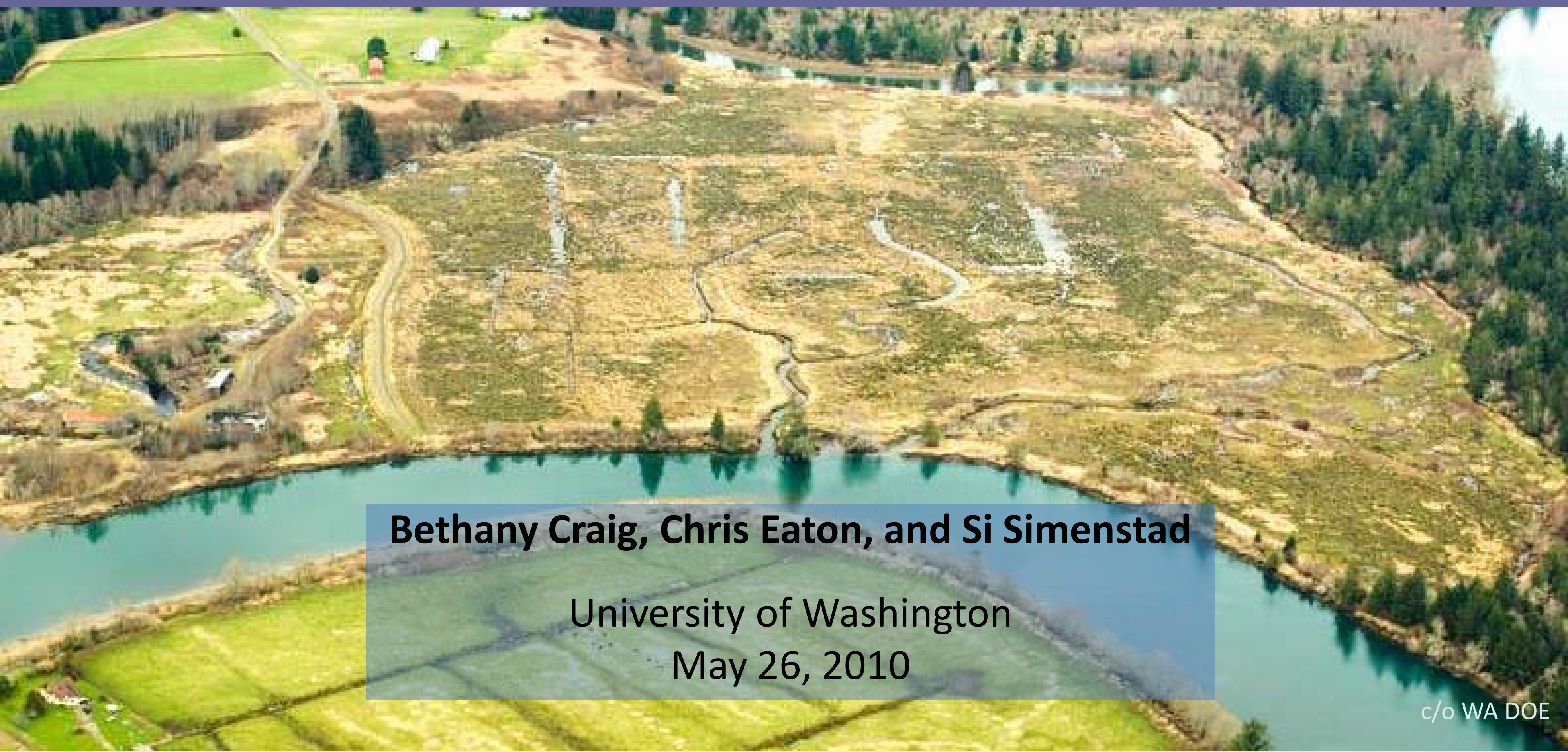
Resource Partitioning and Life History Patterns Among Salmonids in the Estuarine Habitat Mosaic



Bethany Craig, Chris Eaton, and Si Simenstad

University of Washington
May 26, 2010

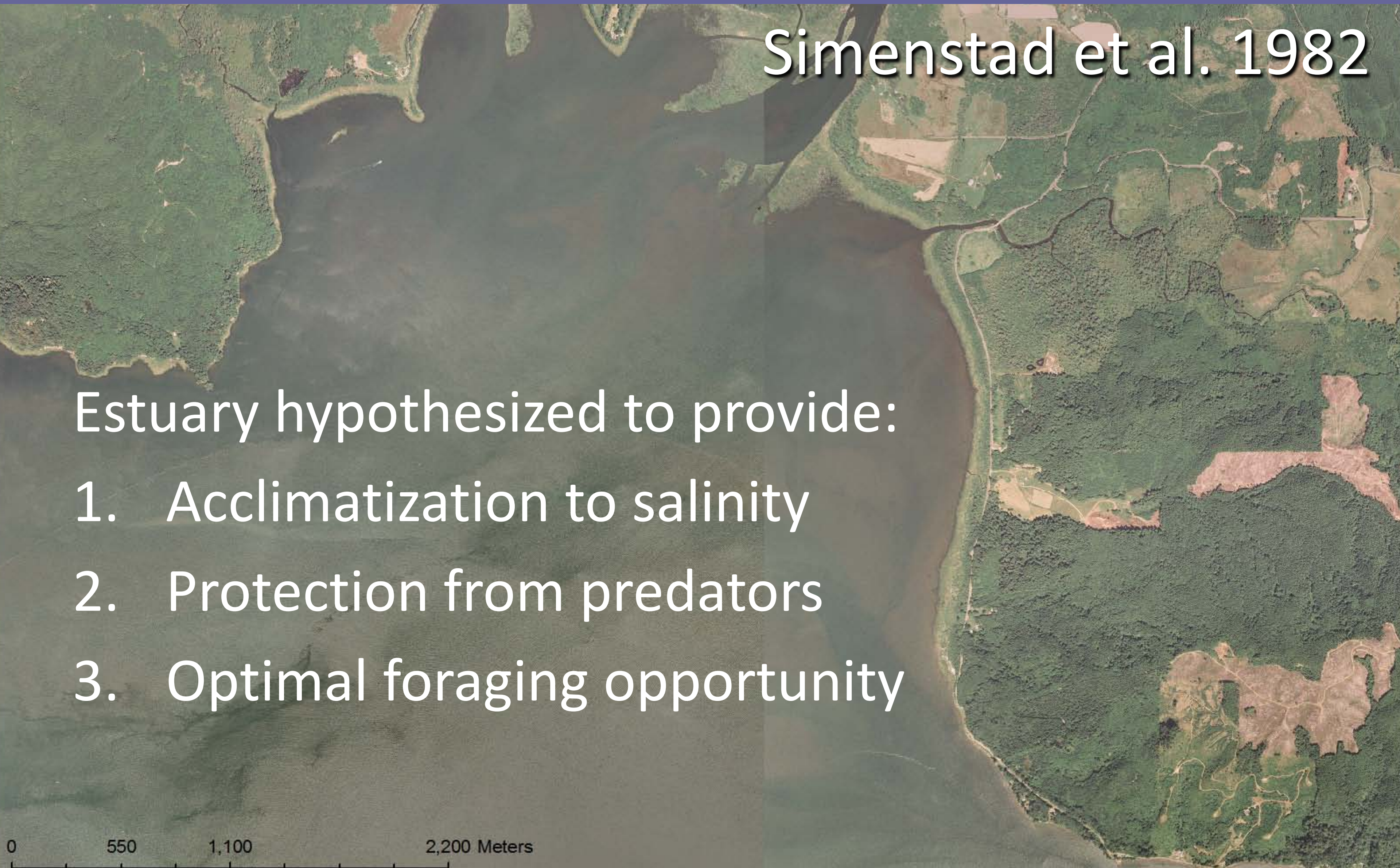
c/o WA DOE

Salmon in the Estuarine Nursery

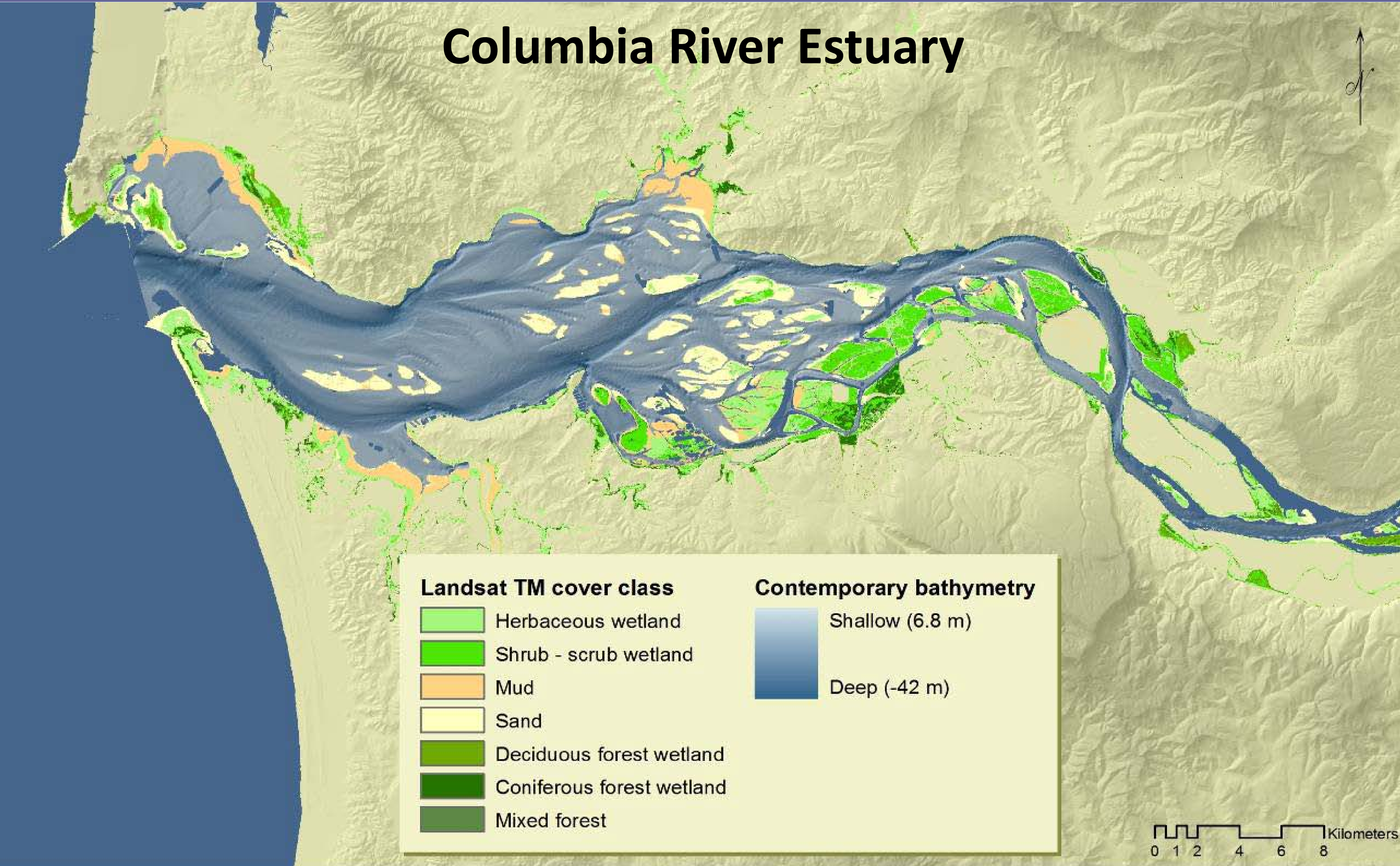
Simenstad et al. 1982

Estuary hypothesized to provide:

1. Acclimatization to salinity
2. Protection from predators
3. Optimal foraging opportunity



Estuarine Habitat Mosaic



Resource Partitioning

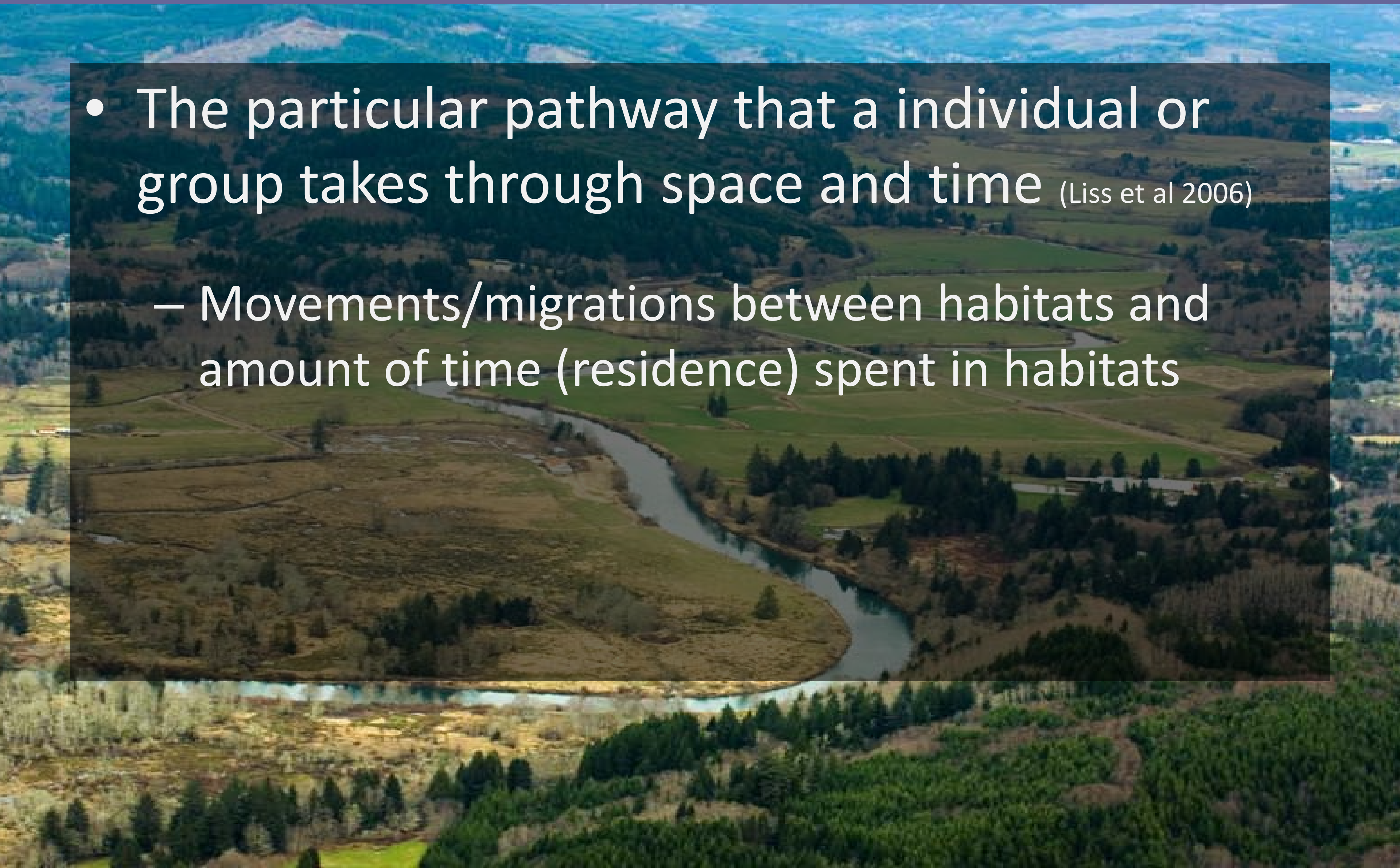
"differences in the way species in the same community utilize resources" Schoener 1974

