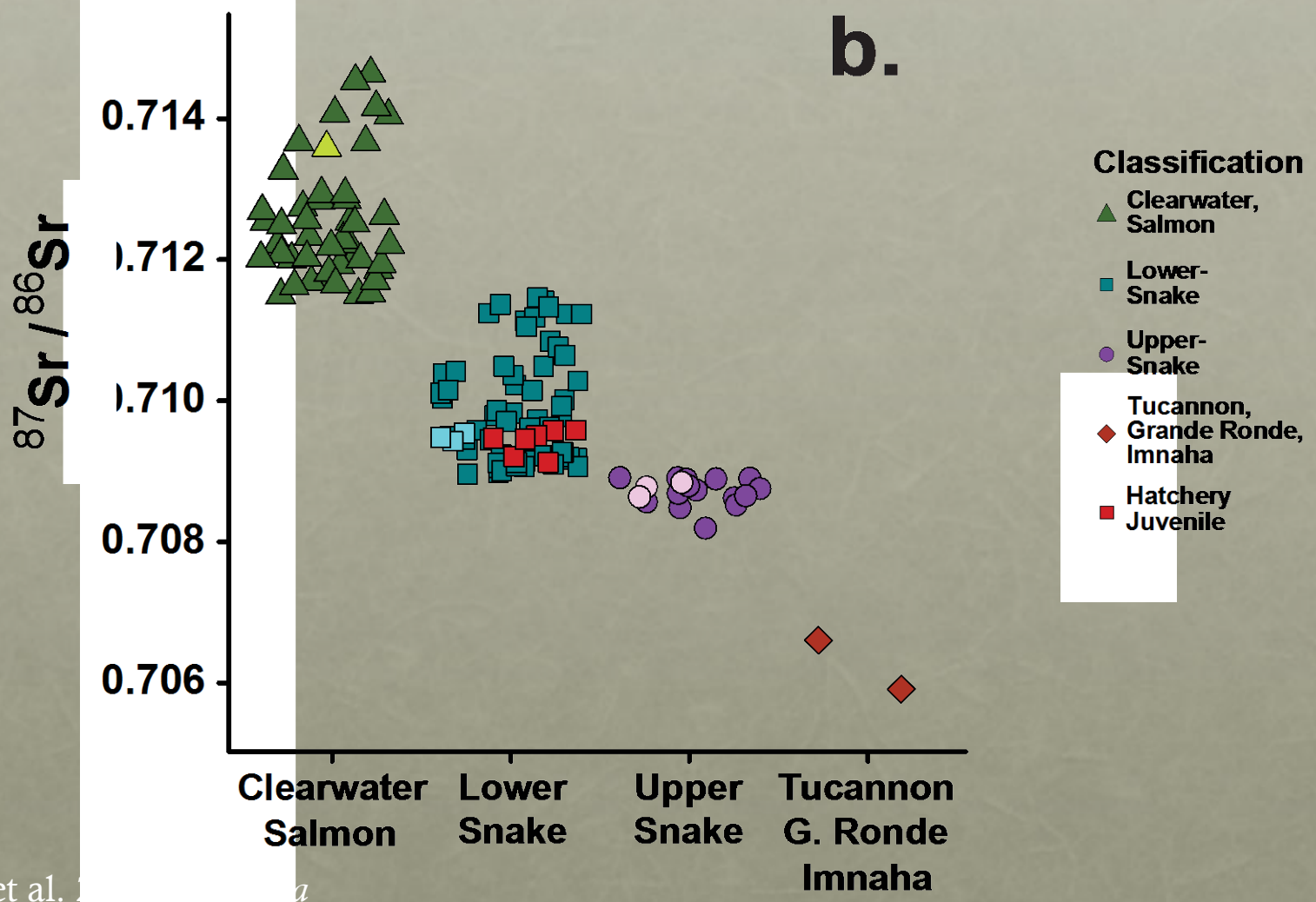
