Contribution to steelhead smolt production from differing life history strategies: downstream movement as parr versus staying until time of smolting

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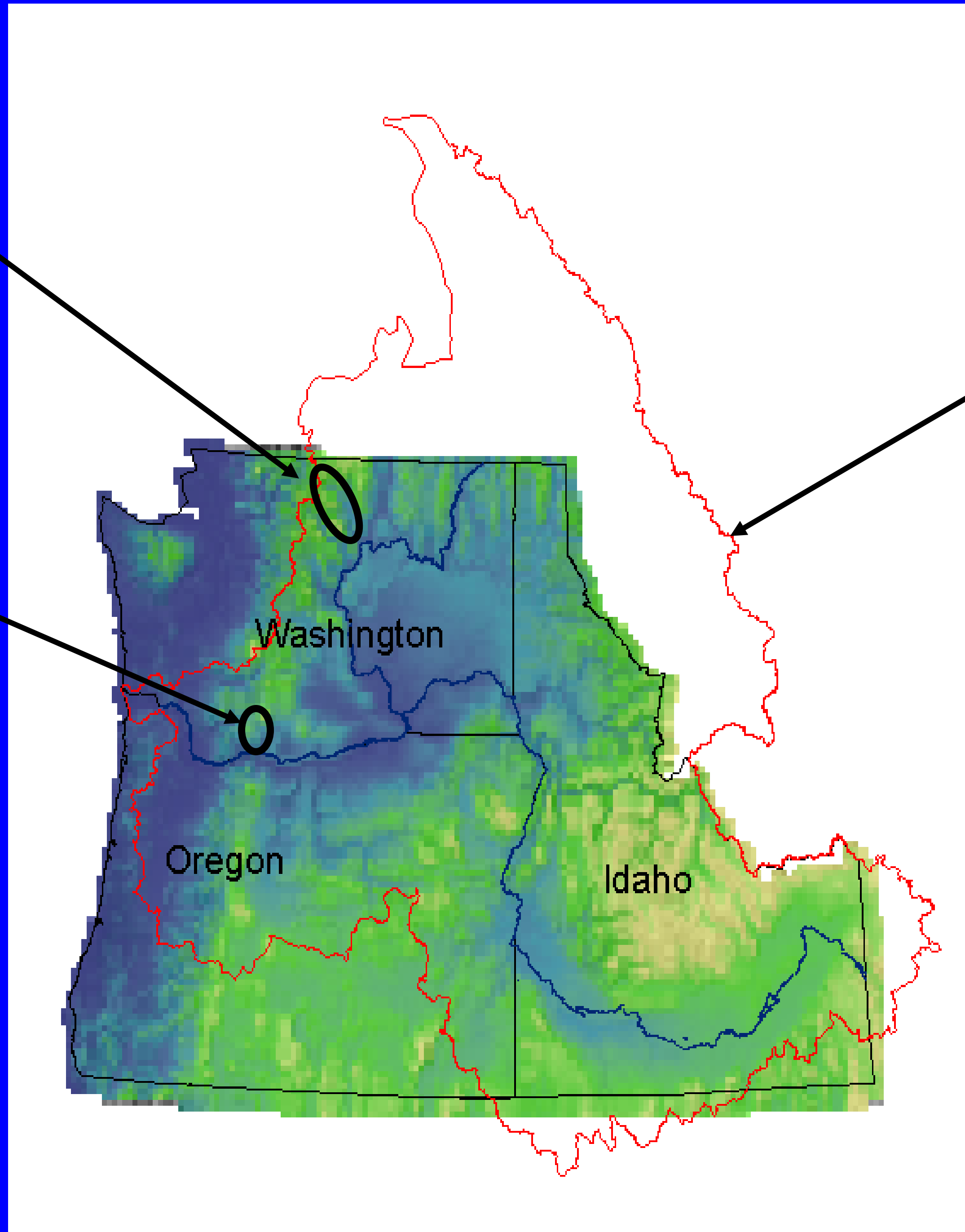
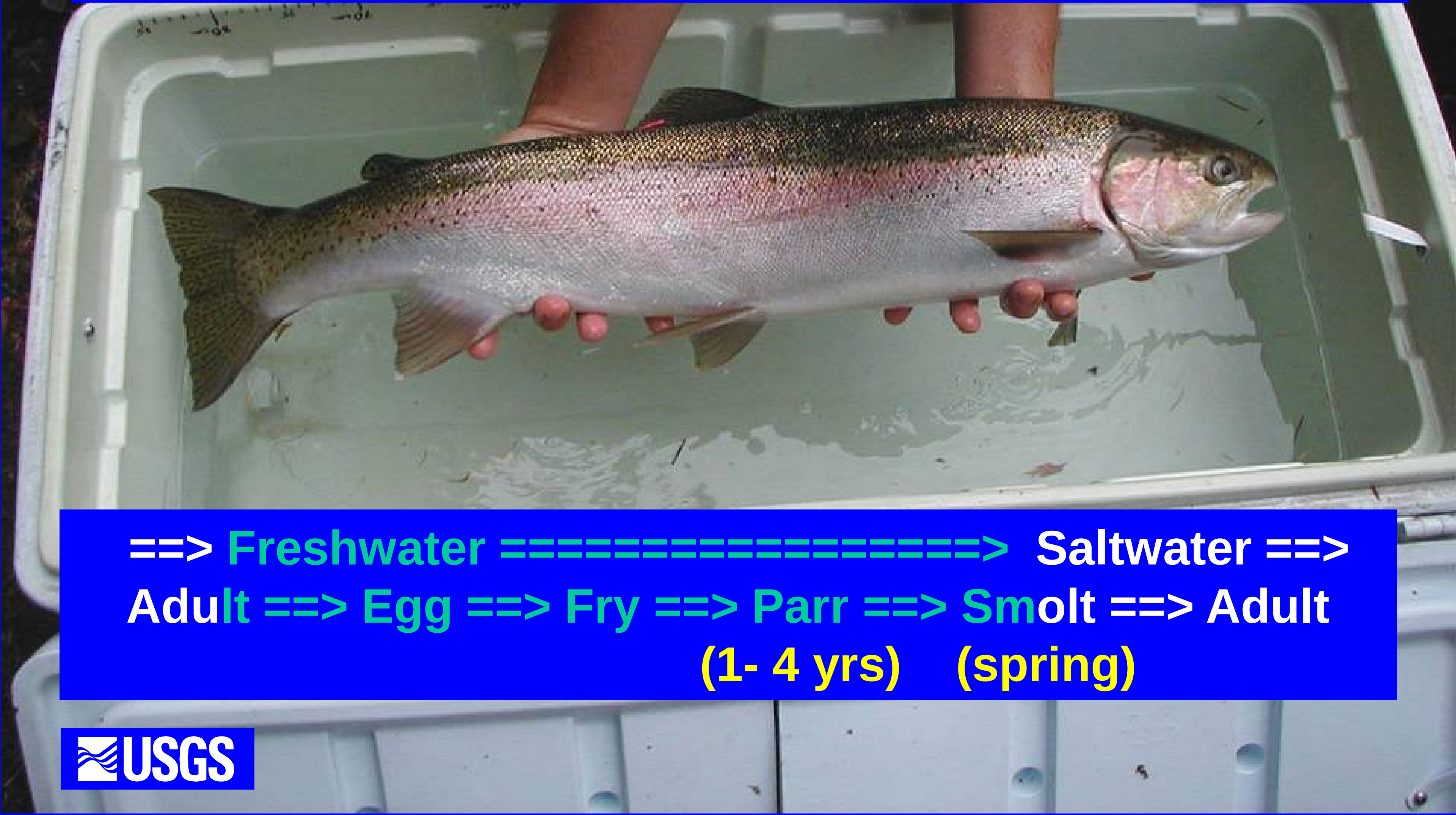
Methow River Watershed ($4,590\ km^2$)

