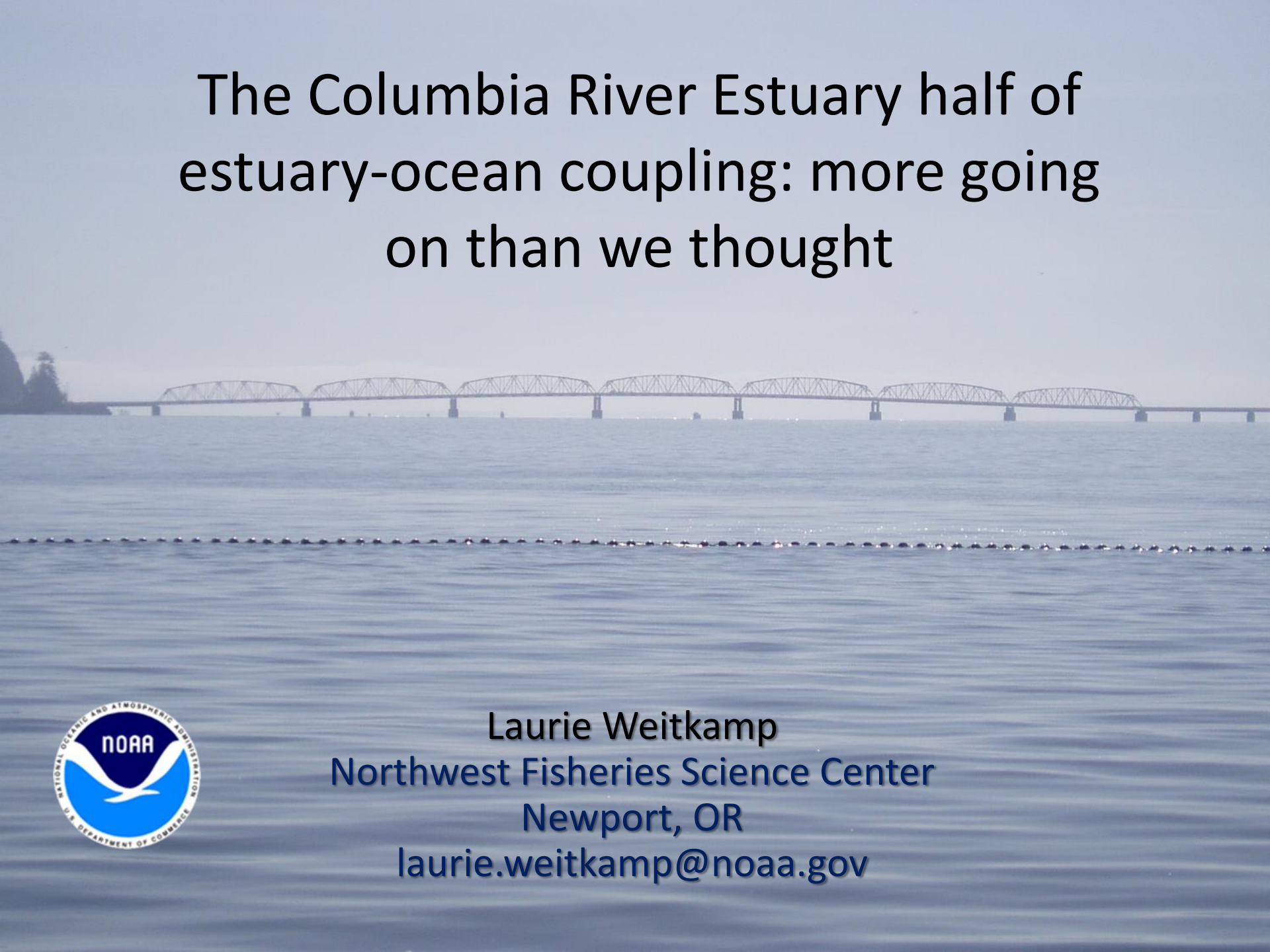
The Columbia River Estuary half of estuary-ocean coupling: more going on than we thought



Laurie Weitkamp
Northwest Fisheries Science Center
Newport, OR
laurie.weitkamp@noaa.gov

Today's talk

- Briefly describe "estuary purse seine" (EPS) study
  - Hypotheses, objectives, methods
- What it has taught us about estuary-ocean coupling
  - General patterns of outmigration
    - Potential for interactions among stocks, hatchery/wild fish?
  - Stock-specific timing by juvenile salmon
    - influence on ocean growth potential
- New upper estuary work in 2016 (and 2017)
  - Blowing holes in the "estuary = pipe" paradigm

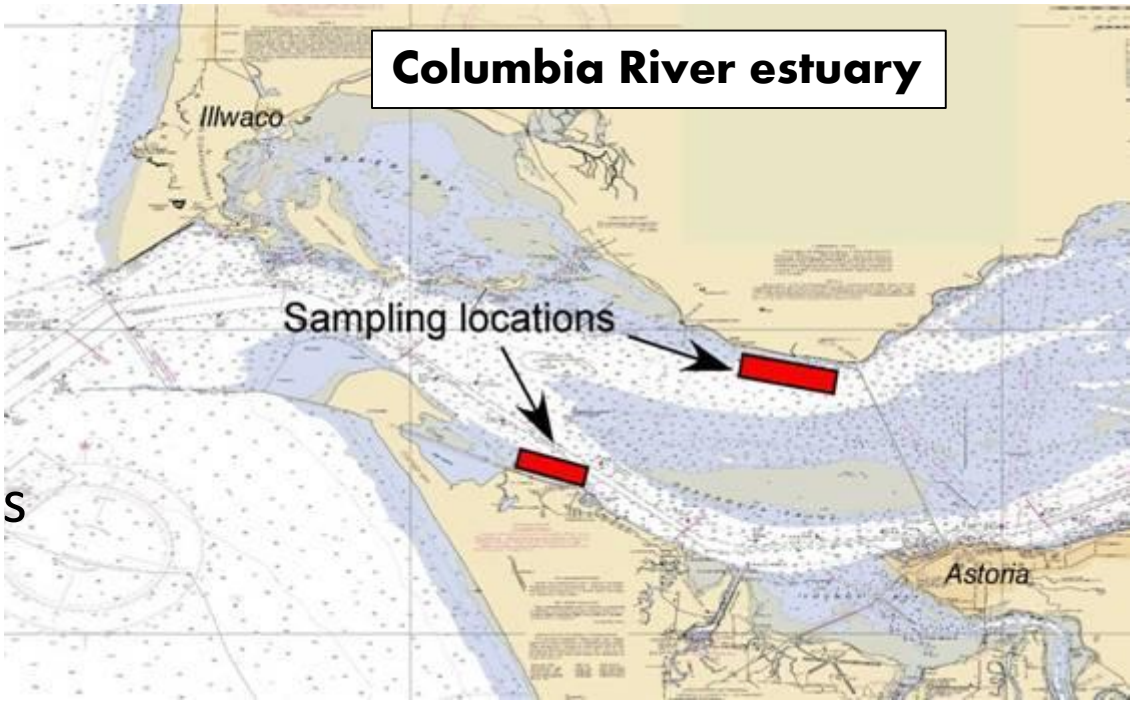
EPS juvenile salmonid hypotheses

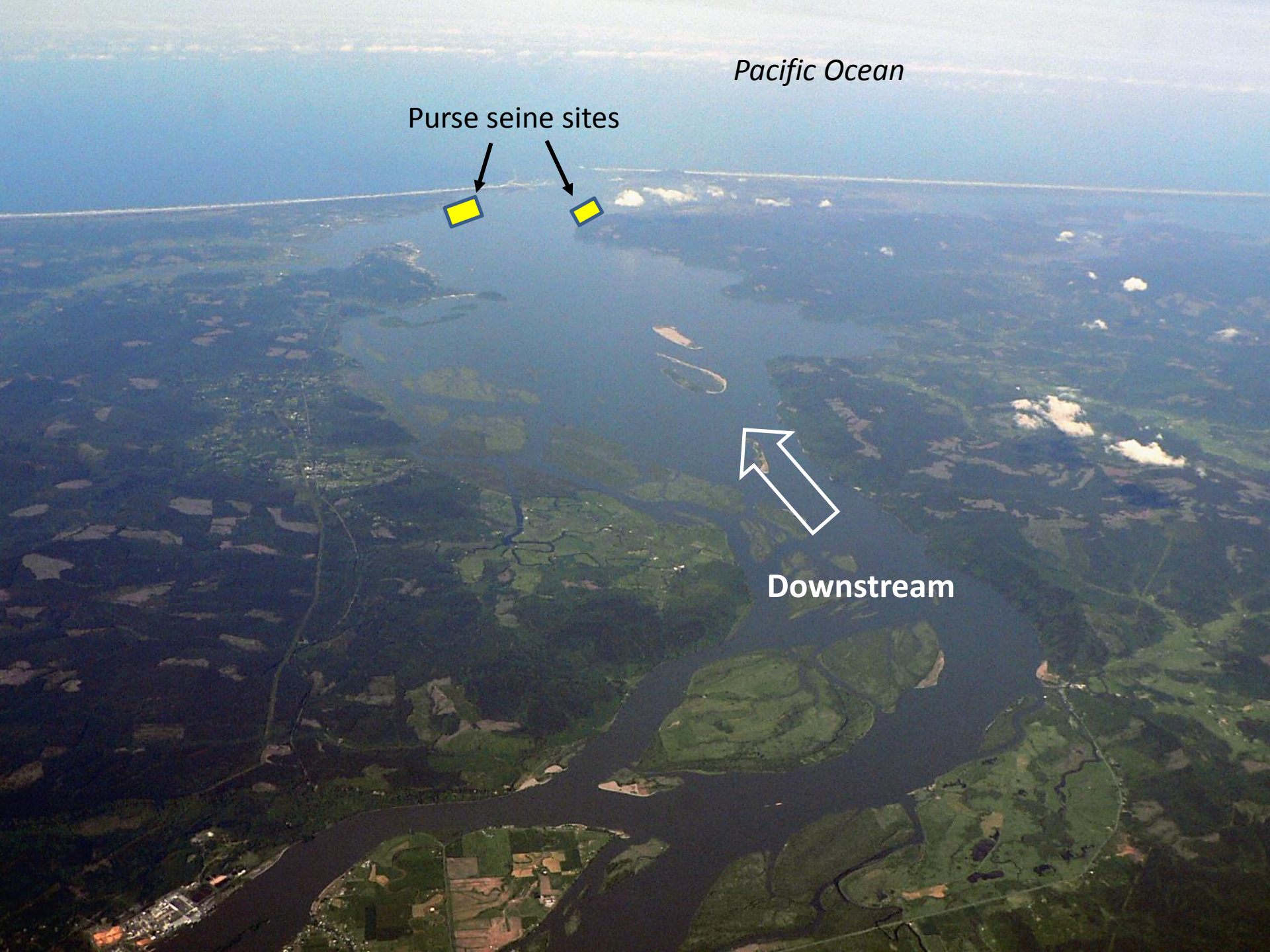
- Better understand **salmon marine ecology** by knowing when and ***what*** is entering the ocean
- Better understand **salmon river passage** by knowing when and ***what*** reach the estuary
- ***What*** = species, age class, abundance, stock origin, condition (size, diet, parasites, pathogens, etc.), hatchery/wild

Estuary purse seine methods

Focus on spring outmigration of juvenile salmonids

- Sampling at edges of deep channels
- Mid April to late June
  - every other week (2007-13)
  - Monthly (2016, 2017)
- Monthly
  - Sep. only (2007-08)
  - July-Oct. (2009-12)
- 6-8 sets per station per cruise
- Temp/salinity profiles every set




Pacific Ocean
Purse seine sites
Downstream

Setting the net

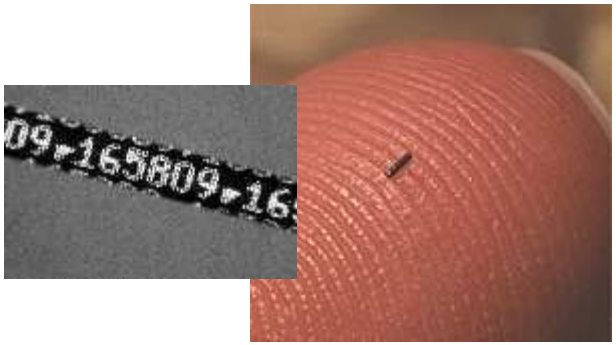
Sorting, counting and measuring fish

How to determine stocks of Columbia salmon

Genetics

Everything "tagged" Parental Based Tagging (PBT) for hatchery of origin (Idaho only)

Coded wire tags (CWT)



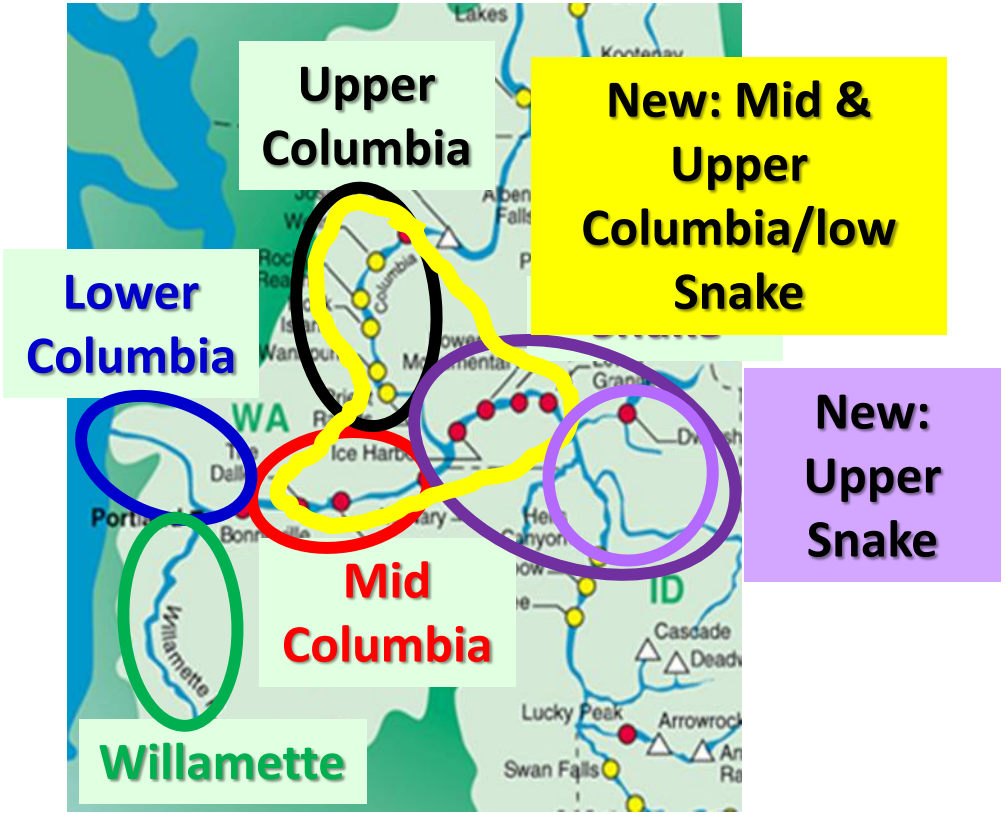
24 mil tagged annually (h)

