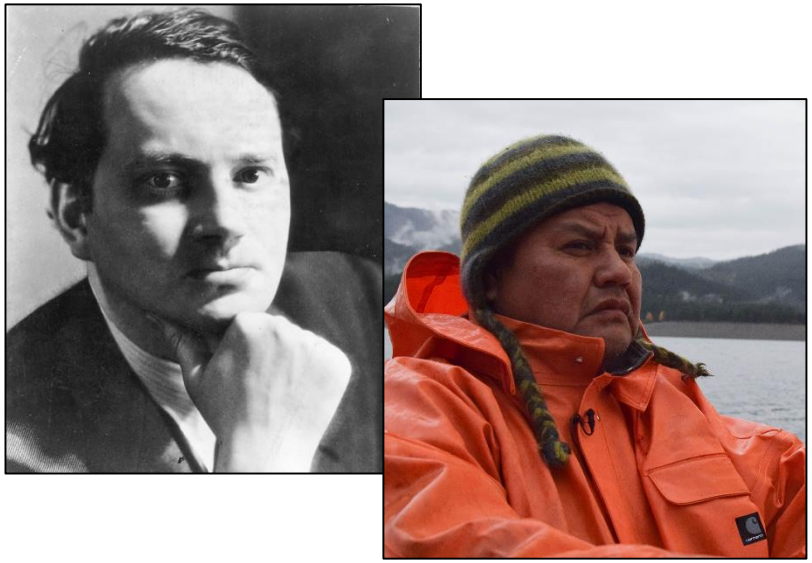
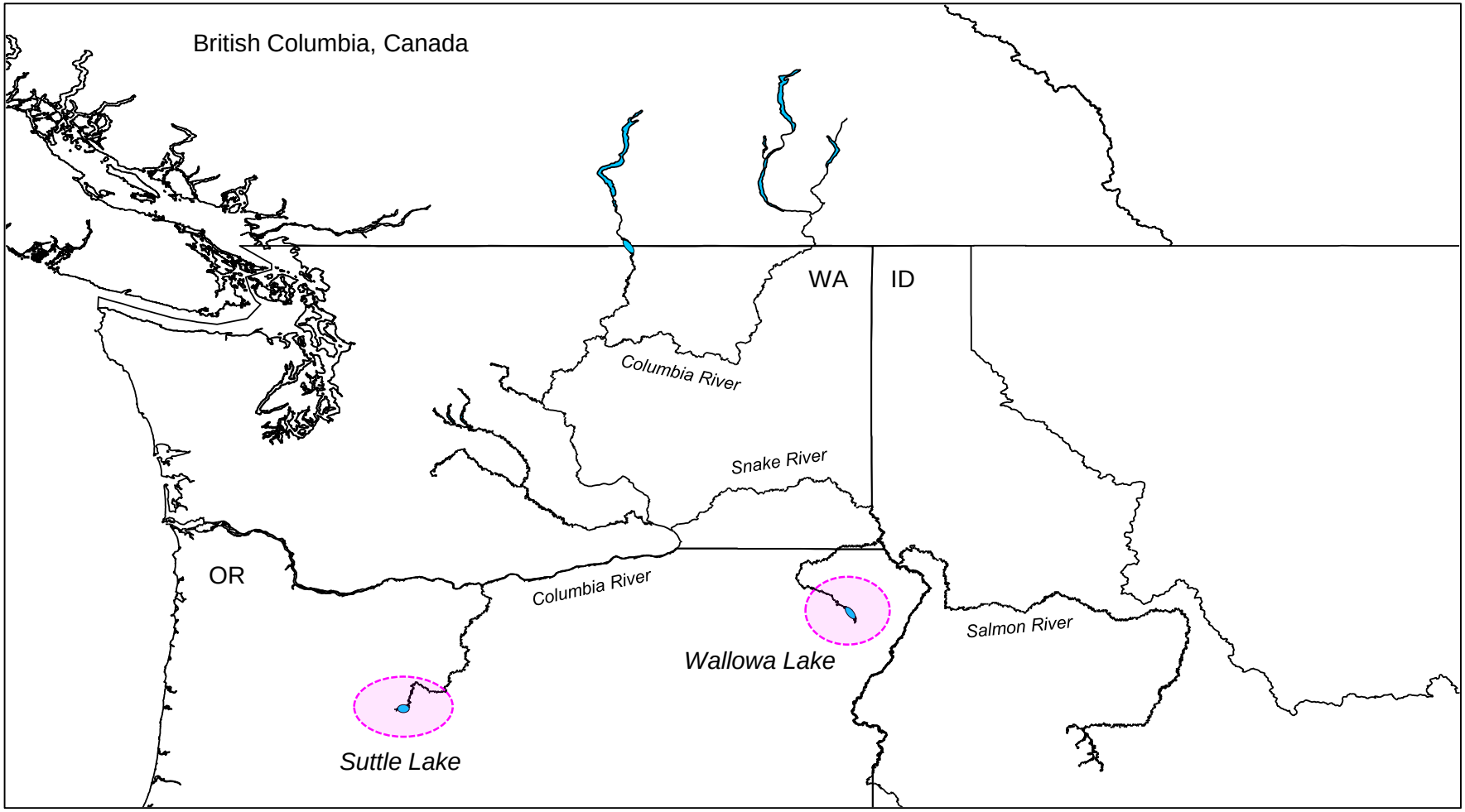
Sockeye Salmon Reintroduction:
Who says you can't go home again?



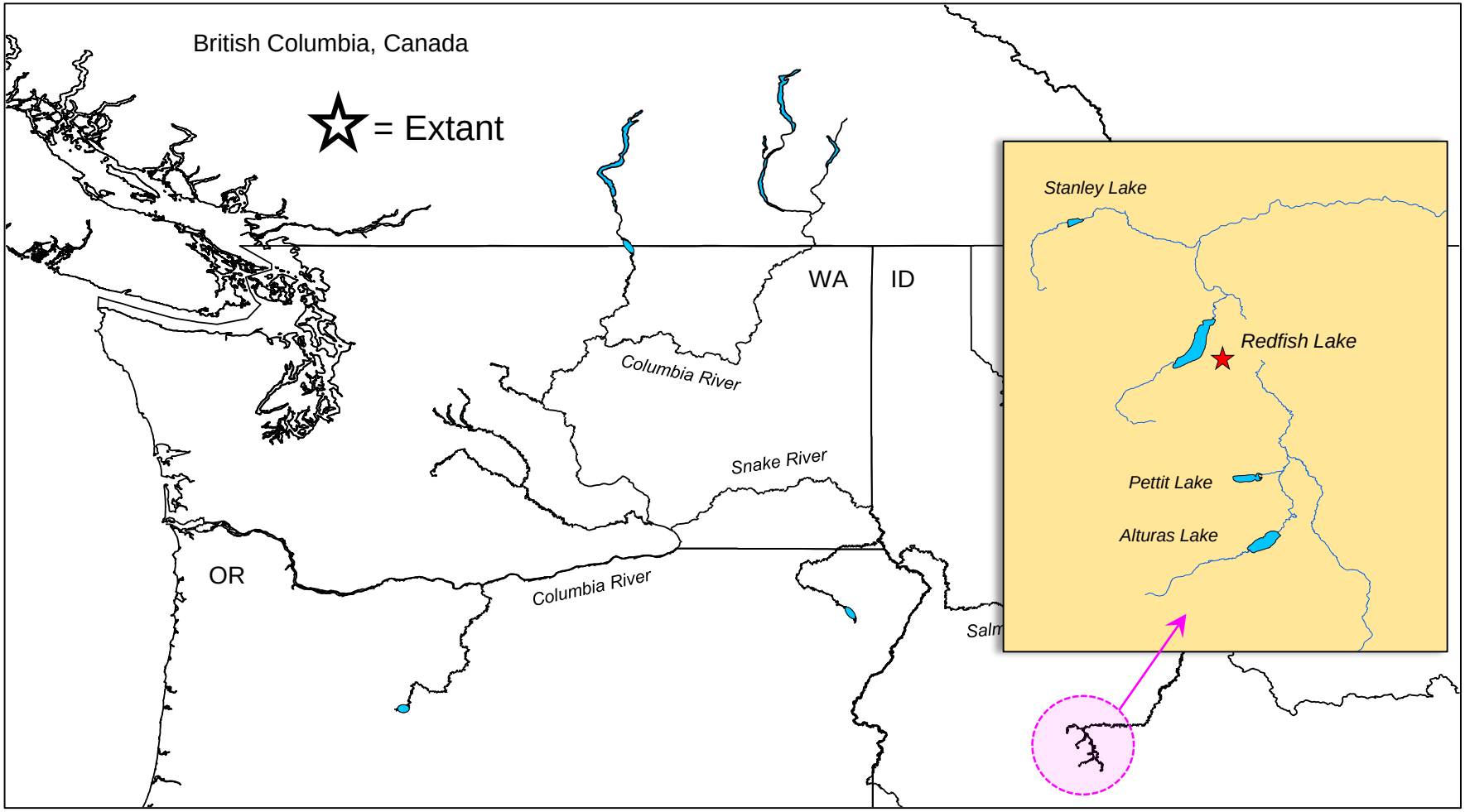
Andrew P. Matala, Shawn R. Narum, Jeremiah E. Newell, and Peter F. Galbreath
Columbia River Inter-Tribal Fish Commission

Brian Saluskin, Mark Johnston
The Confederated Tribes and Bands of the Yakama Nation