Wind River Watershed ($583\ km^2$)

Columbia River Basin ($567,000\ km^2$)



Steelhead, AKA: anadromous rainbow trout
Oncorhynchus mykiss
Methow River: ESA "Endangered"
Wind River: ESA "Threatened"



==> Freshwater ====================> Saltwater ==>

Adult ==> Egg ==> Fry ==> Parr ==> Smolt ==> Adult

(1- 4 yrs) (spring)

USGS

Wind River Salmonid Monitoring for Response to Restoration

Dan Rawding

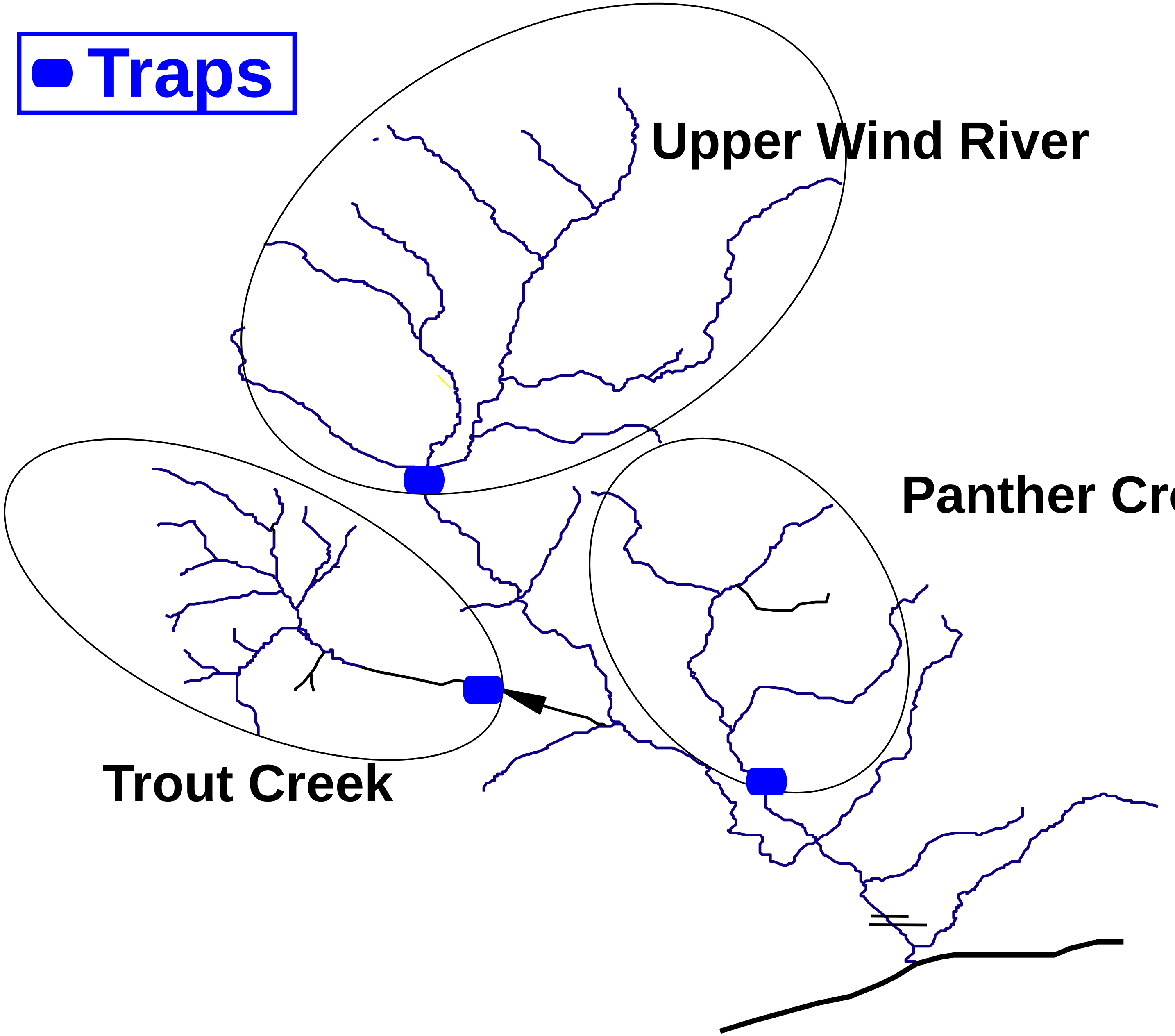
Washington Department of FISH and WILDLIFE