PIT tags

2 mil tagged annually (h & w)
Bias: UCR & Snake

Genetics stock groups of salmon

Steelhead

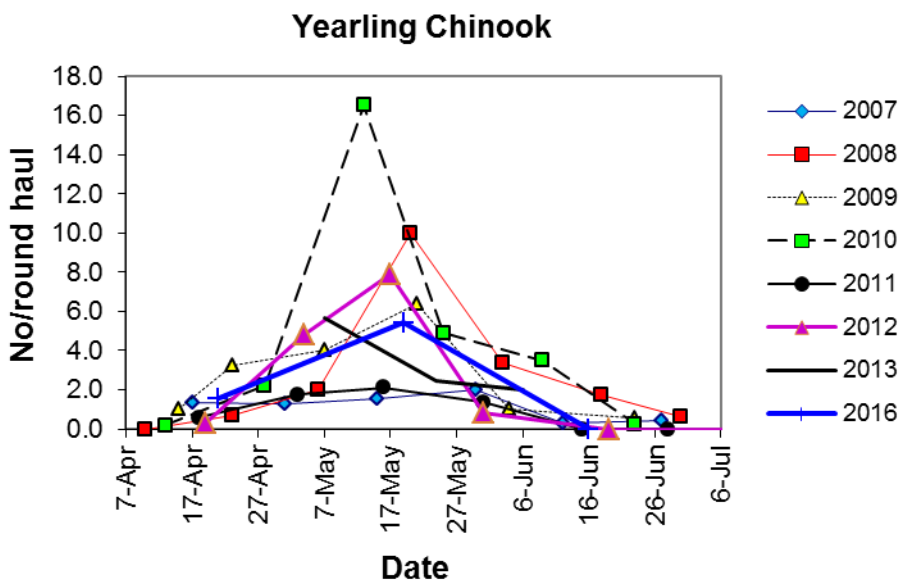


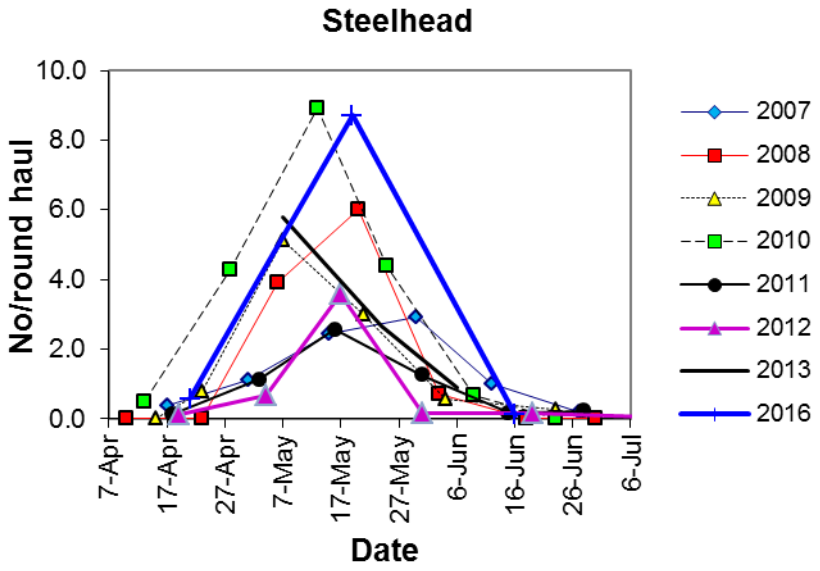
What the estuary purse seine study has taught us about estuary-ocean coupling

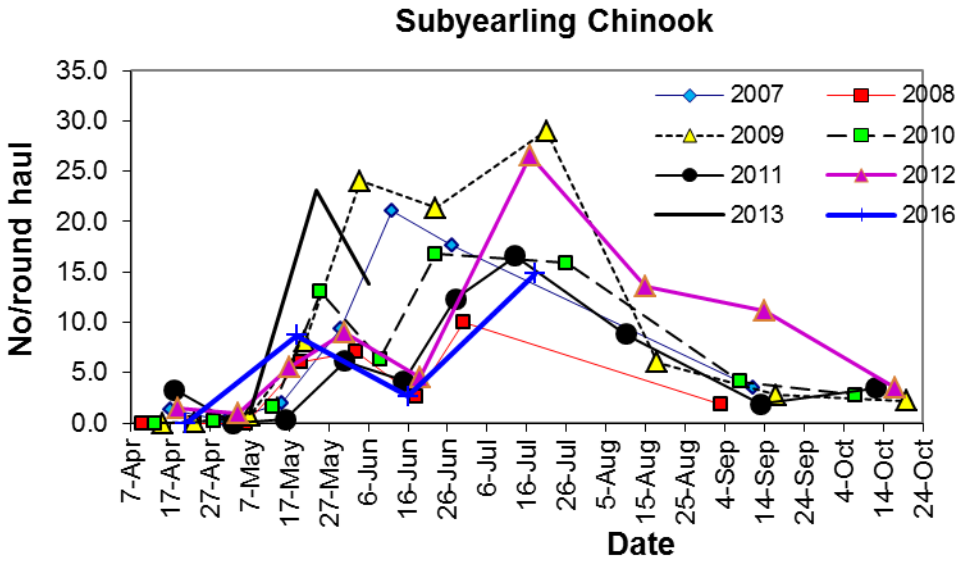
1. Many salmon stocks in the estuary at the same time
   - Possible interactions may influence survival

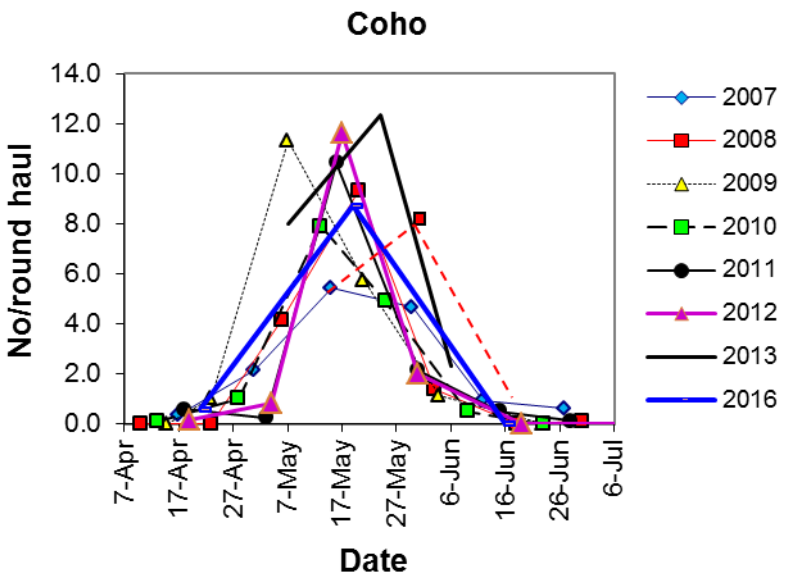
2. Stock-specific timing by juvenile salmon
   - influence on ocean growth potential

1. Timing of juvenile salmon in the Columbia Estuary





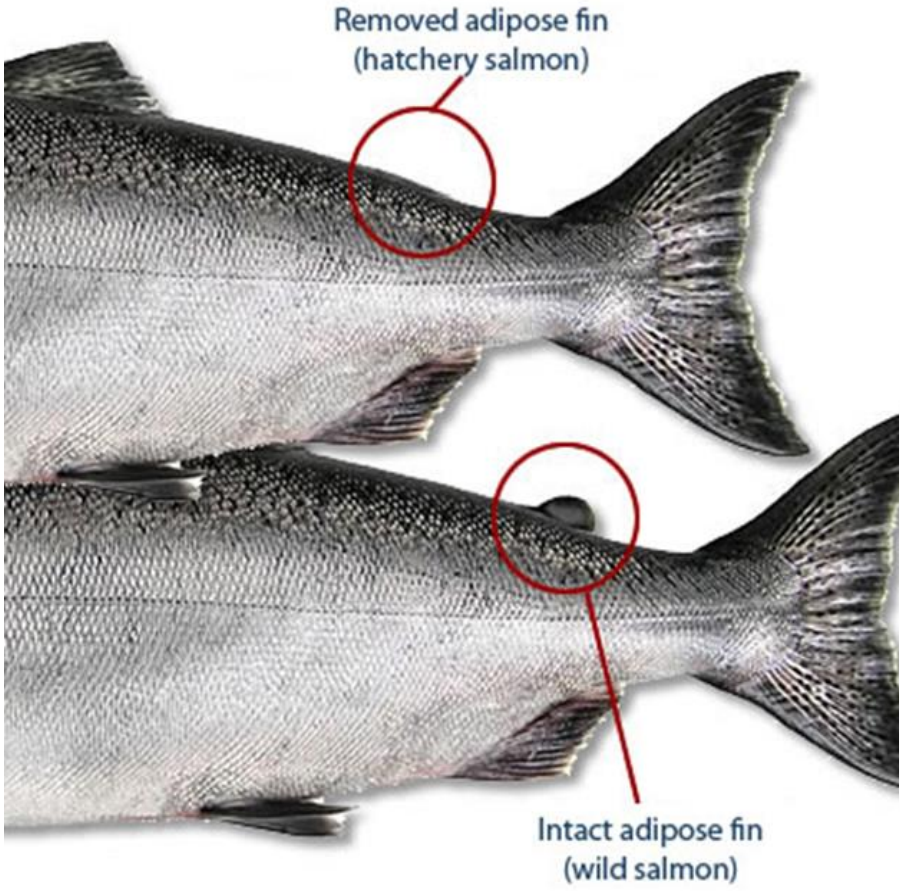




Most juvenile salmon are of hatchery origin

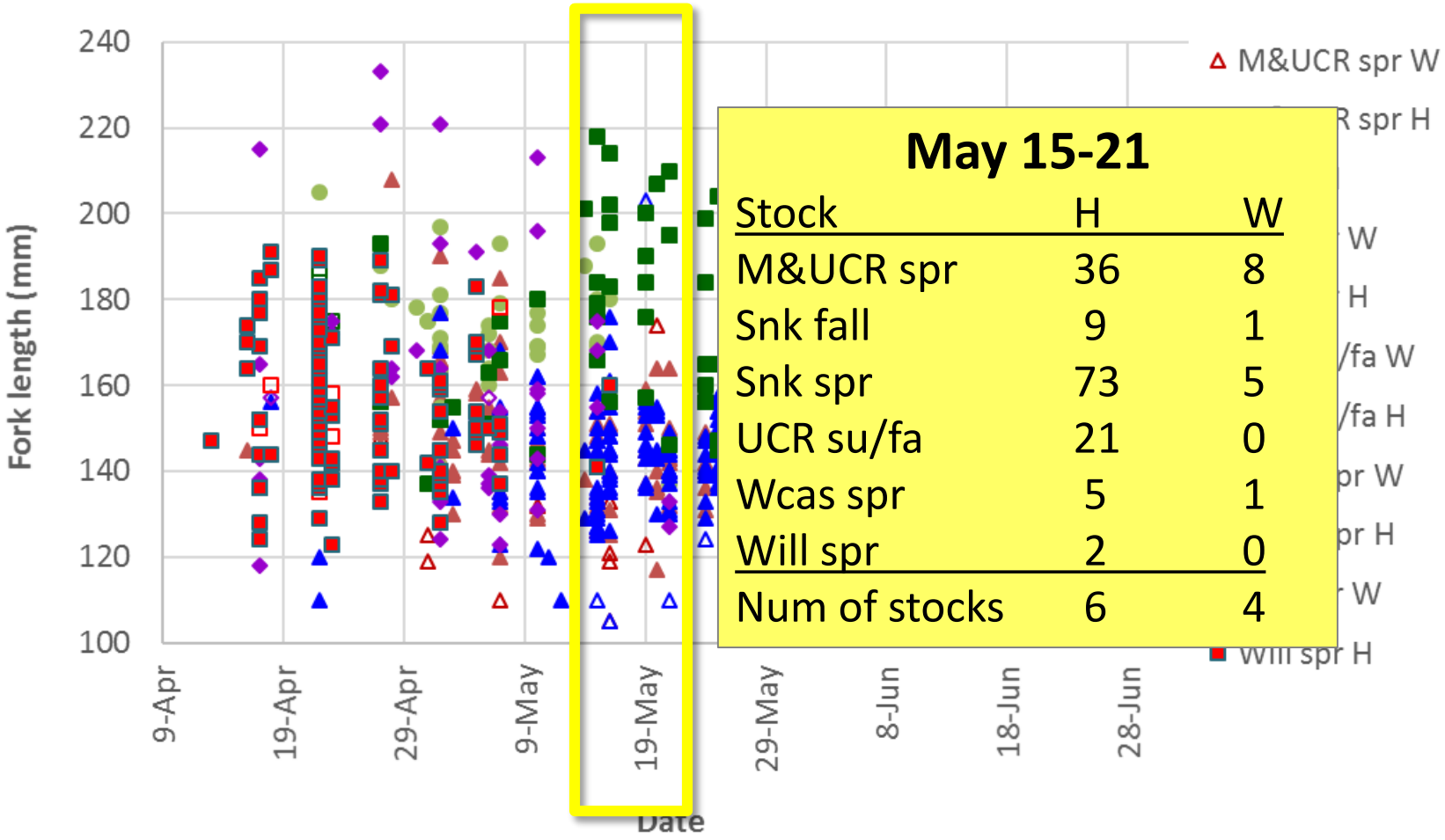
Hatchery-wild origins (2007-12 combined)

Species/ age class	% hatchery	% wild
Yearling Chinook	94.7	5.3
Subyr. Chinook	85.8	14.2
Coho	98.7	1.3
Steelhead	91.6	8.4