Resource Axes:

- Temporal
- Spatial (habitat)
- Trophic (diet)

Life history patterns

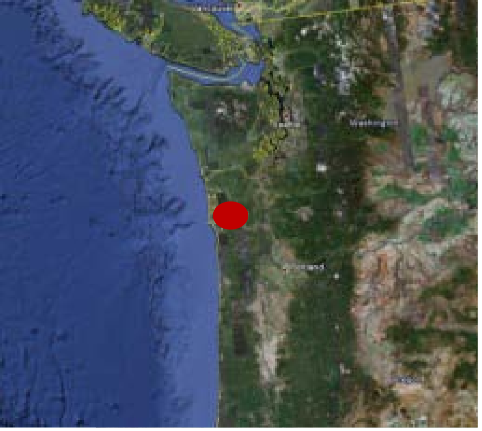
- The particular pathway that a individual or group takes through space and time (Liss et al 2006)
  - Movements/migrations between habitats and amount of time (residence) spent in habitats

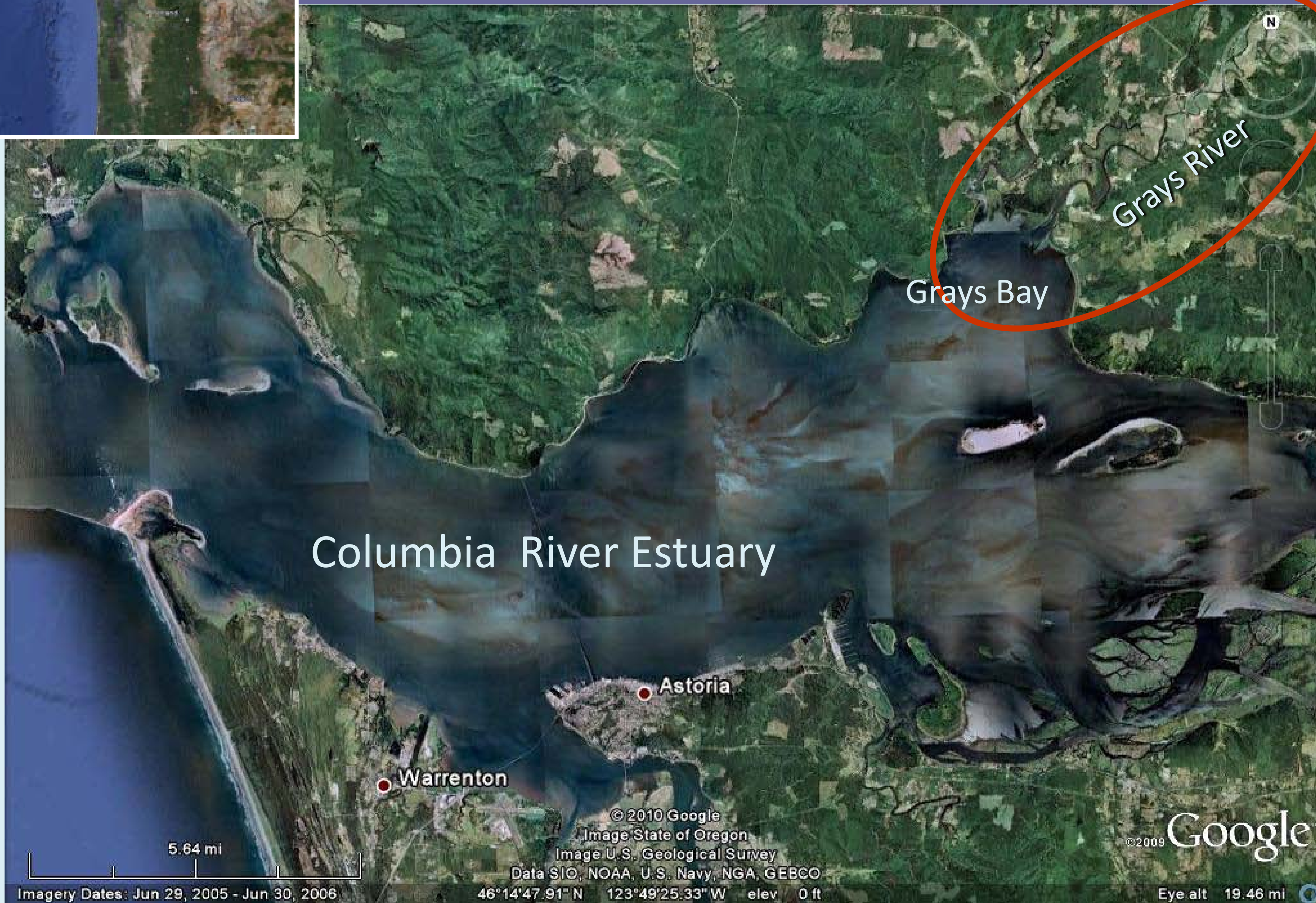


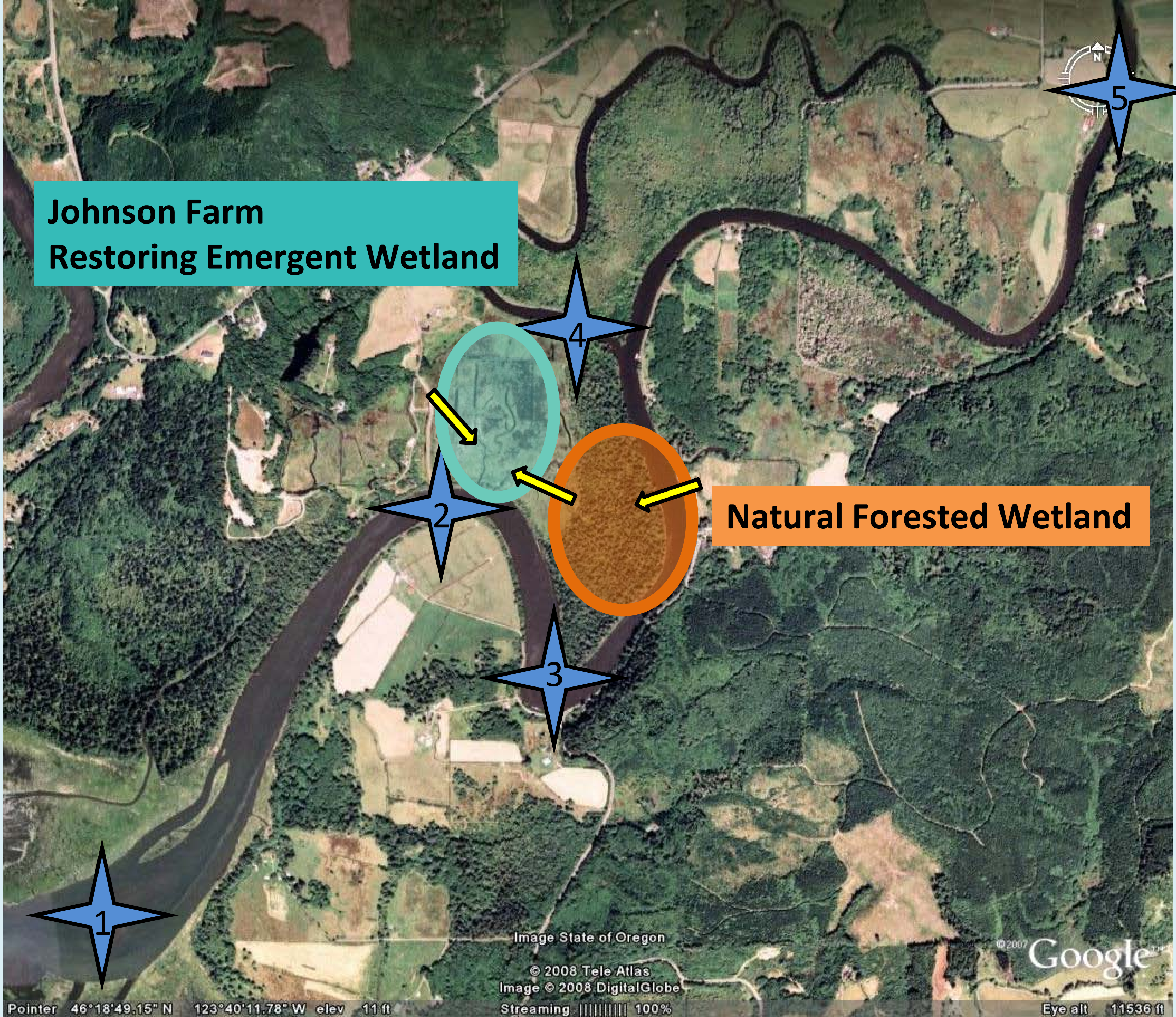
Objectives

- Examine how different salmon species and life histories use heterogeneous estuarine habitats
  - Resource partitioning among juvenile coho, chum, and Chinook salmon
  - Life history patterns among juvenile coho salmon

Grays River Estuary

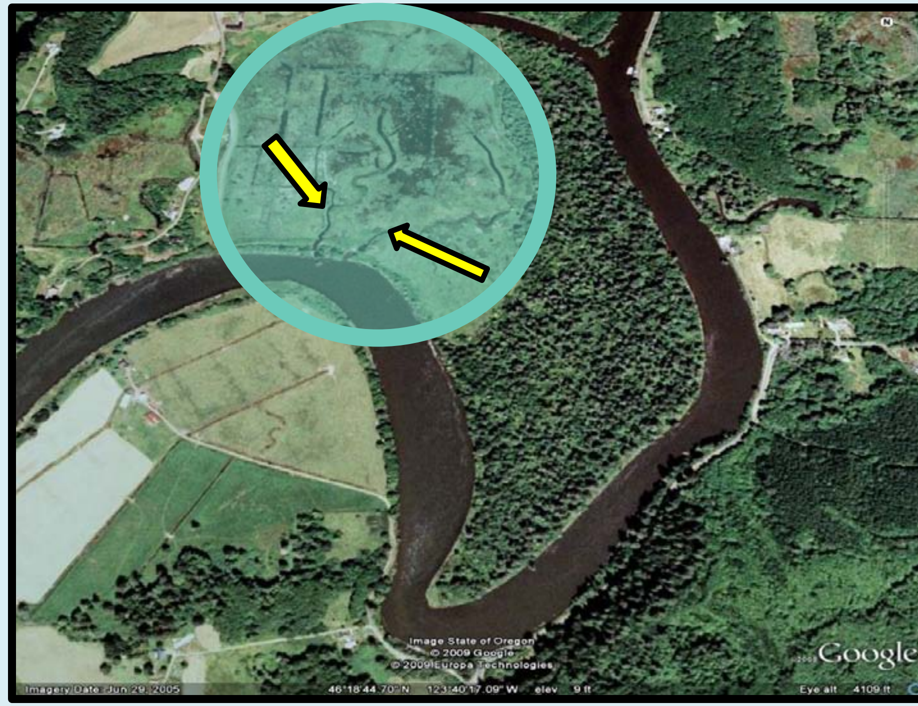






Johnson Farm
Restoring Emergent Wetland
Natural Forested Wetland
1
2
3
4
5
Image State of Oregon
© 2008 Tele Atlas
Image © 2008 DigitalGlobe
©2007 Google
Pointer 46°18'49.15" N 123°40'11.78" W elev 11 ft
Streaming |||||||||| 100%
Eye alt 11536 ft

