Snake River spring/summer Chinook salmon:

An historical perspective on factors for decline and prospects for recovery

Robin Waples

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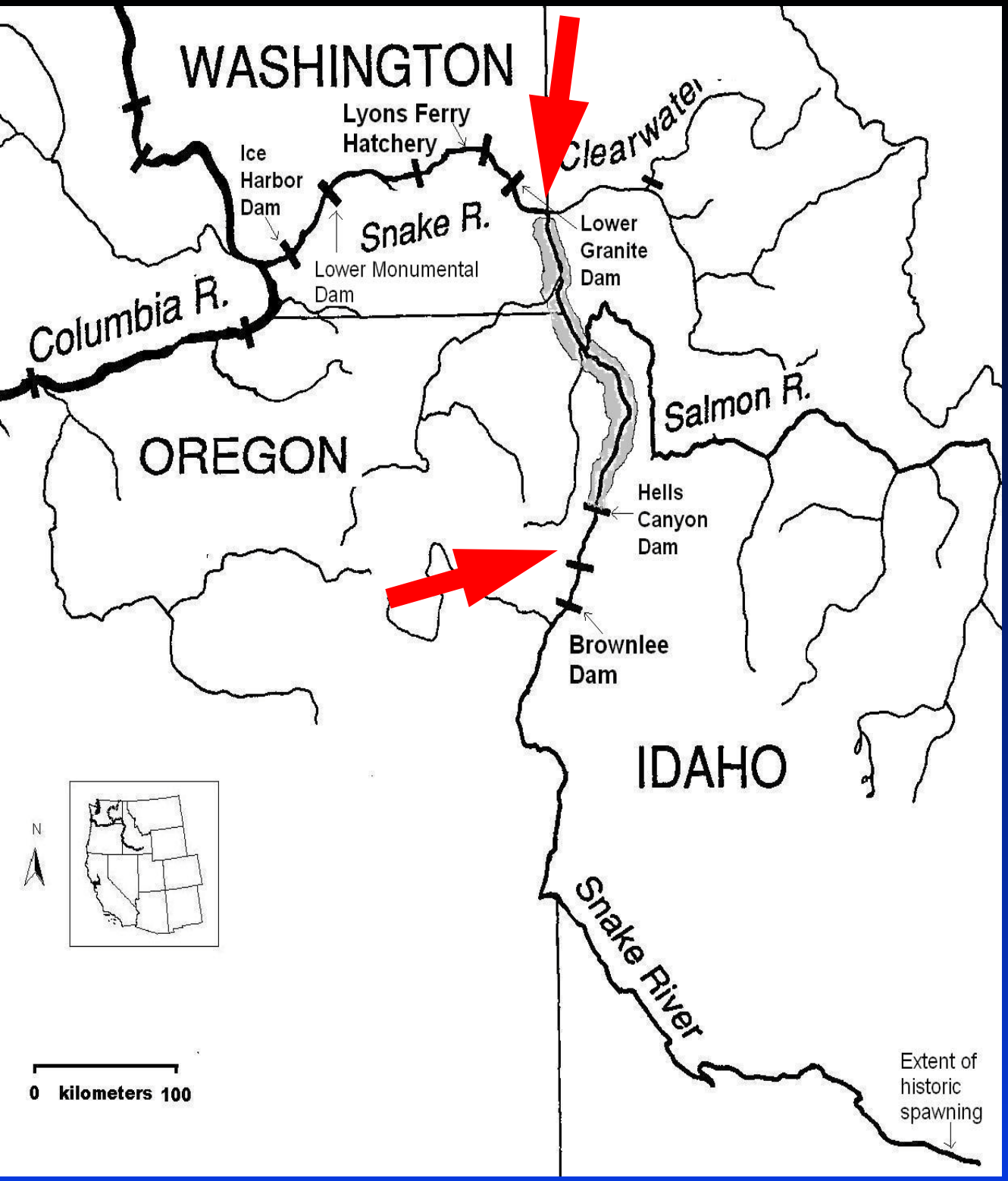
National Marine Fisheries Service
Seattle, Washington USA