Many stocks of salmon are present in the lower estuary at the same time

Yearling Chinook

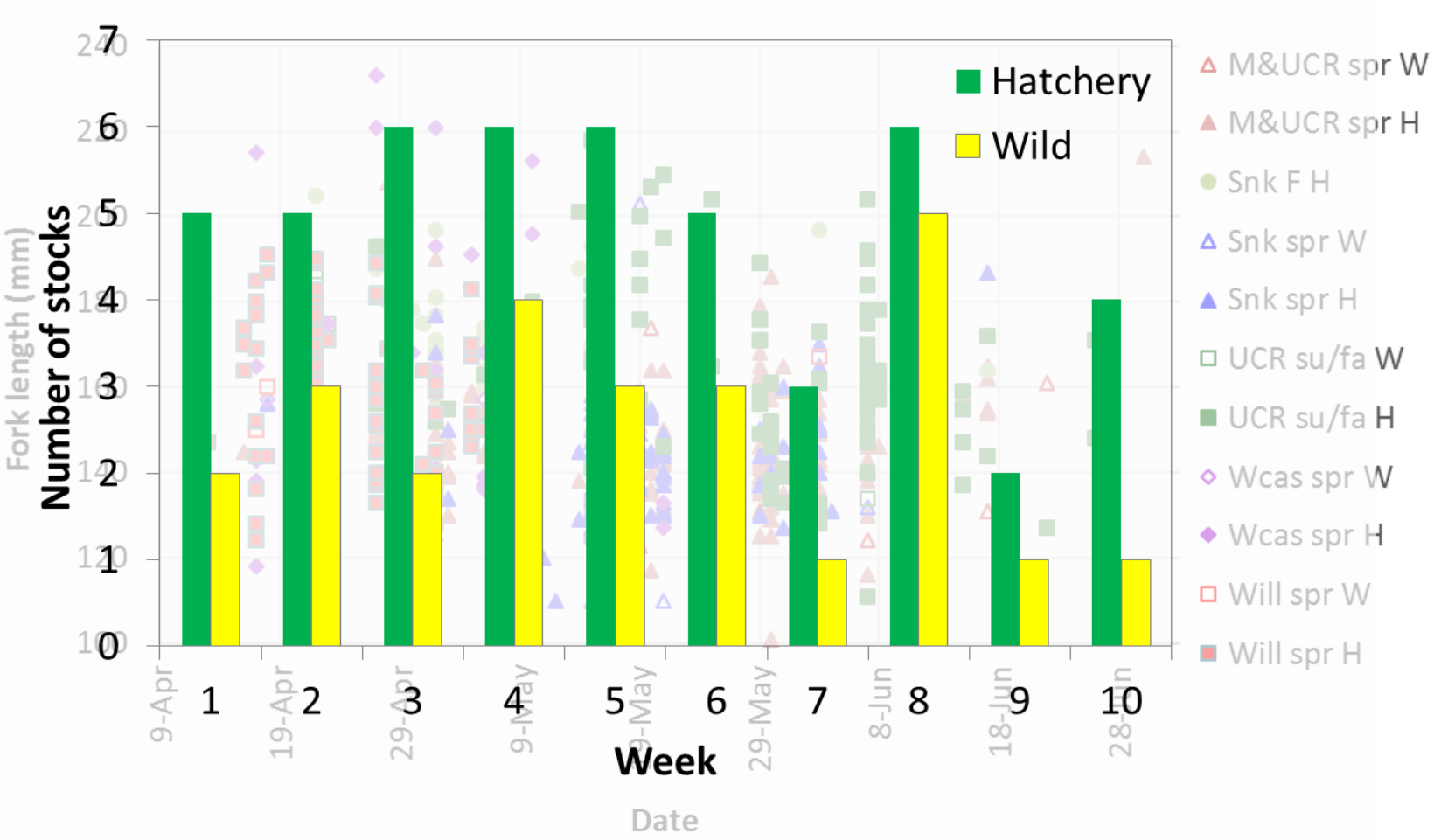


May 15-21

Stock	H	W
M&UCR spr	36	8
Snk fall	9	1
Snk spr	73	5
UCR su/fa	21	0
Wcas spr	5	1
Will spr	2	0
Num of stocks	6	4

Many stocks of salmon are present in the lower estuary at the same time

Yearling Chinook



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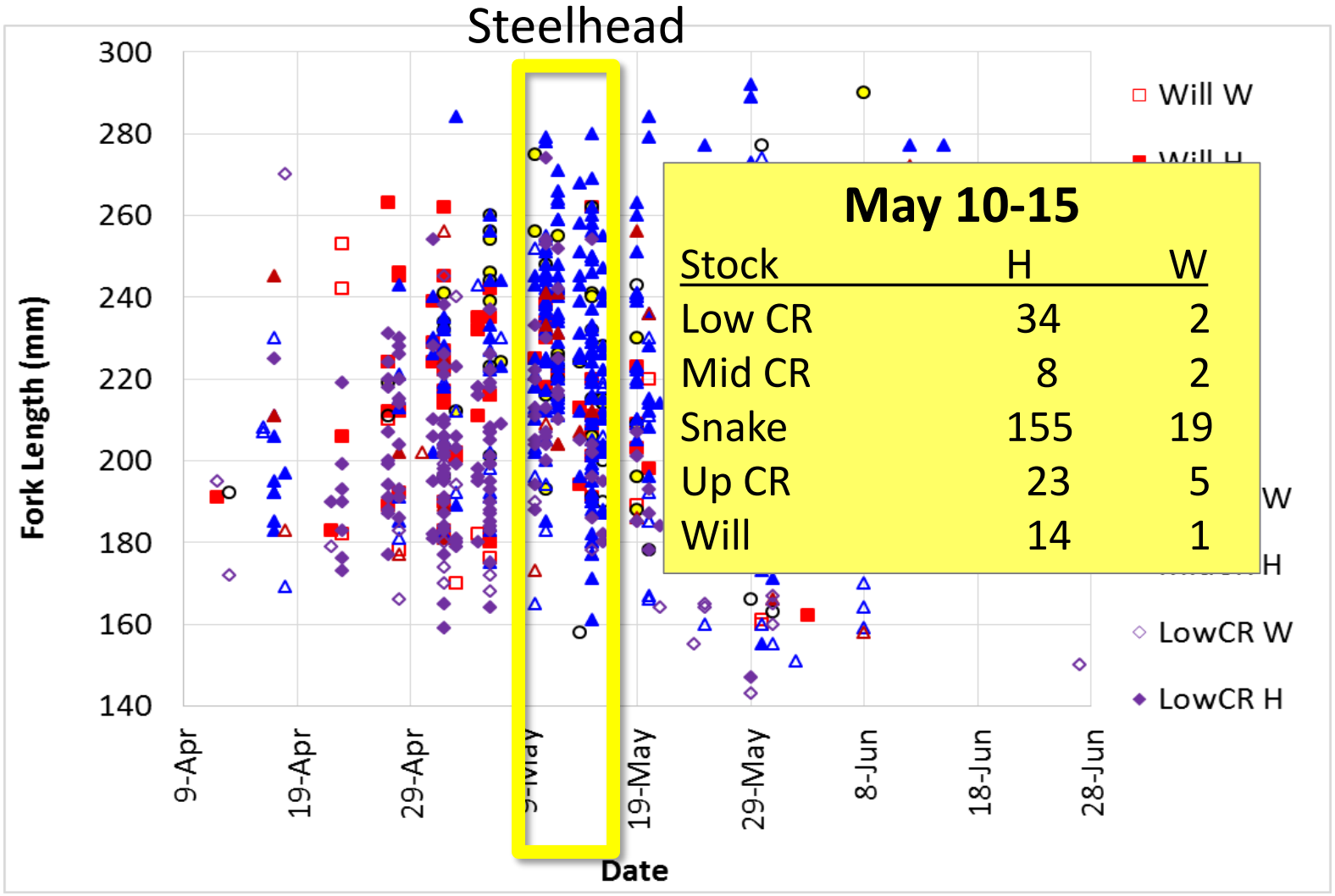
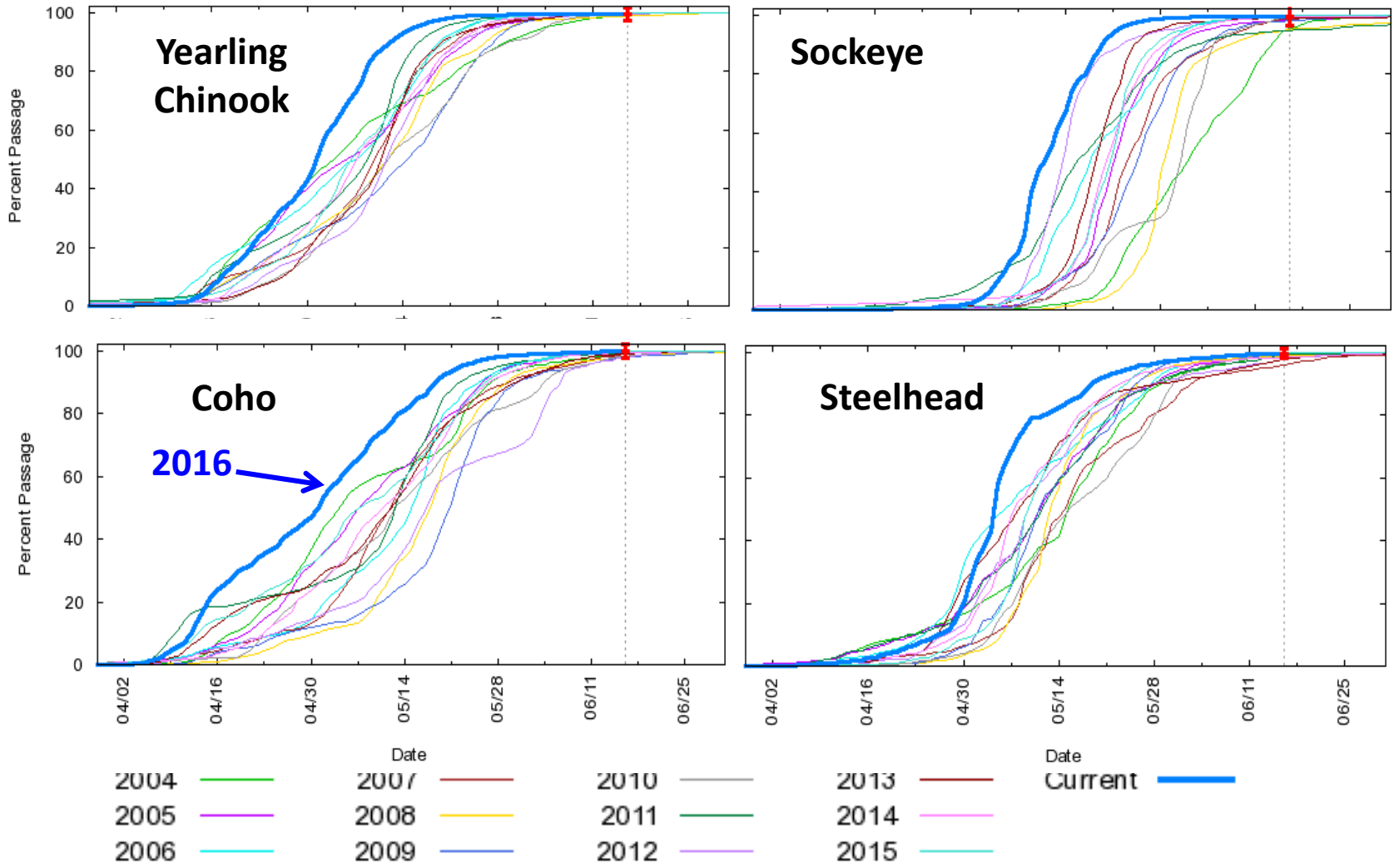


Does overlap among salmon stocks/types lead to interactions that might influence survival?

- Juvenile Chinook, coho, and steelhead have high diet overlap in the estuary
  - 66-83% of diet consists of amphipods and insects
  - If these prey are limited, then completion for food resources may occur
- Behavioral interactions (chasing, biting) are harder to detect or measure
  - If bigger fish have a size advantage over smaller fish, interactions may be detrimental to small wild fish

2016 salmon outmigration timing is extremely early for all yearling migrants

(cumulative outmigration timing at Bonneville Dam; graphs from DART)



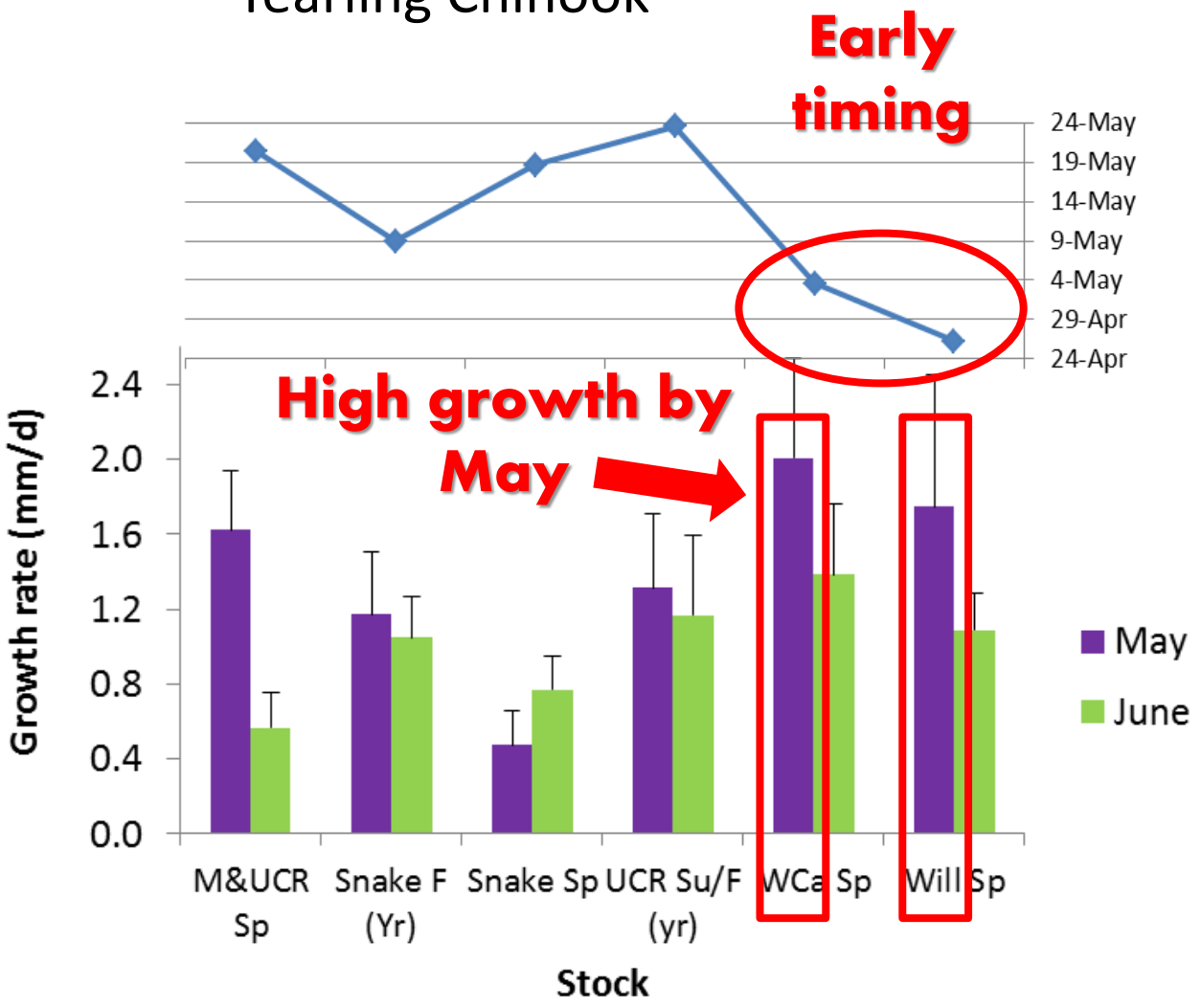
2. Timing of ocean entry influences ocean growth opportunity