USGS science for a changing world

Funded by:
Bonneville Power Administration

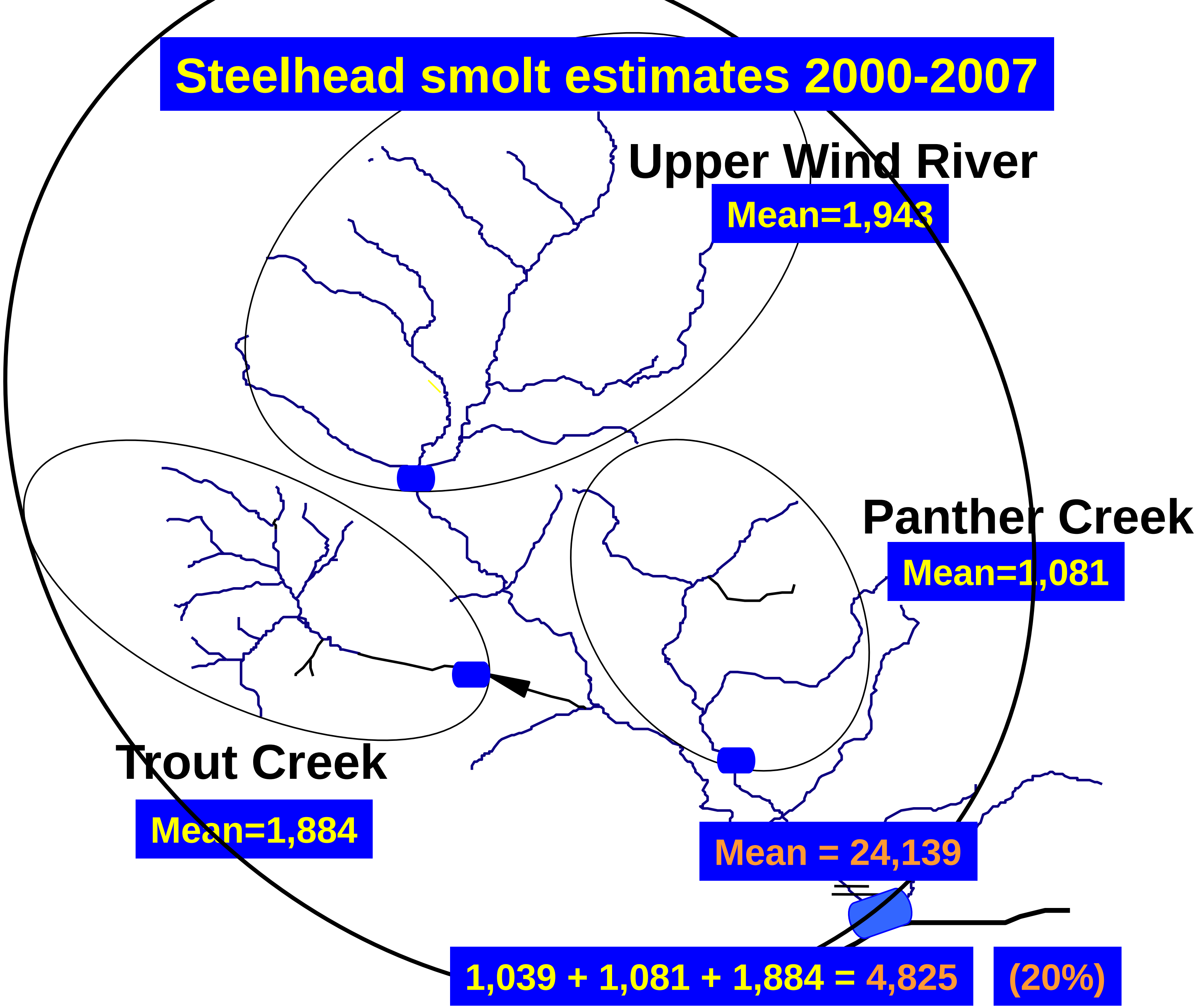
Trapping for emigrating salmonids

USGS



Traps
Upper Wind River
Panther Creek
Trout Creek
USGS

Steelhead smolt estimates 2000-2007



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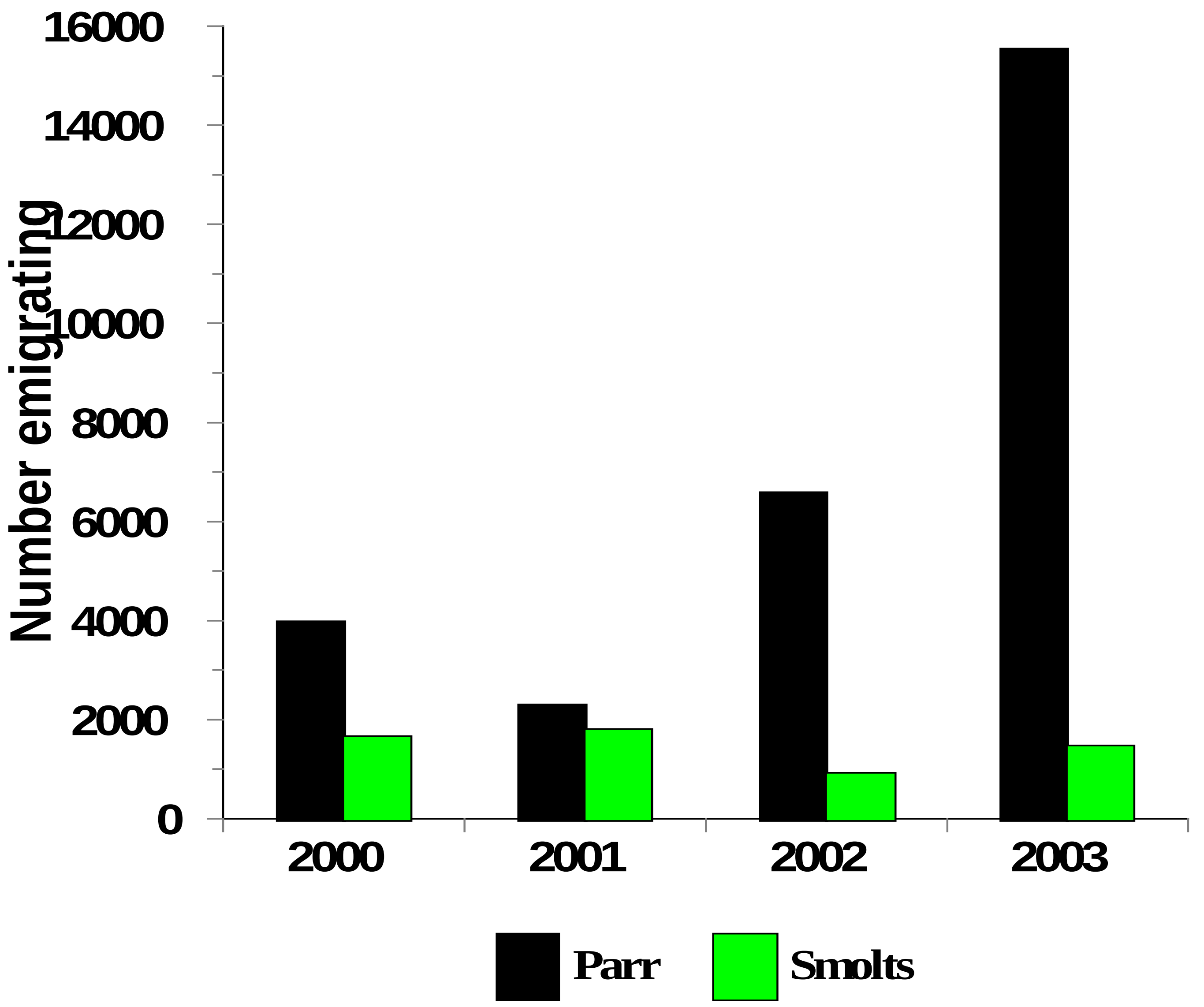
Upper Wind River—Juvenile steelhead emigration



Data from WDFW (D. Rawding and C. Cochran)

Conclusions from Wind River Studies

- Wind River Canyon (lower 15 km of the watershed) appears to be a major rearing area for parr that are spawned well upstream, moving downstream at age-1, and smolting the next year (= Dominant life history strategy)

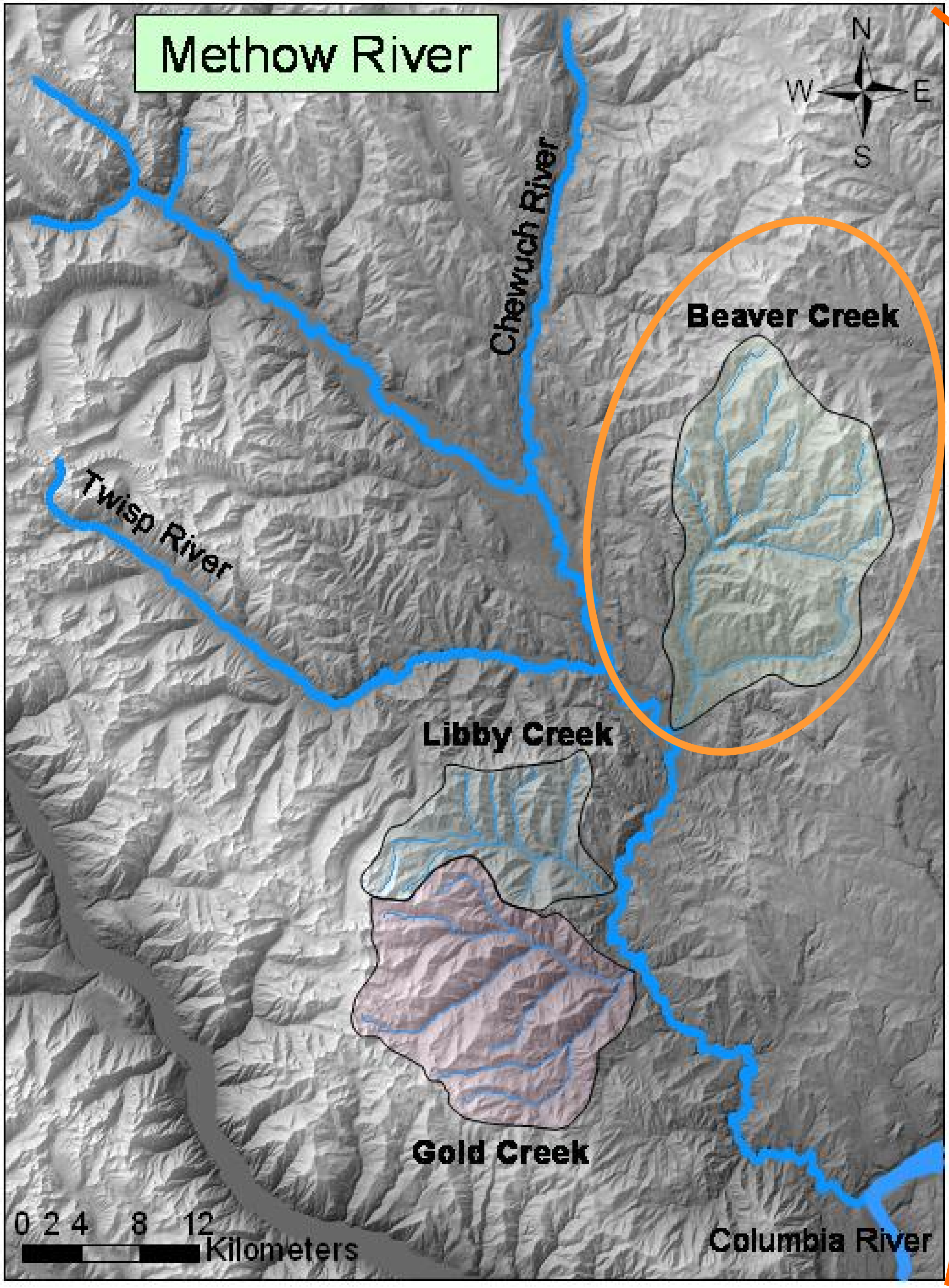
- Maintenance of connectivity and habitat quality of the Canyon is extremely important, but since the Canyon is relatively pristine, restoration efforts should be focused in the tributary watersheds