JOHNSON FARM RESTORING EMERGENT WETLAND




NATURAL FORESTED WETLAND

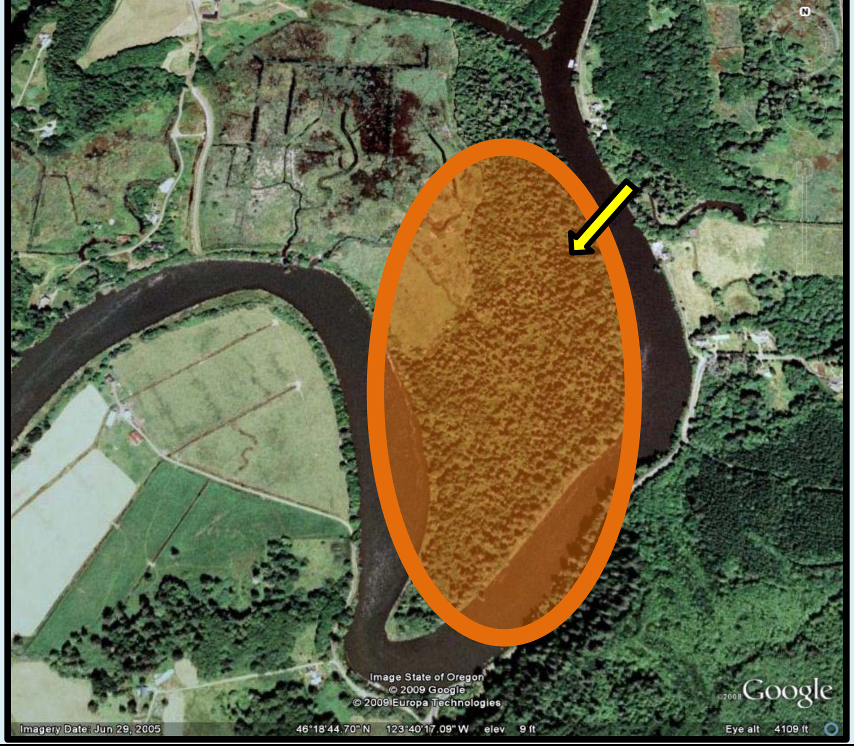


Image State of Oregon
© 2009 Google
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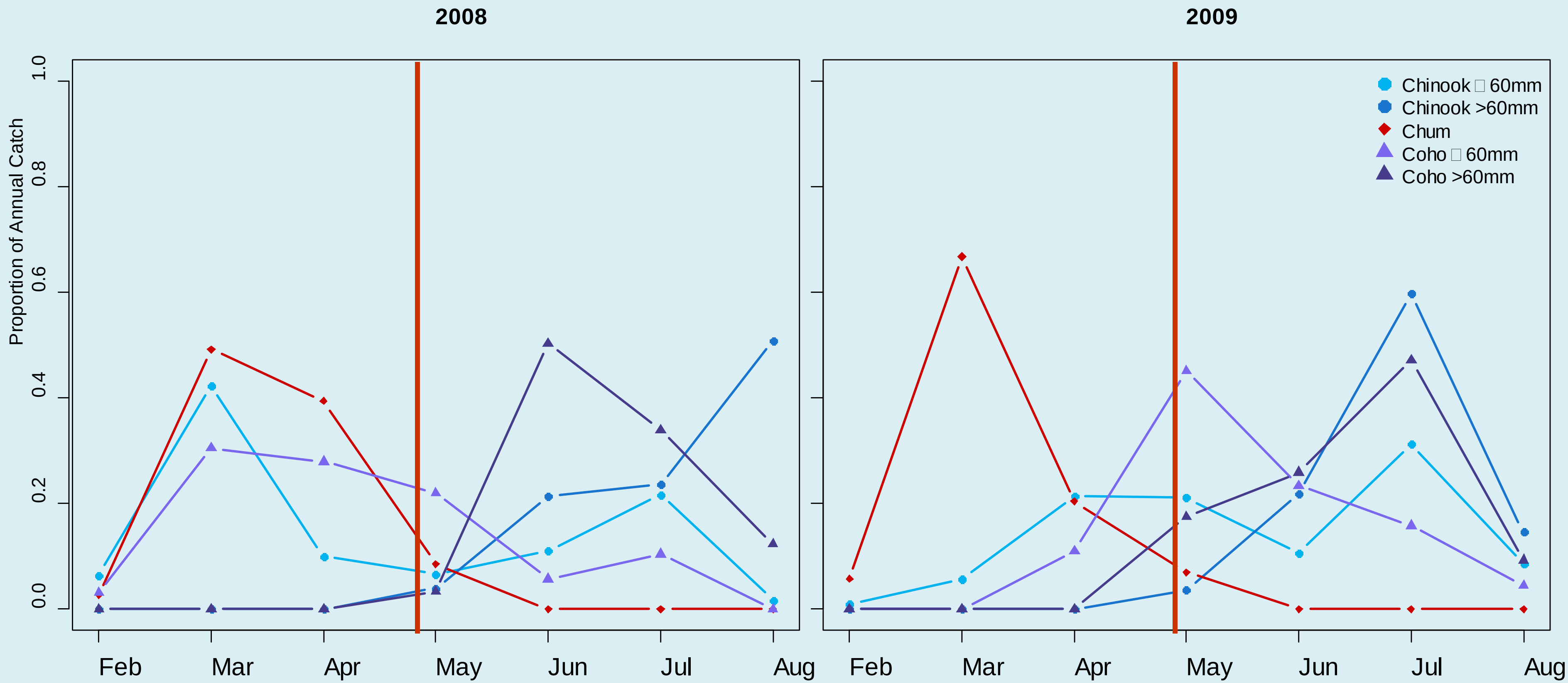
Google
Imagery Date: Jun 29, 2005
46°18'44.70" N 123°40'17.09" W elev 9 ft
Eye alt 4109 ft


2/10/2007 1:16 PM

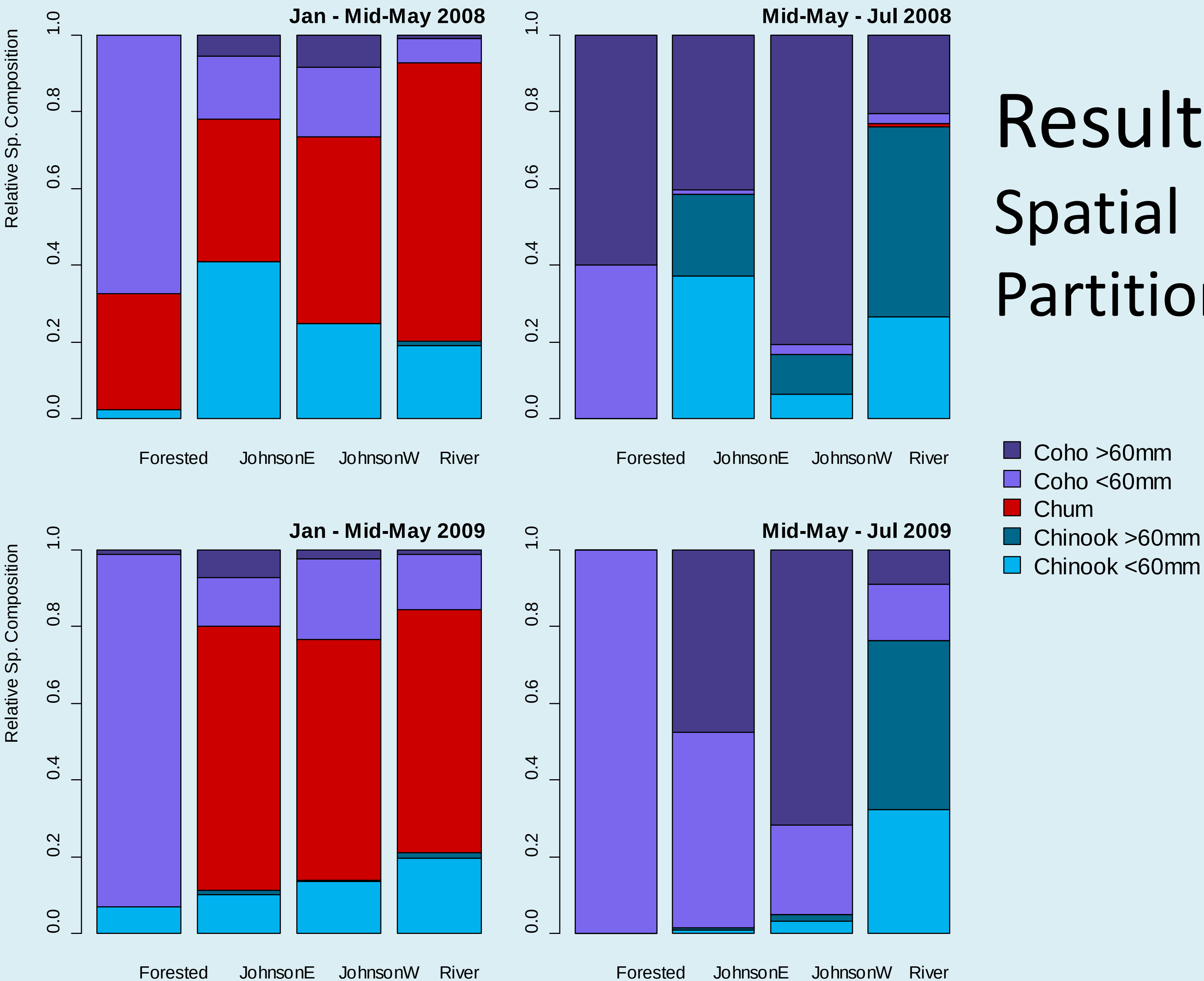
Resource Partitioning

Results: Temporal Partitioning



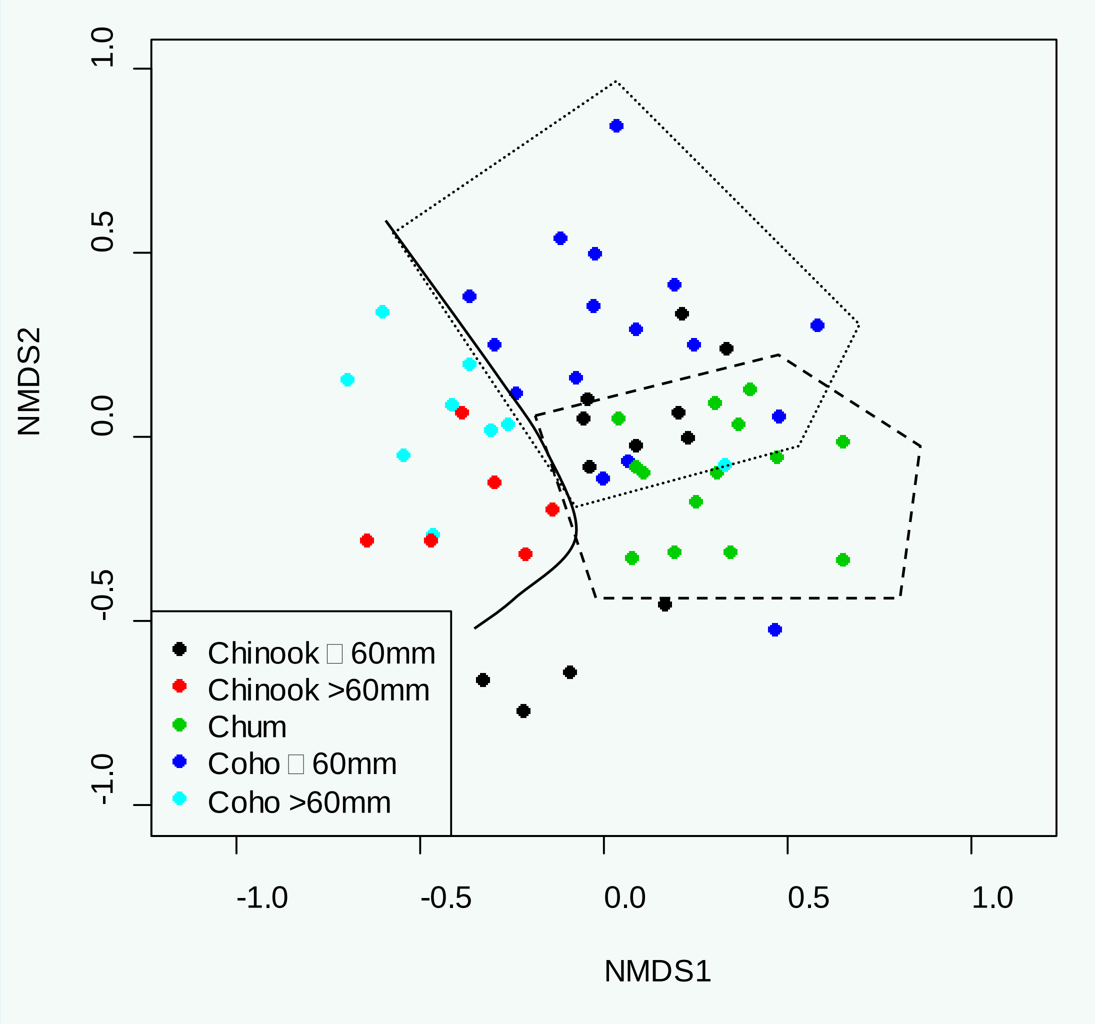
- Bimodal migration
- Chum earlier than coho/Chinook
- Coho/Chinook early peak in 2008

Results: Spatial Partitioning



Results: Trophic Partitioning

Relative gravimetric diet composition



- Larger fish- epibenthic prey
- Smaller fish- drift insects

Schoener's Index of Overlap

$$\alpha = 1 - 0.5 * \sum \left| p_{xi} - p_{yi} \right|$$

for all *i*, where p_{xi} is the proportion of item *i* in group *x* and p_{yi} is the proportion of item *i* in group *y*

$$0 \leq \alpha \leq 1$$

1 - complete overlap
0 - complete partitioning
<0.60 - some partitioning

Indices of Overlap

Species Pair	Temporal	Spatial	Trophic
Chinook ≤60mm – Chinook >60mm	.464	.821	.384
– Chum	.481	.446	.442
– Coho ≤60mm	.650	.489	.299
– Coho > 60mm	.530	.408	.250
Chinook >60mm – Chum	.039	.410	.409
– Coho ≤60mm	.331	.397	.432
– Coho >60mm	.715	.389	.264
Chum – Coho ≤60mm	.440	.752	.482
– Coho >60mm	.052	.423	.257
Coho ≤60mm – Coho >60mm	.405	.734	.352
Mean	*.411*	*.538*	*.357*