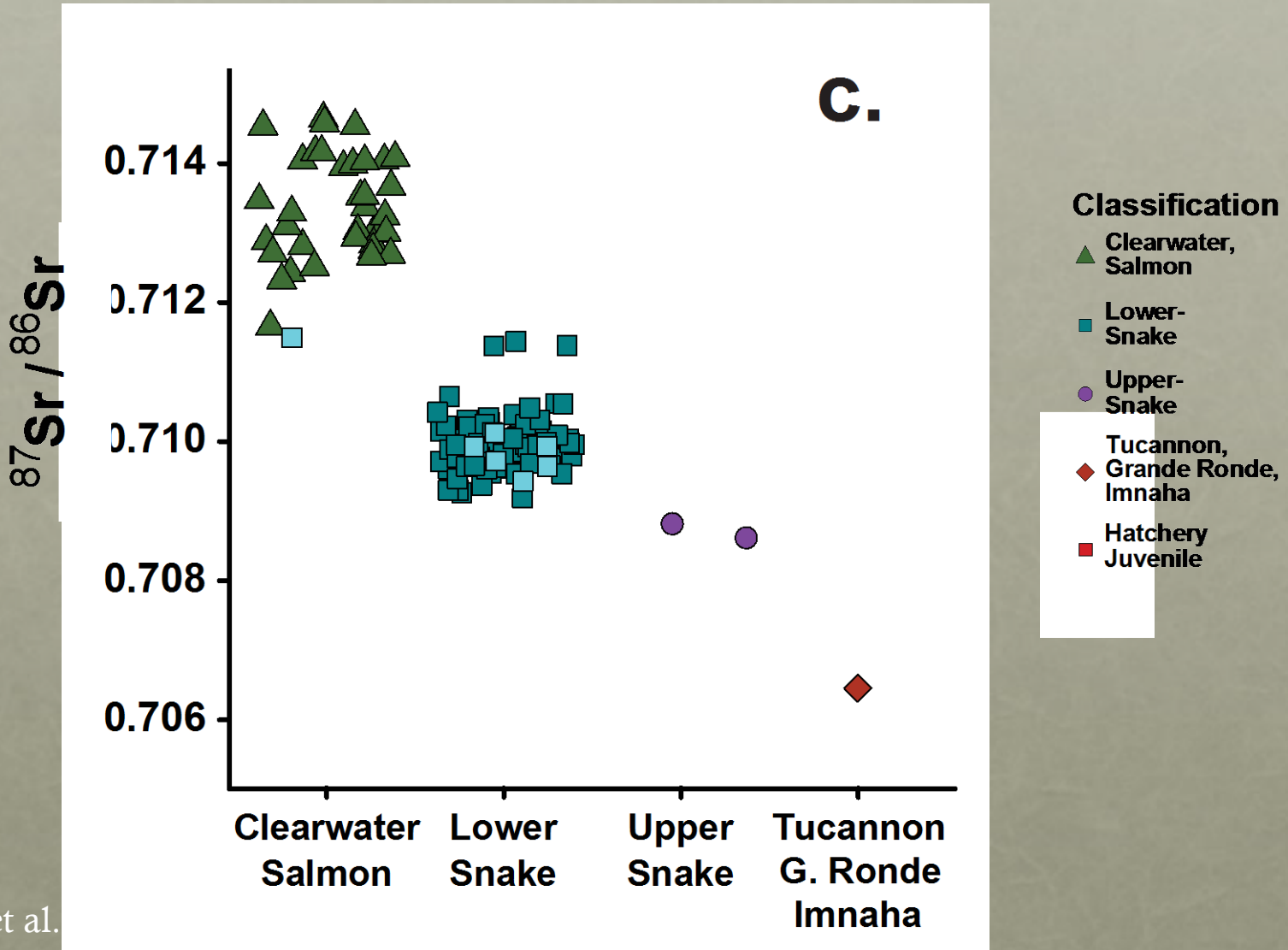
NATAL LOCATION