Sockeye pops: past & present



Sockeye pops: past & present



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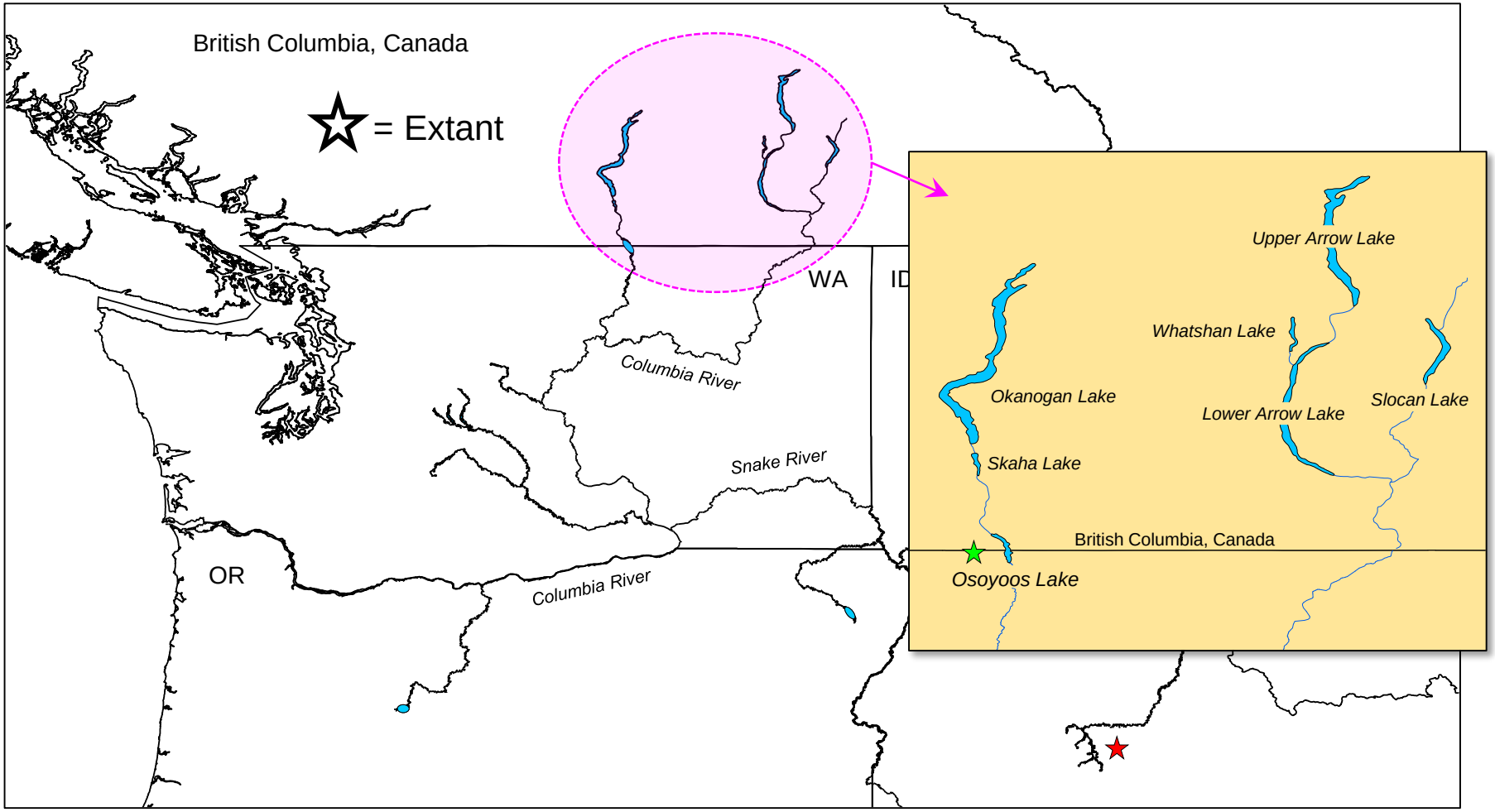

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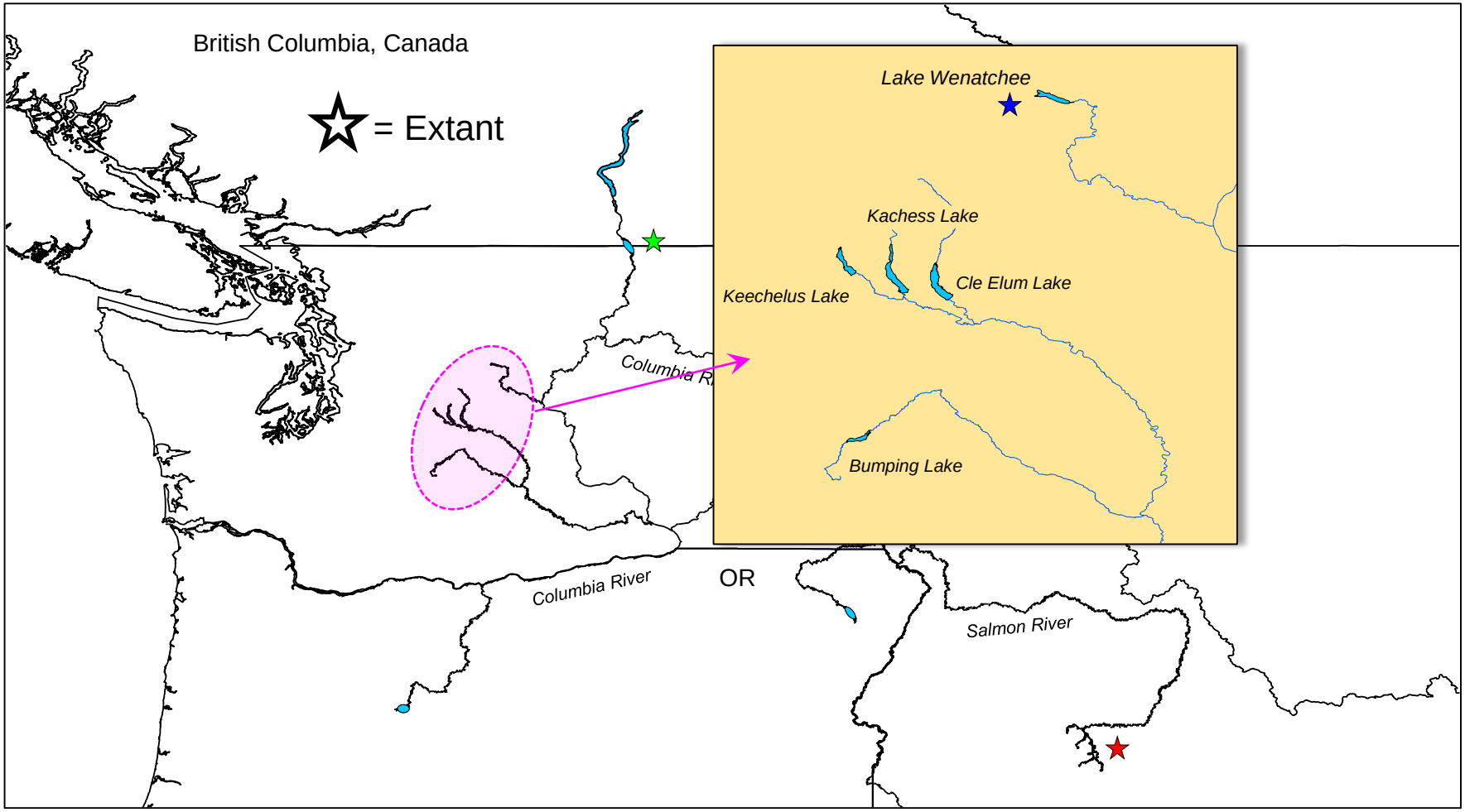

Cle Elum Lake reintroduction:
the basics

1. **Feasibility study results *(NOAA - early 2000's)**
   - ✓ ultra-oligotrophic limnology: low nutrient levels
   - ✓ low primary productivity: low zooplankton densities
   - ✓ small standing crop of macroinvertebrates

**Flagg et al. 2000; BOR 2007; BOR 2011*

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   - ✓ different life history: age structure, spawn time
   - ✓ habitat: Osoyoos warm, Wenatchee cold

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   - ✓ Hybridization minimal (<5%)