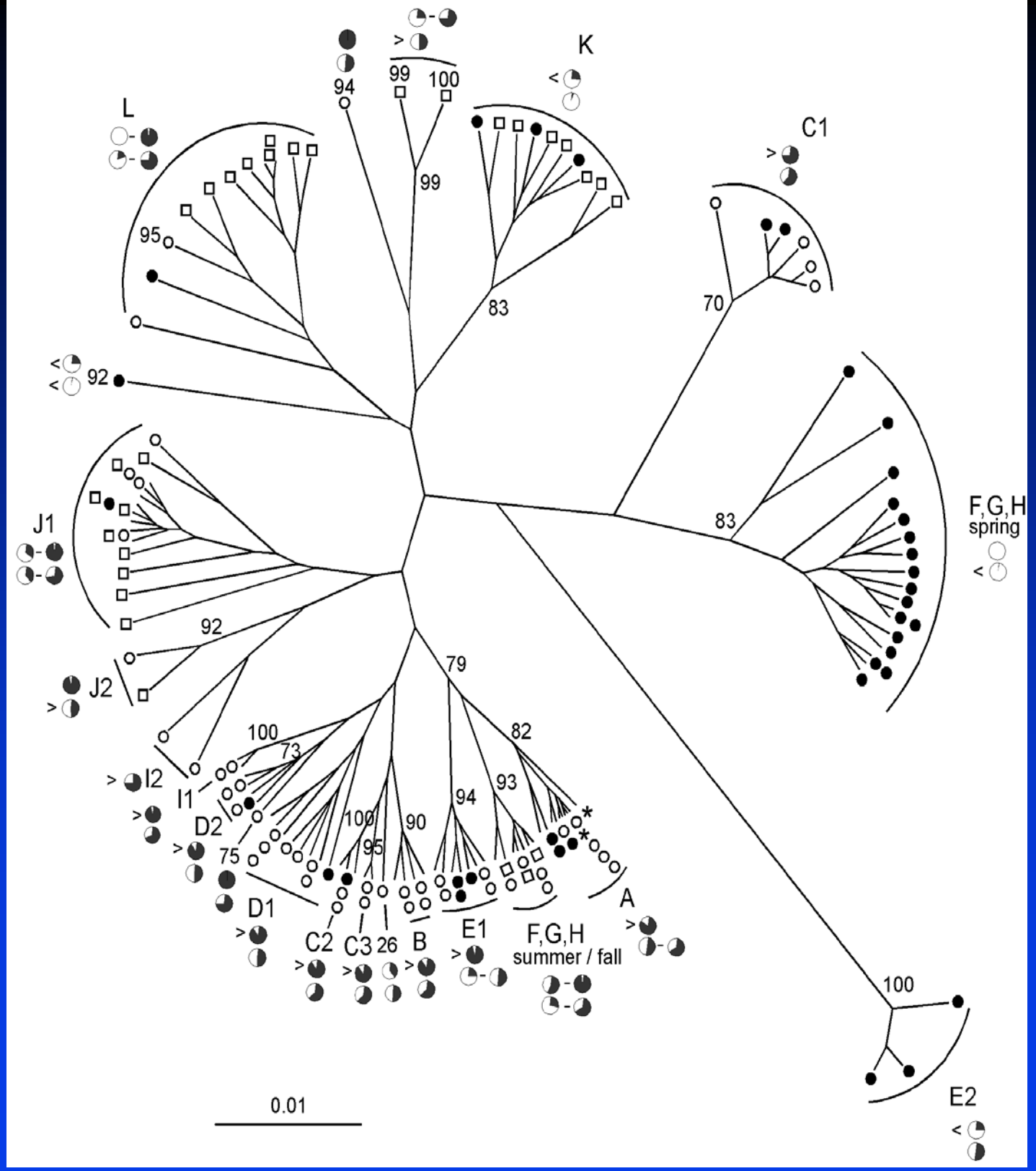
Columbia River

Historical center of distribution for Chinook salmon

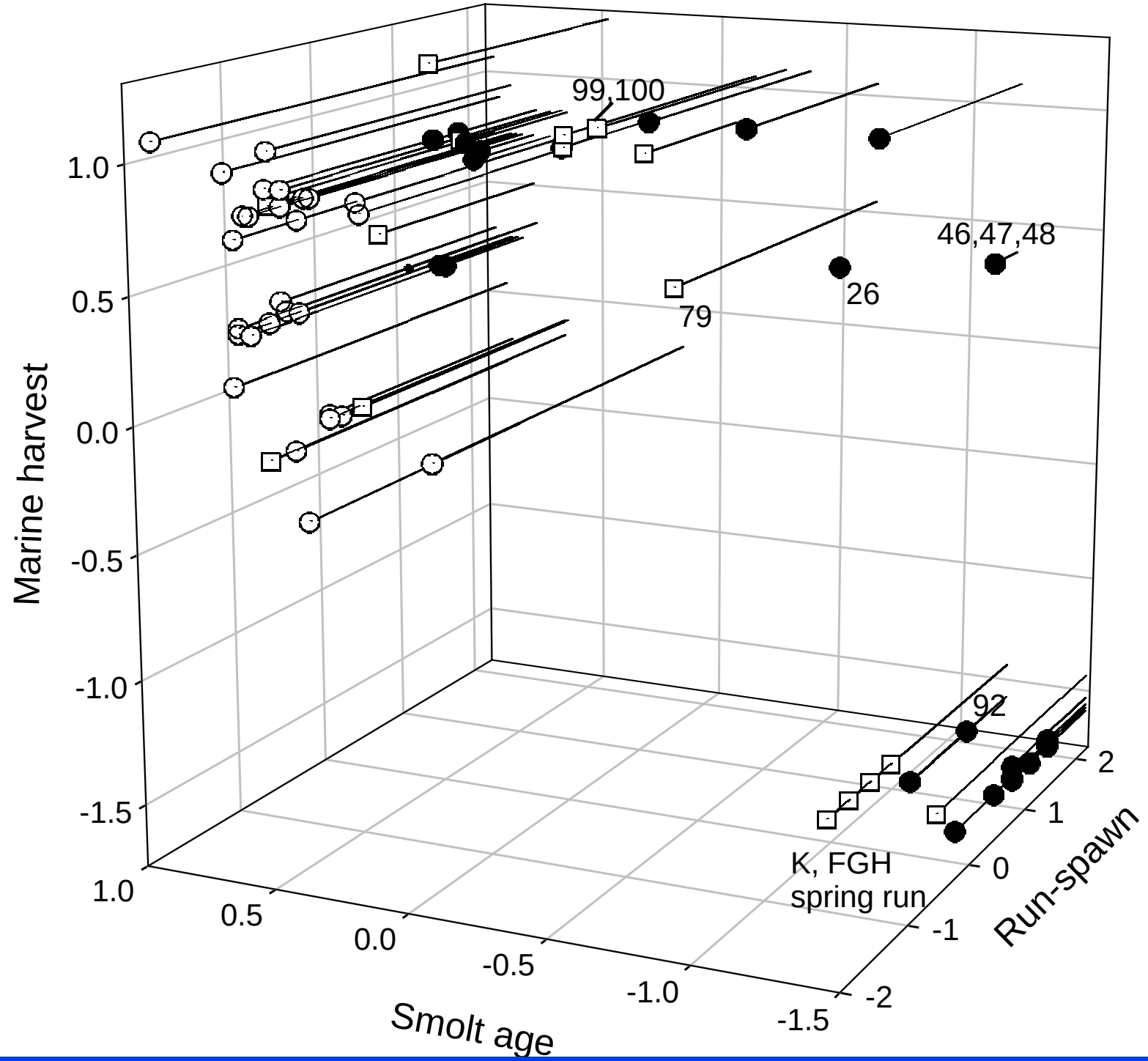
Distinctive habitats

Chinook CA-BC

Waples, Teel, Myers, Marshall
Evolution 2004