Timing of ocean entry influences initial ocean growth opportunity

Yearling Chinook

Mean date in estuary

Ocean growth rate by late May or June



Timing of ocean entry influences initial ocean growth opportunity

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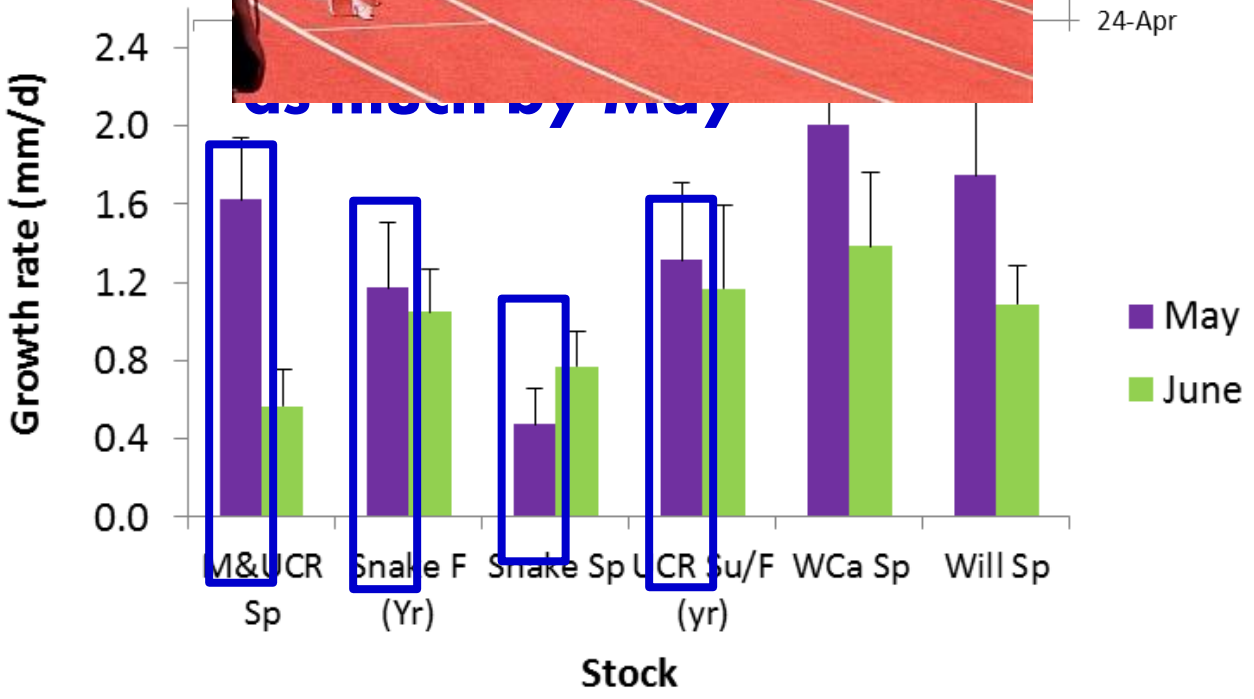
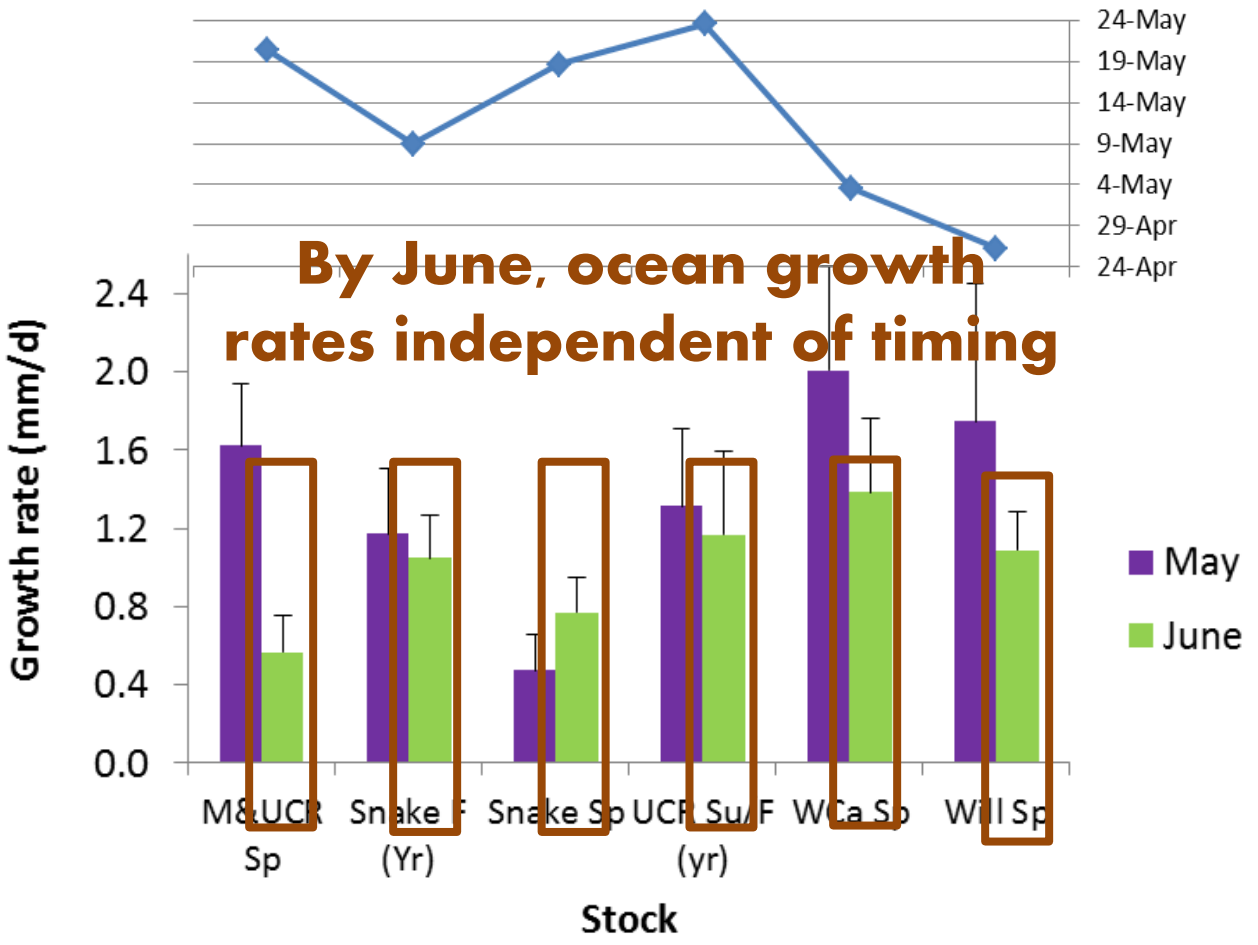