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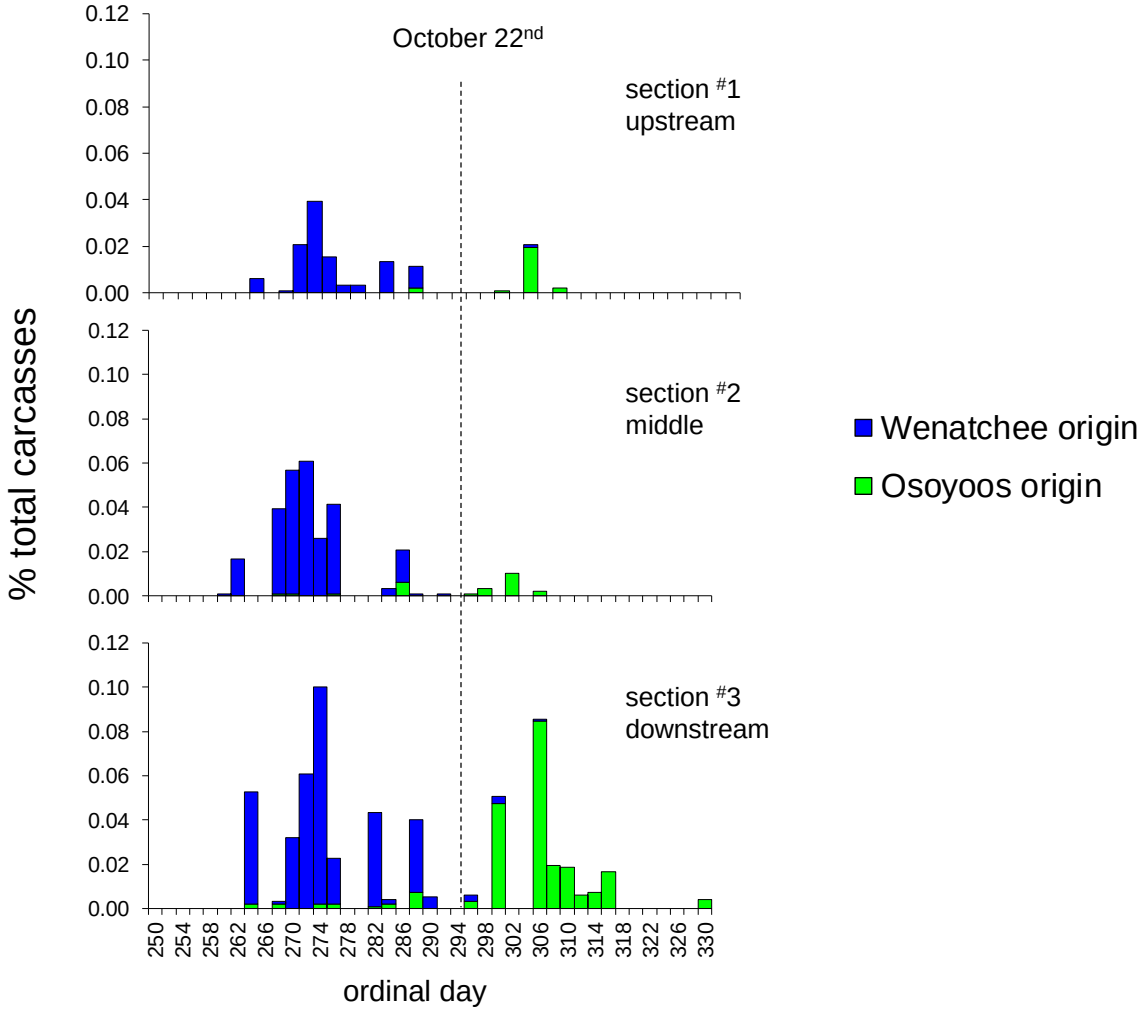
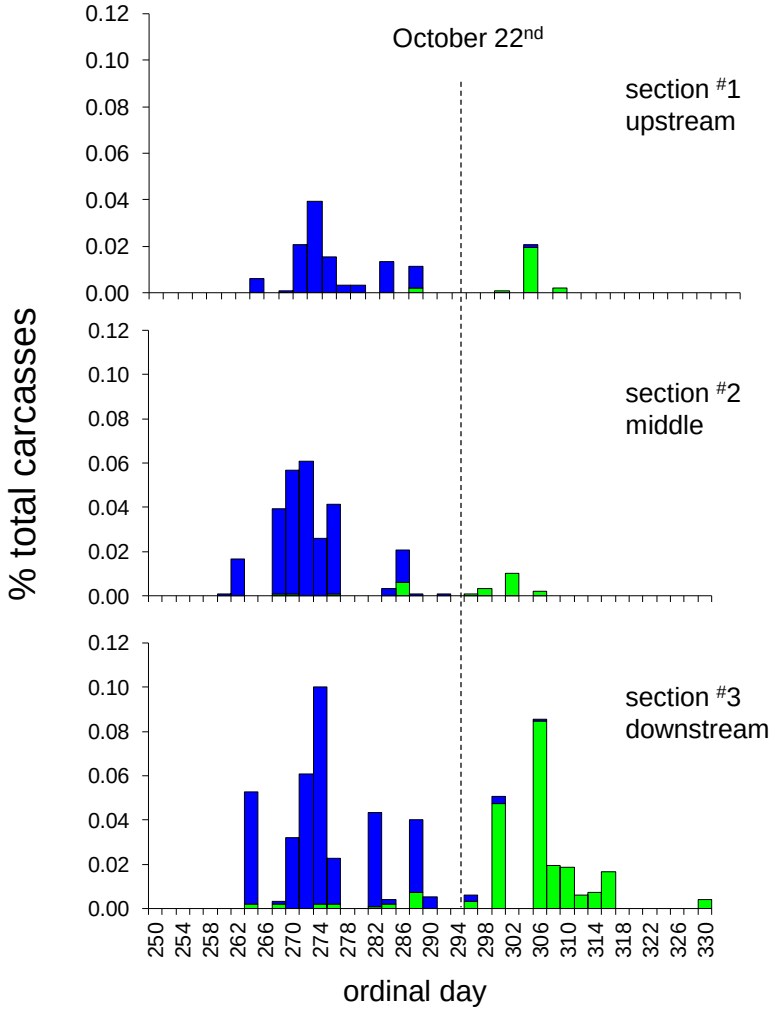
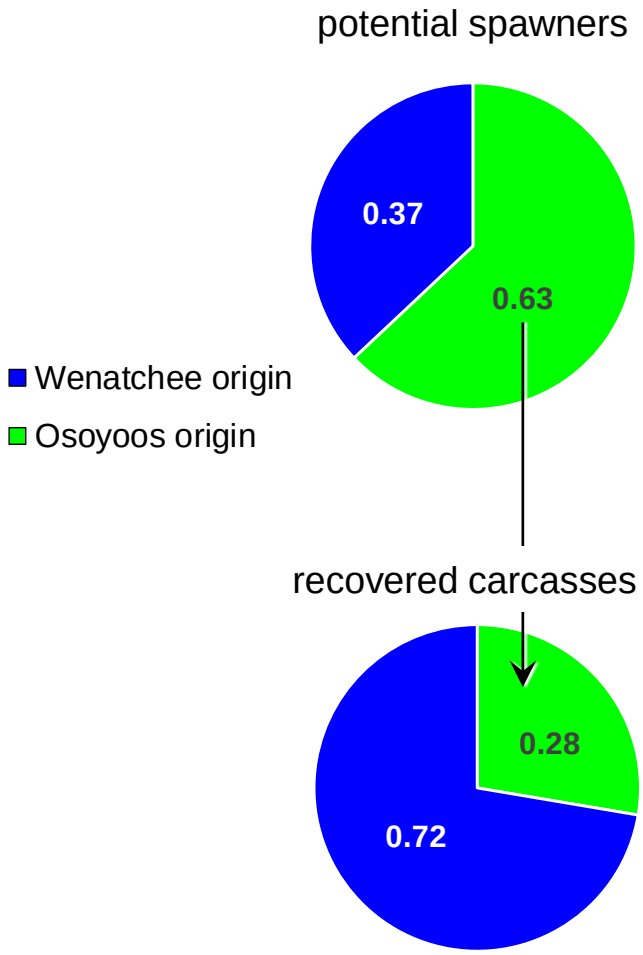
4. **Relative stock productivity is difficult to estimate**
   - ✓ some observations were expected
   - ✓ some **"curiosities"** need to be investigated further

Spawning ground surveys

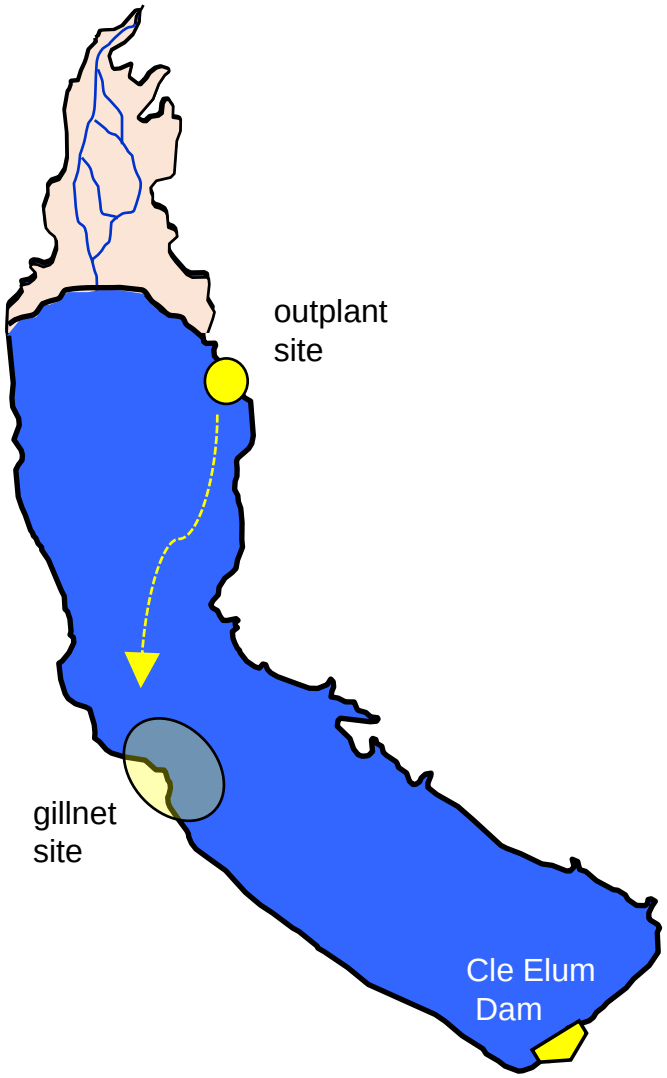


Spawning ground surveys





Gillnetting: Sockeye bycatch



- ✓ 100% Osoyoos origin (n=164)
- ✓ Some Sockeye spilling gametes
- ✓ extent of shore spawning unknown

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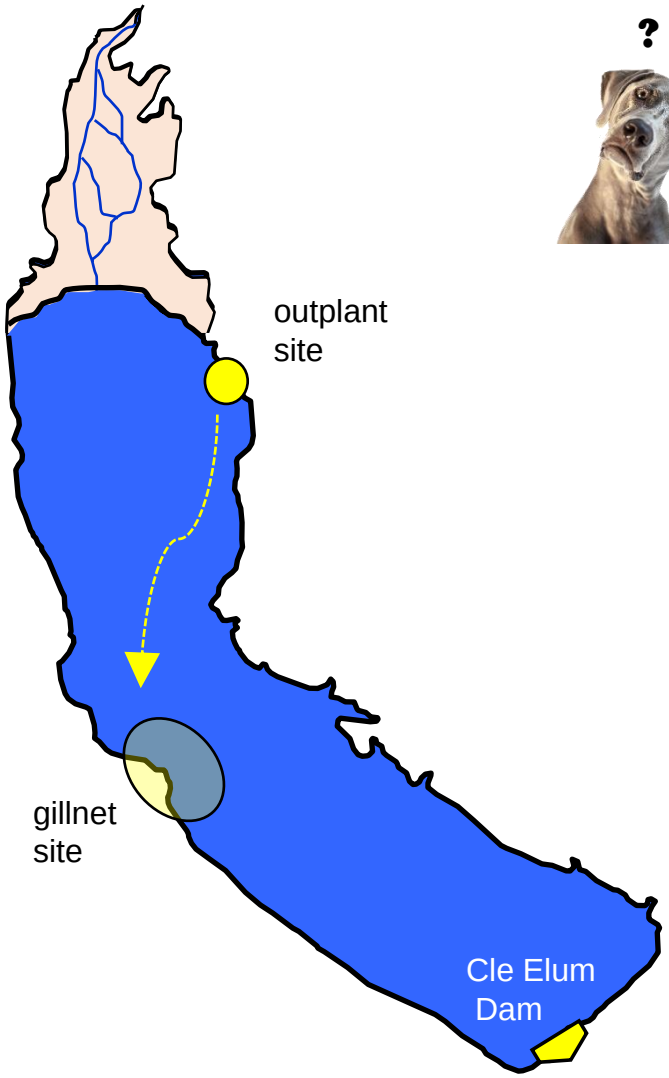