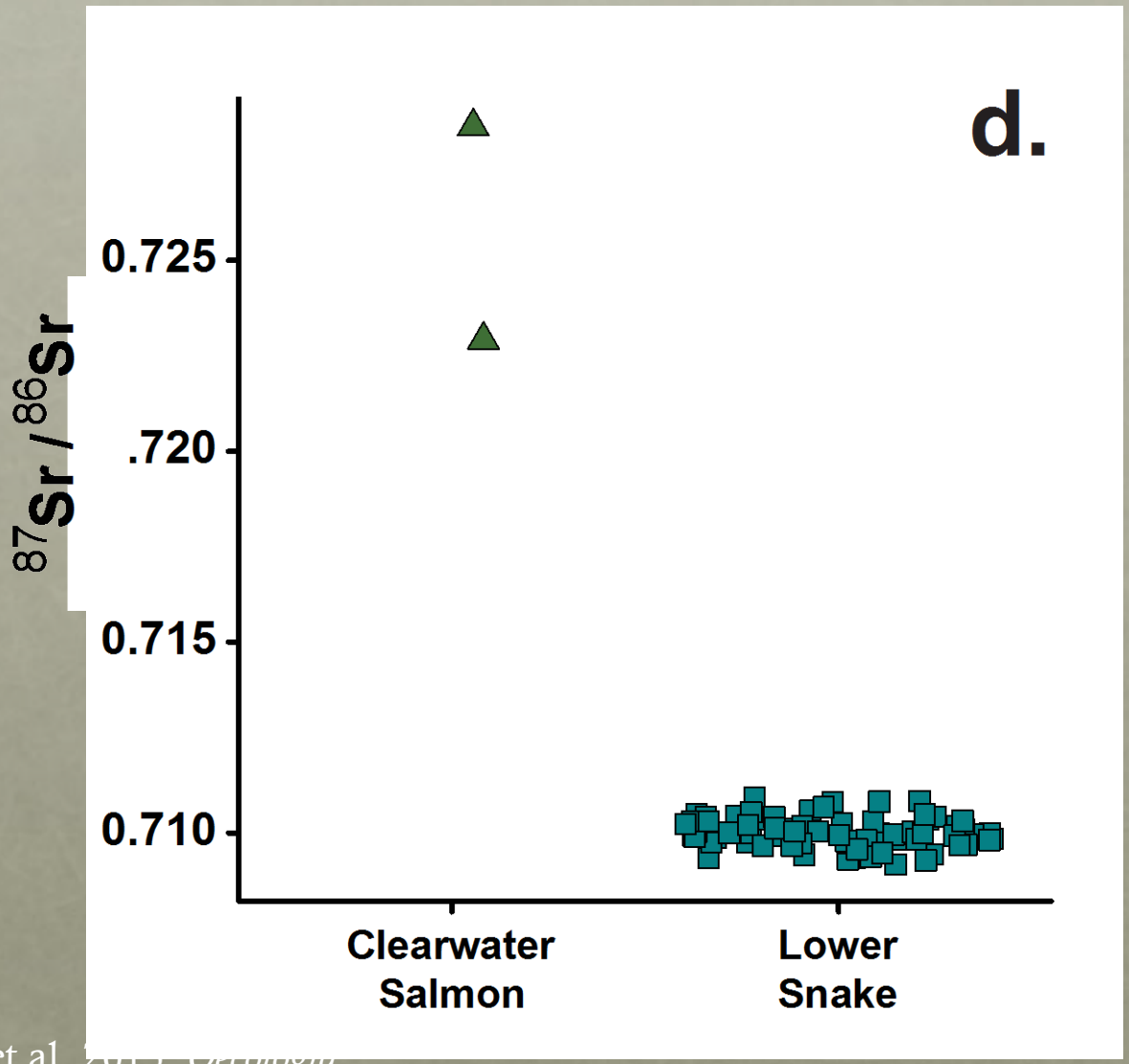
From Hegg et al.