Timing of ocean entry influences initial ocean growth opportunity

Yearling Chinook

Mean date in estuary

Ocean growth rate by late May or June

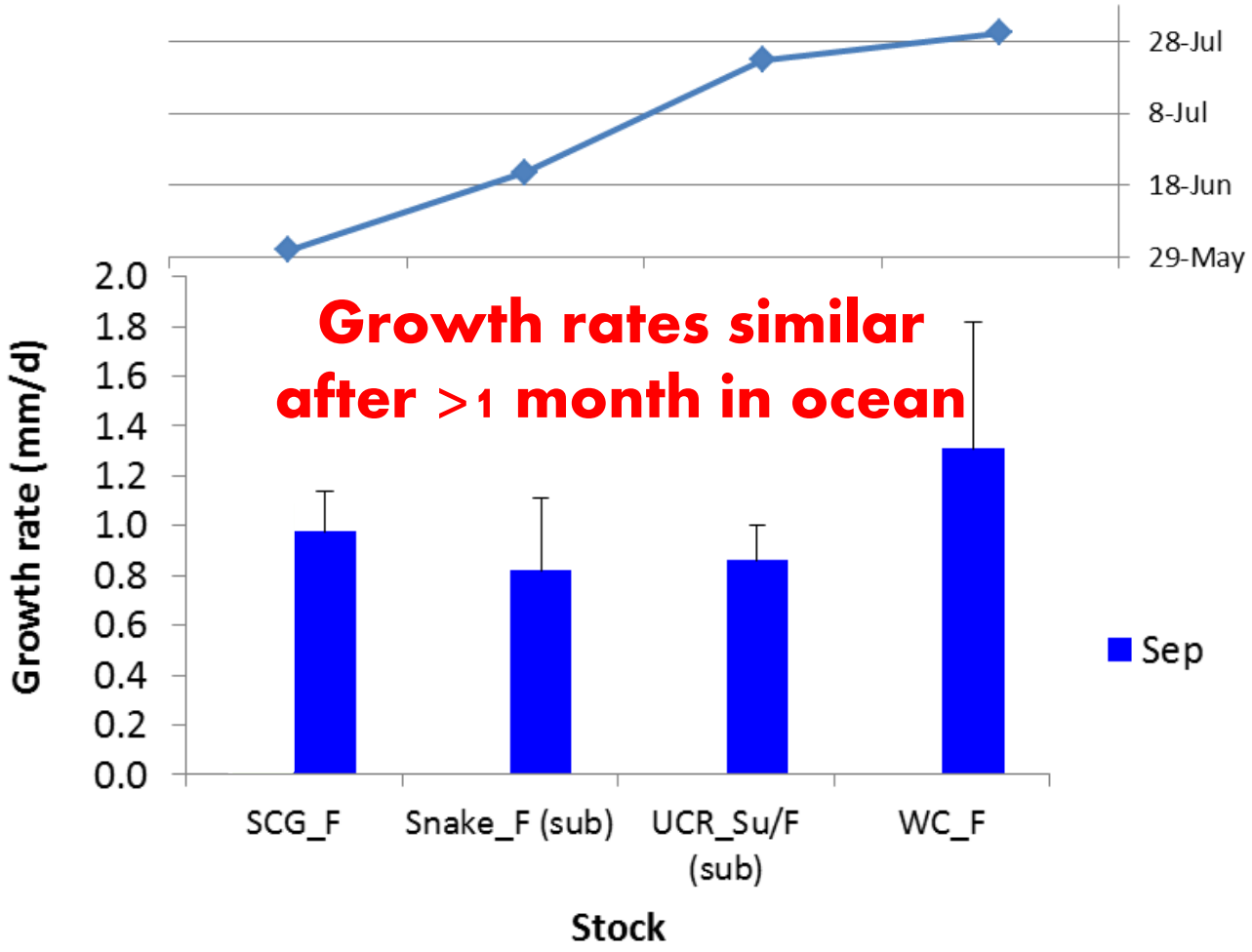


Timing of ocean entry influences initial ocean growth opportunity

Subyearling Chinook

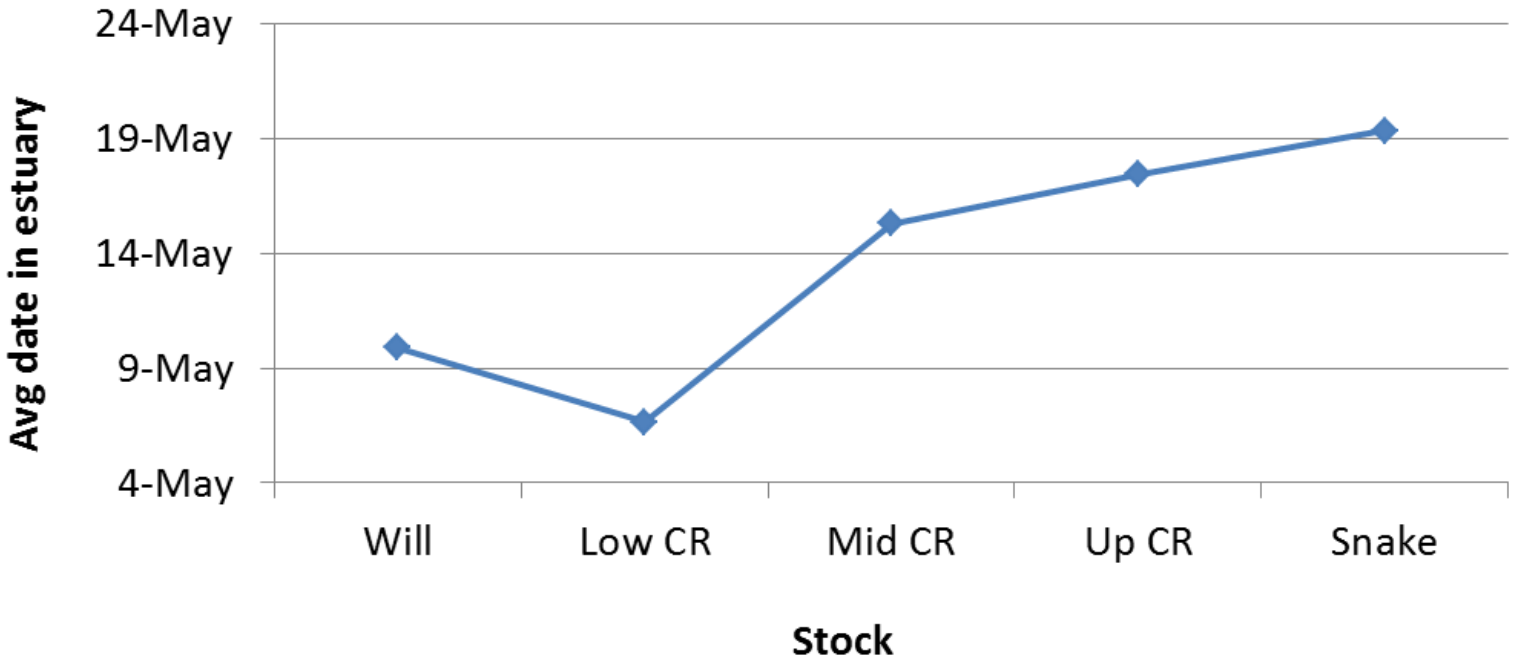
Mean date in estuary

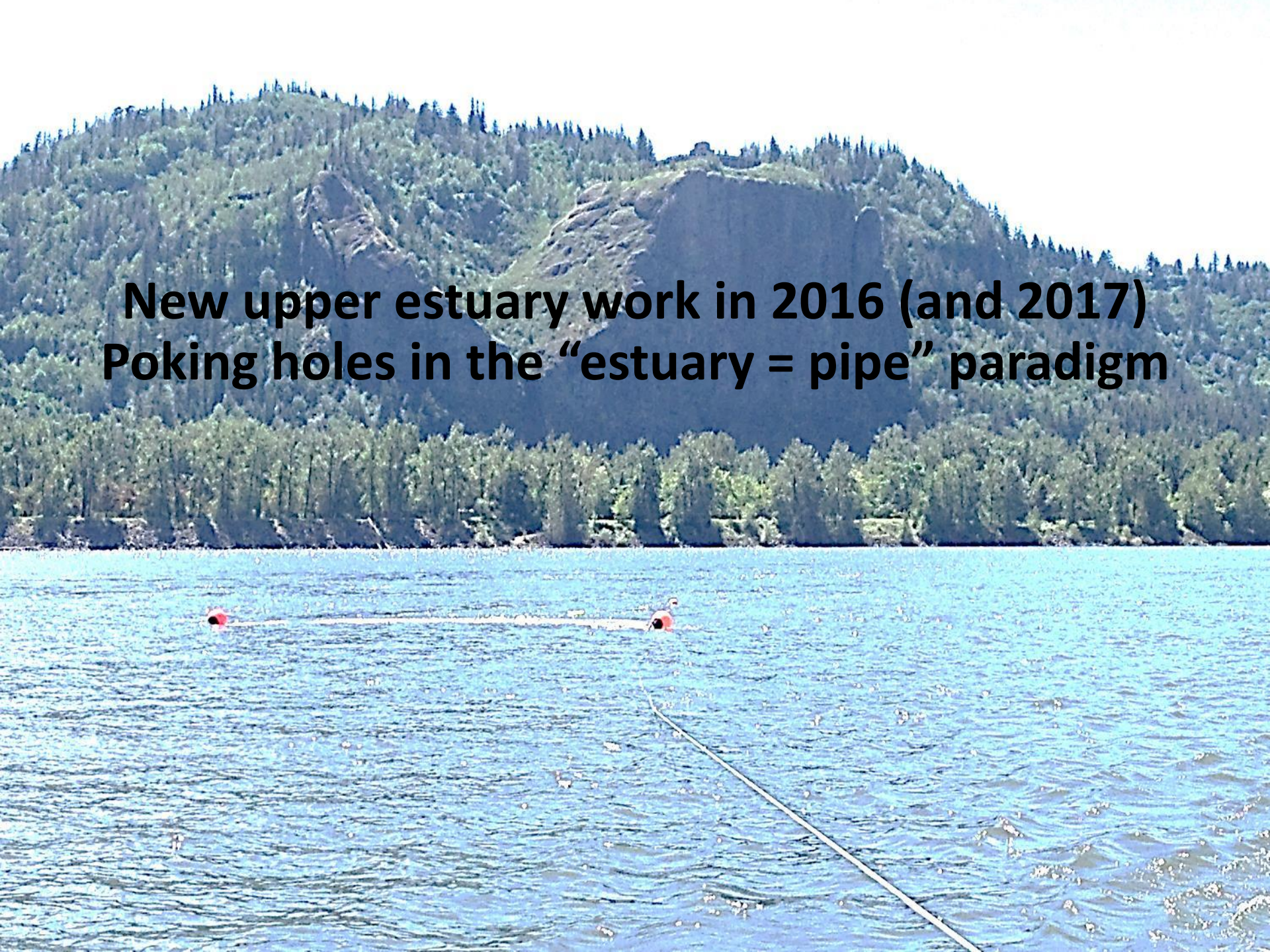
Ocean growth rate by September



Expect variation in steelhead timing also influences initial ocean growth rates

don’t catch enough steelhead in ocean to estimate growth rates



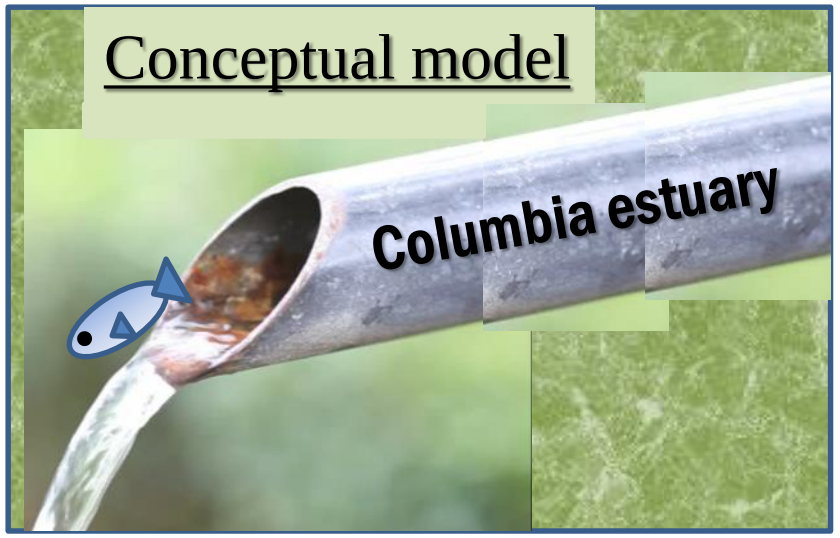

New upper estuary work in 2016 (and 2017)
Poking holes in the “estuary = pipe” paradigm

Columbia River estuary as a pipe

Pipe paradigm

Fish migrating from Bonneville Dam to the ocean:

- don't feed
- don't grow
- don't stop



Our new USACE-funded research shows the pipe paradigm is full of holes

Evaluating the Effectiveness of Habitat Restoration Actions in the Lower Columbia River and Estuary

Research question

- Do interior stocks of chinook and steelhead benefit from marsh habitat restoration in the Columbia Estuary?

Objectives

- Investigate the direct and indirect effects of habitat restoration on juvenile salmon at the landscape scale (outside wetlands).

Approach

- Sample juvenile salmon in mainstem from below Bonneville Dam to the mouth to determine if they change
- Use suite of effectiveness indicators to determine change

Evaluating the Effectiveness of Habitat Restoration Actions in the Lower Columbia River and Estuary

Research question

- Do interior stocks of chinook and steelhead benefit from mars

These habitats have not been sampled in at least 40 years (if ever)

Objecti

- Investigate the direct and indirect effects of habitat restoration on juvenile salmon at the landscape scale (outside wetlands).

Approach

- Sample juvenile salmon **in mainstem from below Bonneville Dam to the mouth** to determine if they change
- Use suite of effectiveness indicators to determine change

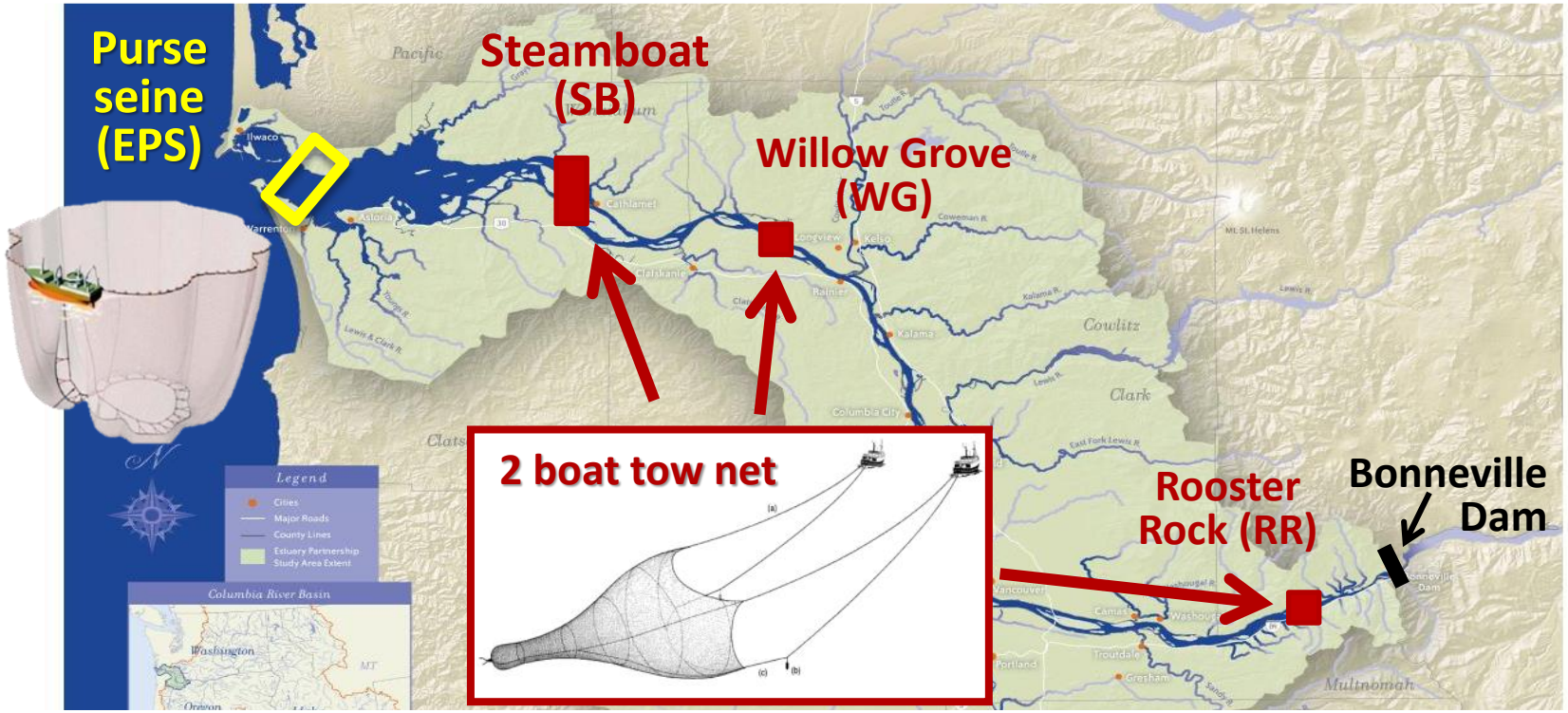
Effectiveness Indicators

- Species composition*
- Juvenile salmon density*
- Genetic stock*
- Fish condition (length, weight, ratio)
- Diet*/gut fullness
- Growth physiology markers (IGF-1*, liver glycogen)
- Stable isotopes (prey, juvenile salmon*)
- Growth from otoliths

*will be presented today

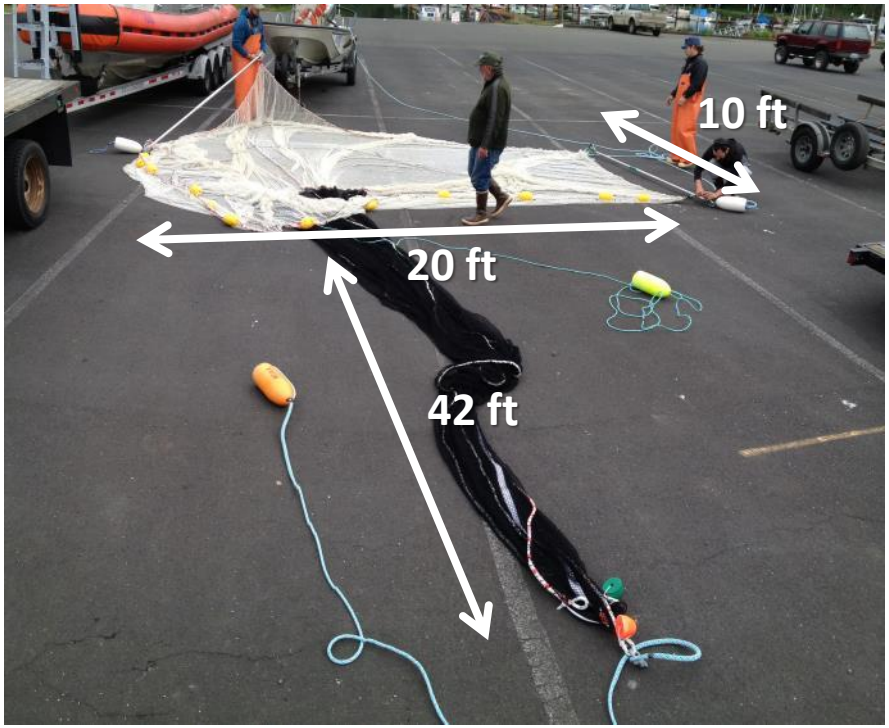
Landscape-scale approach

Compare stock-specific indicators of fish performance along longitudinal transect across the Columbia estuary