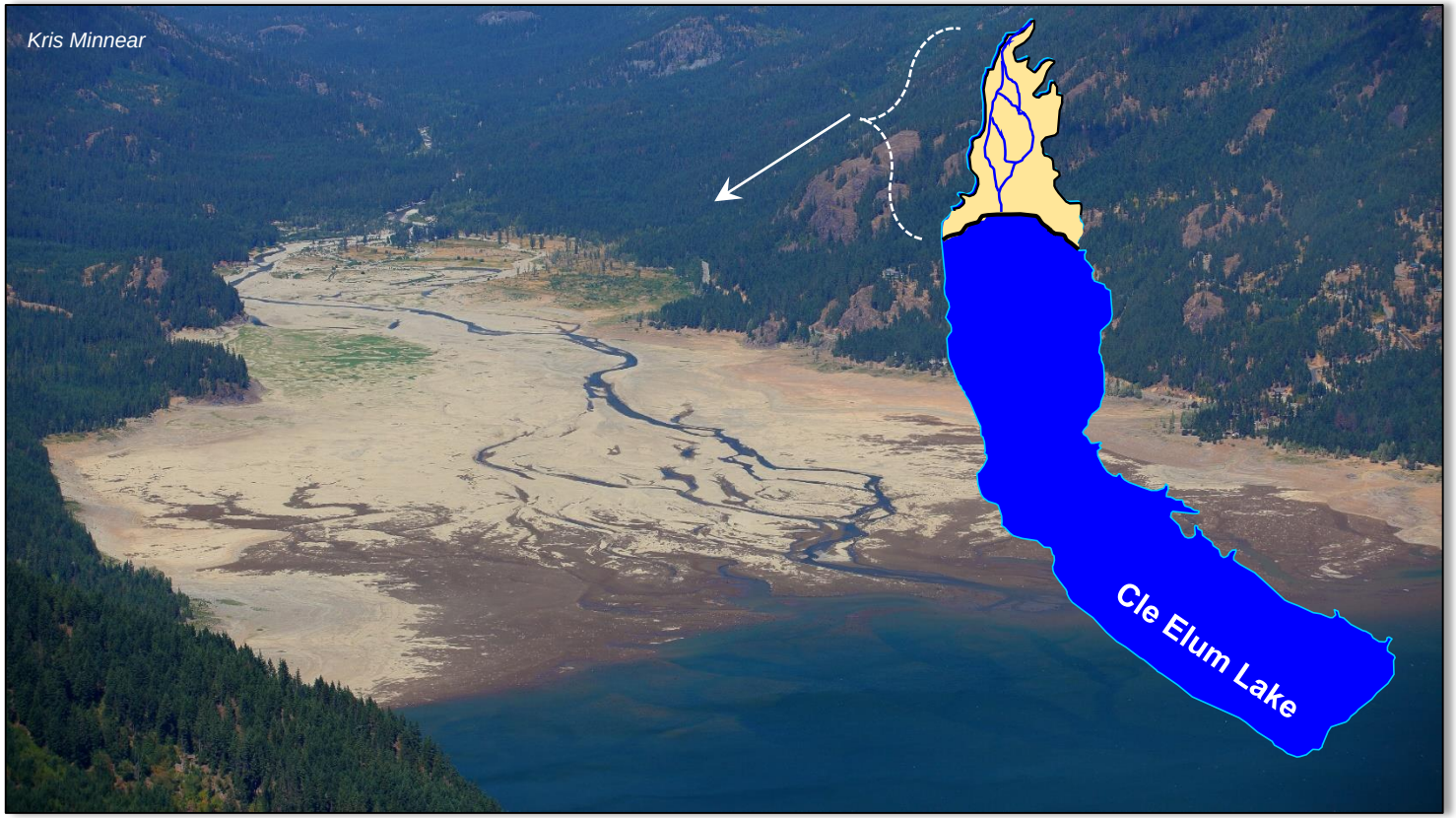
Curious

?

- ✓ 100% Osoyoos origin (n=164)
- ✓ Some Sockeye spilling gametes
- ✓ extent of shore spawning unknown
- ✓ **No lake spawning in Osoyoos Lake**

Carcass recoveries

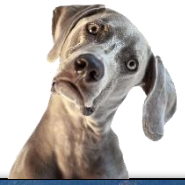
Section #3



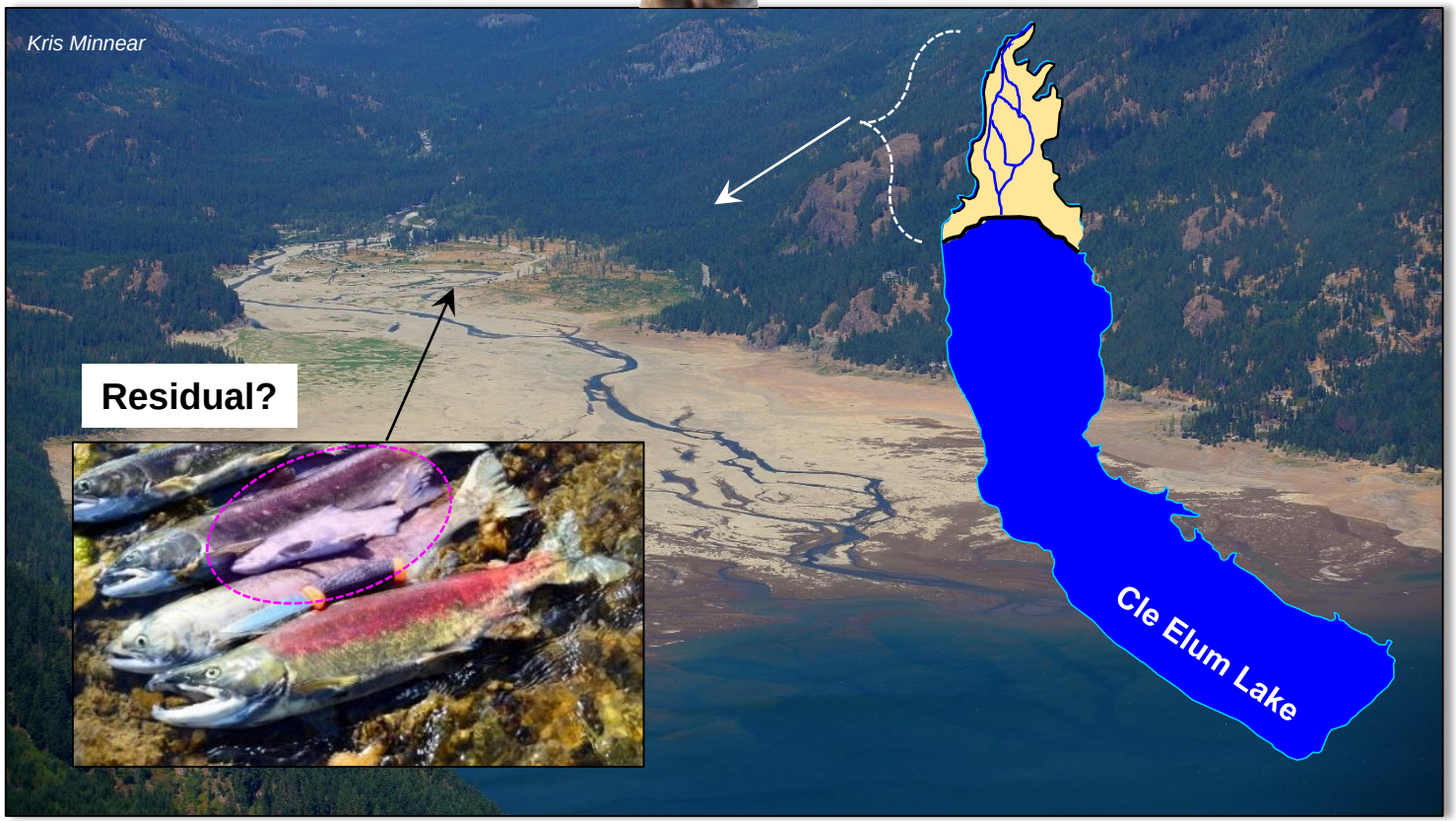
Carcass recoveries

Curious

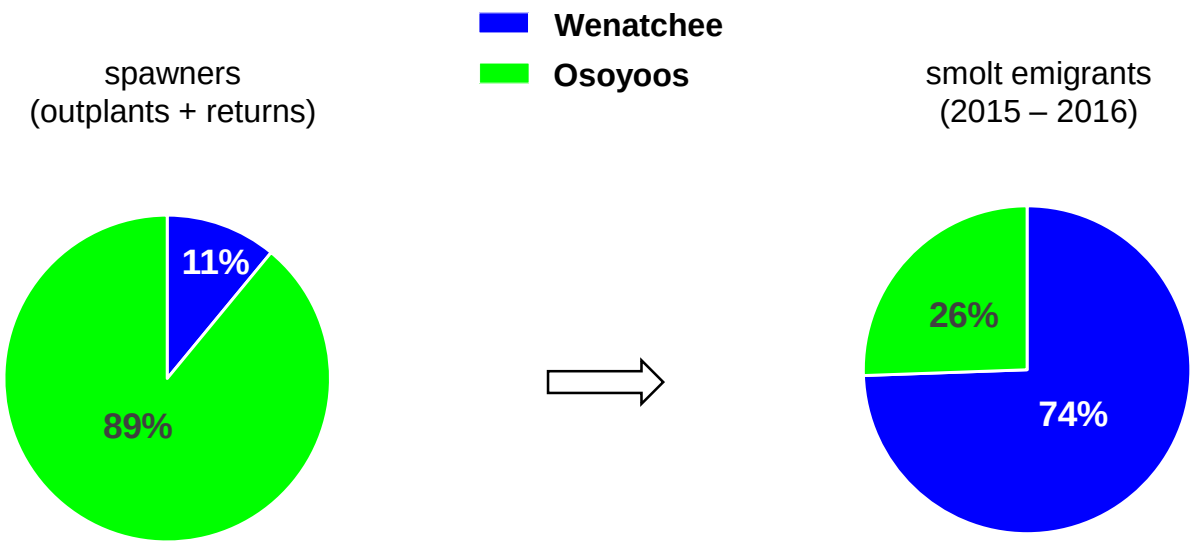
?



Section #3



Relative productivity: BY 2013



Relative productivity: BY 2013

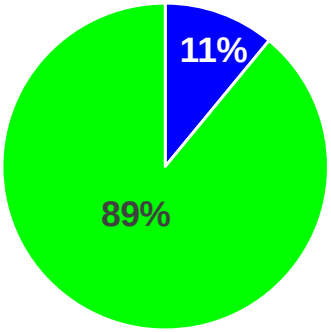
Curious

?