REARING LOCATION



From Hegg et al.

OVER-WINTERING LOCATION



From Hegg et al. 2015, *Ecology*

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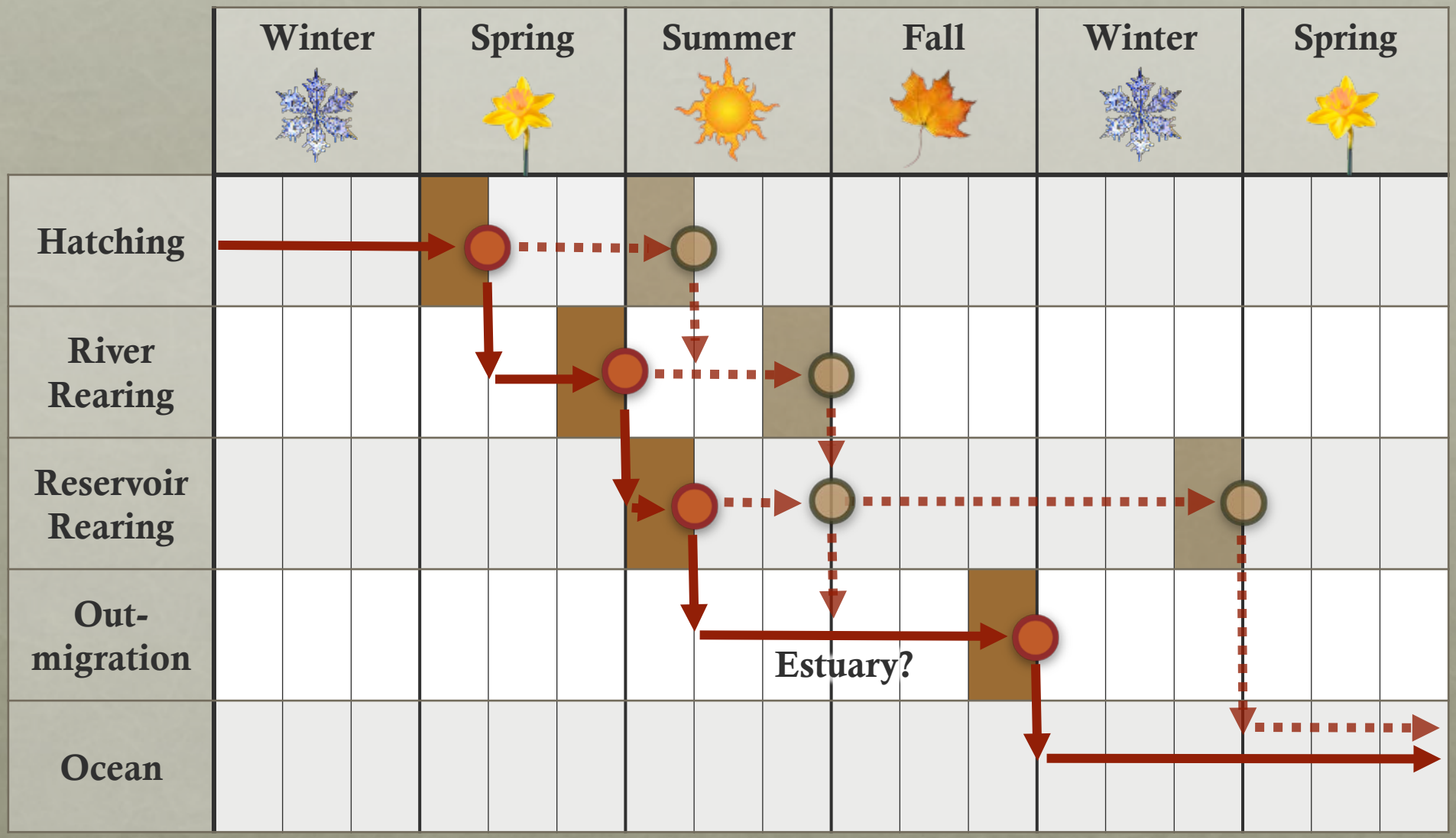
LIFE CYCLE MODELING

Can we model migration timing in terms of fitness?

Stage Dependent Modeling of Steelhead out-migration

- **Mangel & Satterthwaite, 2008.** ***Bulletin of Marine Science***
- **Satterthwaite et al. 2009, 2012.** ***Transactions of the American Fisheries Society***

JUVENILE MIGRATION STRATEGIES



MIGRATION RECONSTRUCTION

Important Inputs

- Life Stage Survival
- Lifetime Fecundity
- Habitat Specific Bioenergetics
  - Growth
  - Food Availability
  - Temperature

MIGRATION RECONSTRUCTION

What data can we get from otoliths?

- **Location (trace chemical signature)**
- **Yearling vs. Subyearling**
- **Growth**
  - **Juvenile otoliths**
  - **Adult Otoliths**

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LONG-TERM TRENDS

- **Collections at Lyons Ferry**
  - **Otolith collections 2006-2012**
  - **700-800 otoliths per season collected.**
- **Juvenile Otolith Collections**
  - **6 – Upper Snake**
  - **6 – Lower Snake**
  - **6 – Grande Ronde**
  - **12 – Clearwater**
  - **Sort-by-code juveniles (variable numbers)**
- **Modeling will allow us to understand year-to-year variation.**