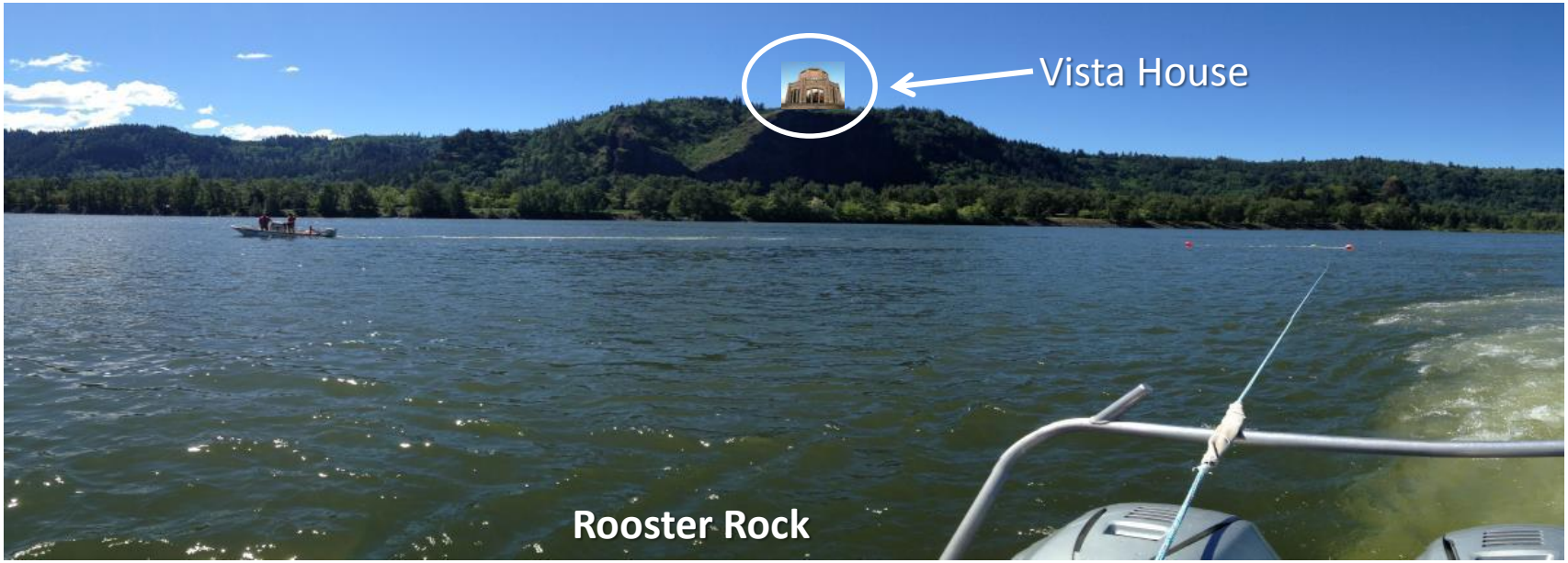


Sampled all sites in April, May, June and July

Two-boat tow net



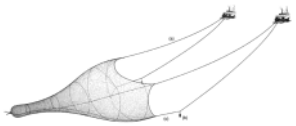
Tow net sites



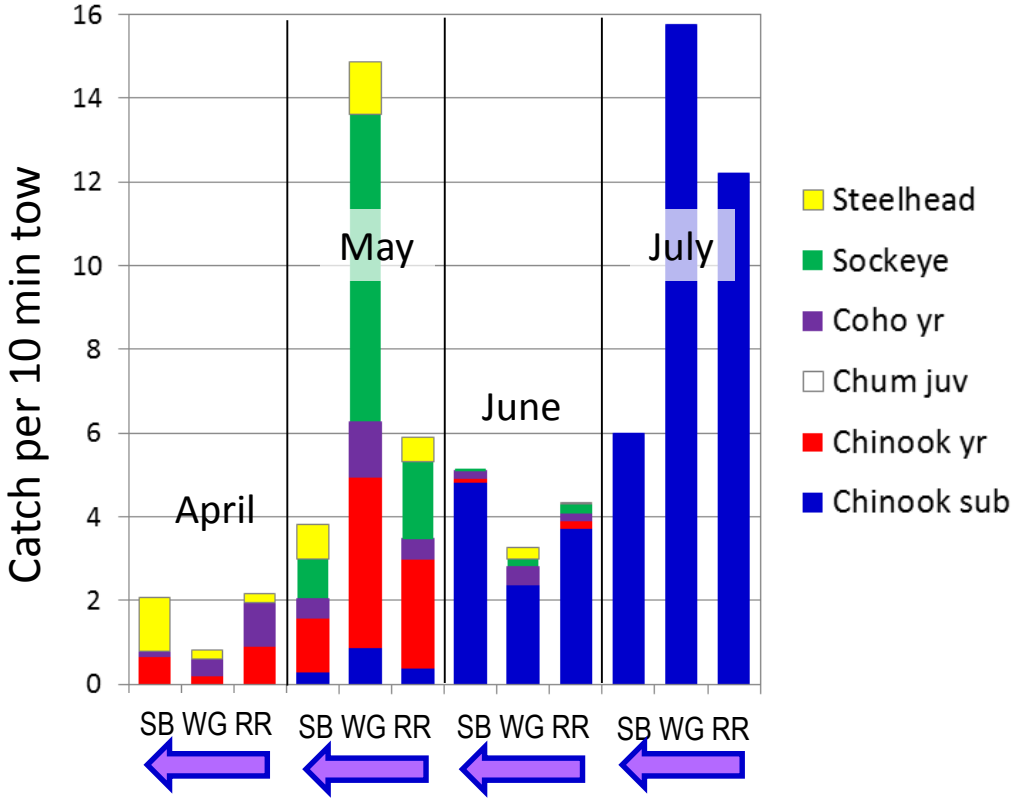
Results

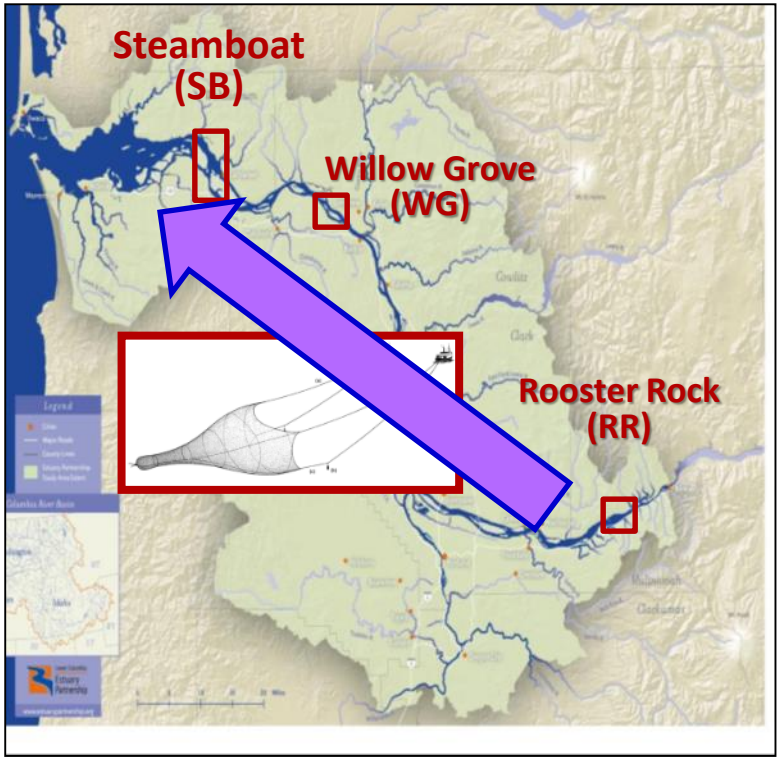
- Species composition
- Juvenile salmon density
- Genetic stocks of Yr Chinook & Steelhead
- Diets
- Growth physiology markers (IGF-1)
- Stable isotopes (juvenile salmon)

2016 Juvenile salmon catches

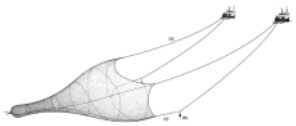


Townet





2016 Juvenile salmon catches



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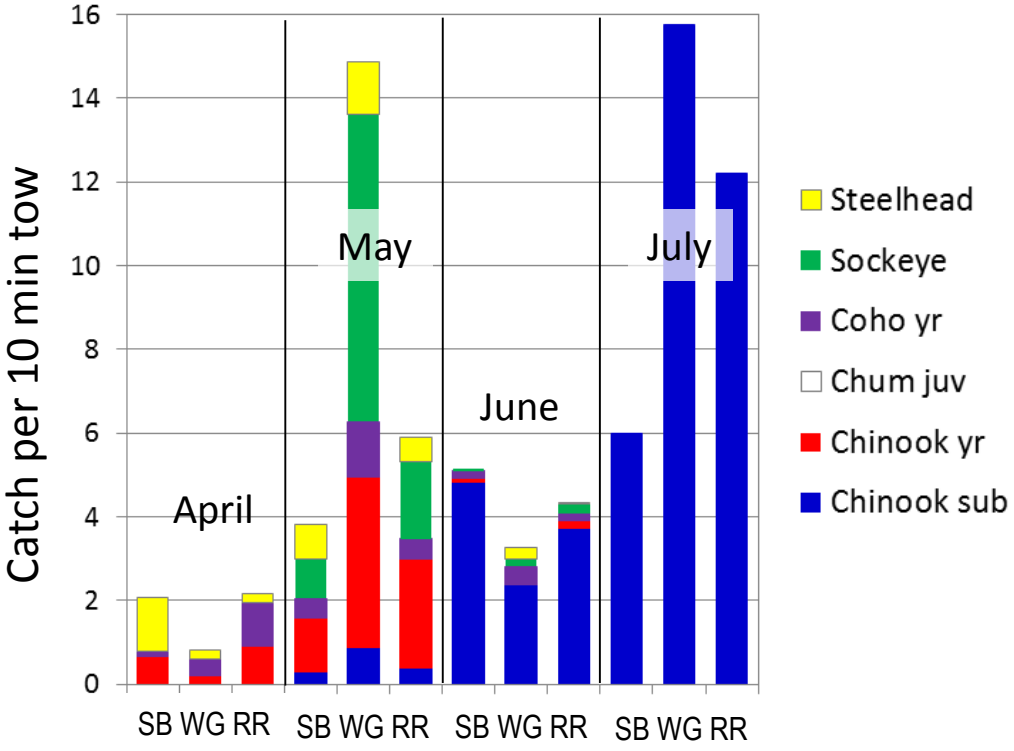
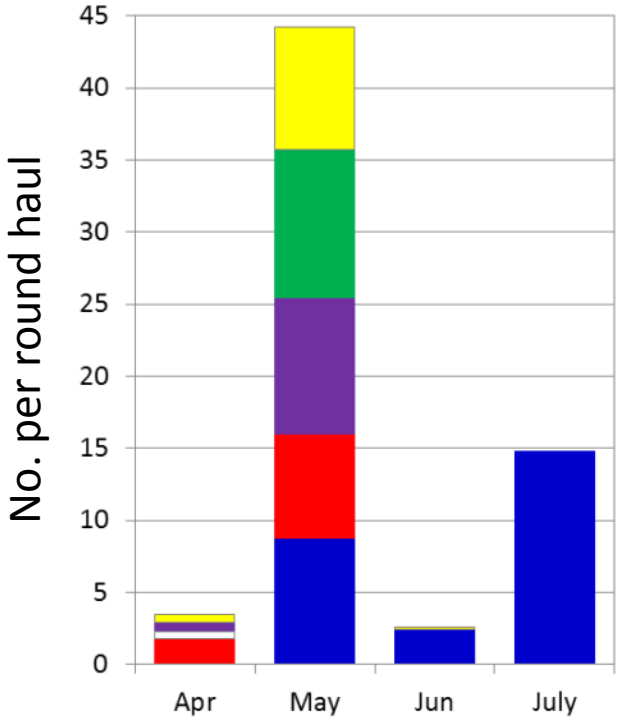
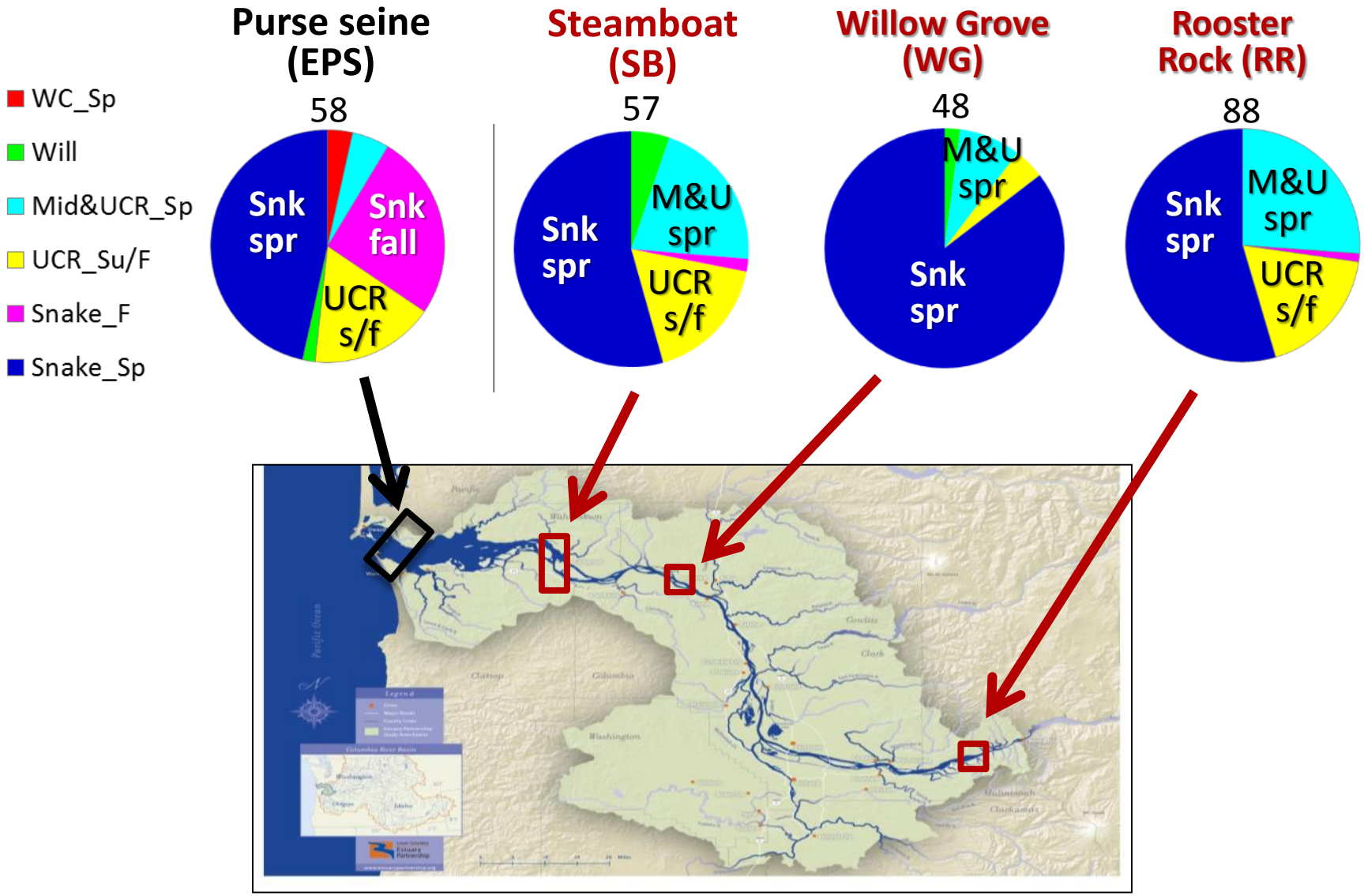


Purse seine



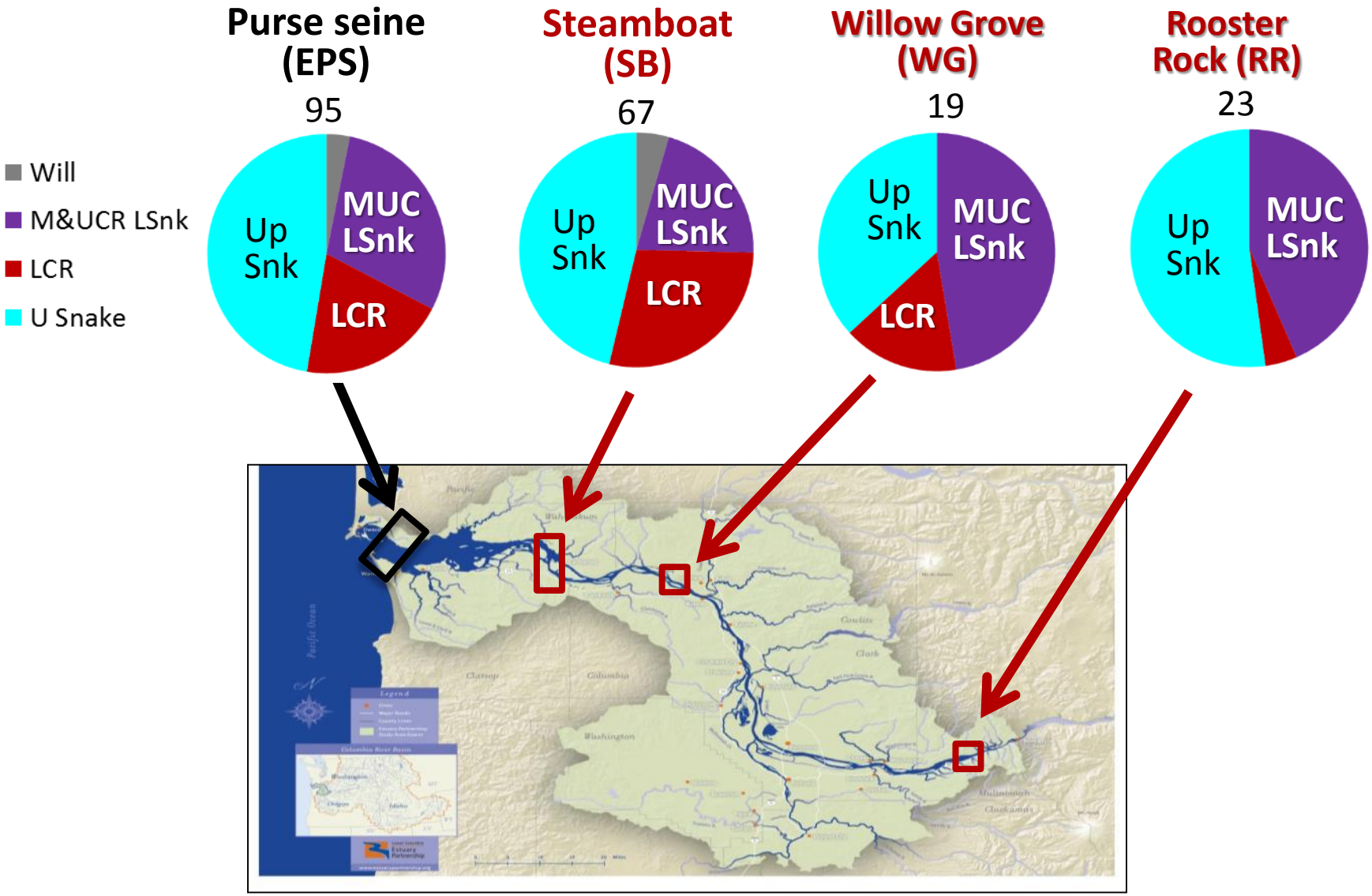
Stocks of salmon: Yearling Chinook

(Genetics and tags)