Wenatchee

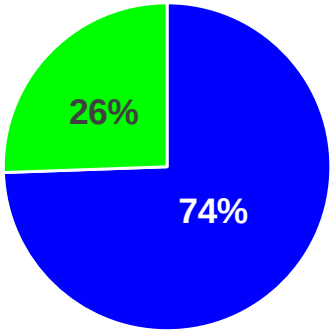
Osoyoos

spawners
(outplants + returns)

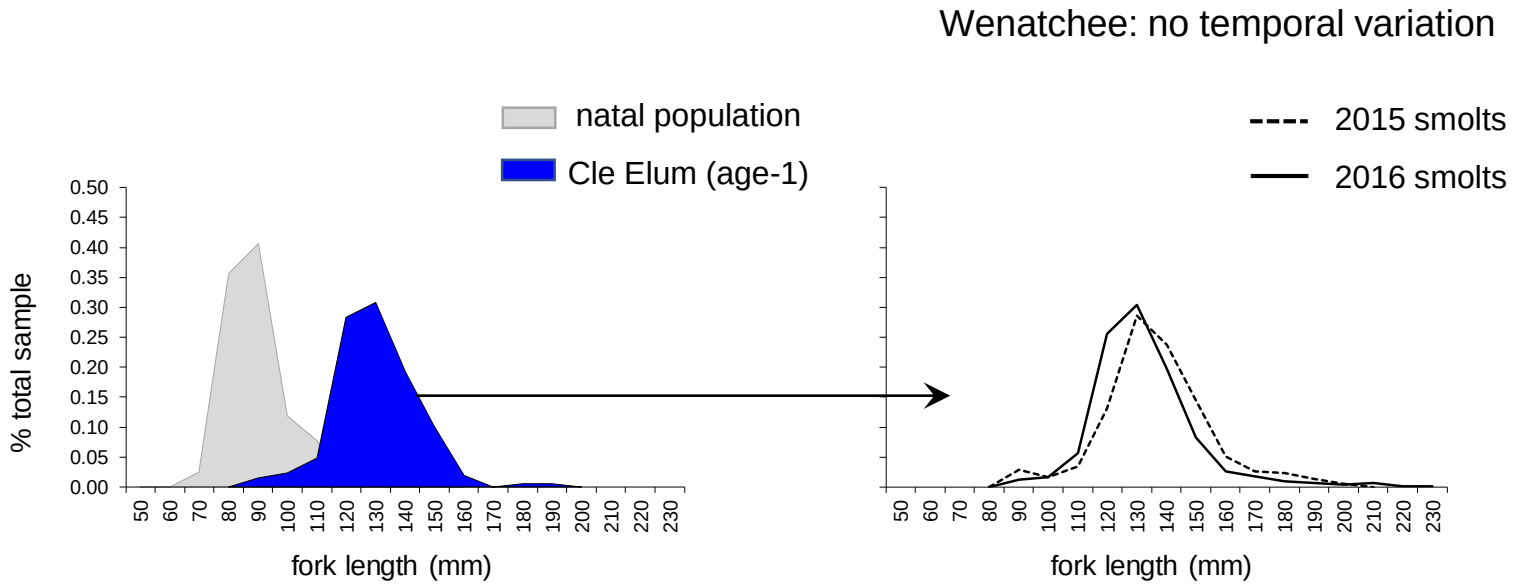


Does this represent a rearing / survival advantage?

smolt emigrants
(2015 – 2016)



Smolt: large size-at-age

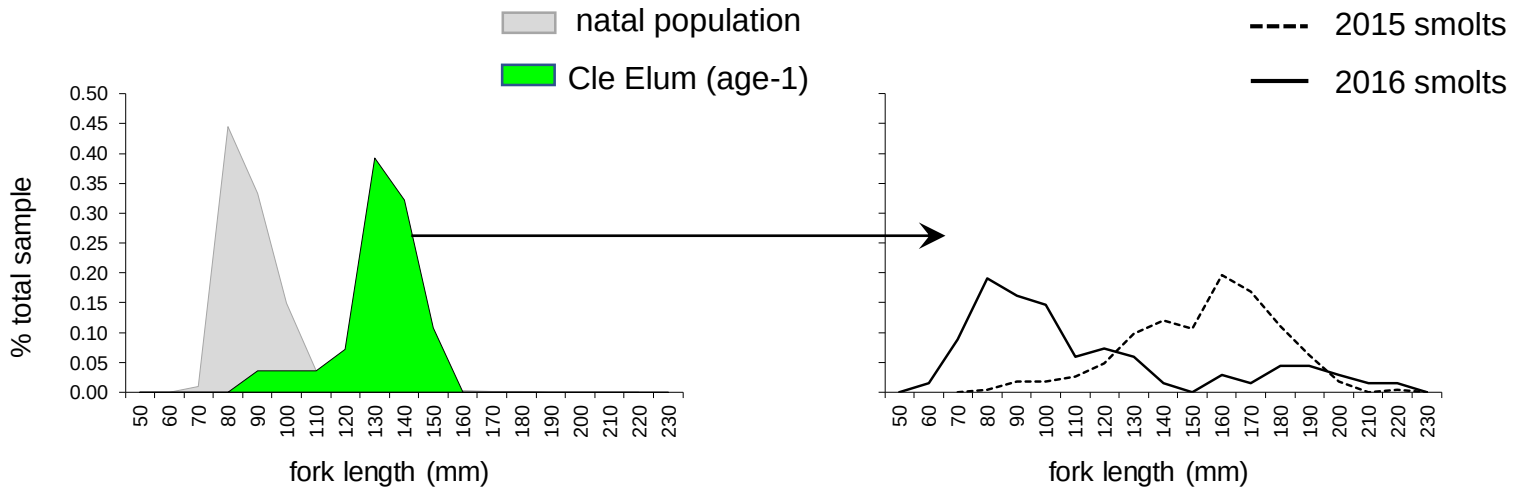


Smolt: large size-at-age

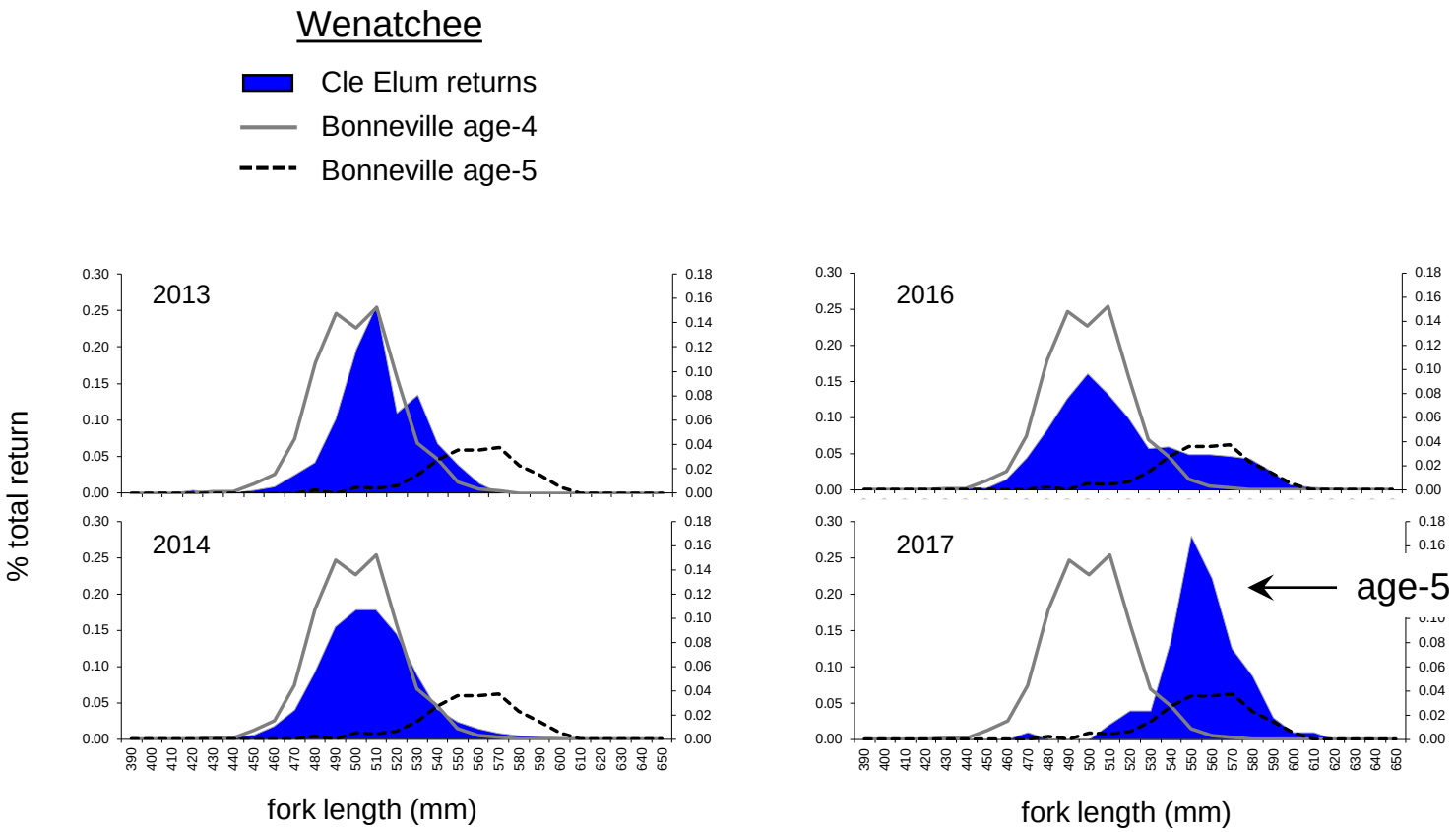
Curious

?