Primary | Secondary

Realized Benefits of Partitioning

- Hypothesis: Expect greater ration sizes when overlap is minimal

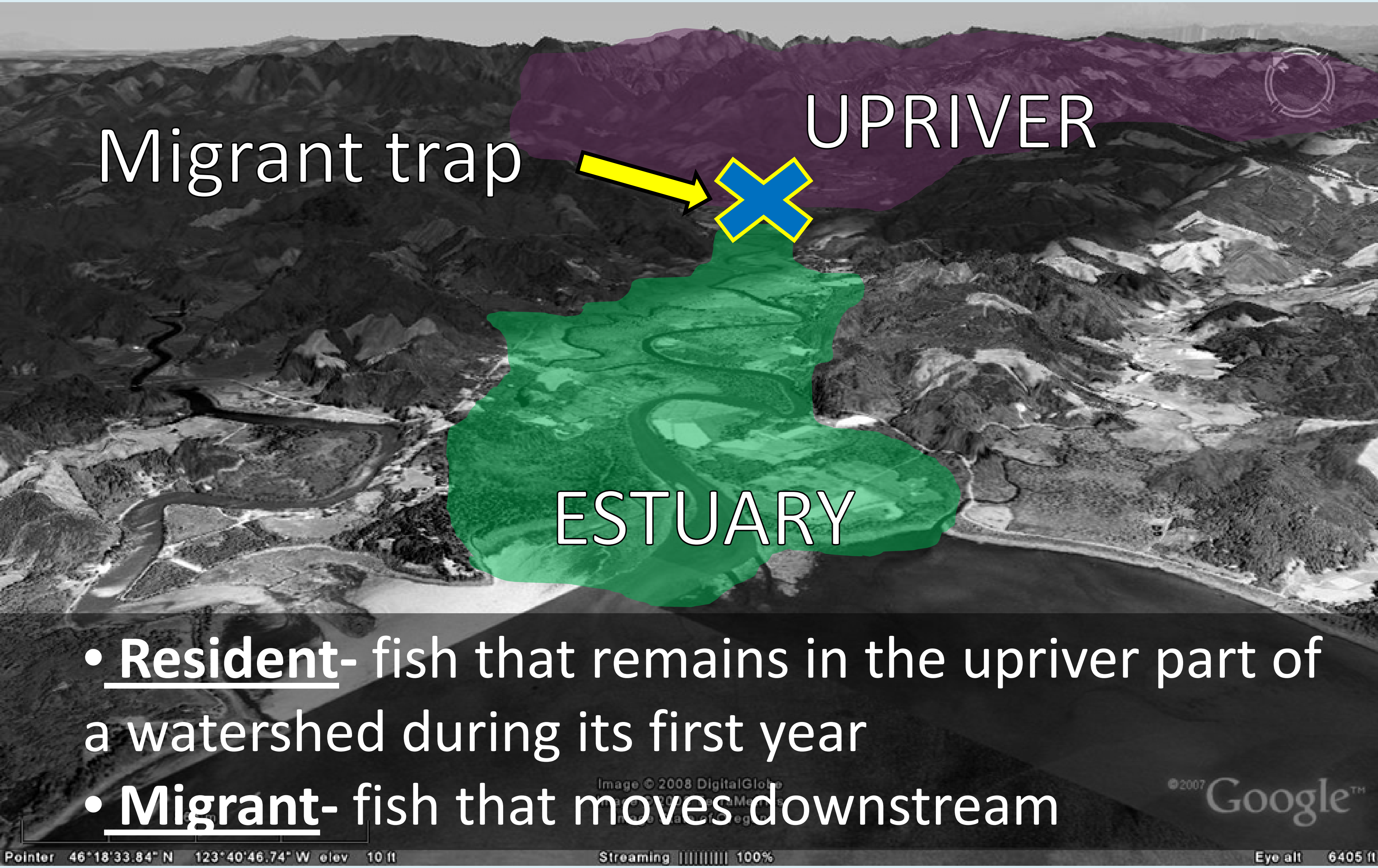
- Results: Not apparent from regression of ration against any indices of overlap

Conclusions: Resource Partioning

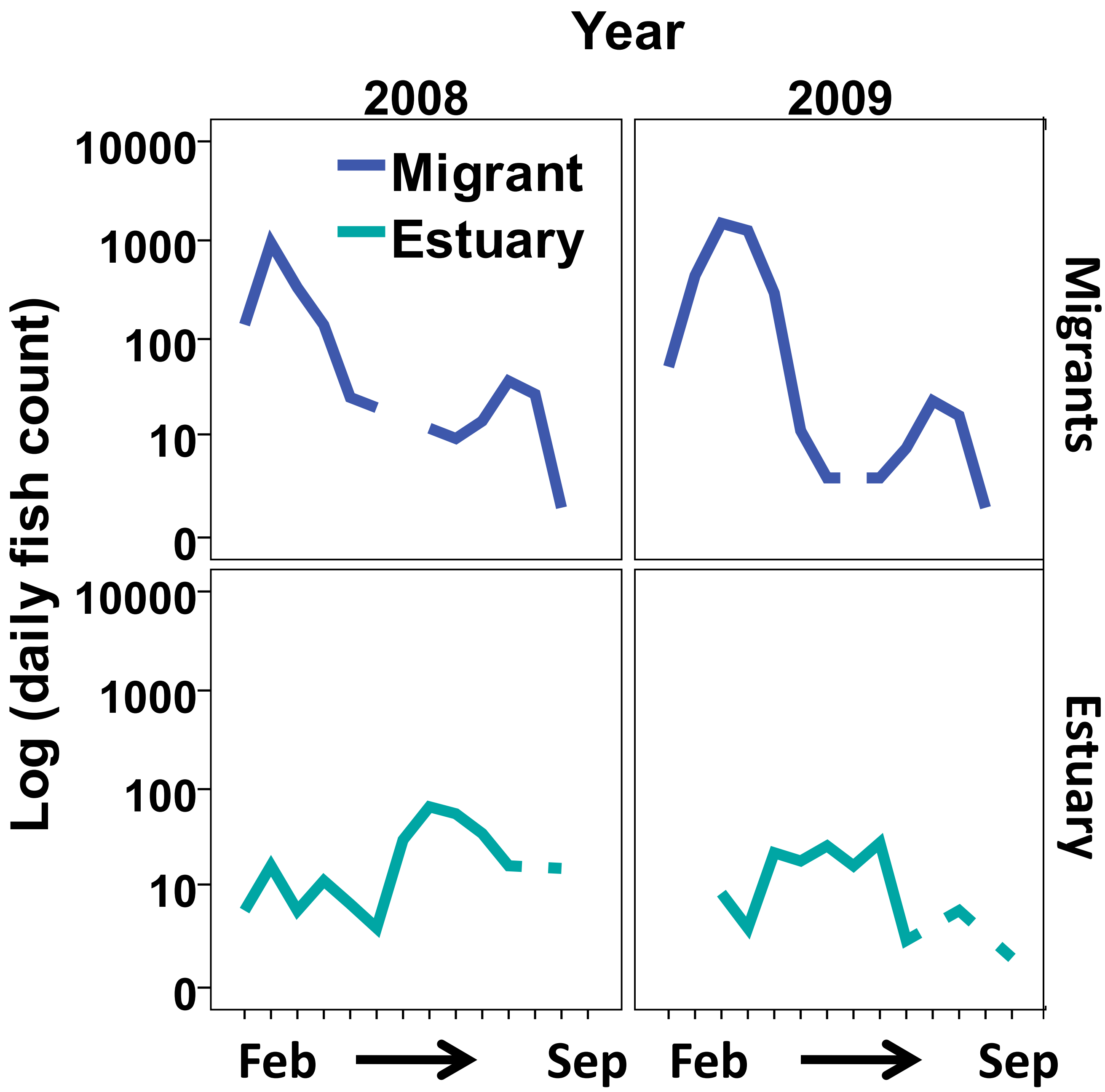
- Dominant mechanism: Trophic
  - Ontogenetic diet shifts
  - Surface vs. Epibenthic feeding (Coho v. Chinook)
- Secondary mechanism: Temporal
  - Migration timing
- Spatial partitioning?
- No realized benefit?
  - Low juvenile salmon densities?
  - Wrong measure?

Juvenile coho salmon life history patterns

Patterns of movements and residence



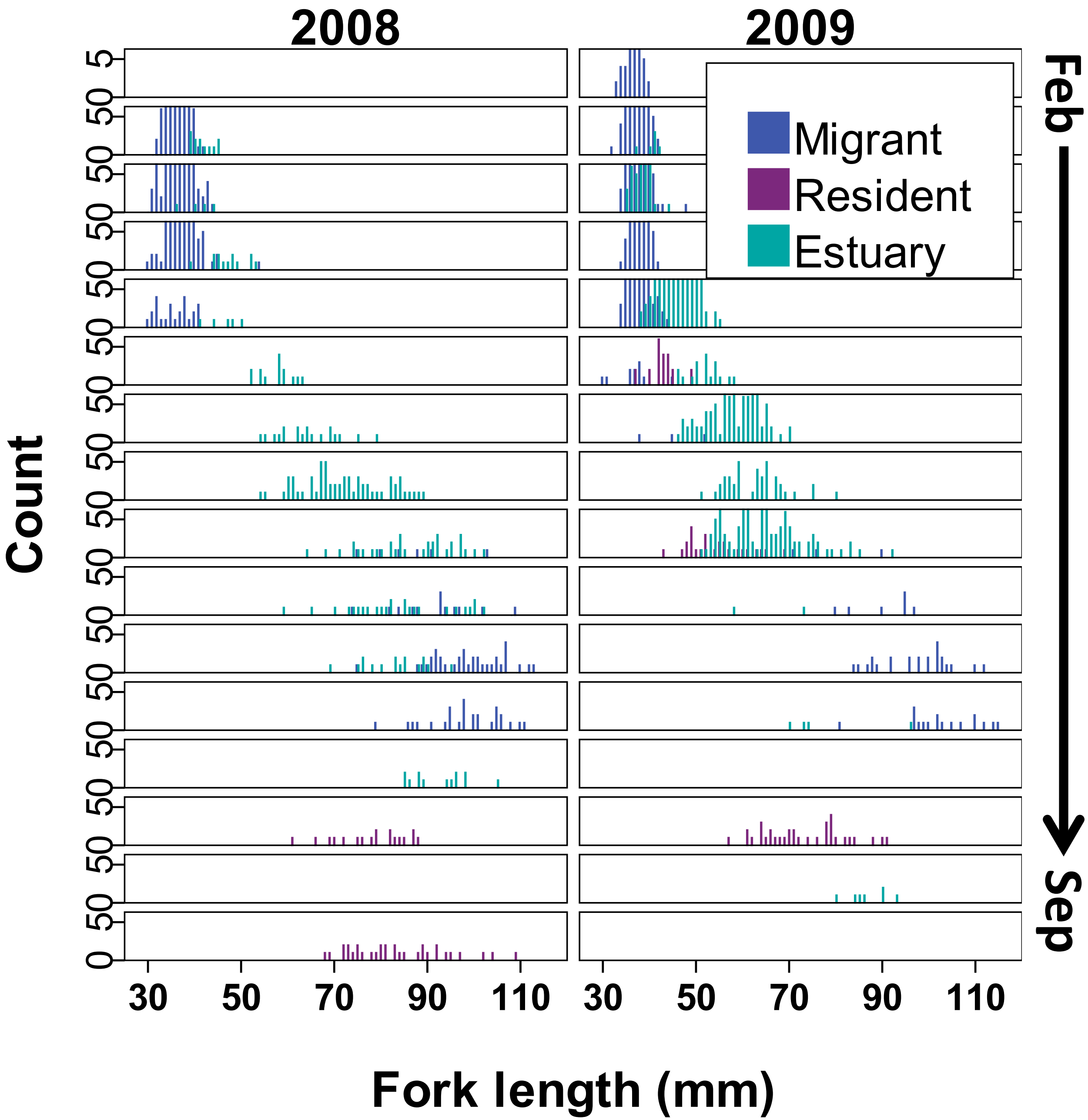
- **Resident**- fish that remains in the upriver part of a watershed during its first year
- **Migrant**- fish that moves downstream



Results: Migrations and Estuarine Residence

- Estuary catches persist past migrations

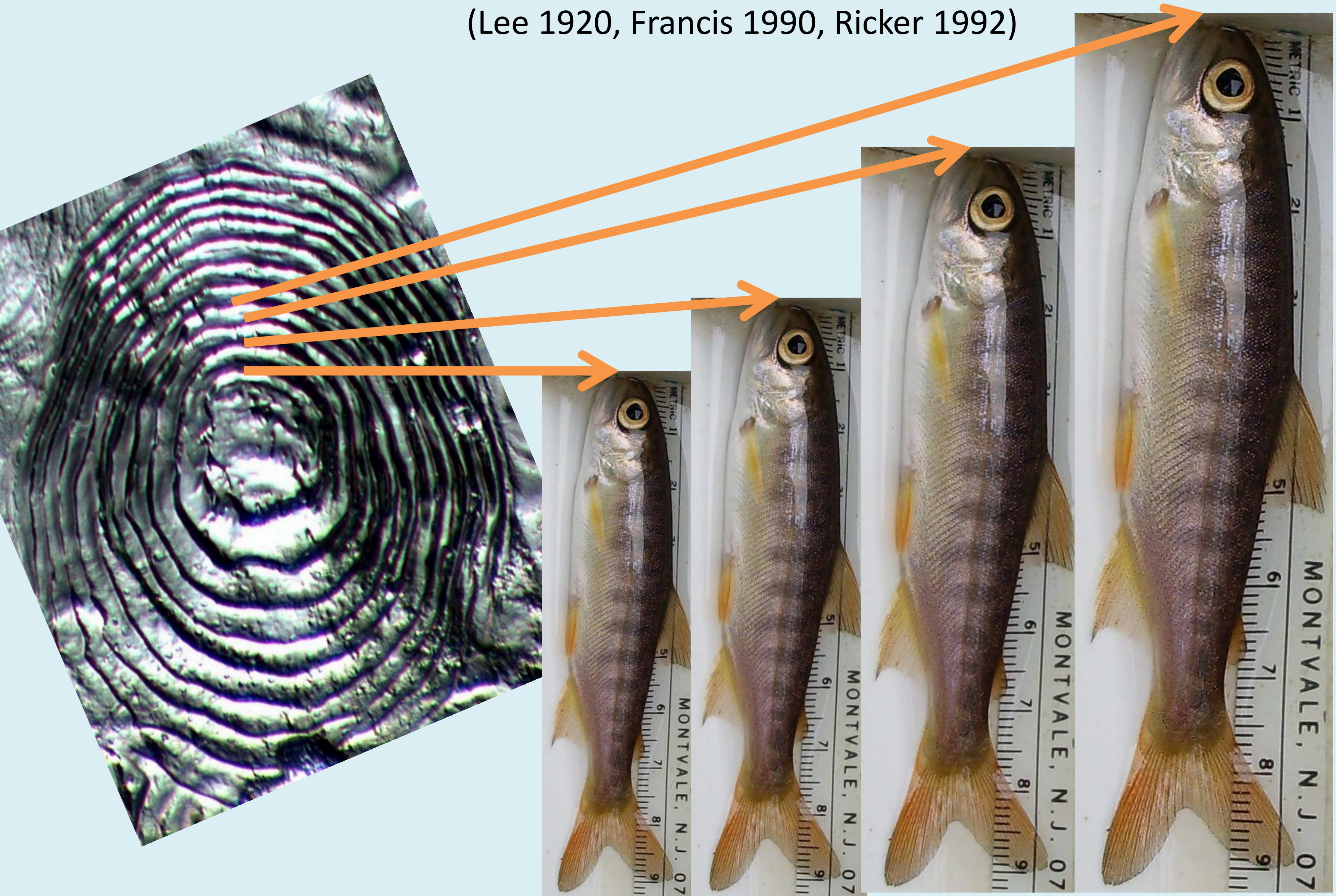
Results: Migrations and Estuarine residence