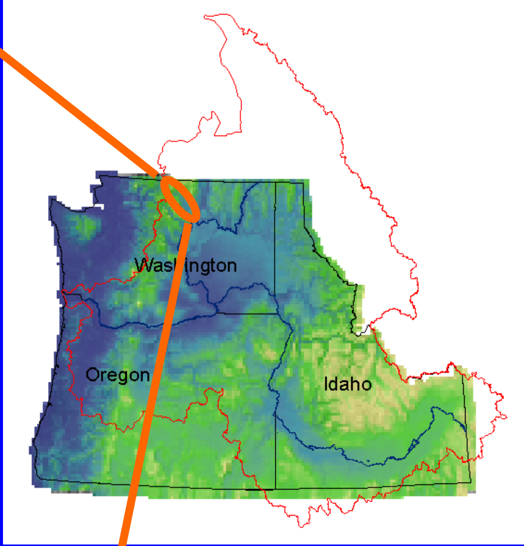
Lower Methow Tributaries Effectiveness Monitoring Study

Michael Newsom
Dana Weigel

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

USGS
science for a changing world


Methow River
N
W
E
S
Chewuch River
Beaver Creek
Twisp River
Libby Creek
Gold Creek
0 2 4 8 12
Kilometers
Columbia River

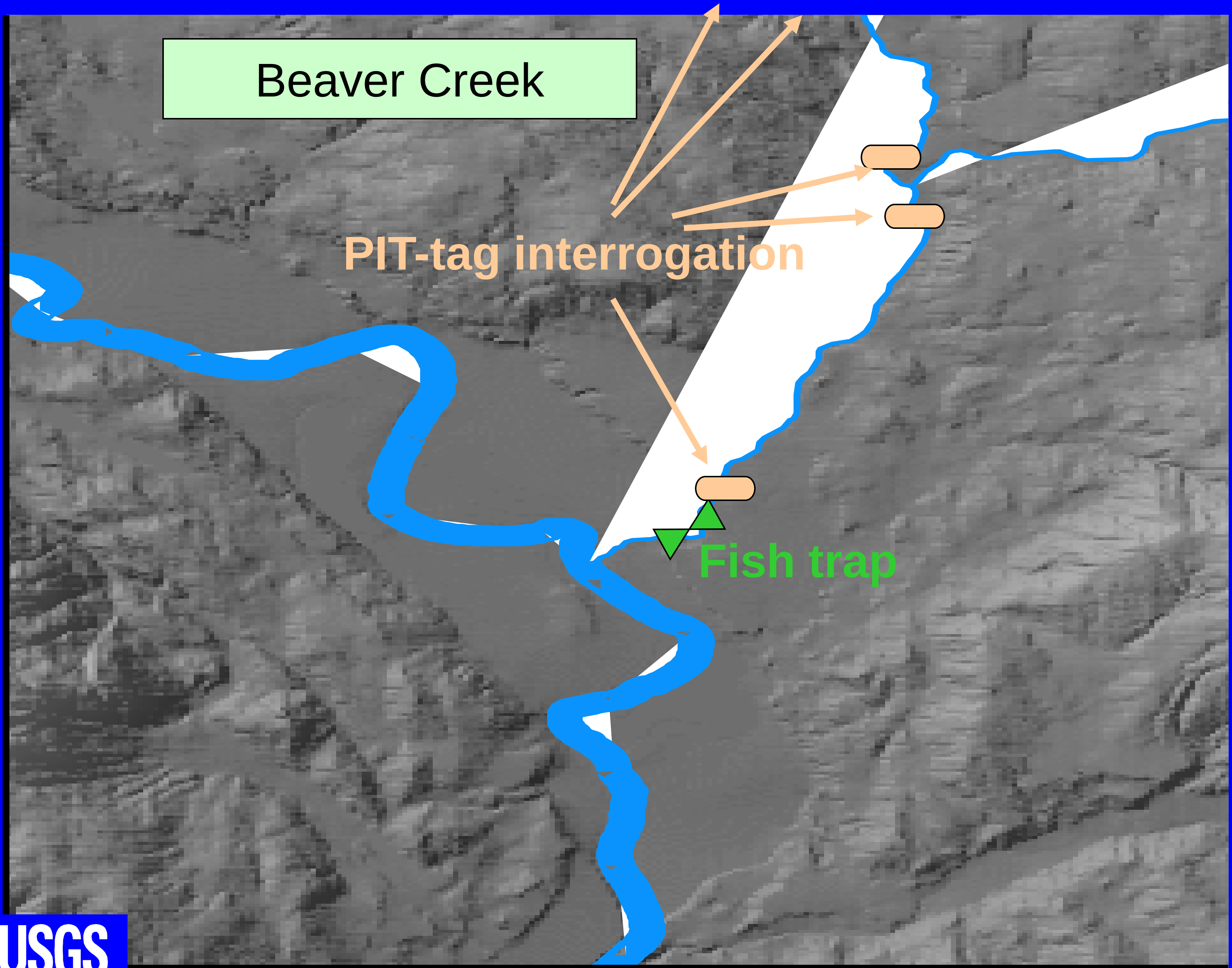

Washington
Oregon
Idaho

USGS

Barrier removals in Beaver Creek 2000-2005:

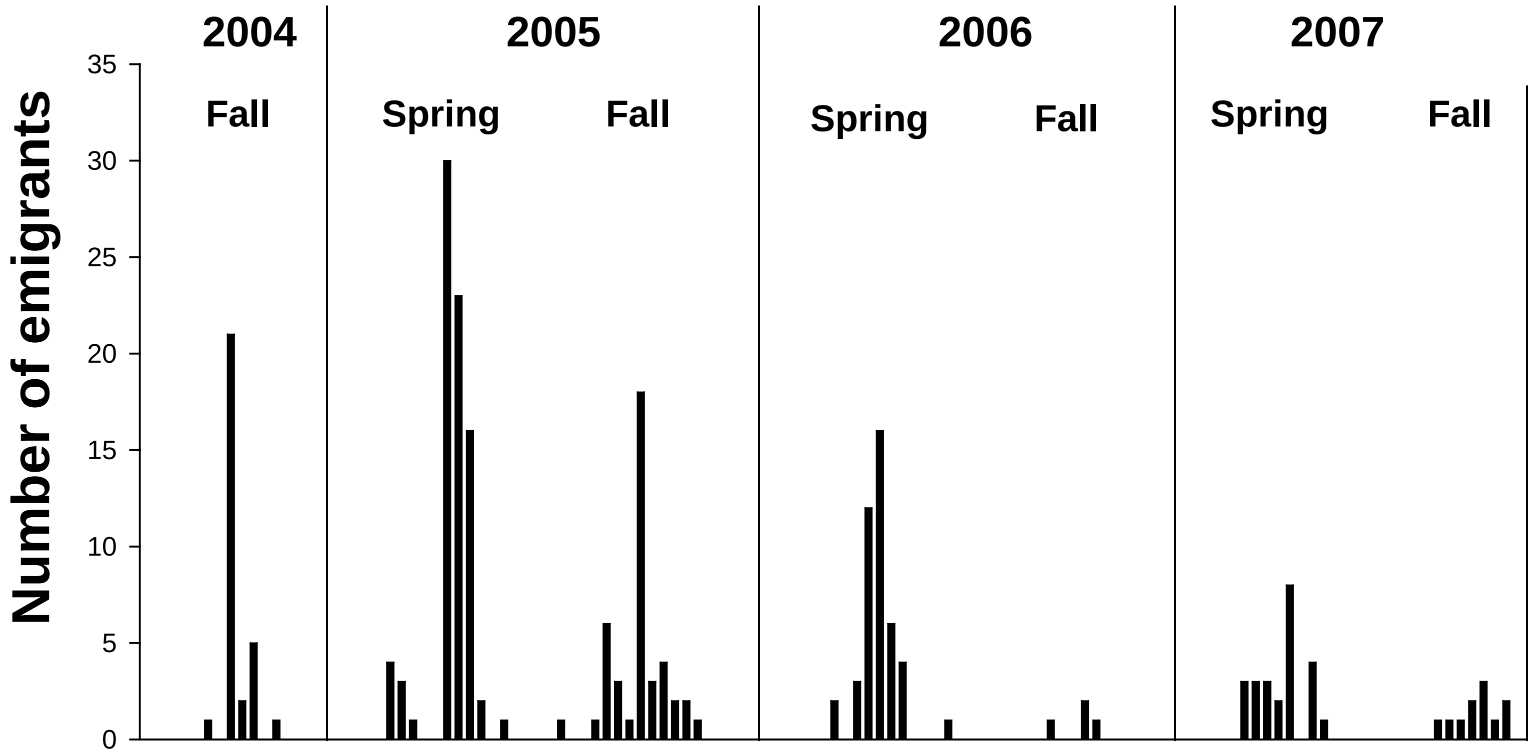
Small dams
Culverts
(Reclamation, USFS)