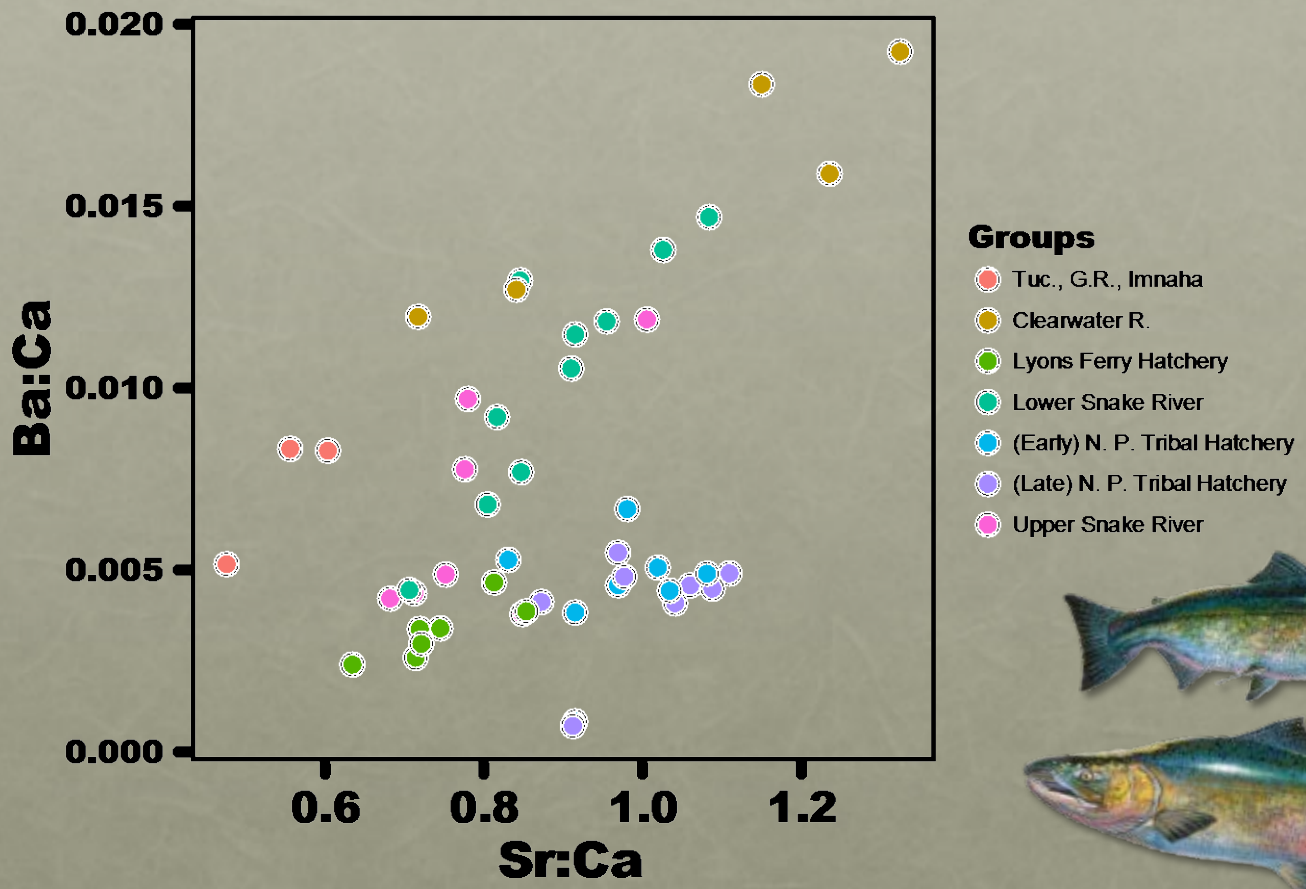
NEW DEVELOPMENTS

Determining hatchery origin has been difficult using otolith microchemistry.

- **We have used scale analysis and presence/absence of tags to determine hatchery vs. wild origin in the past**

HATCHERY/WILD ORIGINS

- **We are now able to determine hatchery origin using a suite of chemical tracers**