- Emigrate at threshold size
- Residents smaller than migrants/estuary residents

Scale pattern analysis

(Lee 1920, Francis 1990, Ricker 1992)



Scale pattern analysis

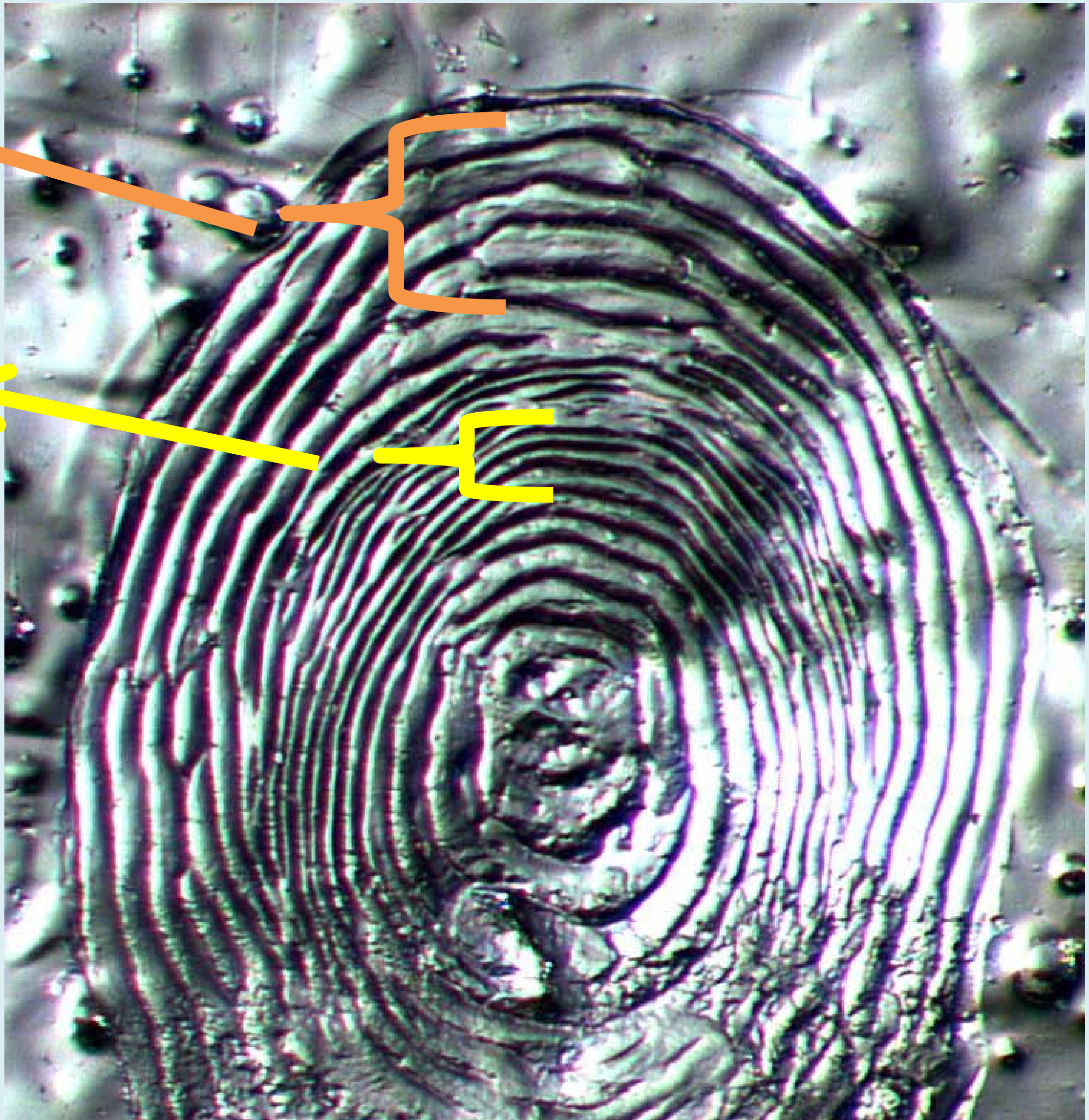
Faster growth=

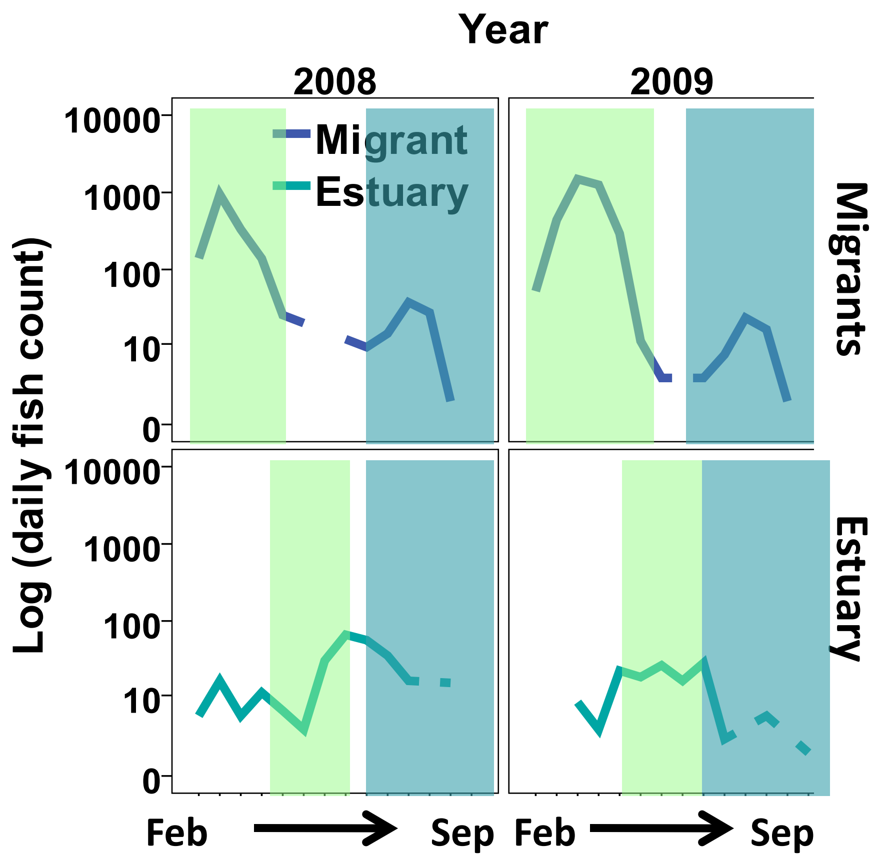
- Widely spaced circuli
- Thicker circuli

Slower growth=

- Narrowly spaced circuli
- Thinner circuli

- Direct comparisons of the same circuli→ compare fish collected at different times

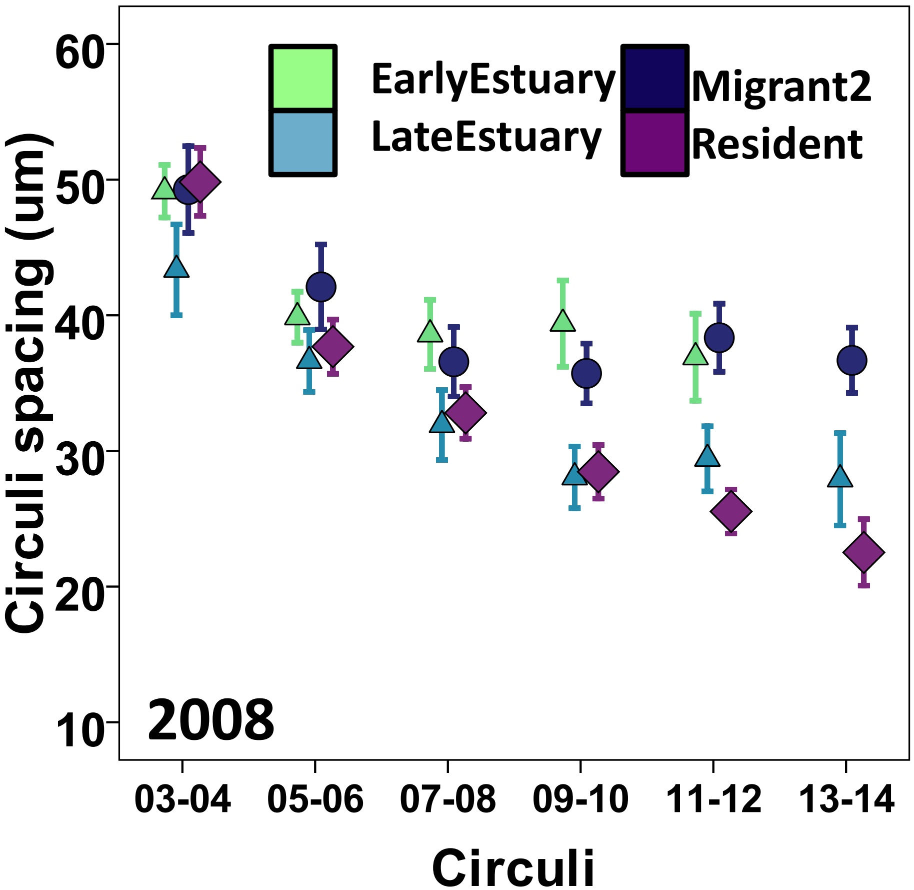


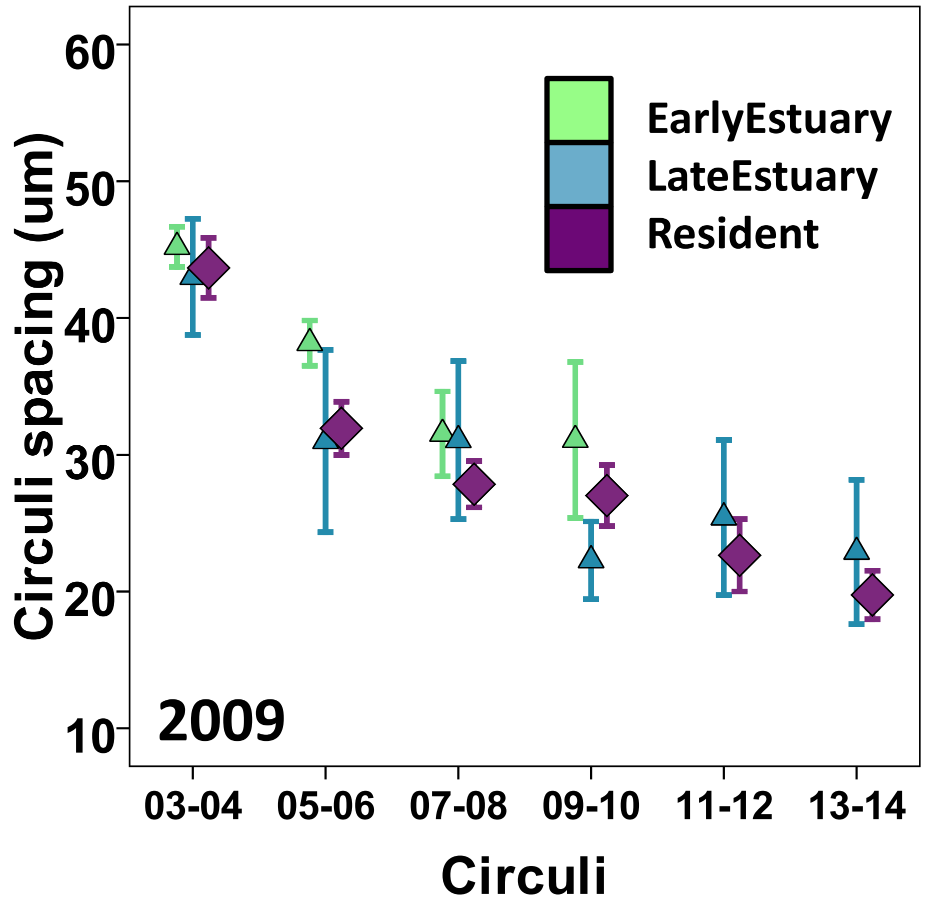


Scale pattern analysis

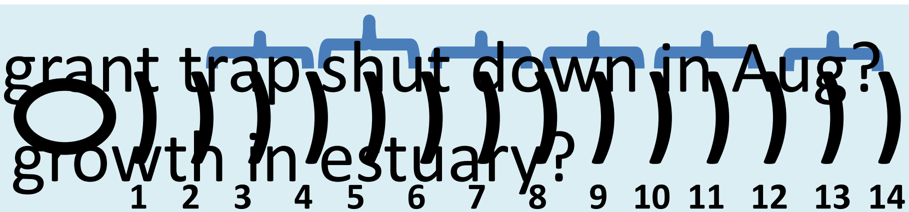
- Migrant 1- NO scales
- Early Estuary
  - Estuary growth signature
- Migrant 2
- Estuary Late
  - Mix of upriver and estuary-formed circuli