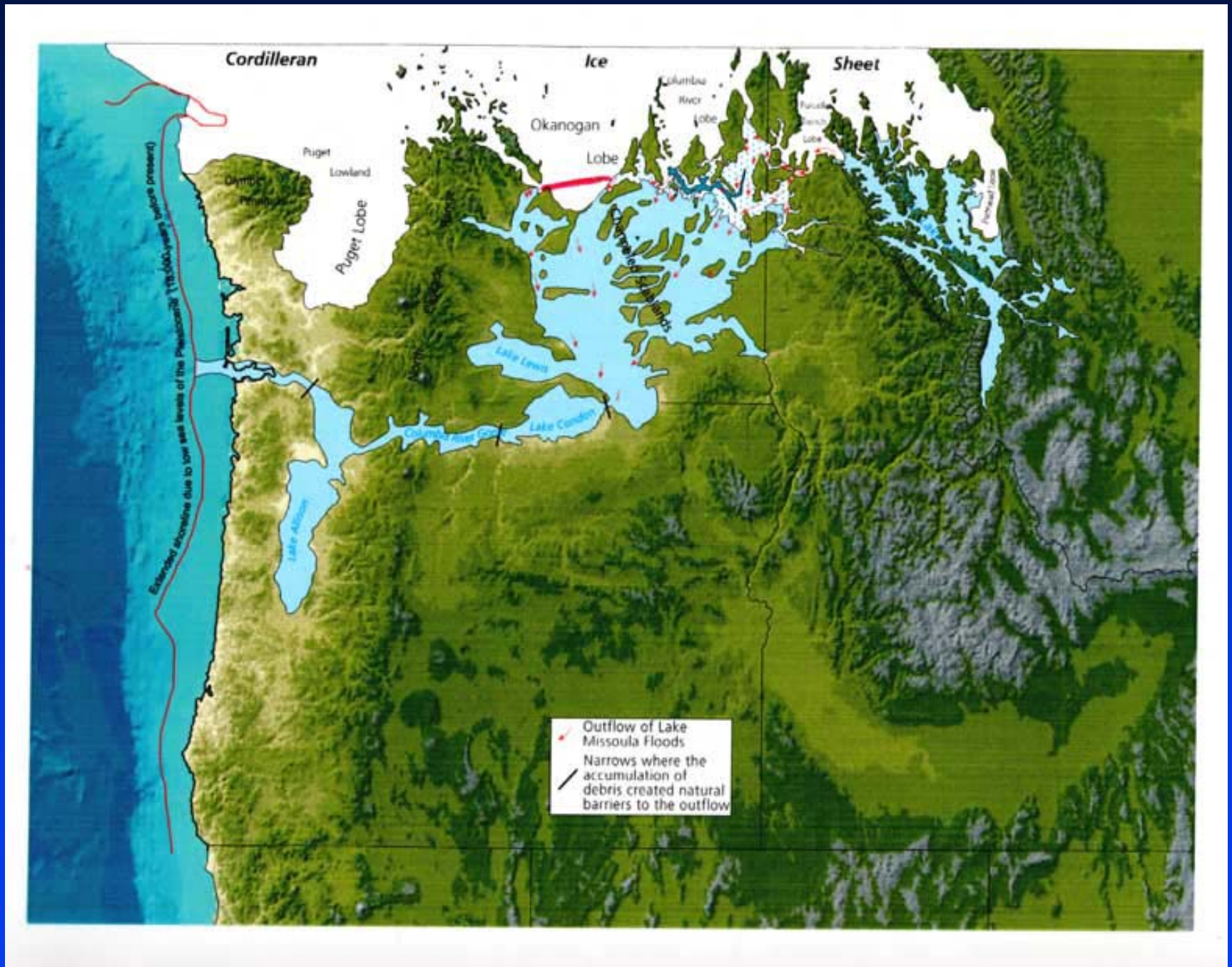


Chinook CA-BC



Waples et al. 2004

Bretz floods



1950s & 1960s

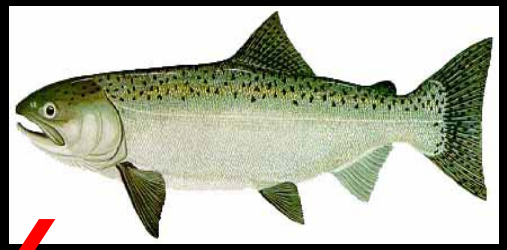
Early research on survival and migration of Snake River spring Chinook