Osoyoos: **significant** temporal variation



Natural-origin adult size-at-age



Natural-origin adult size-at-age

Curious

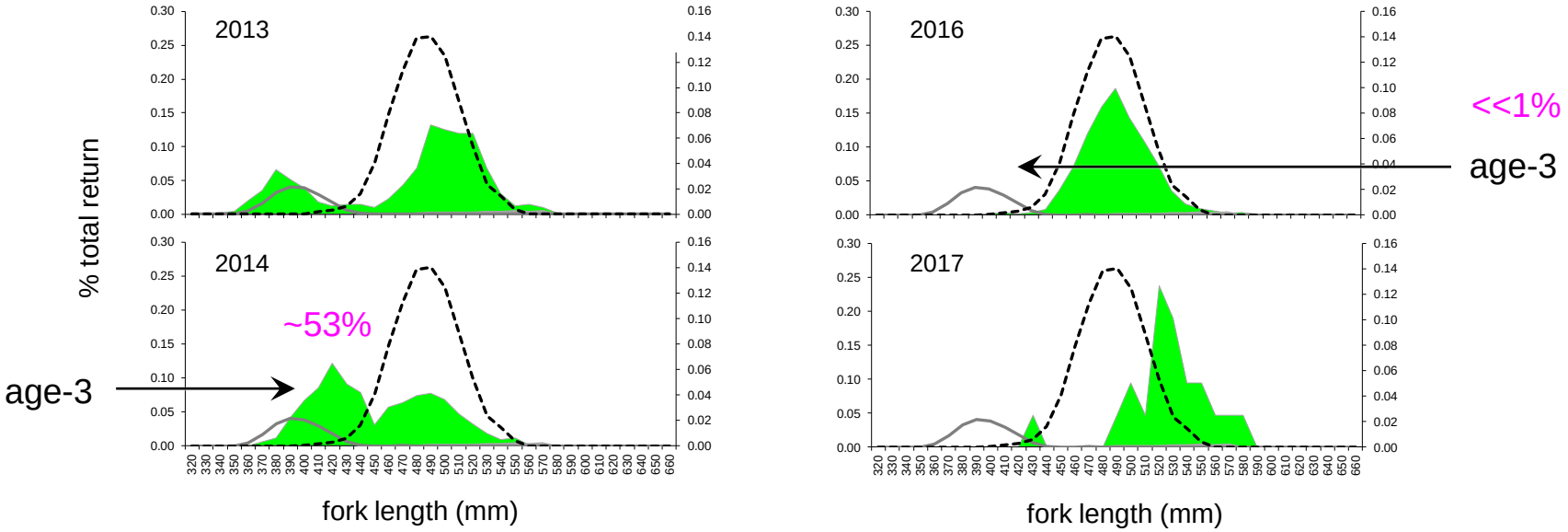
?

Osoyoos

Cle Elum returns

Bonneville age-3

Bonneville age-4



Relative return on investment

	potential spawners			natural-origin returns (n)			
BY	PRD	Roza	total	age-3	age-4	age-5	%R
	Osoyoos (n)						
2011	3000	0	3000	---	---	---	---
2012	8400	135	8535	135	---	---	---
2013	4185	420	4605	114	303	---	---
2014	6600	1052	7652	563	471	19	---
2015	5900	75	5975	1	70	4	---
2016	6200	1399	7599	79	1285	35	0.23
2017	510	22	532	1	15	5	0.15
	Wenatchee (n)						
2011	1000	0	1000	---	---	---	---
2012	1600	3	1603	0	---	---	---
2013	315	240	555	0	238	---	---
2014	3400	1351	4751	0	1275	76	---
2015	4100	17	4117	0	16	1	---
2016	3800	2046	5846	0	1590	455	0.47
2017	490	111	601	0	77	27	1.01

Osoyoos origin

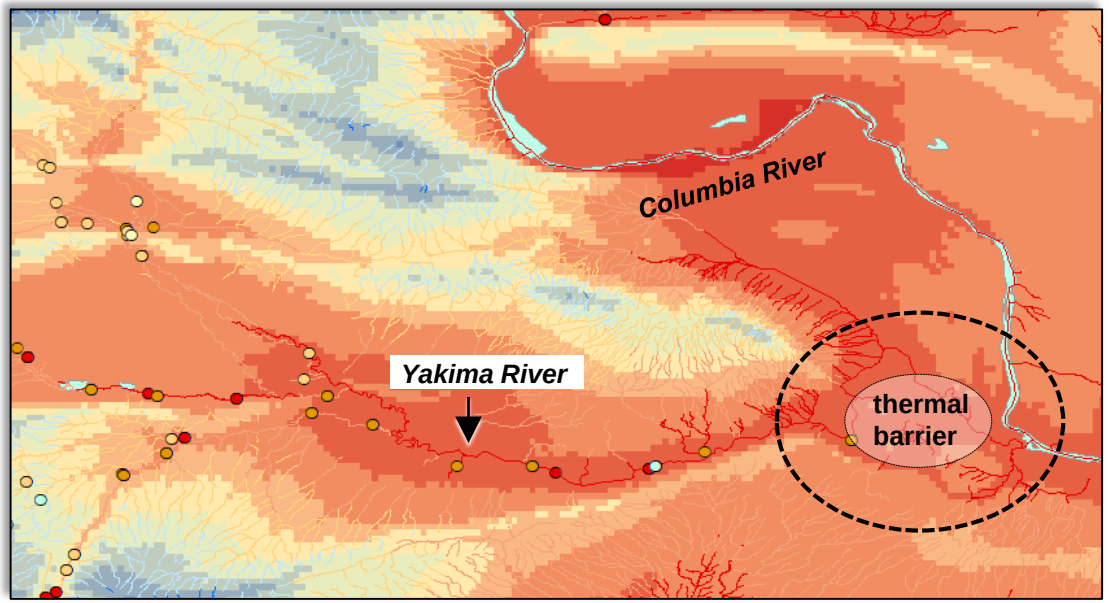
only 1/4 replacement at best

Wenatchee origin

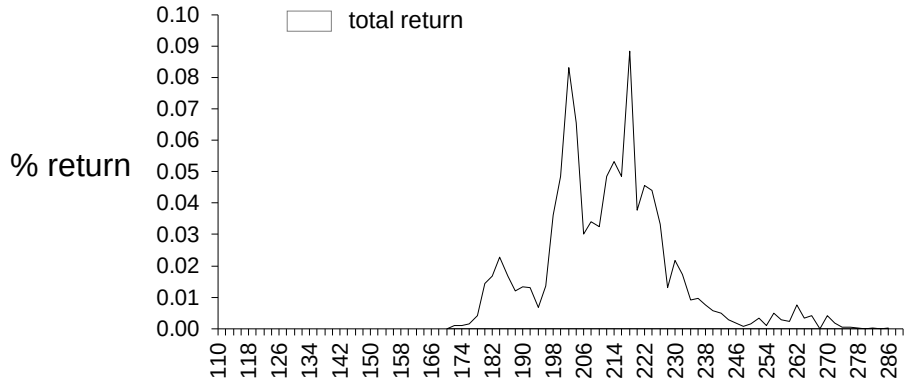
at least 1/2 replacement

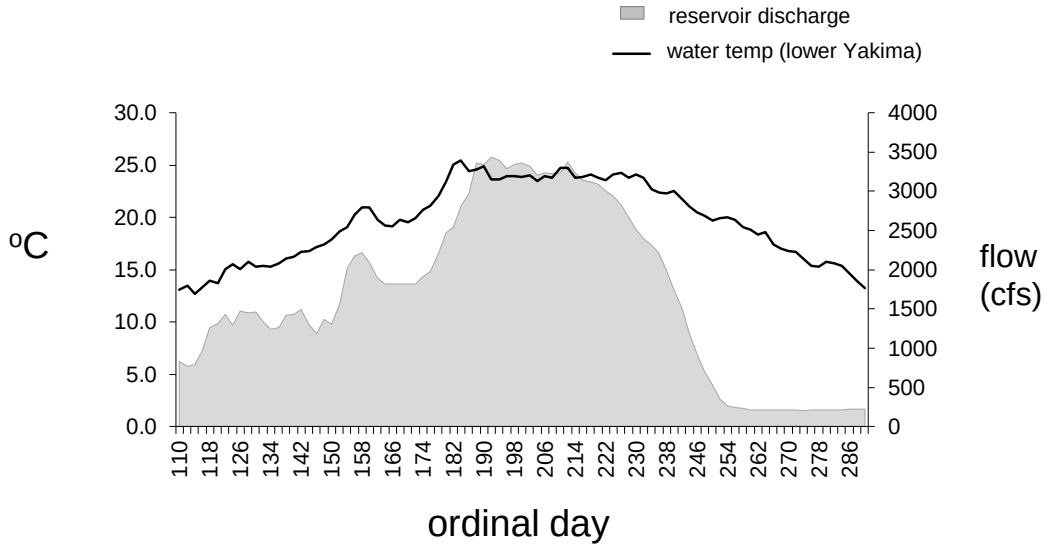
factors influencing perceived productivity & numbers of spawners

Responses to conditions in the lower Yakima?



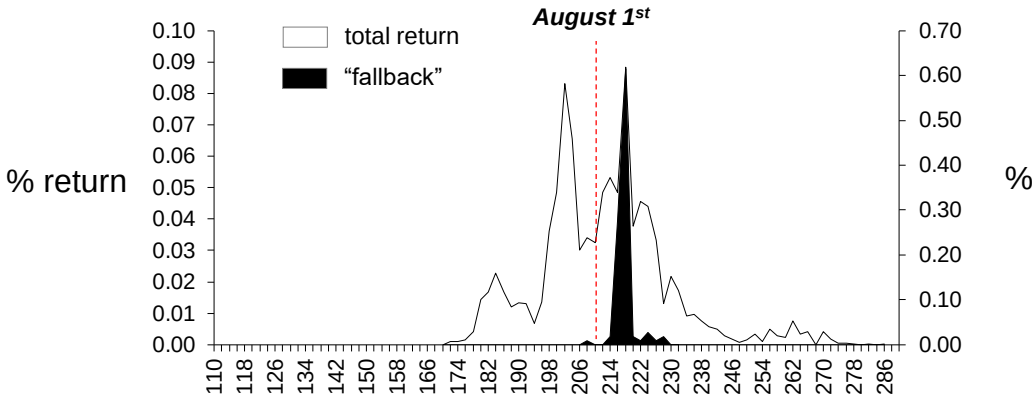
Actual spawner abundance?