Results: Growth trajectories and life history patterns



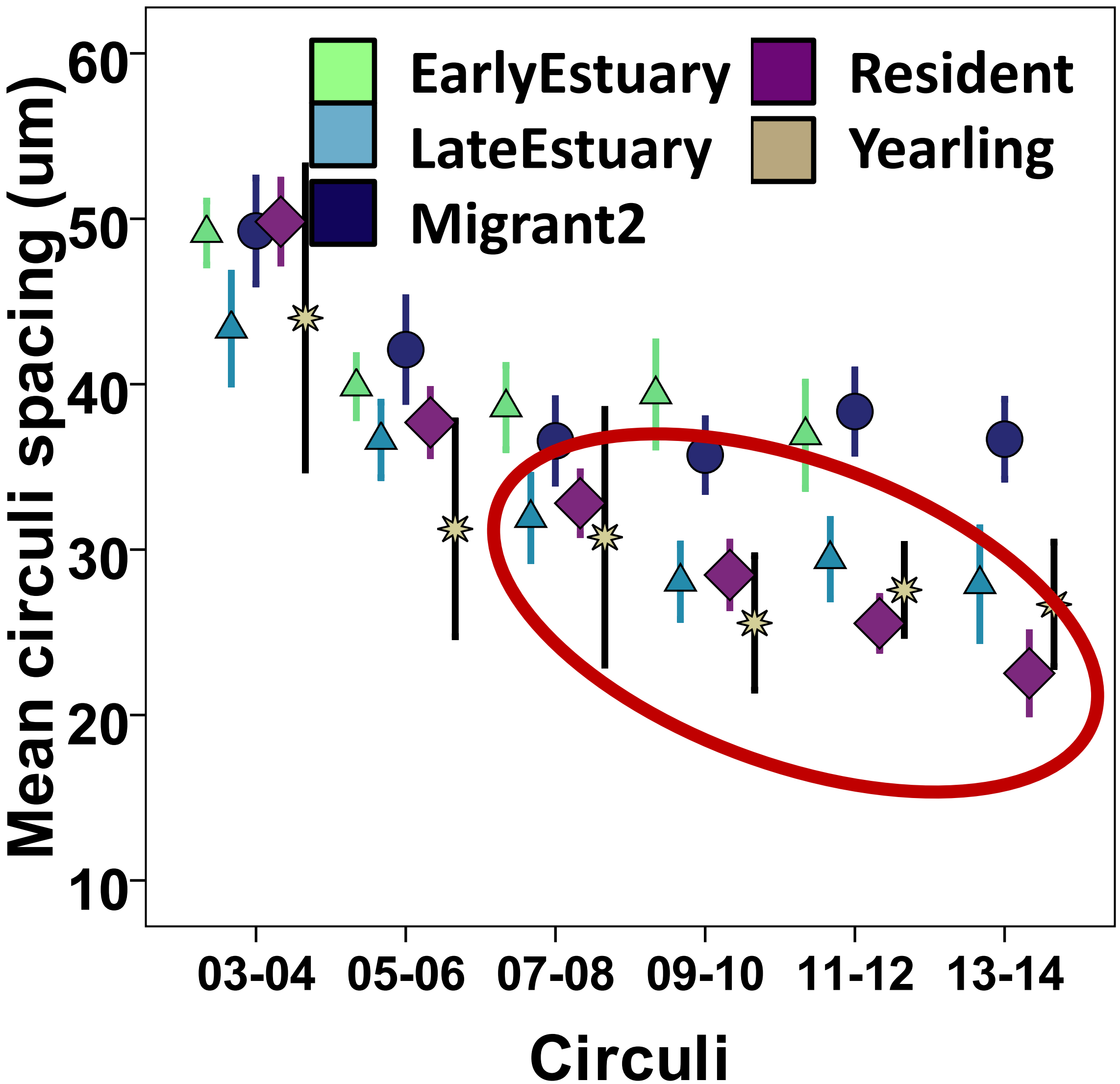


- Late estuary= migrate after migrant trap shut down in Aug?
- From another river?   OR slow growth in estuary?



Results: Life history patterns

Do migrants return back upriver?



- Yearlings group with Residents and Late Estuary
- May be Upriver Residents OR may be Late Estuary that return back upriver for the winter

Conclusions: Coho salmon life history patterns

- Diversity of patterns
  - Multiple migrations
  - Estuary utilization

- Benefits may vary among years

Synthesis

- Estuary used by multiple species
  - Resource partitioning among species
    - Trophic dominant
    - Temporal secondary
  - Multiple patterns within coho salmon
- Heterogeneous habitats, diverse habitat use

Conservation Implications

- Manage from a watershed perspective
- Conserve/restore broad range of habitats
- Conserve/restore interconnected habitats

Acknowledgements

- Chris Eaton
- WET lab
- Field help
- Washington Dept of Fish and Wildlife
- NOAA
- CREST

wetland
ECOSYSTEM TEAM
UNIVERSITY OF WASHINGTON AQUATIC & FISHERY SCIENCES

Resource Partitioning

Schoener 1974

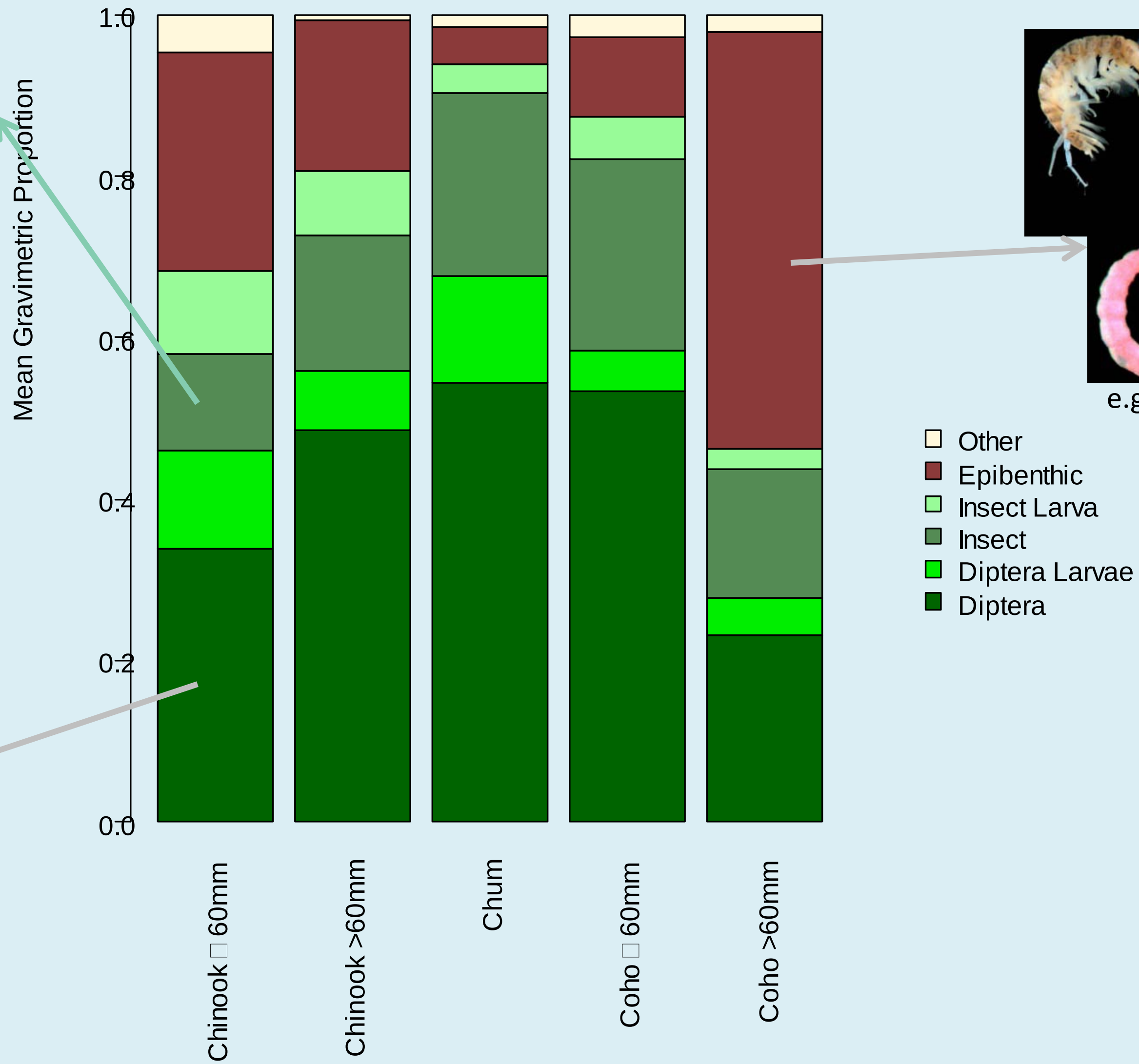
- Habitat/spatial partitioning dominant in terrestrial systems

Ross 1994

- Trophic partitioning dominant in aquatic systems
  - Less habitat heterogeneity
  - Greater resource mobility

Mean Diet Composition

e.g. Collembolans,
Hempiterans



e.g. Americorophium,
Annelids

e.g. Chironomids

Photos c/o Jeff Cordell

Dominant Prey

Index of Preponderance

(Marshall & Elliott 1997)

$$IP_i = \frac{p_i f_i}{\sum p_i f_i}$$

p_i = mean gravimetric proportion of prey item *i* in diets
f_i = frequency of occurrence of prey item *i* in diets

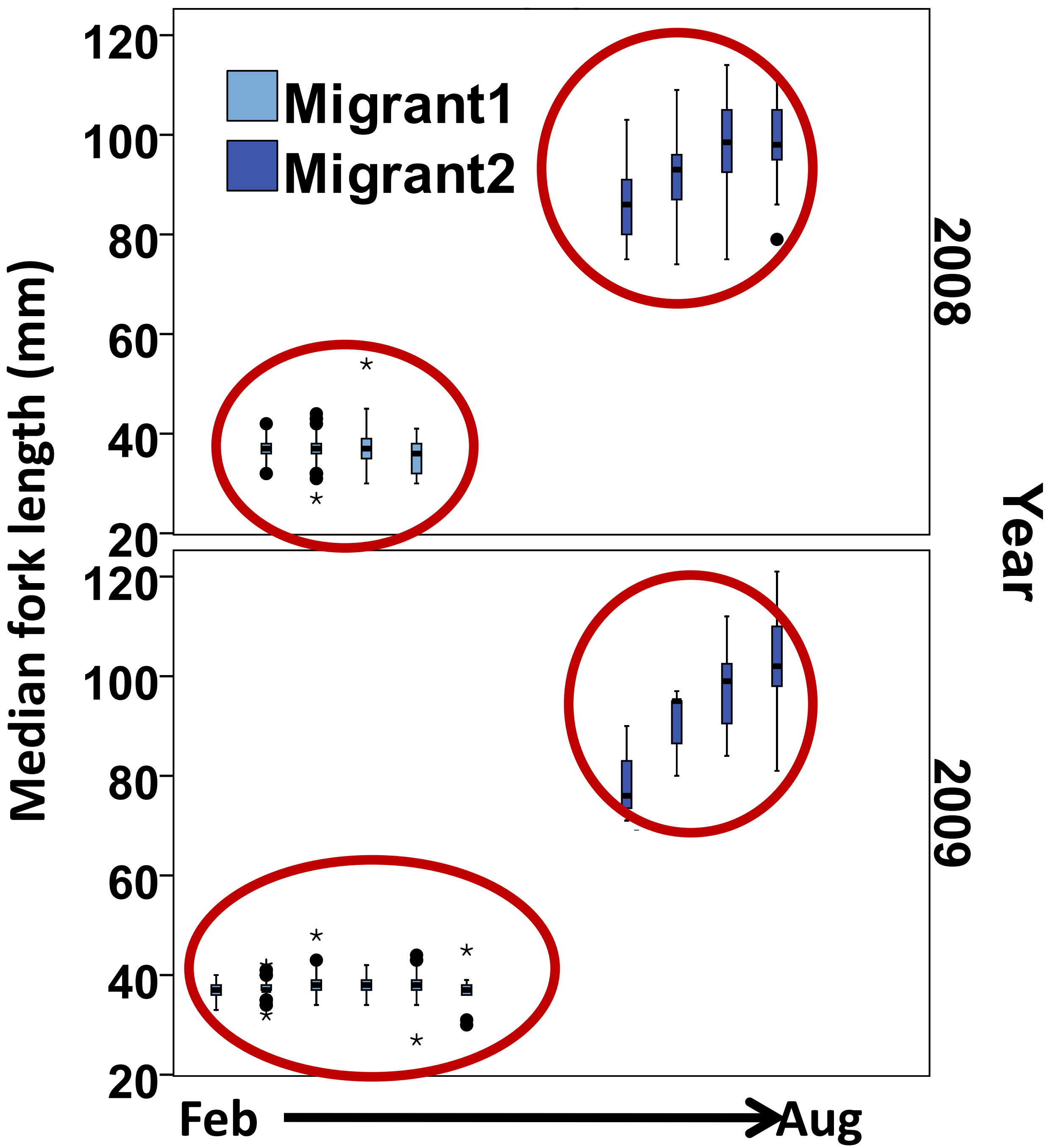
Chinook ≤60mm		Chinook > 60mm		Coho ≤60mm		Coho >60mm	
Prey	**IP**	**Prey**	**IP**	**Prey**	**IP**	**Prey**	**IP**
Emergent Chironomid	0.56	[illegible]	[illegible]	[illegible]	[illegible]	Epibenthic	0.63
Epibenthic	0.30	[illegible]	[illegible]	[illegible]	[illegible]	Drift	0.24
Drift	0.14	[illegible]	[illegible]	[illegible]	[illegible]	Emergent Chironomid	0.13

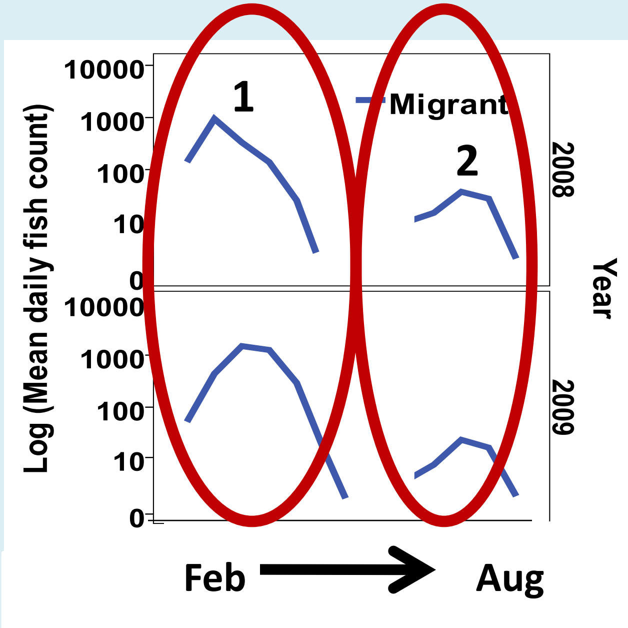
Chinook ≤60mm		Coho ≤60mm	
Prey	**IP**	**Prey**	**IP**
Emergent Chironomid	0.56	Emergent Chironomid	0.56
Epibenthic	0.30	Drift	0.31
Drift	0.14	Epibenthic	0.12