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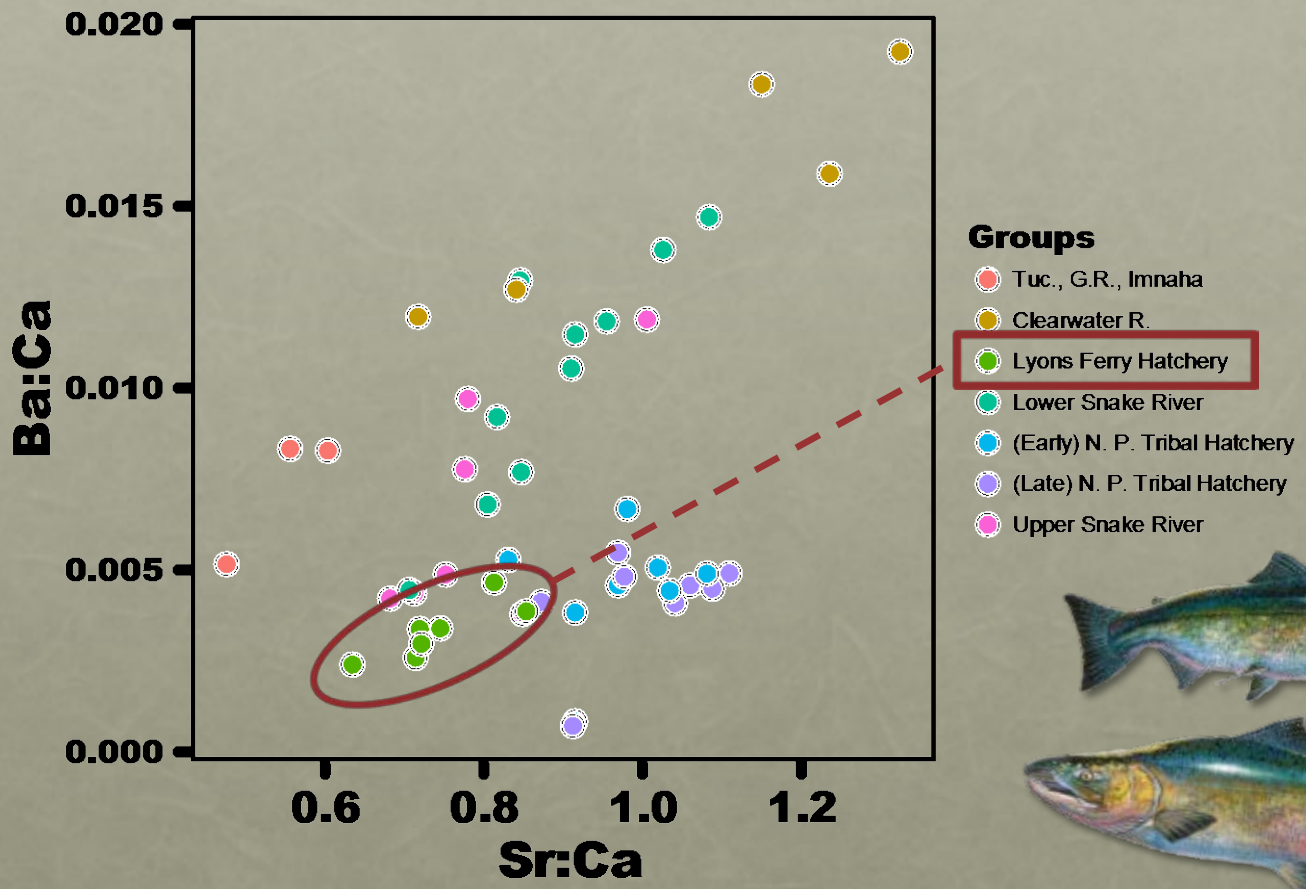