Smolt traps
Freeze brands
Acoustic tags

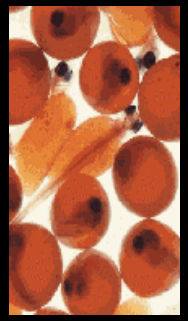
Snake River Spring/Summer Chinook Life Cycle

Kareiva et al. 2000 *Science*

2 spawners



4,000-5,000 eggs



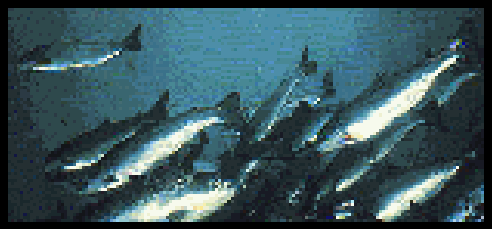
97% mortality

120-151 1-year-olds to Lower Granite Dam

95-119 Migrants Below Bonneville Dam (77% transported, 23% in River)

20%

4-5 Youngsters To 3rd Birthday (Estuary & Ocean)



96%

2-3 Adults return to mouth of Columbia

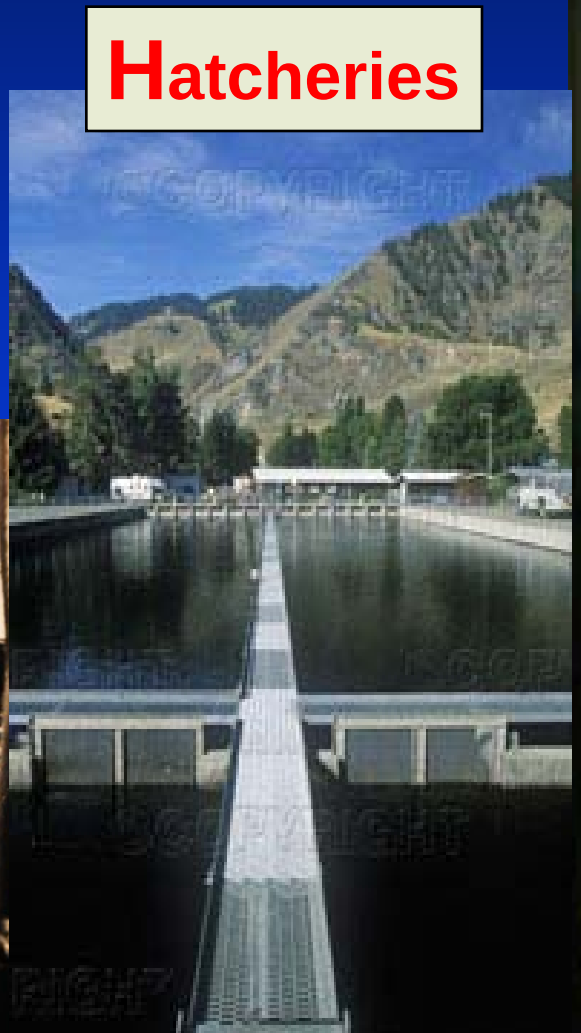
45%

1-1.4 Migrants return to spawning grounds

52%


"It's not my fault"
Agriculture
Commercial Fishing
Sport Fishing
Timber
Ranching
Mining
Hydropower