Prey Groupings

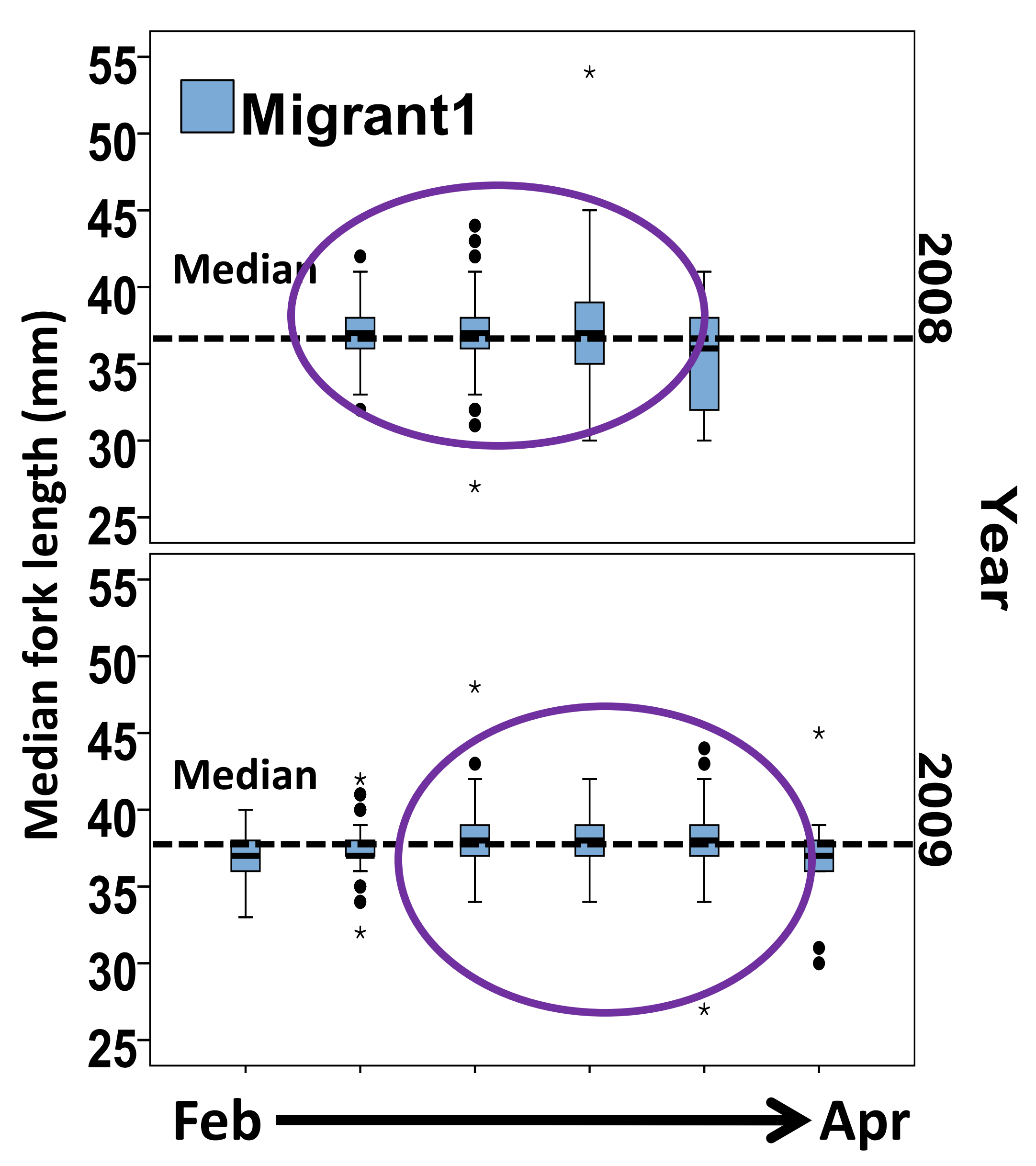
Grouping	Order(s)	Primary Taxa
Americorophium	Amphipoda	*A. spinicorne, A. salmonis*
Anisogammaridae	Amphipoda	Eogammarus, Ramellogammarus
Annelida	Clitellata (class)	Oligochaeta, Hirudinea
Brachycera	Diptera	Empididae, Ephydridae
Brachycera larvae	Diptera	unknown
Chironomidae	Diptera	Chironomidae
Chironomidae larvae	Diptera	Chironomidae
Coleoptera	Coleoptera	Staphylinidae, Cantharidae
Collembola	Collembola	Isotomidae, Sminthuridae
Other Diptera	Diptera	unknown
Ephemeroptera	Ephemeroptera	Baetidae
Ephemeroptera larvae	Ephemeroptera	Baetidae
Fish	Gasterosteiformes	Eggs & juveniles
Hemiptera	Hemiptera	Aphidoidea, Cicadellidae, Psyllidae
Hymenoptera	Hymenoptera	Ichneumonidae, Chalcidoidea
Other Insecta	Insecta (class)	Thysanoptera, Psocoptera, Neuroptera
Insecta larvae	Insecta (class)	Coleoptera, Hymenoptera, Neuroptera
Nematocera	Diptera	Ceratopogonidae, Sciaridae, Psychodidae
Nematocera larvae	Diptera	Ceratopogonidae
Other	n/a	Hatchery food
Other Epibenthic	Various	Isopoda, Mysidacea, Amphipoda
Other Terrestrial	Various	Acari, Araneae, Pseudoscorpionida
Plecoptera	Plecoptera	unknown
Plecoptera larvae	Plecoptera	unknown
Trichoptera	Trichoptera	Hydroptilidae
Trichoptera larvae	Trichoptera	unknown