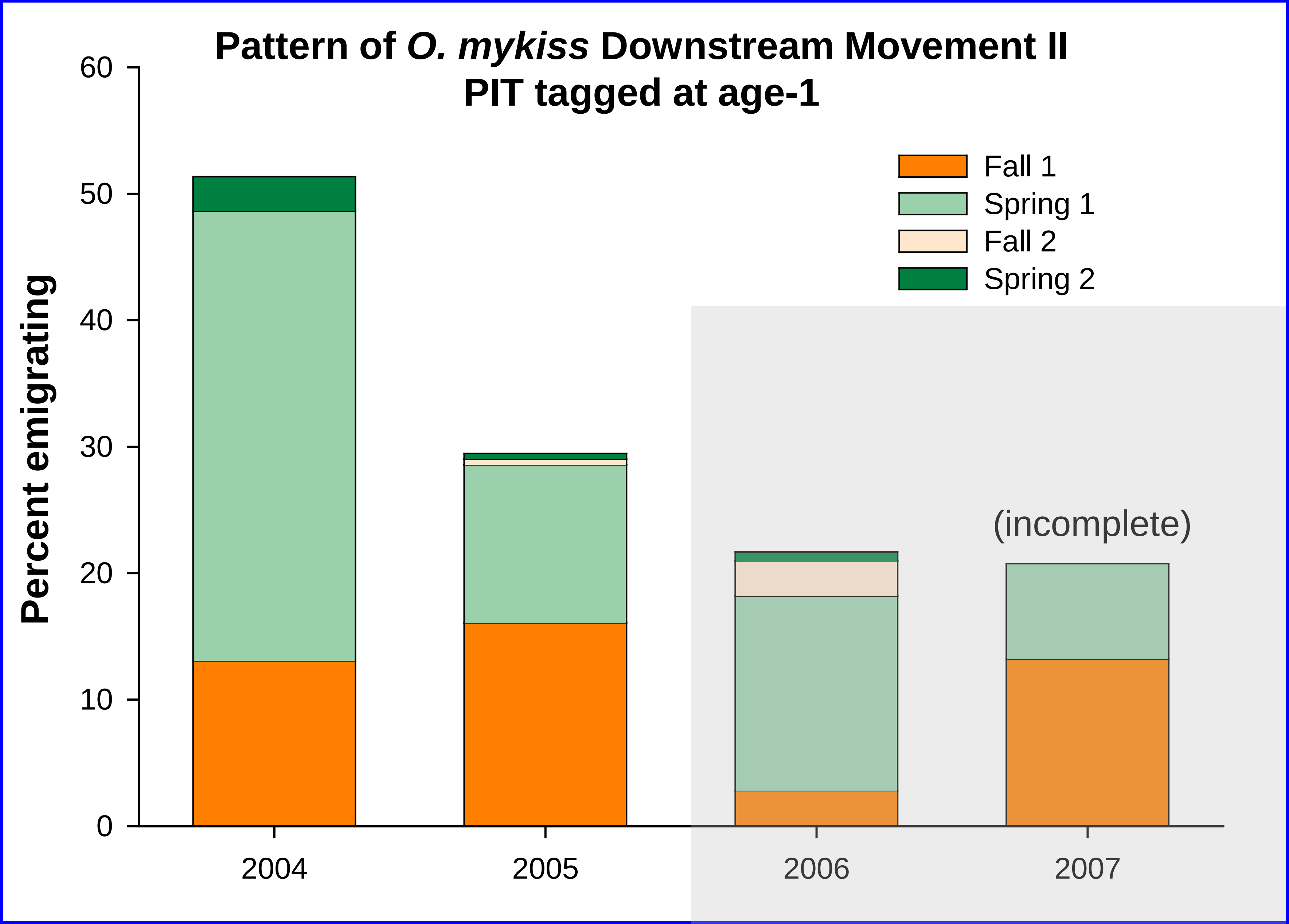
USGS



USGS

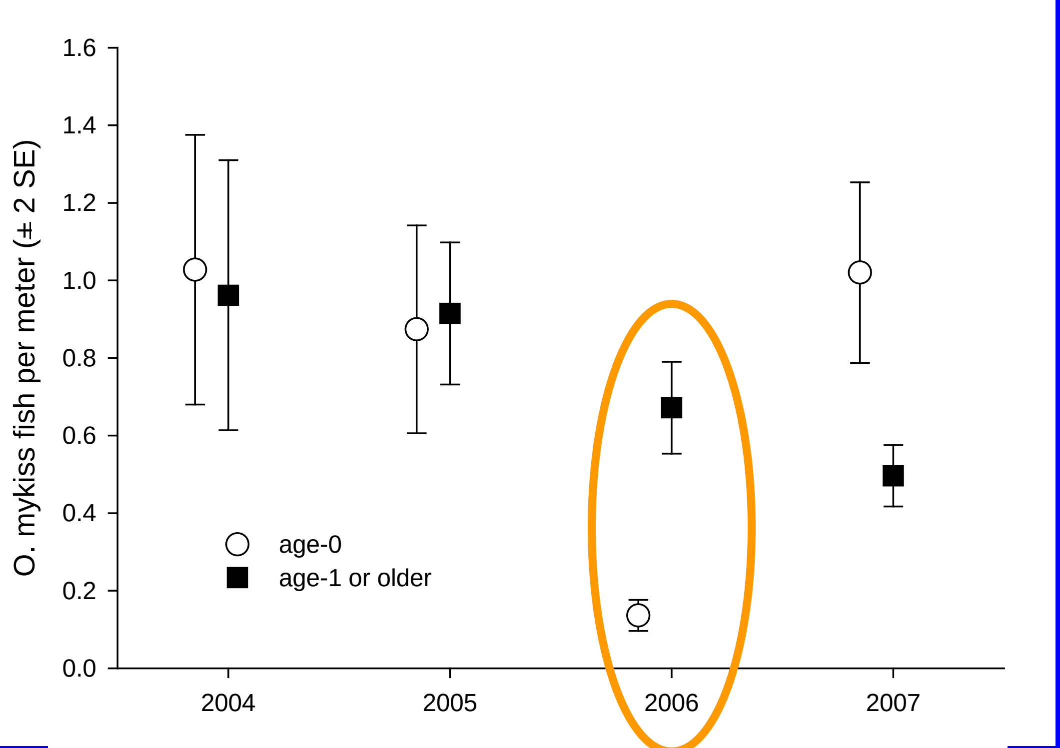
Pattern of *O. mykiss* Downstream Movement

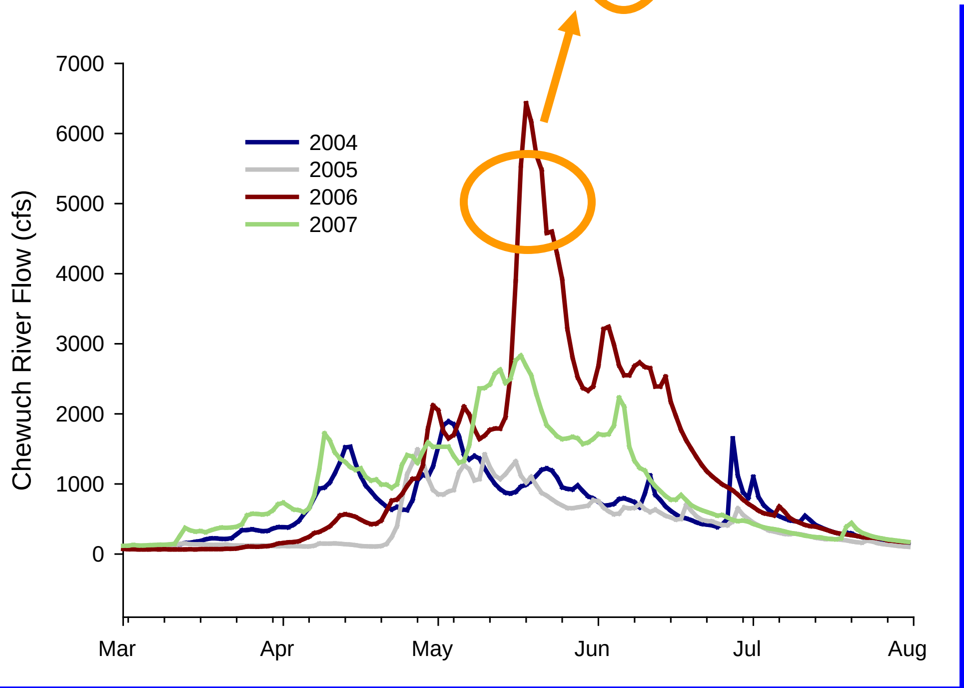



Pattern of *O. mykiss* Downstream Movement II
PIT tagged at age-1
Percent emigrating
0
10
20
30
40
50
60
2004
2005
2006
2007
Fall 1
Spring 1
Fall 2
Spring 2
(incomplete)