Actual spawner abundance?

short of what is put in the lake



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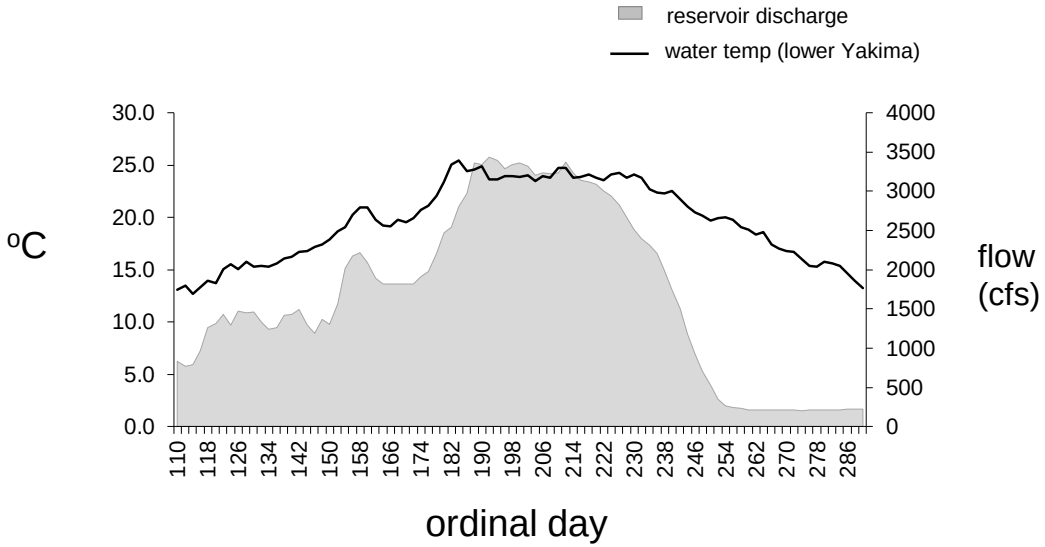

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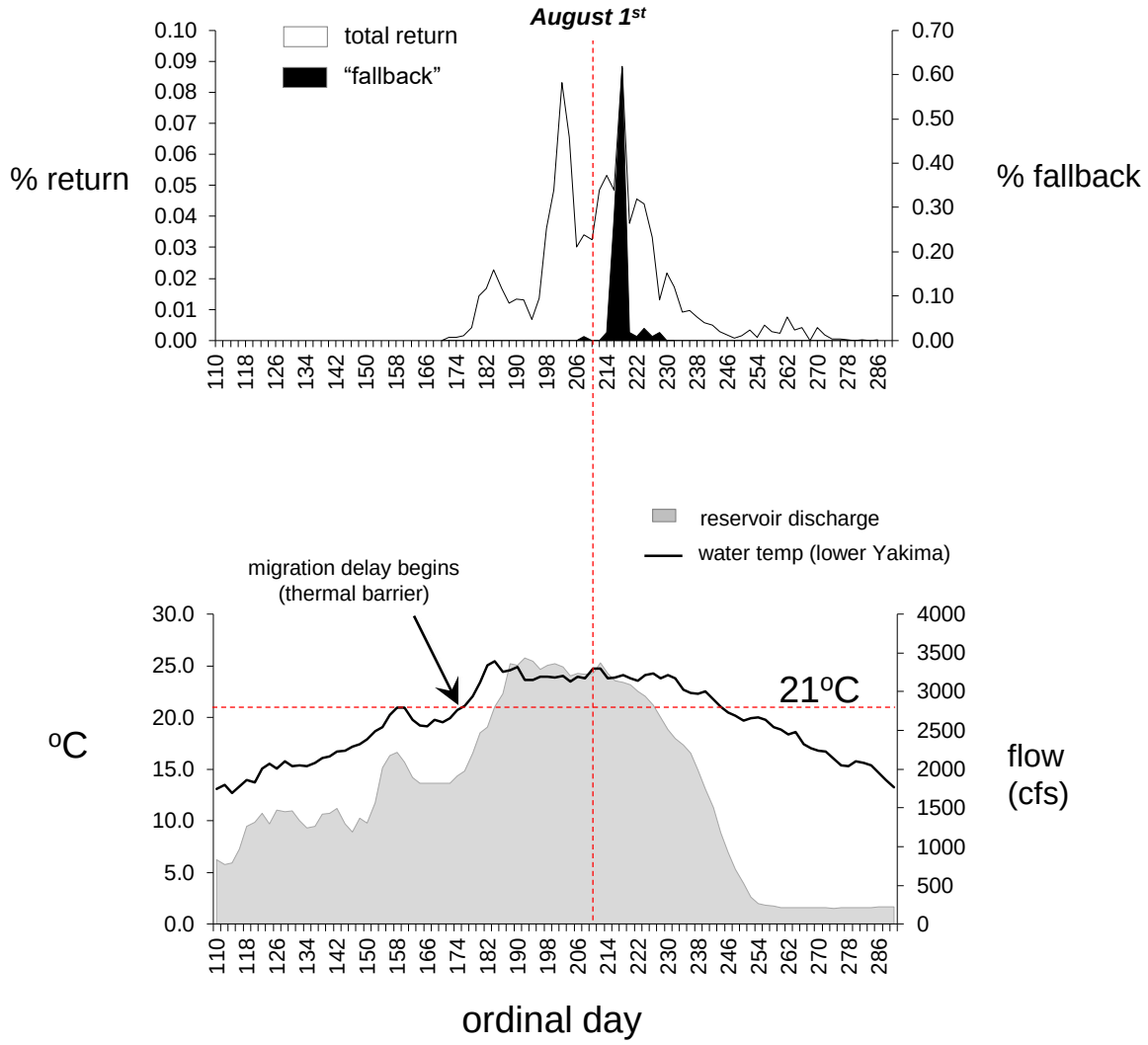
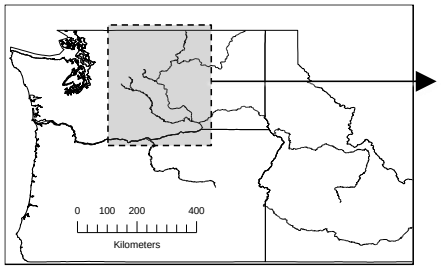
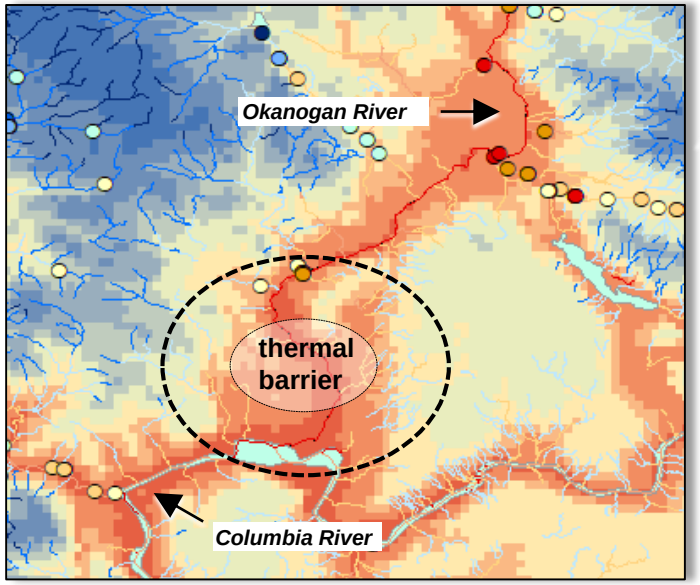


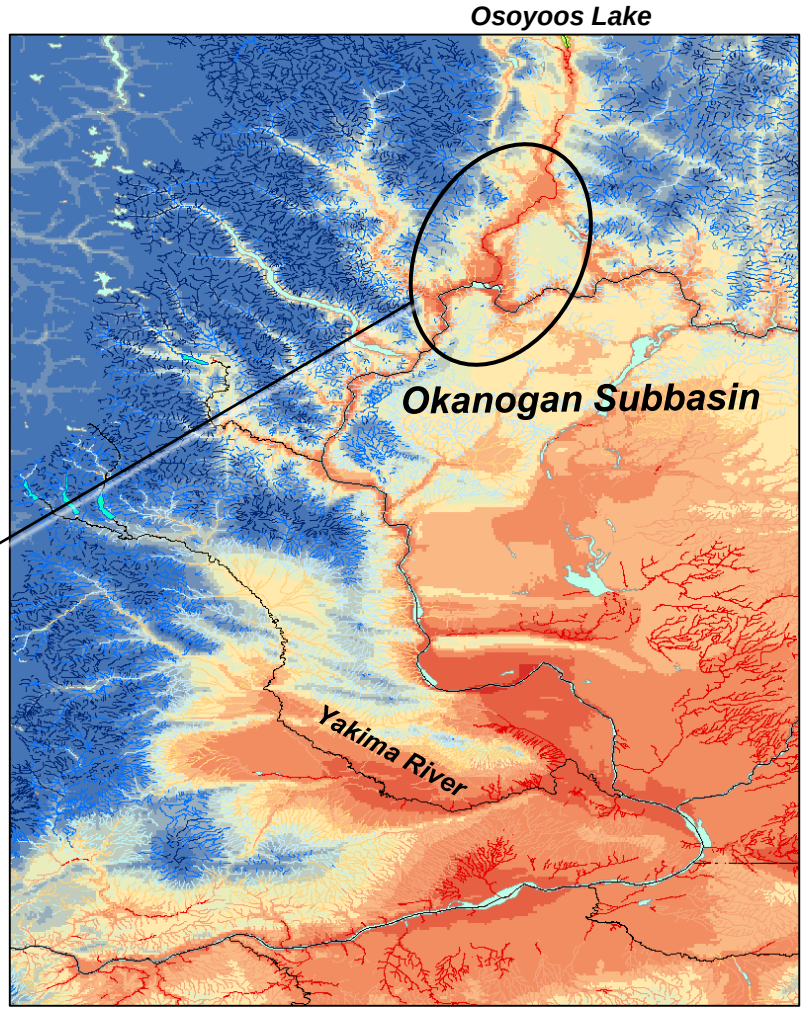
Environment:

acclimation potential



- ✓ eutrophic Lake; warm water adapted
- ✓ delayed migration; thermal barrier





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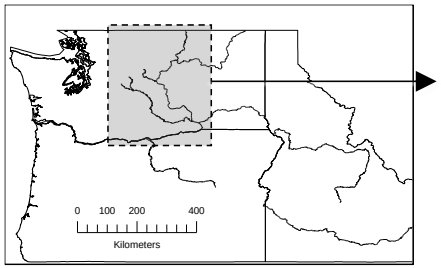
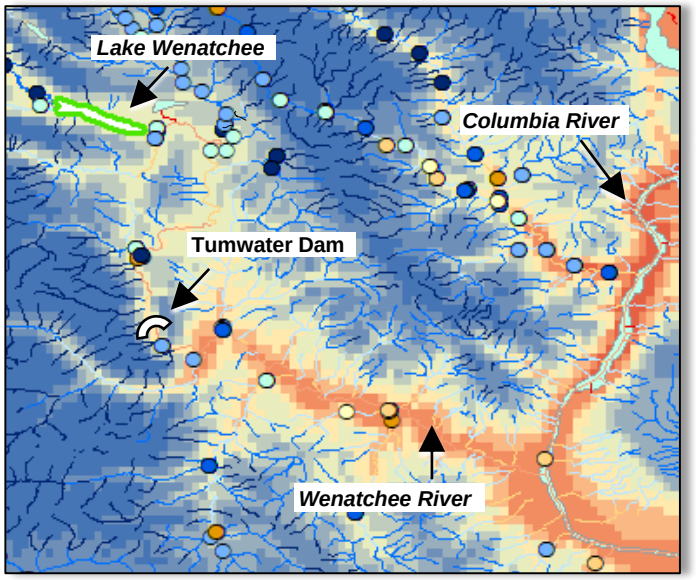
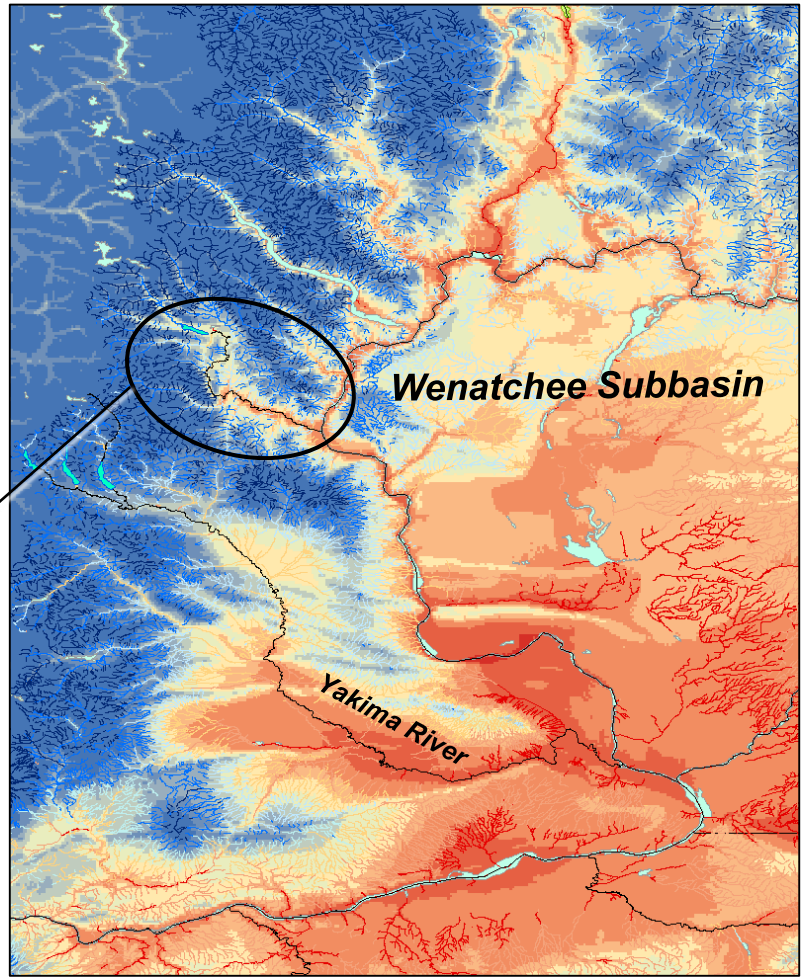
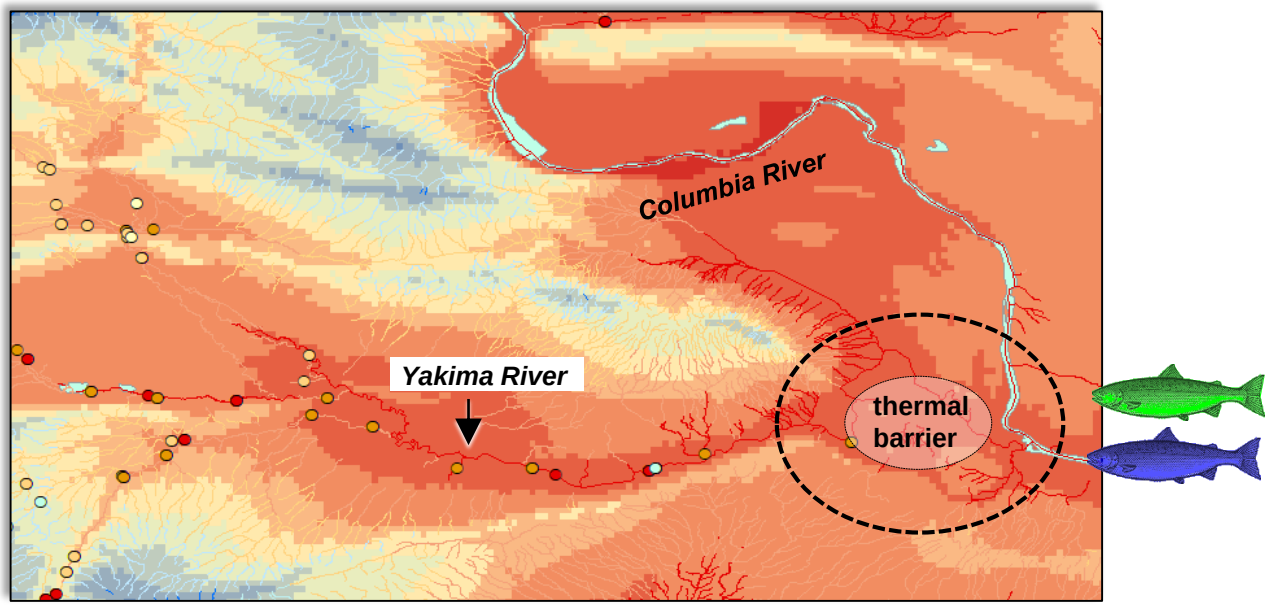


- ✓ oligotrophic Lake; cold water adapted
- ✓ early migration; no thermal barrier





Responses to conditions in the lower Yakima?



Osoyoos: more likely to **remain on queue?**

Wenatchee: more likely to stray? - **behavioral thermoregulation**

reached replacement, but actual returns may be greater

Wenatchee return abundance

brood year 2011 cohort:

- below replacement

	potential spawners			natural-origin returns (n)			
BY	PRD	Roza	total	age-3	age-4	age-5	%R
2011 →	1000	0	1000	---	---	---	---
2012	1600	3	1603	0	---	---	---
2013	315	240	555	0	238	---	---
2014	3400	1351	4751	0	1275	76	---
2015	4100	17	4117	0	16	1	---
2016	3800	2046	5846	0	1590	455	0.47
2017	490	111	601	0	77	27	1.01

Wenatchee return abundance

brood year 2011 cohort:

- below replacement
- typically **age-4** is most abundant…but not here

	potential spawners			natural-origin returns (n)			
BY	PRD	Roza	total	age-3	age-4	age-5	%R
2011 →	1000	0	1000	---	---	---	---
2012	1600	3	1603	0	---	---	---
2013	315	240	555	0	238	---	---
2014	3400	1351	4751	0	1275	76	---
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Wenatchee return abundance

brood year 2012 cohort:

- at replacement

	potential spawners			natural-origin returns (n)			
BY	PRD	Roza	total	age-3	age-4	age-5	%R
2011	1000	0	1000	---	---	---	---
2012 →	1600	3	1603	0	---	---	---
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Wenatchee return abundance

brood year 2012 cohort:

- at replacement
- as expected, **age-4** is most abundant age class

	potential spawners			natural-origin returns (n)			
BY	PRD	Roza	total	age-3	age-4	age-5	%R
2011	1000	0	1000	---	---	---	---
2012 →	1600	3	1603	0	---	---	---
2013	315	240	555	0	238	---	---
2014	3400	1351	4751	0	1275	76	---
2015	4100	17	4117	0	16	1	---
2016	3800	2046	5846	0	1590	455	0.47
2017	490	111	601	0	77	27	1.01

Actual Columbia return?

Dangerously high temps in 2015:

- most fish died in the mainstem Columbia
- In all other return years age-4 is most abundant

Cle Elum - Wenatchee origin

	natural-origin returns (n)			
BY	age-3	age-4	age-5	%R
2011	---	---	---	---
2012	0	---	---	---
2013	0	238	---	---
2014	0	1275	76	---
2015 →	0	16	1	---
2016	0	1590	455	0.47
2017	0	77	27	1.01

Cle Elum - Osoyoos origin

	natural-origin returns (n)			
BY	age-3	age-4	age-5	%R
2011	---	---	---	---
2012	135	---	---	---
2013	114	303	---	---
2014	563	471	19	---
2015 →	1	70	4	---
2016	79	1285	35	0.23
2017	1	15	5	0.15

So….just for 💩💩 & 🤭🤭

Actual BY11 productivity

Calculate expected age-4 abundance based on BY12 cohort:

$$\frac{27}{27+1590} = \mathbf{1.6\%} = \text{age-5 proportion}$$

	potential spawners			natural-origin returns (n)			
BY	PRD	Roza	total	age-3	age-4	age-5	%R
2011	1000	0	1000	---	---	---	---
2012	1600	3	1603	0	---	---	---
2013	315	240	555	0	238	---	---
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Actual BY11 productivity

Calculate expected age-4 abundance based on BY12 cohort:

1.6% (x) = 455 x = age-4 abundance = ?

	potential spawners			natural-origin returns (n)			
BY	PRD	Roza	total	age-3	age-4	age-5	%R
2011	1000	0	1000	---	---	---	---
2012	1600	3	1603	0	---	---	---
2013	315	240	555	0	238	---	---
2014	3400	1351	4751	0	1275	76	---
2015	4100	17	4117	0	x	1	---
2016	3800	2046	5846	0	1590	455	0.47
2017	490	111	601	0	77	27	1.01

Actual BY11 productivity

Calculate expected age-4 abundance based on BY12 cohort:

1.6% (x) = 455 x = **28,500**

the true natural-origin escapement for Wenatchee origin

	potential spawners			natural-origin returns (n)			
BY	PRD	Roza	total	age-3	age-4	age-5	%R
2011	1000	0	1000	---	---	---	---
2012	1600	3	1603	0	---	---	---
2013	315	240	555	0	238	---	---
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Summary:

Is reintroduction SUCCEEDING?

goal: SELF-SUSTAINING population

Things to pay attention to

Fish that residualize – spawn as “resident

- ✓ stock-specific rates?
- ✓ underlying cause?

How fish utilize the habitat – lake and stream

- ✓ Synchronicity between spawn time and optimal conditions
- ✓ Phenotypic plasticity – prevalence of lake spawning

Stock-specific juvenile survival & growth

- ✓ Density dependence influence?
- ✓ Dispersal – foraging locations and prey availability

Adult age structure

- ✓ Correlation with smolt size and age?
- ✓ Environmental factors (acclimation)