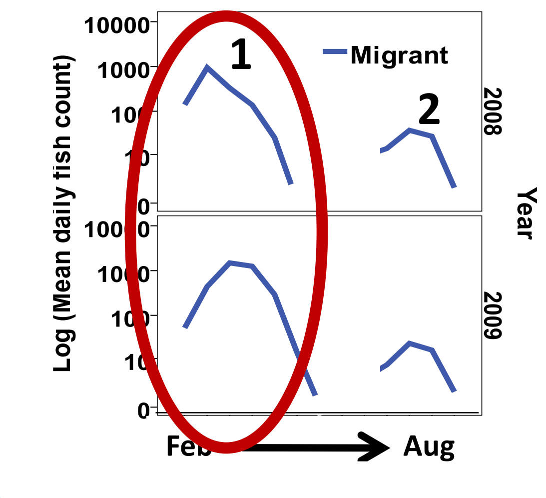
Results: Fish size





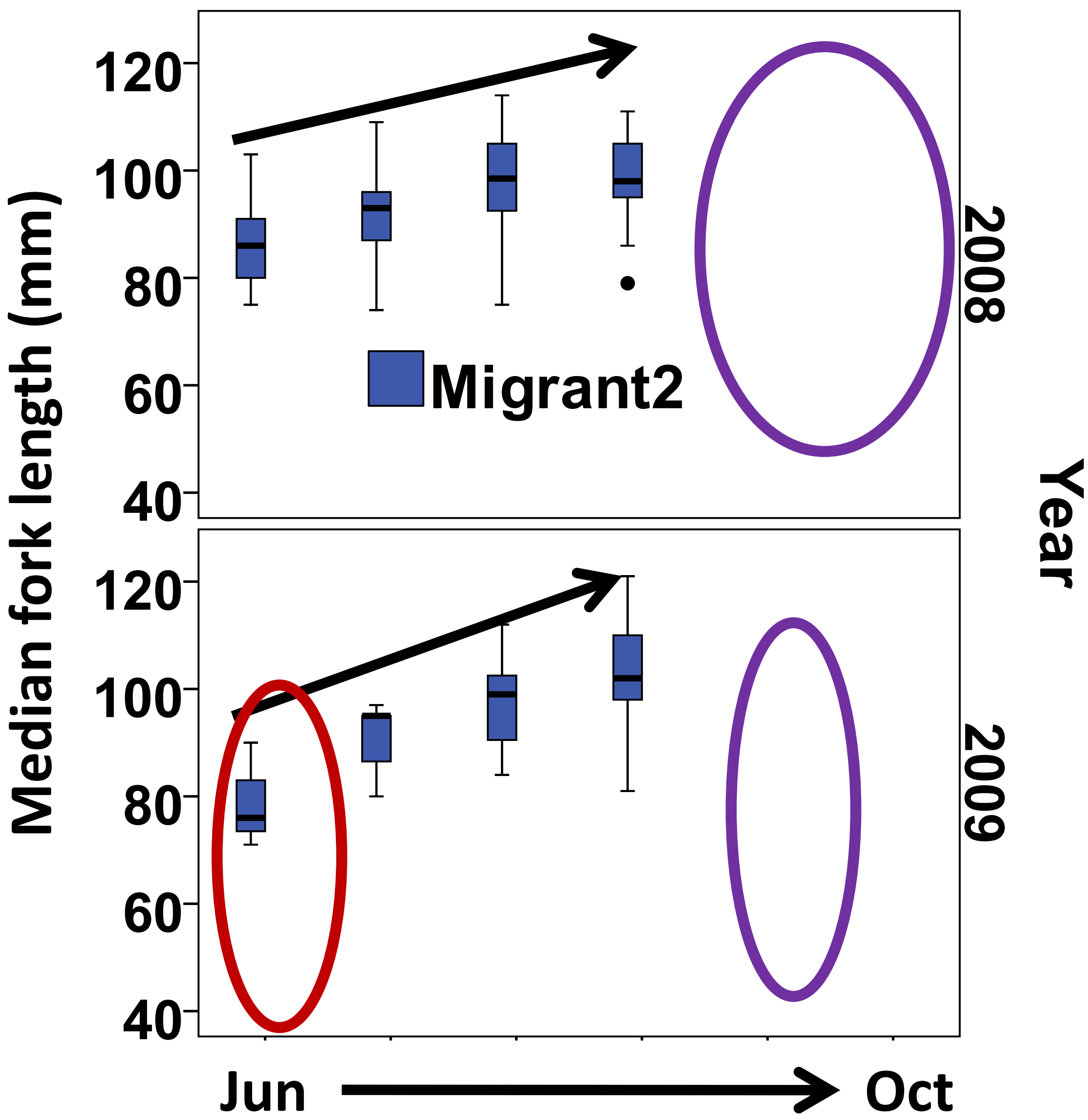
Results: Fish size

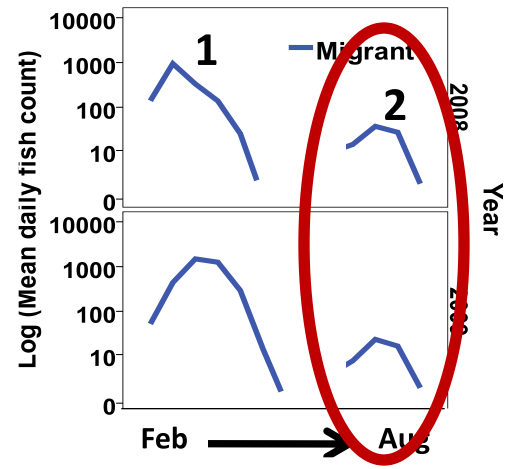




- Size remains constant
  = migrate following emergence

Results: Fish size



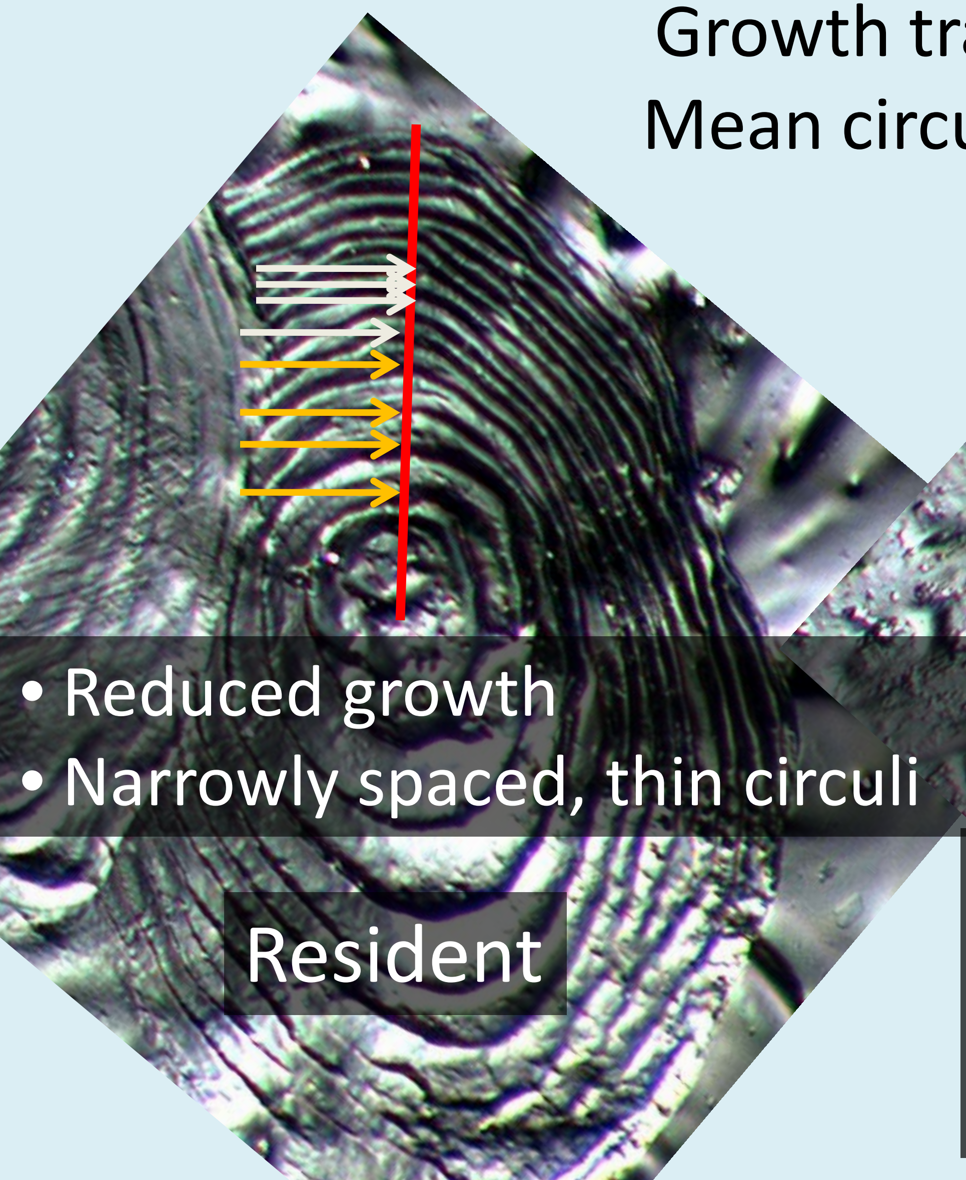


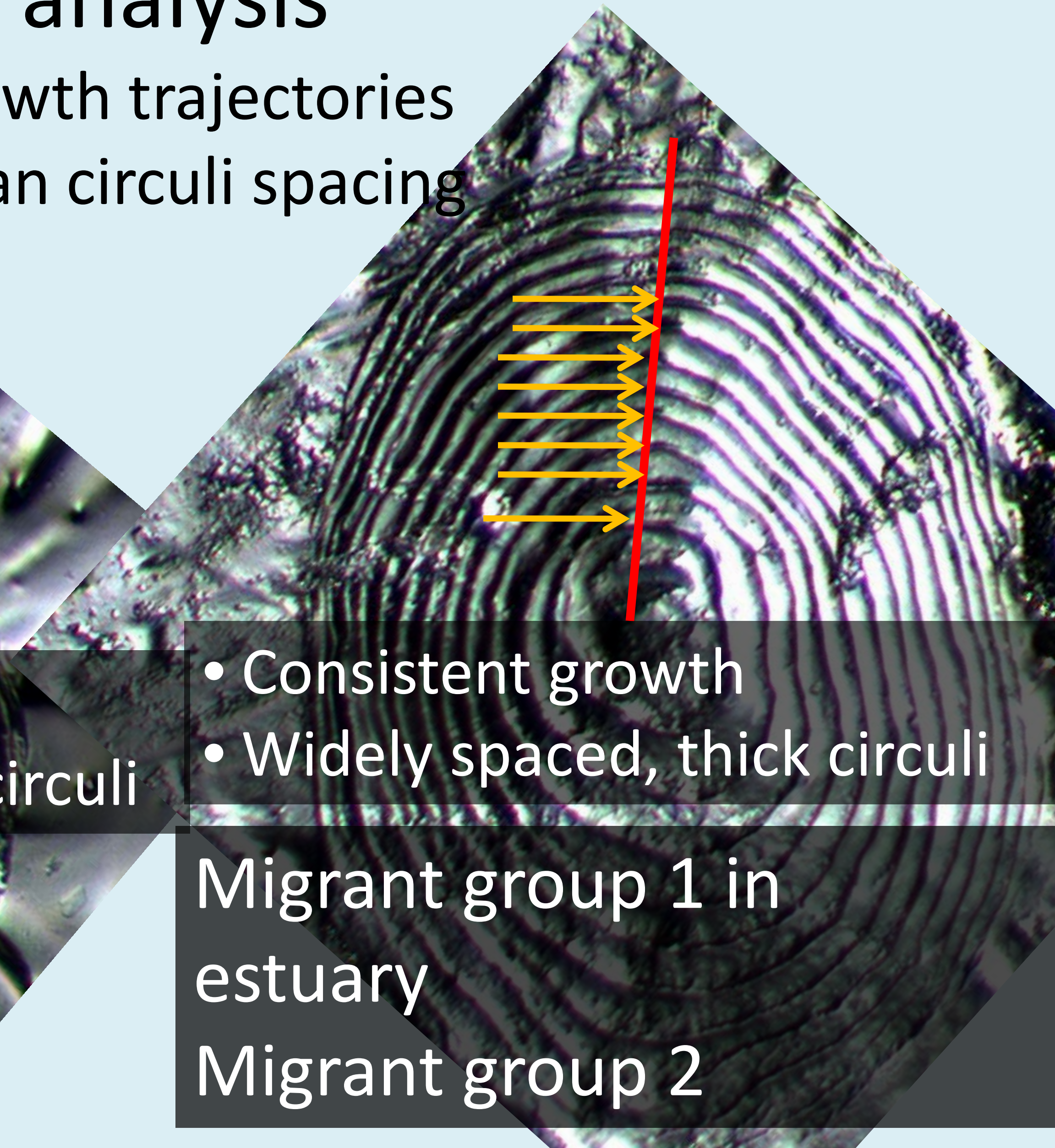
- Size increases
- Migrants larger than residents

Chapter 2B: Methods- Scale pattern analysis

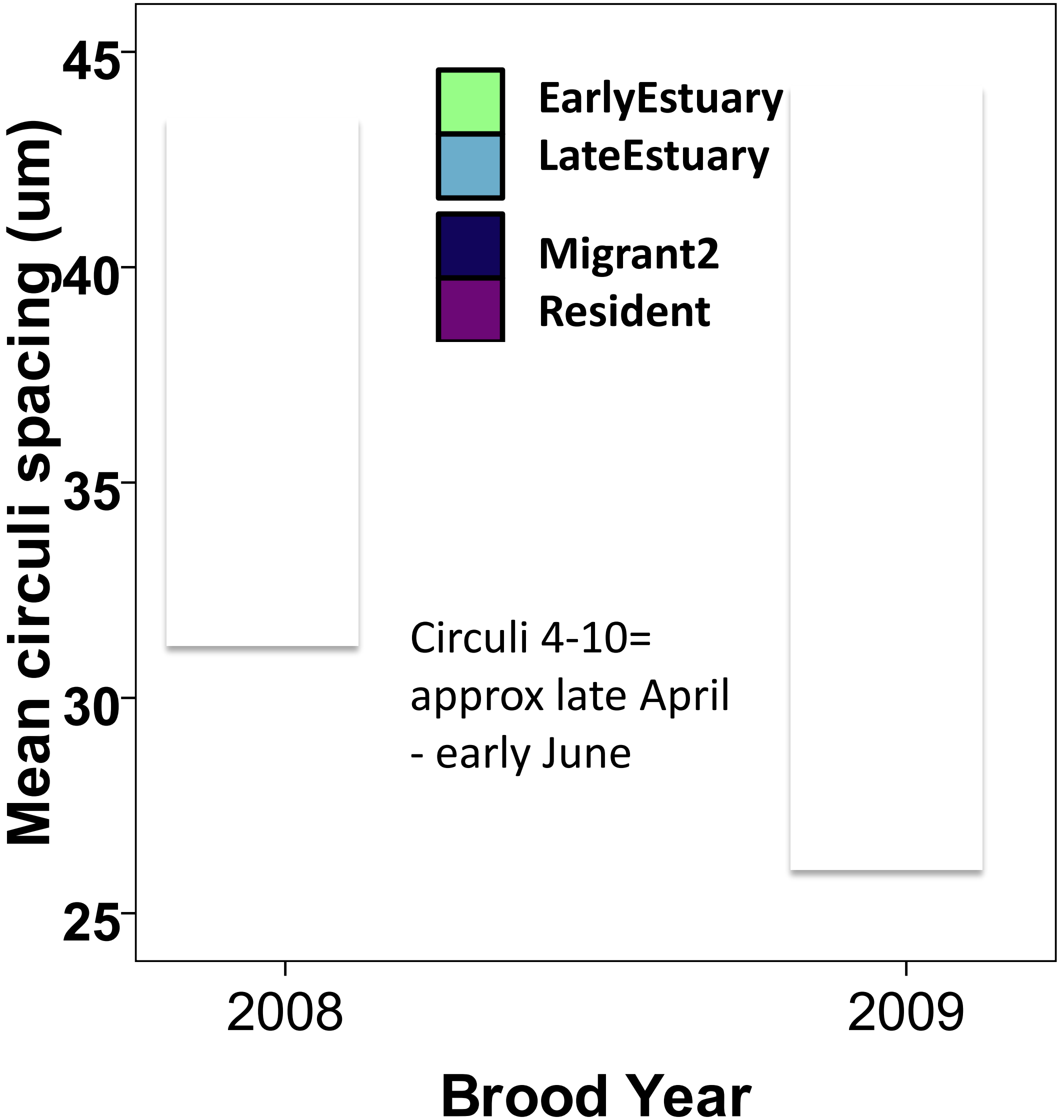
Growth trajectories

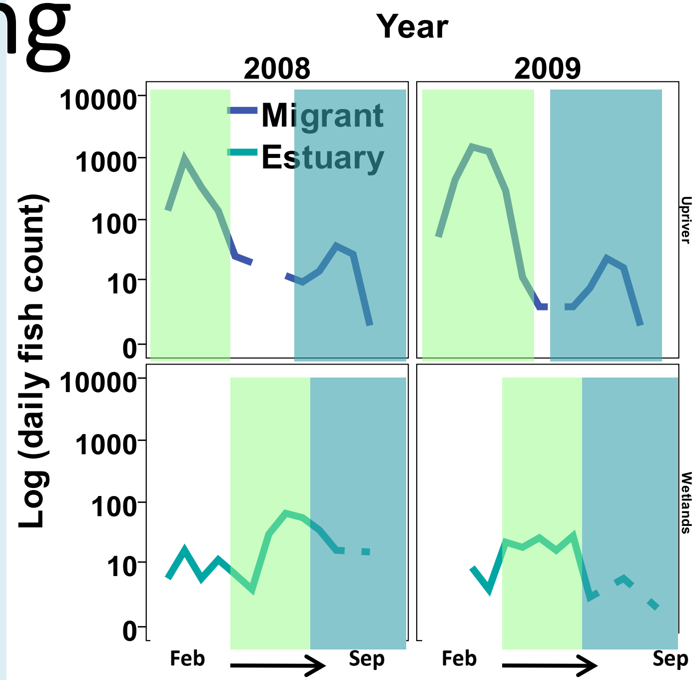
Mean circuli spacing



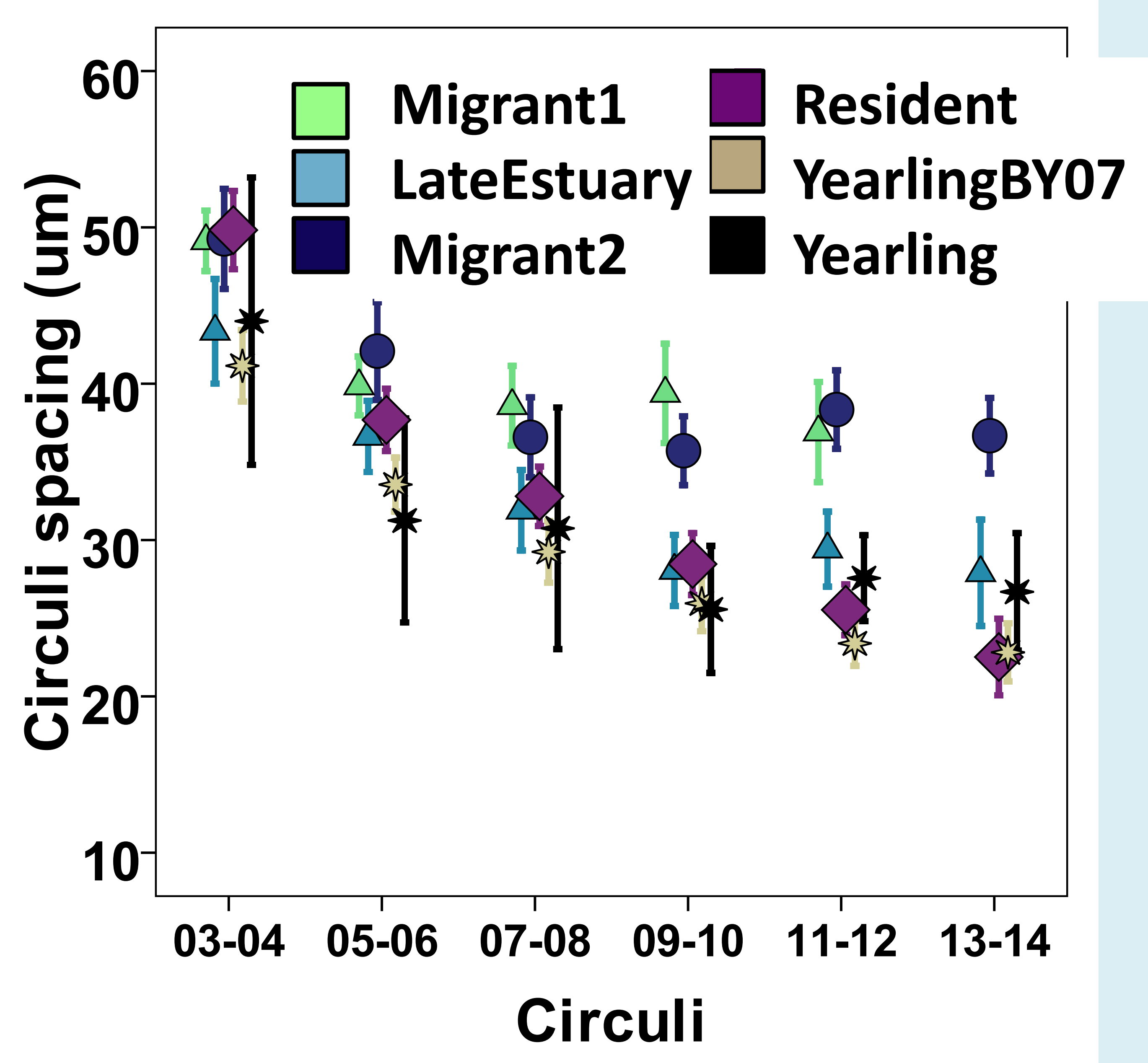


Results: Mean circuli spacing
Mean growth rates





- Early Estuary and Migrant 2 highest growth rates
- Late Estuary different pattern than Early Estuary



Migrant1
LateEstuary
Migrant2
Resident
YearlingBY07
Yearling
Circuli spacing (um)
60
50
40
30
20
10
03-04
05-06
07-08
09-10
11-12
13-14
Circuli