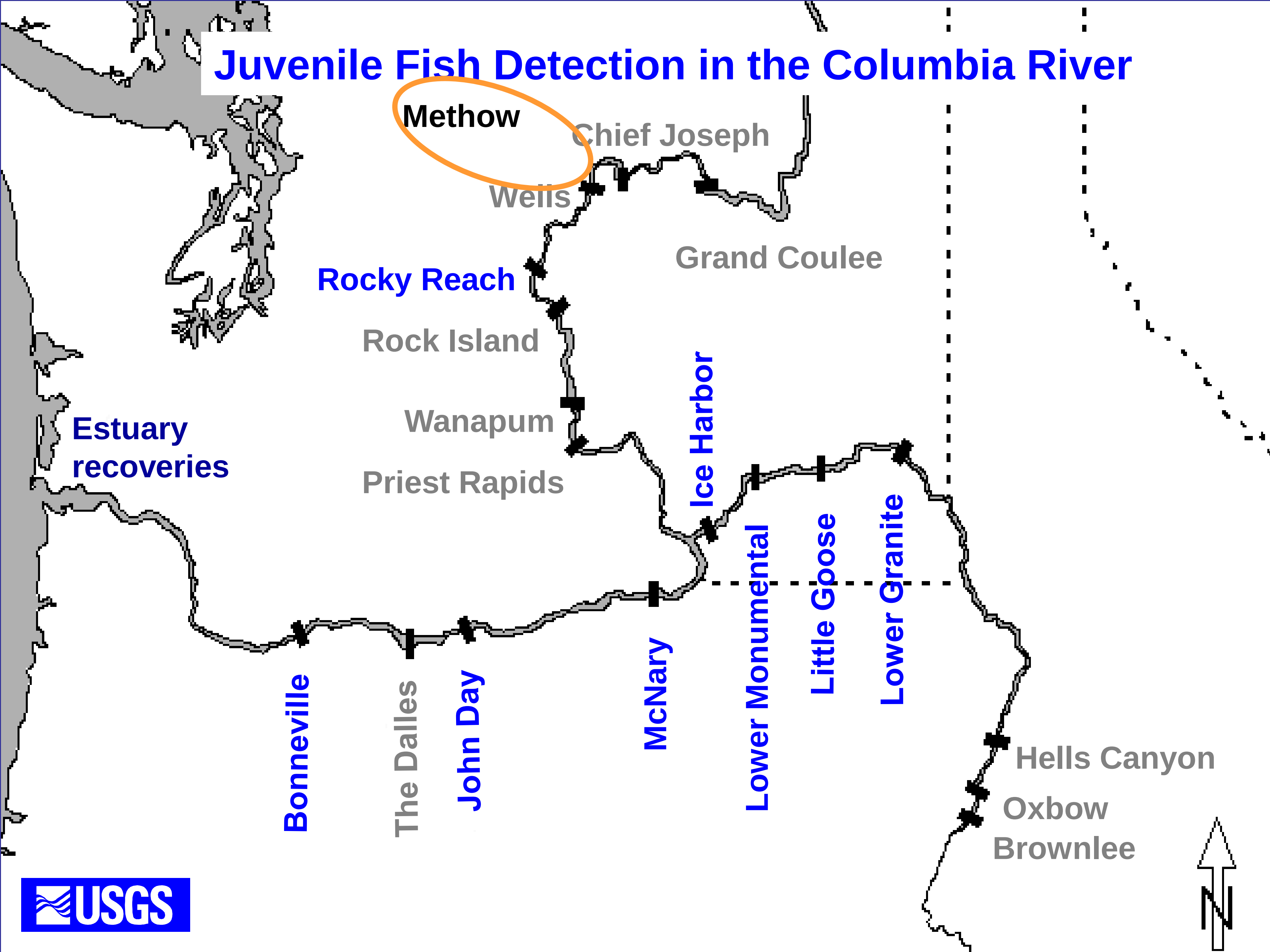
2006

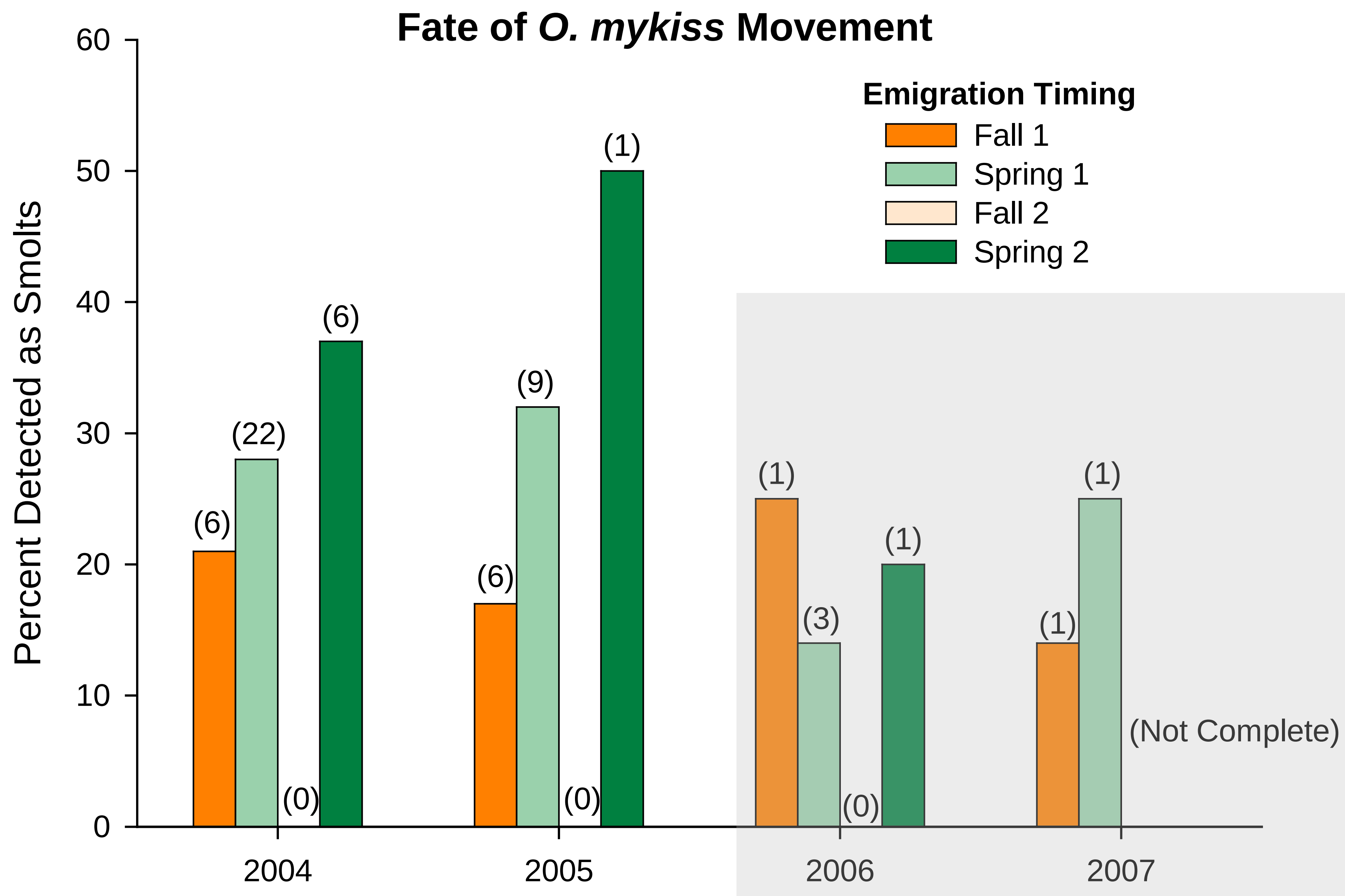
Large flow event in spring with a decided influence on production of *O. mykiss*





Juvenile Fish Detection in the Columbia River




Fate of O. mykiss Movement
Emigration Timing
Fall 1
Spring 1
Fall 2
Spring 2
Percent Detected as Smolts
60
50
40
30
20
10
0
(6)
(22)
(0)
(6)
(6)
(9)
(0)
(1)
(1)
(3)
(0)
(1)
(1)
(1)
(Not Complete)
2004
2005
2006
2007

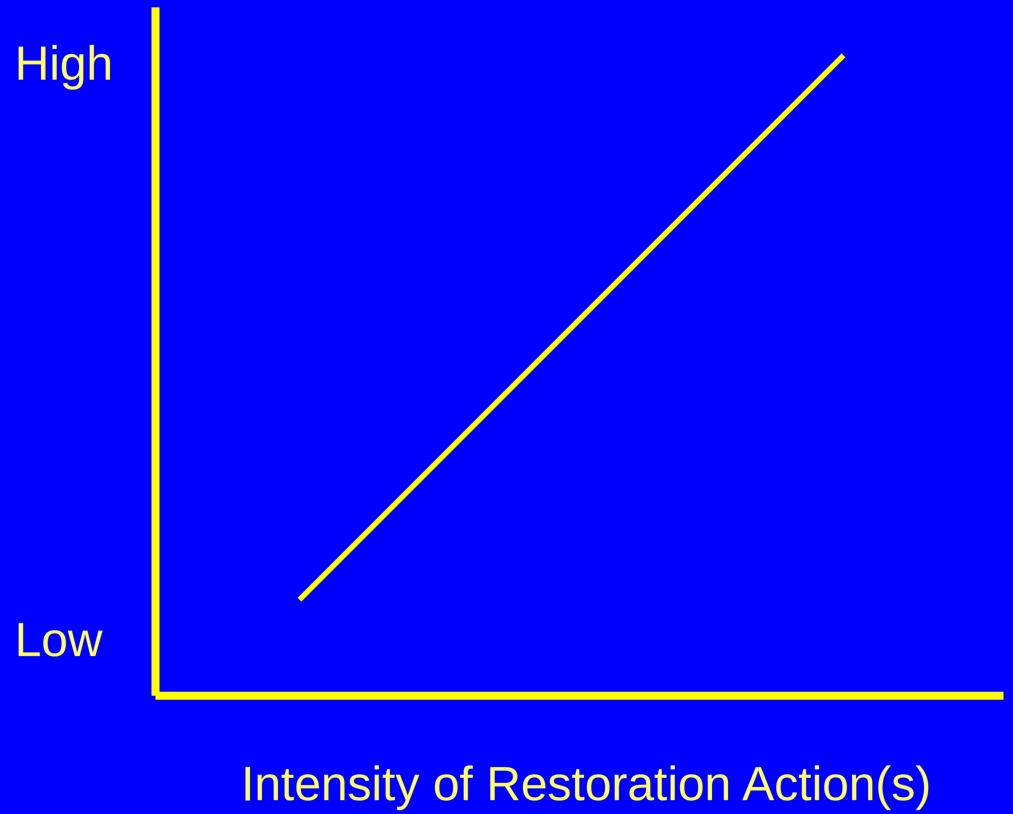
Conclusions—Steelhead Life History in Beaver Creek

- Staying and rearing to time of smolting in their natal Beaver Creek appears to be the dominant life history strategy that contributes to smolt production

- Juvenile steelhead moving downstream from Beaver Creek into the Methow in fall as age-1 parr have much lower parr-to-smolt survival than those that stay in their natal area