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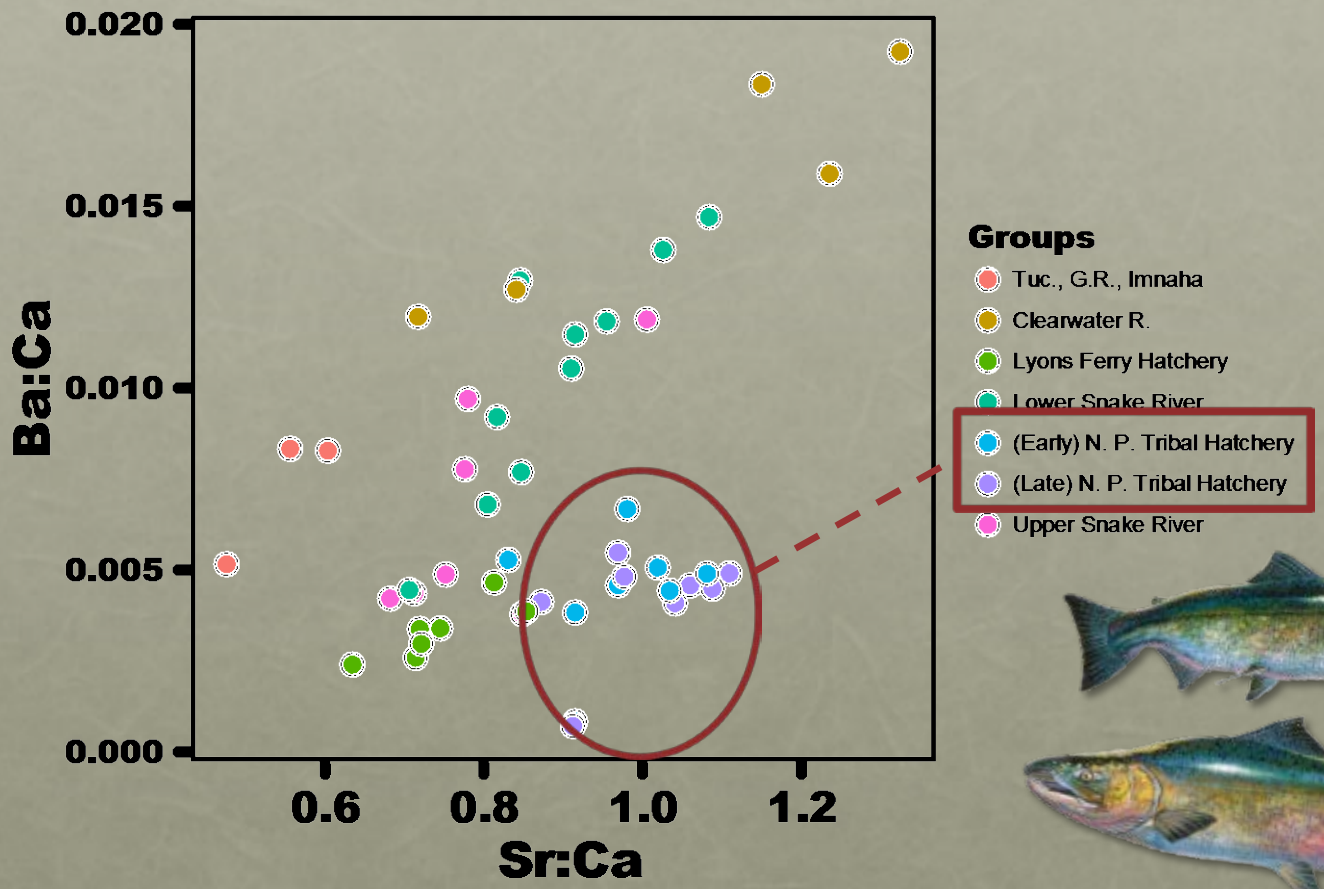

HATCHERY/WILD ORIGINS

- **We are now able to determine hatchery origin using a suite of chemical tracers (83%, $\hat{K}$= 80.1)**

		Discriminate Function Classification							
		Tucannon G.Ronde Imnaha	Clearwater	Lyons Ferry	Lower Snake	NPTH Early	NPTH Late	Upper Snake	Users Error
Actual Classification	Tucannon G. Ronde Imnaha	3	0	0	0	0	0	0	0%
	Clearwater	0	4	0	1	0	0	0	80%
	Lyons Ferry	0	0	6	0	0	0	1	85%
	Lower Snake	0	0	0	9	0	0	1	90%
	NPTH Early	0	0	0	0	7	0	1	88%
	NPTH Late	0	0	0	0	0	8	0	100%
	Upper Snake	0	0	2	2	0	0	3	43%
	Producers Error	100%	100%	75%	75%	100%	100%	50%	

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	NPTH Late	0	0	0	0	0	**8**	0	**100%**
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	Producers Error	**100%**	**100%**	**75%**	**75%**	**100%**	**100%**	**50%**	

ACKNOWLEDGEMENTS

- **Collaborators**
  - **Brian Kennedy** – U. of Idaho Dept. Fish & Wildlife
  - **Rich Zabel** – NOAA - NWFSC
  - **Paul Chittaro** – NOAA – NWFS
  - **Debbie Milks** – Lyons Ferry Hatchery Staff
  - **Bill Arnsberg** – Nez Perce Tribe
  - **Billy Connor** – USFW
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  - NOAA
  - Army Corps of Engineers