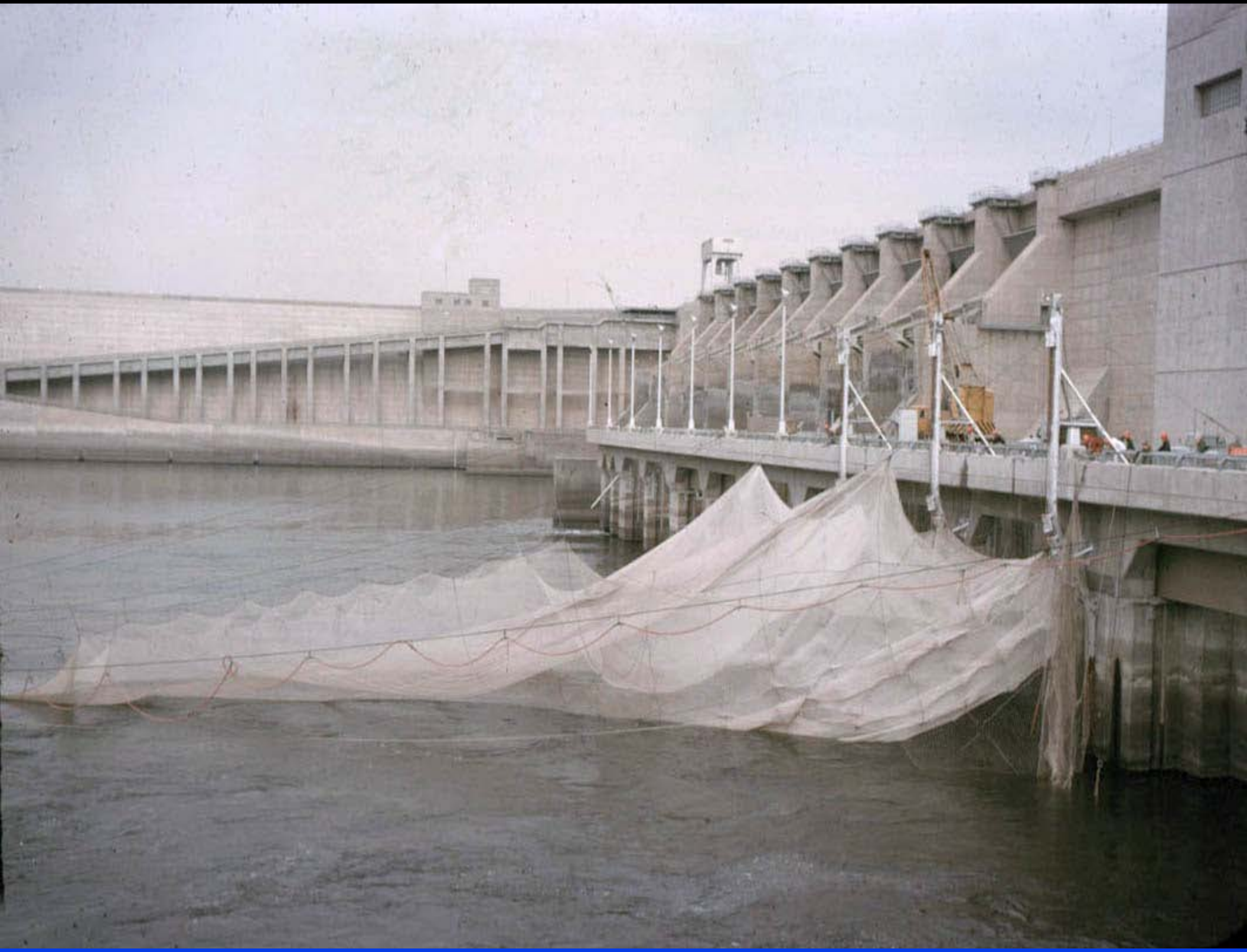
The usual suspects



1960s fish passage research

- Can turbines be made safe for fish?
- Screen turbines and bypass fish
- Transport fish around dams

Hydro




LGD cerca 1975

Snake River spr/sum Chinook Fraction transported

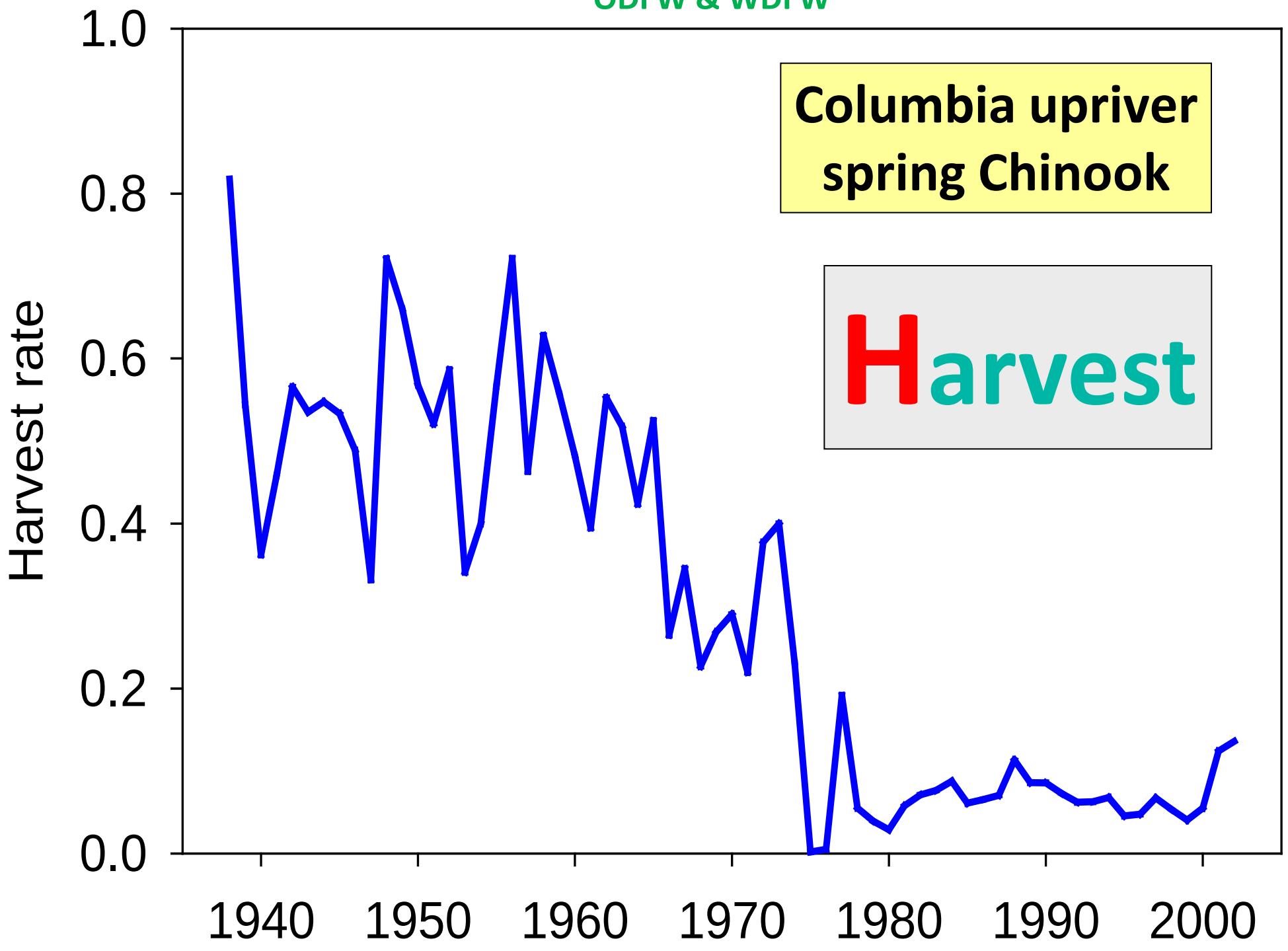
- 1977: all they could collect
- 1980s–1990s: 80-90%
- Since 2005 (remand): 25-40%