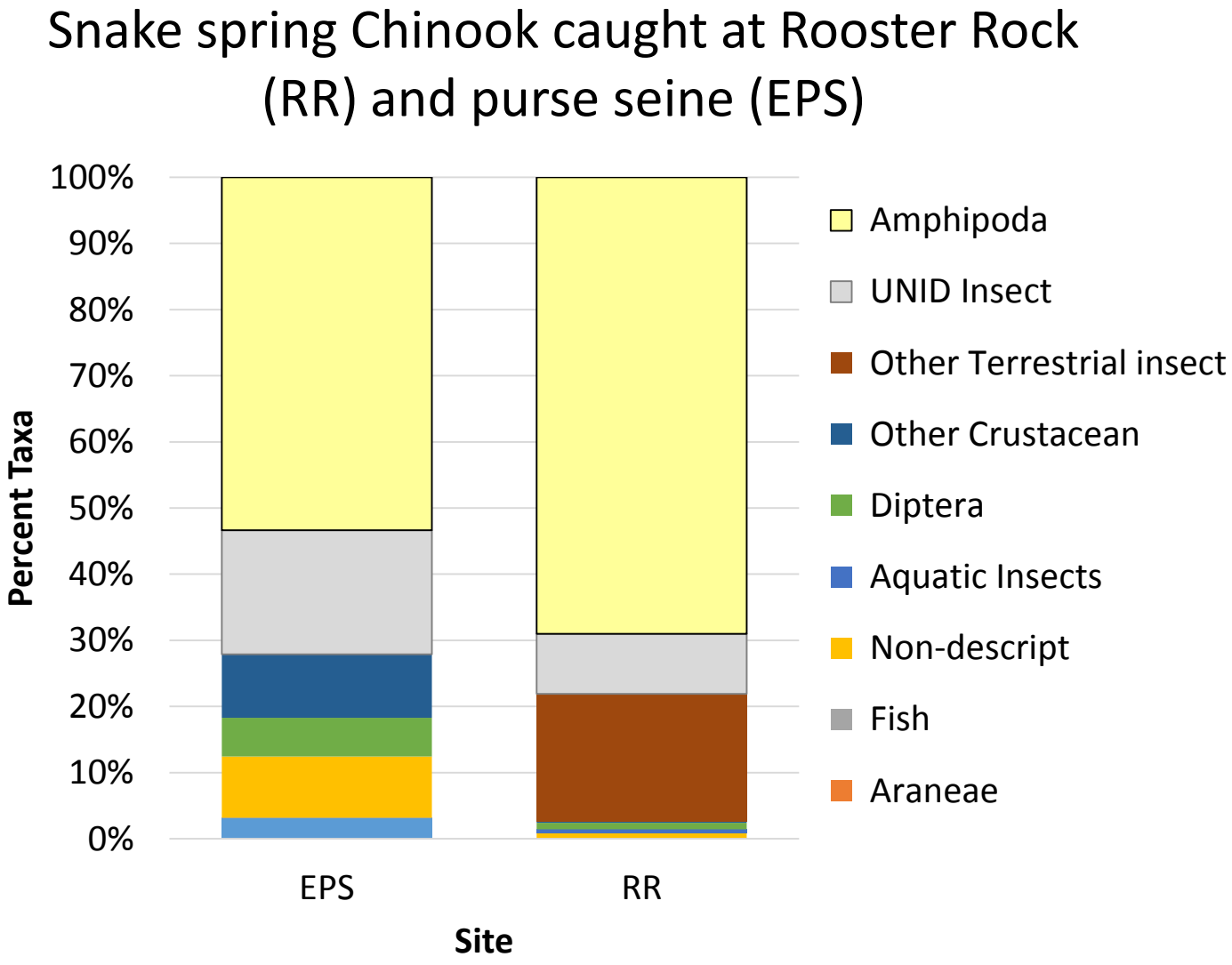


Stocks of salmon: Steelhead

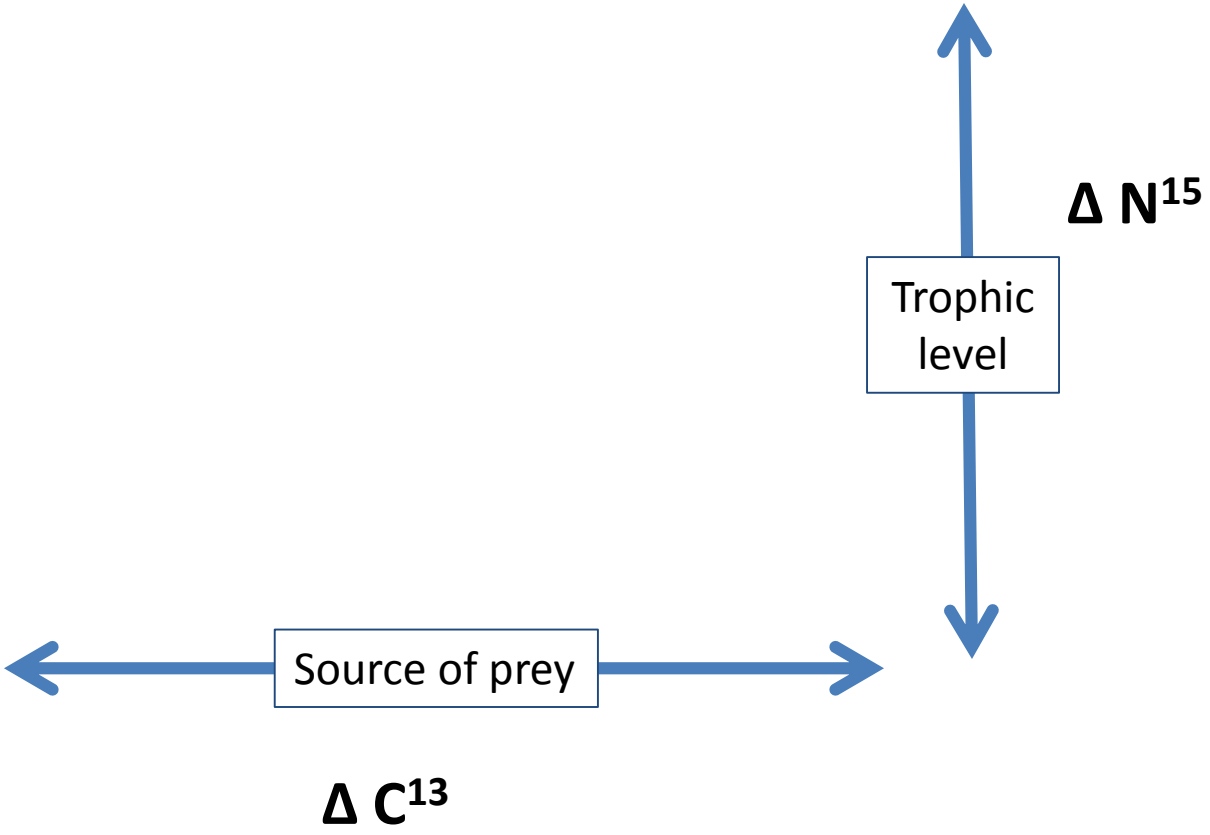
(Genetics and tags)