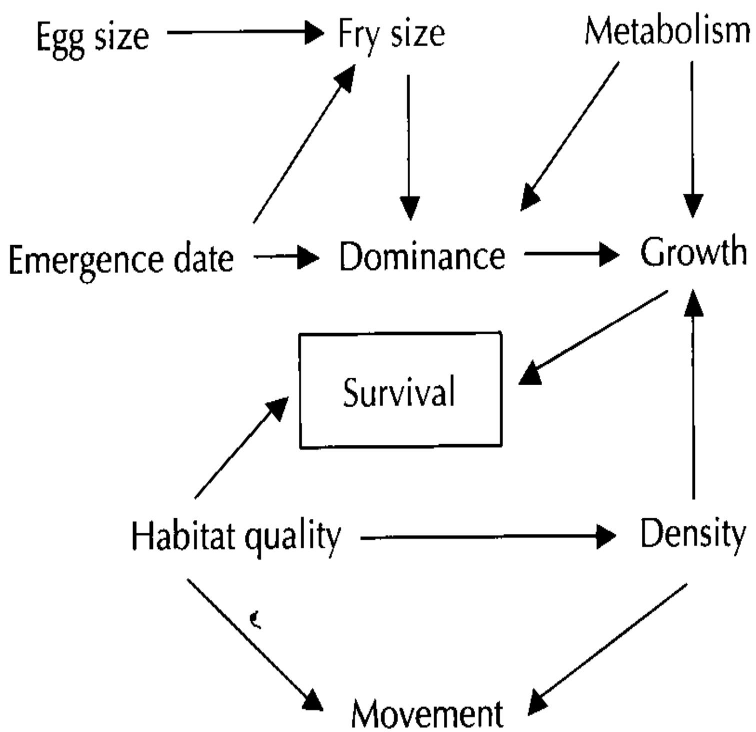
Assessing Restoration Actions to Get a Desired Response

--Smolt output
--Adult numbers
--Other ????



Complex and Dependent Interactions

FIGURE 11-9. Diagrammatic representation of some of the factors influencing movement, growth, and survival of juvenile salmonids in streams.



From Quinn 2005

Modeling for potential response to restoration actions

"Stayers"
vs
"Movers"

Parr–to-Parr
Survival
Estimates

% Staying-Before	20
% Staying-After	20
S stayers-Before	75
S stayers-After	75
S movers-Before	25
S movers-After	50

<u>Test</u>: What if improved parr-to-parr survival of movers from 25% to 50% ?

USGS

% Staying-Before	20
% Staying-After	20
S stayers-Before	75
S stayers-After	75
S movers-Before	25
S movers-After	50

Test

Cohort Model--Deterministic

Inputs: Before = 1,000 smolts
Age-specific rates

				BEFORE		1.6087	**AFTER**	
Initial Values--(Year 0 = Brood year)		1	0.00%	Fry Incr.		Multiple factor		

	Initial Escapement			74		1.0000	74	
	Percent females			60.0	%	1.0000	60.0	%
	Number of females			45			45	
	Repeat spawners			0.00%			0.00%	
	Egg--Smolt survival			0.53%			0.85%	
	Egg-Egg			100.000	%	1.0000	100.0000	%
	Egg--1+Parr		3.5616	1.7808	%		1.7808	%
		Egg--0+Fry		3.5616	%	1.0000	3.5616	%
		0+Fry--1+Parr		50.0000	%	1.0000	50.0000	%
	Stayers	% Age-1 parr staying		20.0000	%	1.0000	20.0000	%
	Survival (%)	1+Parr --2+Parr		75.0000	%	1.0000	75.0000	%
		2+Parr --3+Parr		75.0000	%	1.0000	75.0000	%
		3+Parr --4+Parr		75.0000	%	1.0000	75.0000	%
		Parr-to-Smolt		90.0000	%	1.0000	90.0000	%
	Movers	%Age-1 parr moving		80.0000	%	1.0000	80.0000	%
	Survival (%)	1+Parr --2+Parr		25.0000	%	2.0000	50.0000	%
		2+Parr --3+Parr		25.0000	%	2.0000	50.0000	%
		3+Parr --4+Parr		25.0000	%	2.0000	50.0000	%
		Parr-to-Smolt		90.0000	%	1.0000	90.0000	%

Cohort Model--Deterministic

More Inputs – Differing smolt age based on bioenergetics

SURVIVAL RATES and PERCENT CHANGE TO STAGE			BEFORE			AFTER		
---------------	---------------------------	------------	++++++++	++++++++-	++++++++	=======	========	======
Life history stage		Stage code	Mean percent survival	Percent changing TO stage	Percent by age	Mean percent survival	Percent changing TO stage	Percent by age
Start	End							
PARR-TO-SMOLT (within a year)			20	% staying		20	% staying	
STAYERS			++++++++	++++++++-	++++++++	=======	========	======
Age 1+ parr	1+Smolts@mouth(y1)	IVa	90.000	0.000	0.0%	90.000	0.000	0.0%
Age 2+ parr	2+Smolts@mouth(y2)	IVb	90.000	42.900	50.0%	90.000	42.900	50.0%
Age 3+ parr	3+Smolts@mouth(y3)	IVc	90.000	100.000	50.0%	90.000	100.000	50.0%
Age 4+ parr	4+Smolts@mouth(y4)	IVd	90.000	0.000	0.0%	90.000	0.000	0.0%
			subtotal=	142.9	100.0%		142.9	100.0%
			++++++++	++++++++-	++++++++	=======	========	======
PARR-TO-SMOLT (within a year)			80	% moving		80	% moving	
MOVERS			++++++++	++++++++-	++++++++	=======	========	======
Age 1+ parr	1+Smolts@mouth(y1)	IVa	90.000	0.000	0.0%	90.000	0.000	0.0%
Age 2+ parr	2+Smolts@mouth(y2)	IVb	90.000	100.000	100.0%	90.000	100.000	100.0%
Age 3+ parr	3+Smolts@mouth(y3)	IVc	90.000	0.000	0.0%	90.000	0.000	0.0%
Age 4+ parr	4+Smolts@mouth(y4)	IVd	90.000	0.000	0.0%	90.000	0.000	0.0%
			subtotal=	100	100.0%		100	100.0%
			++++++++	++++++++-	++++++++	=======	========	======

Stayers: 50% age-2, 50% age-3; **Movers**: 100% age-2

USGS

% Staying-Before	20
% Staying-After	20
S stayers-Before	75
S stayers-After	75
S movers-Before	25
S movers-After	50

Test

Cohort Model--Deterministic

Output

	BEFORE	AFTER	x-fold
Escapement (BY-1)	74	74	1.00
Egg-to-Smolt survival	0.53%	0.85%	1.61
Egg-to-Fry survival	3.56%	3.56%	1.00
Fry-to-Age-1 Parr survival	50.00%	50.00%	1.00
Parr-to-Smolt survival	29.57%	47.57%	1.61
Smolts out (BY-1)	1,000	1,609	1.61
% From STAYERS	39%	24%	0.62
% From MOVERS	61%	76%	1.24
Smolts per Female (BY-1)	22.4	36.1	1.61

Increasing parr-to-parr survival of movers from 25% to 50% resulted in a 1.6 fold increase in number of smolts

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Using Information on Life History Expression for Restoration Planning

Case A) Survival= 75% for stayers; 25% for movers

Goal: Increase survival from 25% to 50% for movers

Case B) Survival= 25% for stayers; 75% for movers

Goal: Increase survival from 25% to 50% for stayers

USGS

Conclusion—Modeling for Restoration Planning

- It is important to know how the fish are using the system and to know the diversity (expressed and potential) of life history strategies in order to assess what restoration efforts are best to implement

- Predictive modeling can help guide allocation of effort and funding, and to formulate realistic expectations

My view: Potential for steelhead smolt production from emigrated parr is under appreciated, but is likely to have been the dominant life history and contributor to smolt production in many undisturbed systems

USGS

The USGS-CRRL Watershed Team

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Charlie Cochran (WDFW)
Michael Newsom (Reclamation)
Dana Weigel (Reclamation)
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USGS