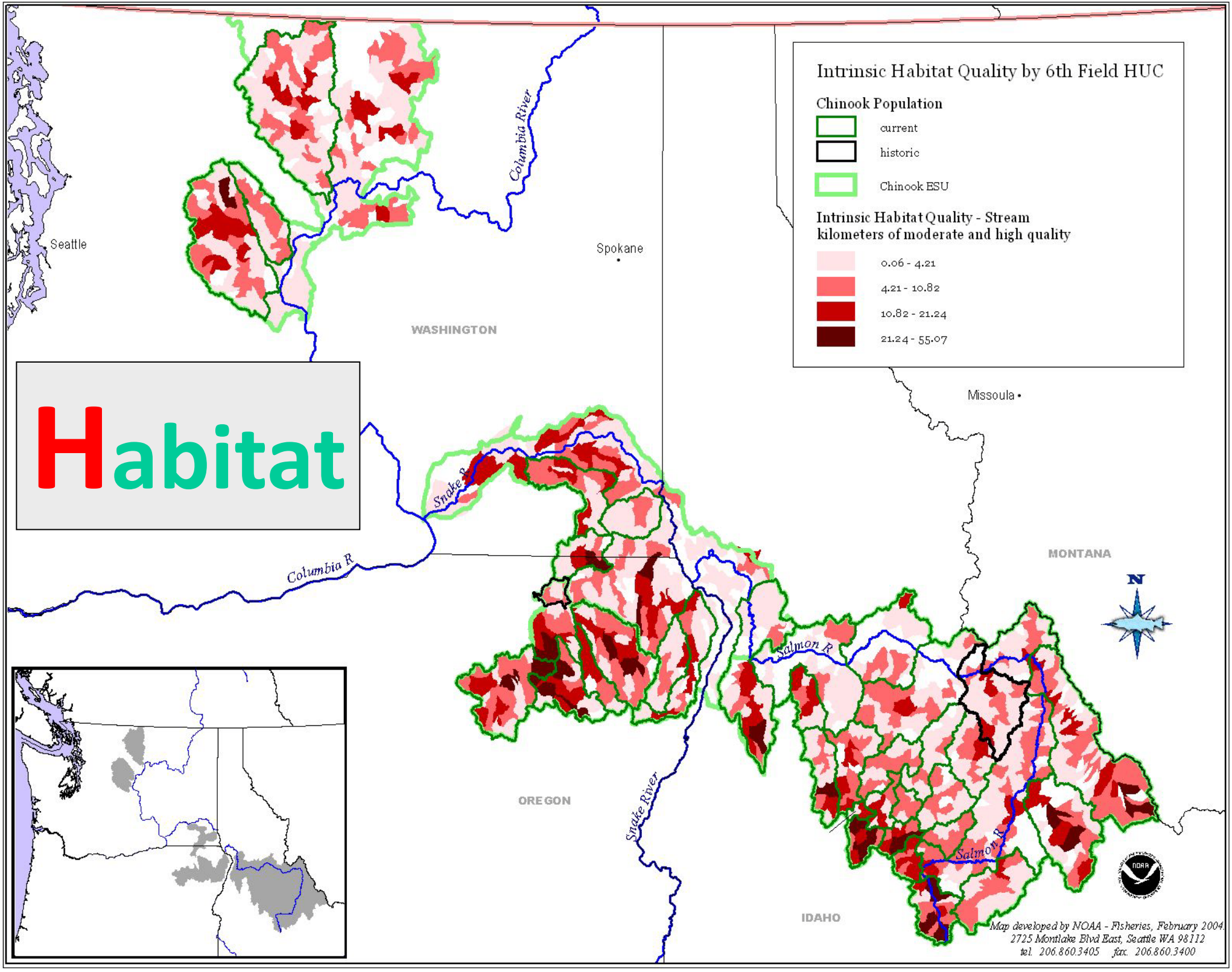
Substantial transport benefits for

- Fall chinook
- Steelead
- [Hatchery spr/sum Chinook]