Chinook salmon diets, May

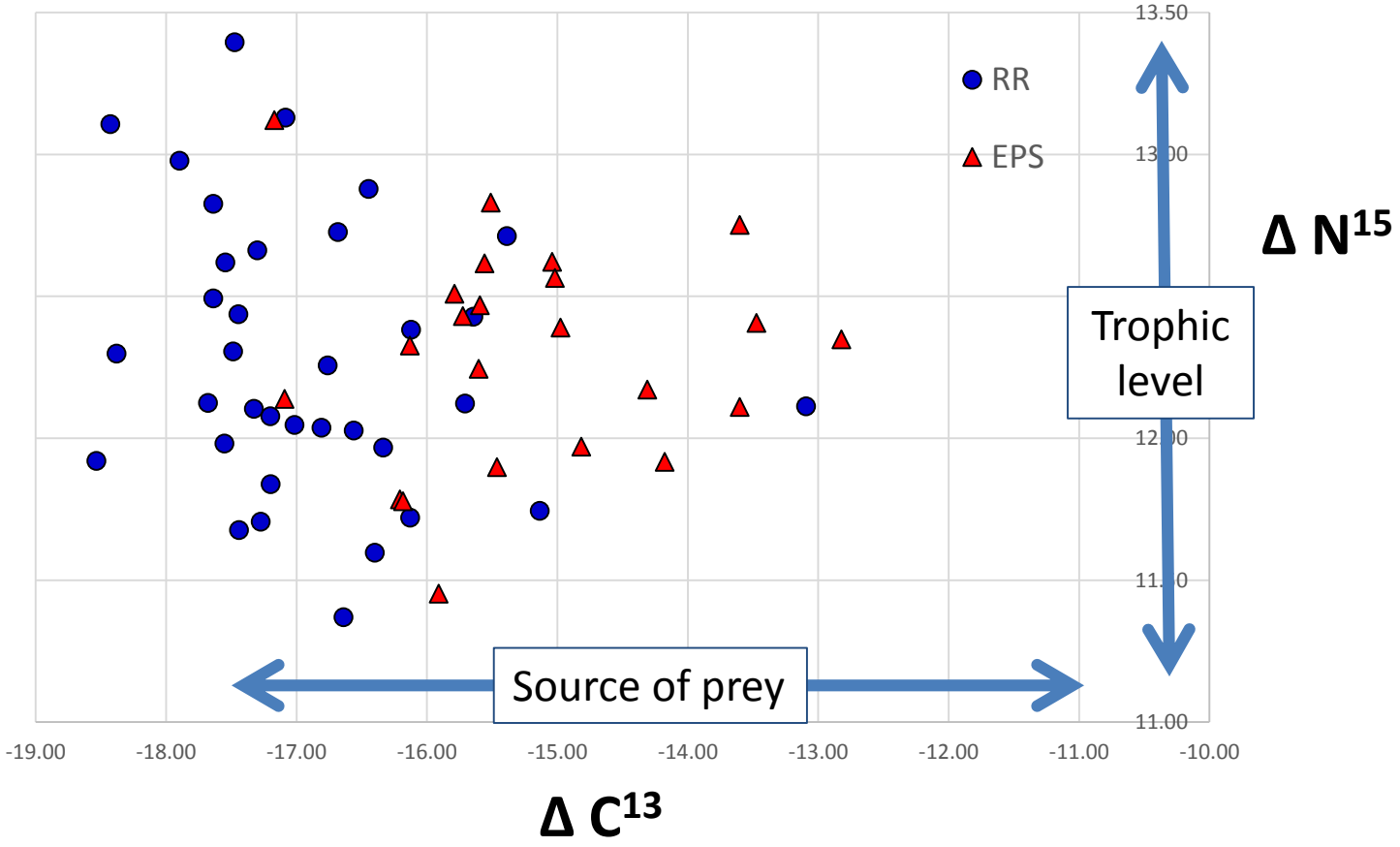


Stable Isotope- Fin tissue

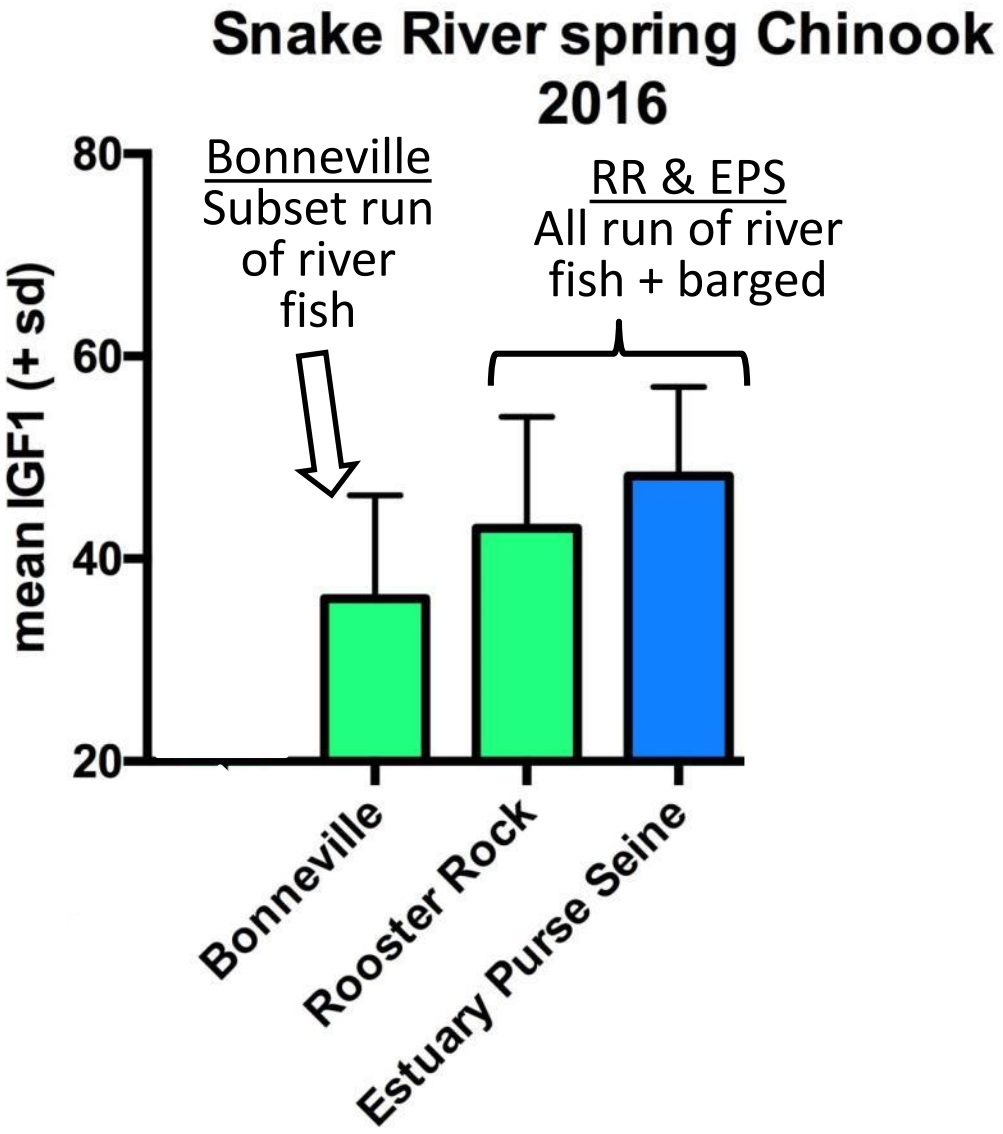


Stable Isotope- Fin tissue

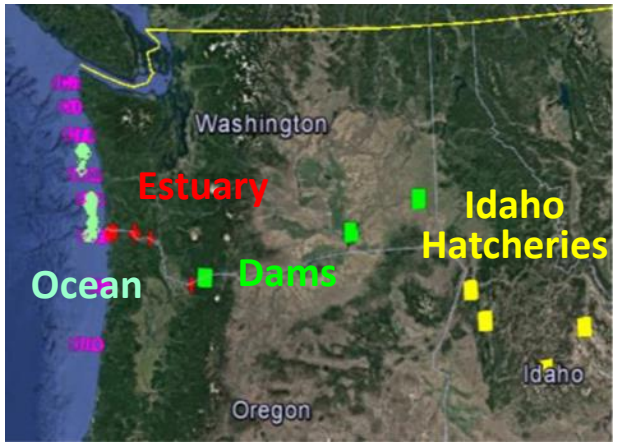
Snake spring Chinook caught at Rooster Rock (RR) and purse seine (EPS)

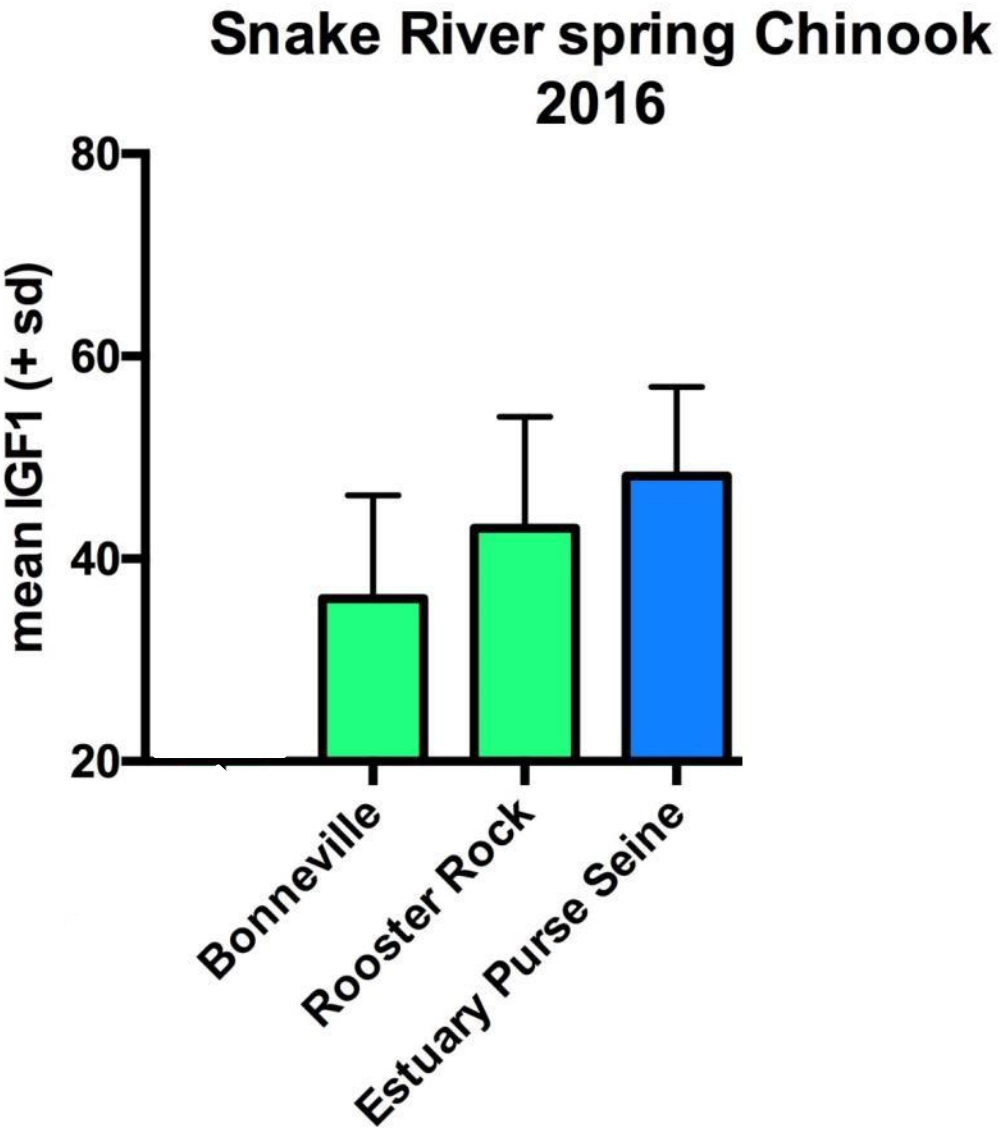


Chinook IGF1 results



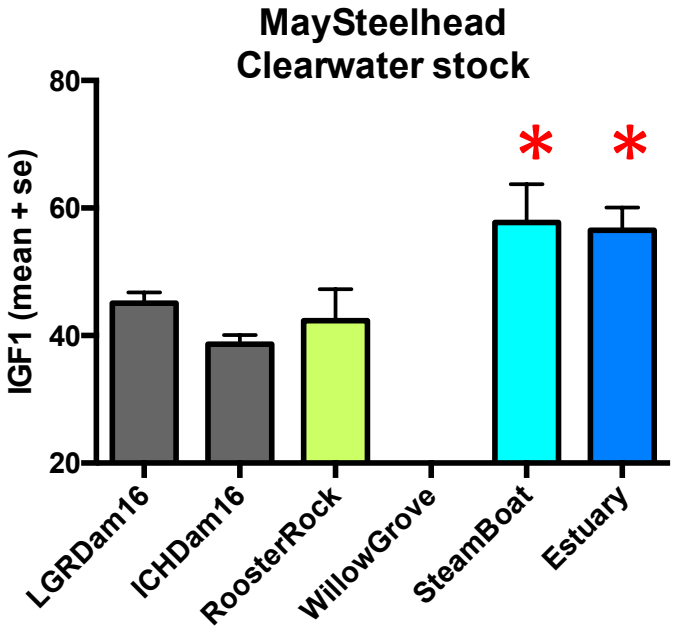
IGF1 results

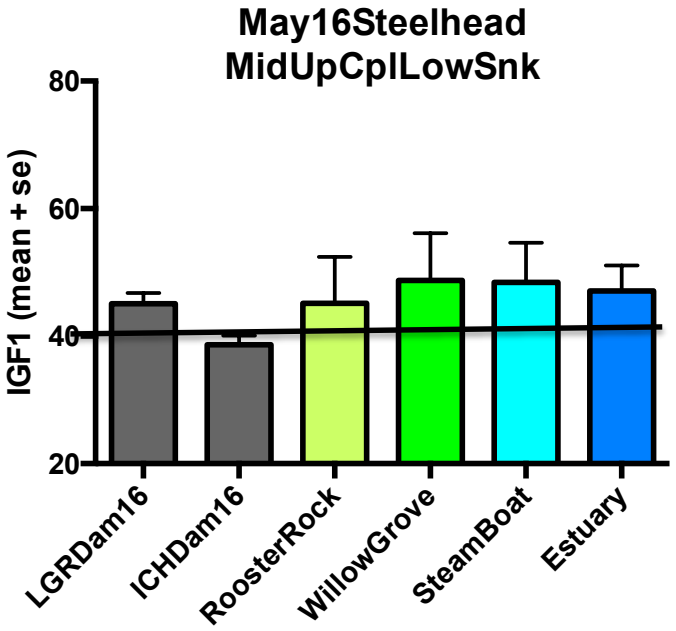


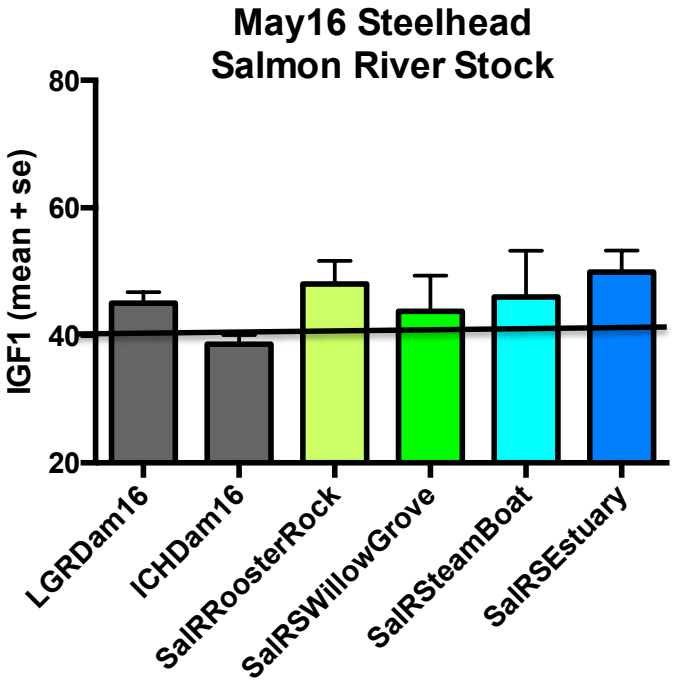


Steelhead IGF results

Stock matters!







Thoughts on estuary-ocean coupling

Estuary-ocean coupling is important to survival but only beginning to understand many aspects of it.

- Early timing of ocean entry allows early start to ocean growth
- Competition/behavioral interactions in estuary difficult to document

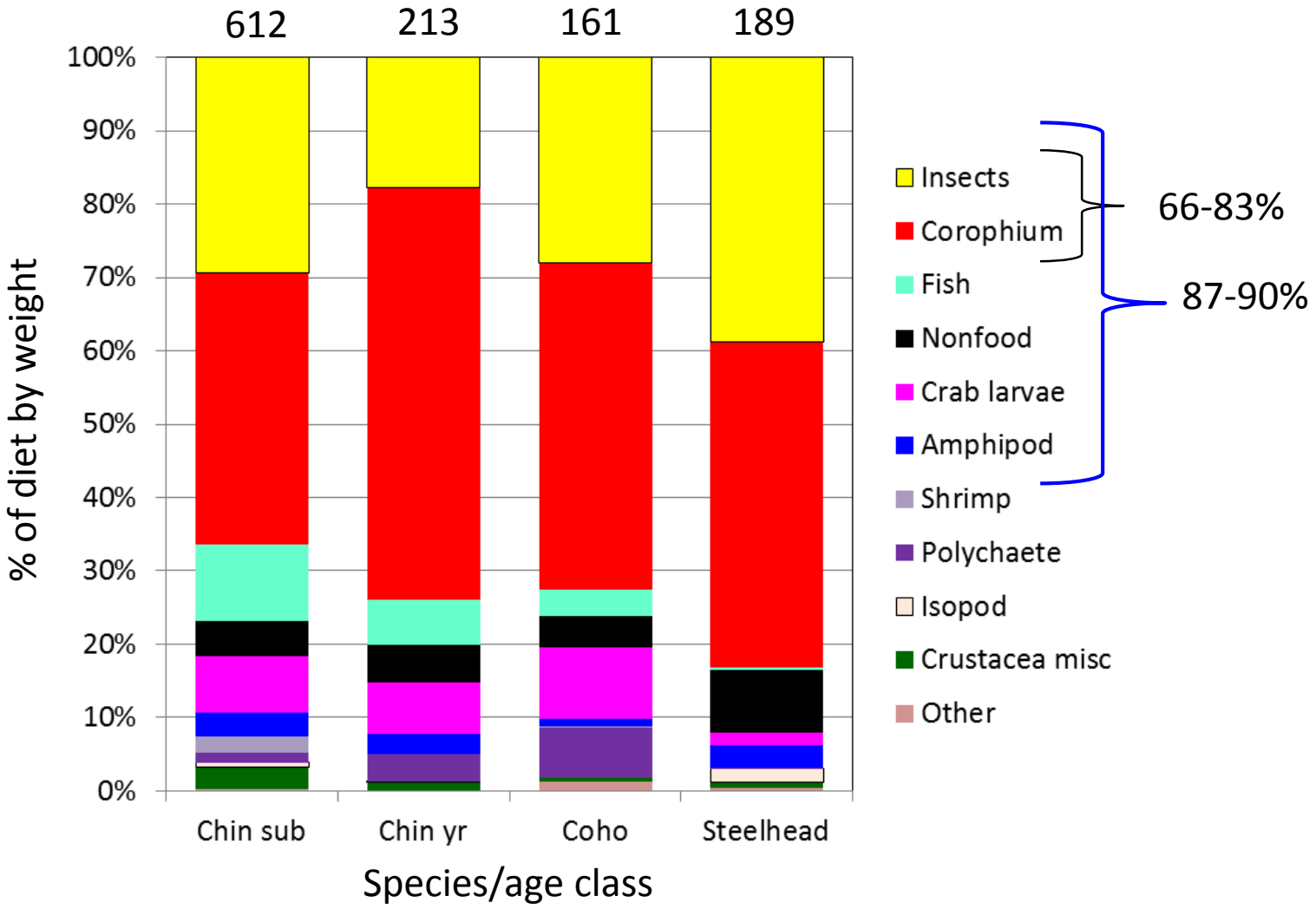
The Columbia estuary is not a pipe

- Salmon caught the **top** of the estuary have changed compared to those at the **bottom** based on our indicators (e.g., IGF1, diets, stable isotopes)
  - relatively short migration distance (a few days travel time?)

- Mainstem river habitats are heterogenous
  - Salmon caught at Steamboat are different than those at Willow Grove (abundance, stock composition, IGF1, size)
  - Not serving as replicates as expected

All juvenile salmon diet composition

Includes fish of unknown stock



Yr. Chinook estuary vs. ocean