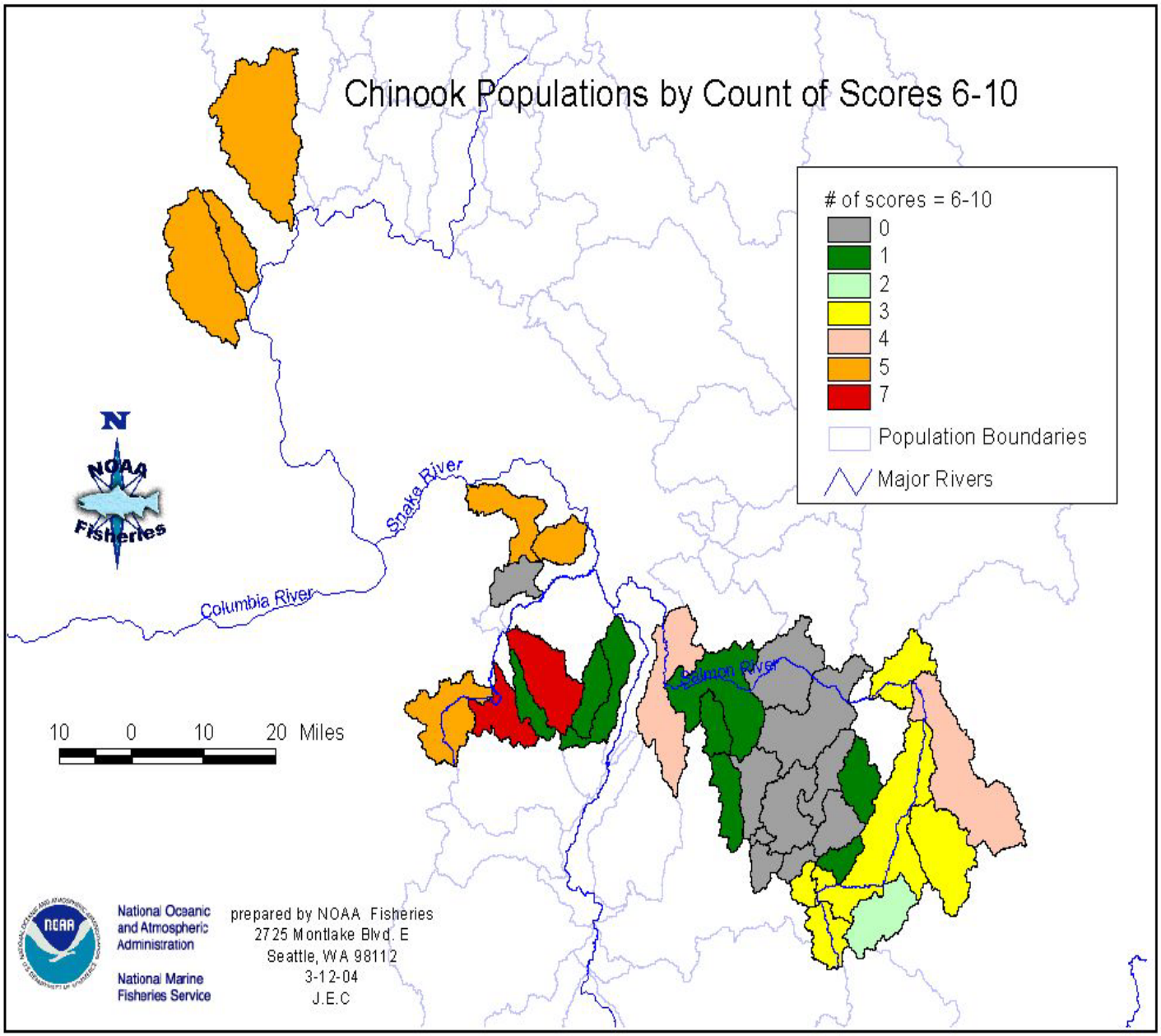
Uncertain benefits for W spr/sum except during low flow years

Source: Status Report, Columbia River Fish Runs and Fisheries, 1938-2002. ODFW & WDFW

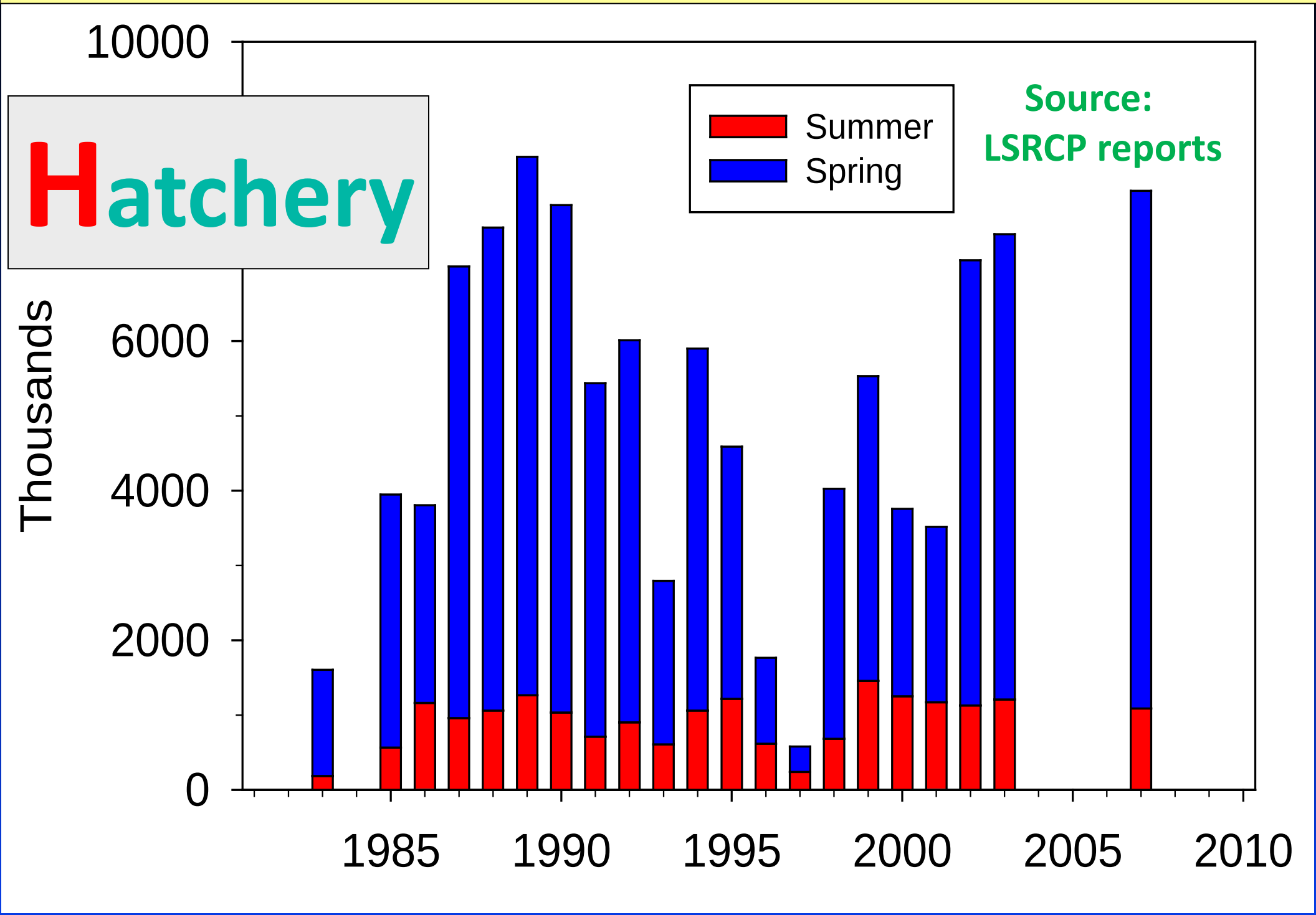


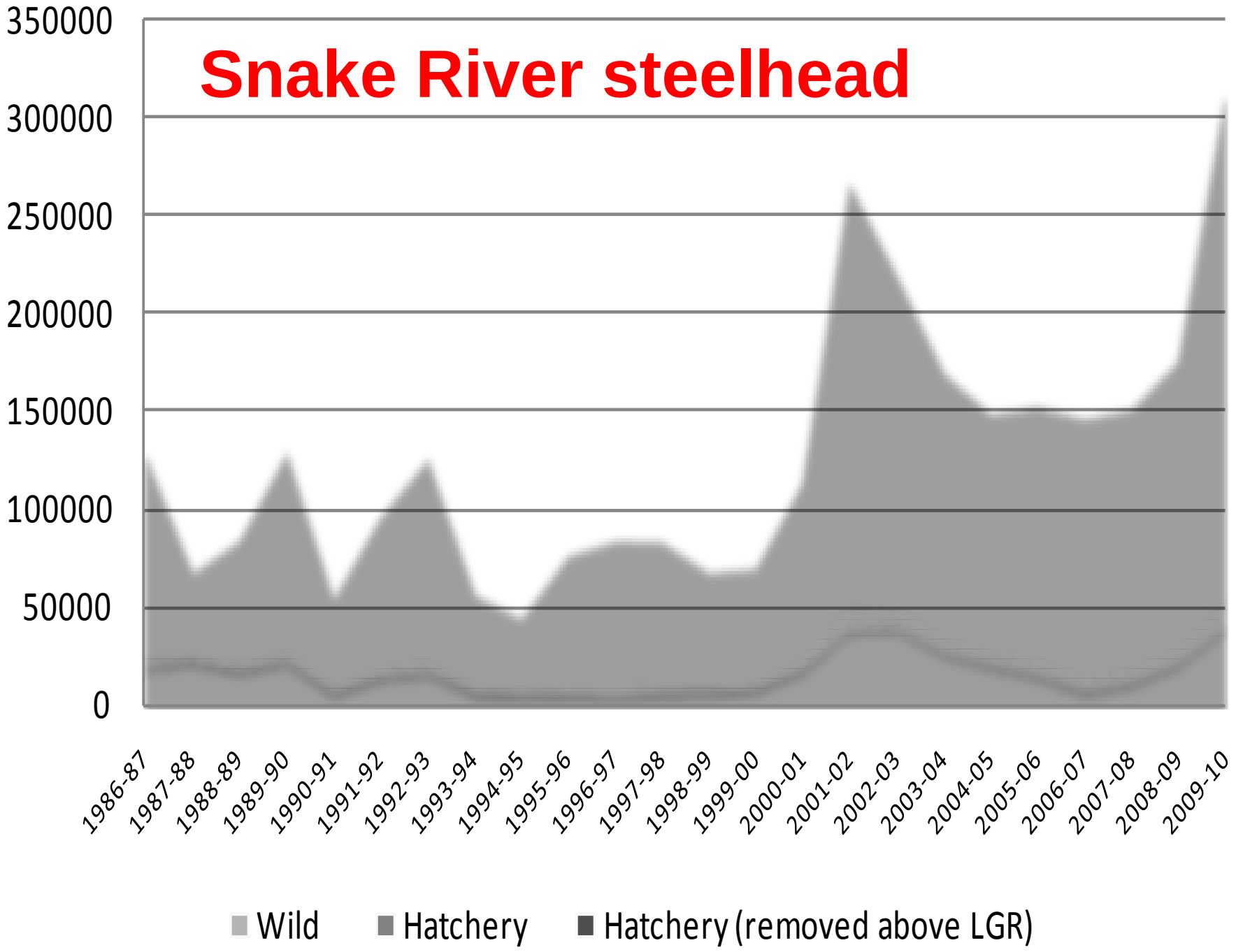

Intrinsic Habitat Quality by 6th Field HUC
Chinook Population
current
historic
Chinook ESU
Intrinsic Habitat Quality - Stream
kilometers of moderate and high quality
0.06 - 4.21
4.21 - 10.82
10.82 - 21.24
21.24 - 55.07
Habitat
Seattle
Spokane
Missoula
Columbia River
Snake R
Columbia R
Salmon R
Salmon River
WASHINGTON
OREGON
IDAHO
MONTANA
N
Map developed by NOAA - Fisheries, February 2004
2725 Montlake Blvd East, Seattle WA 98112
tel. 206.860.3405 fax. 206.860.3400

Cumulative impacts -- moderate and extreme

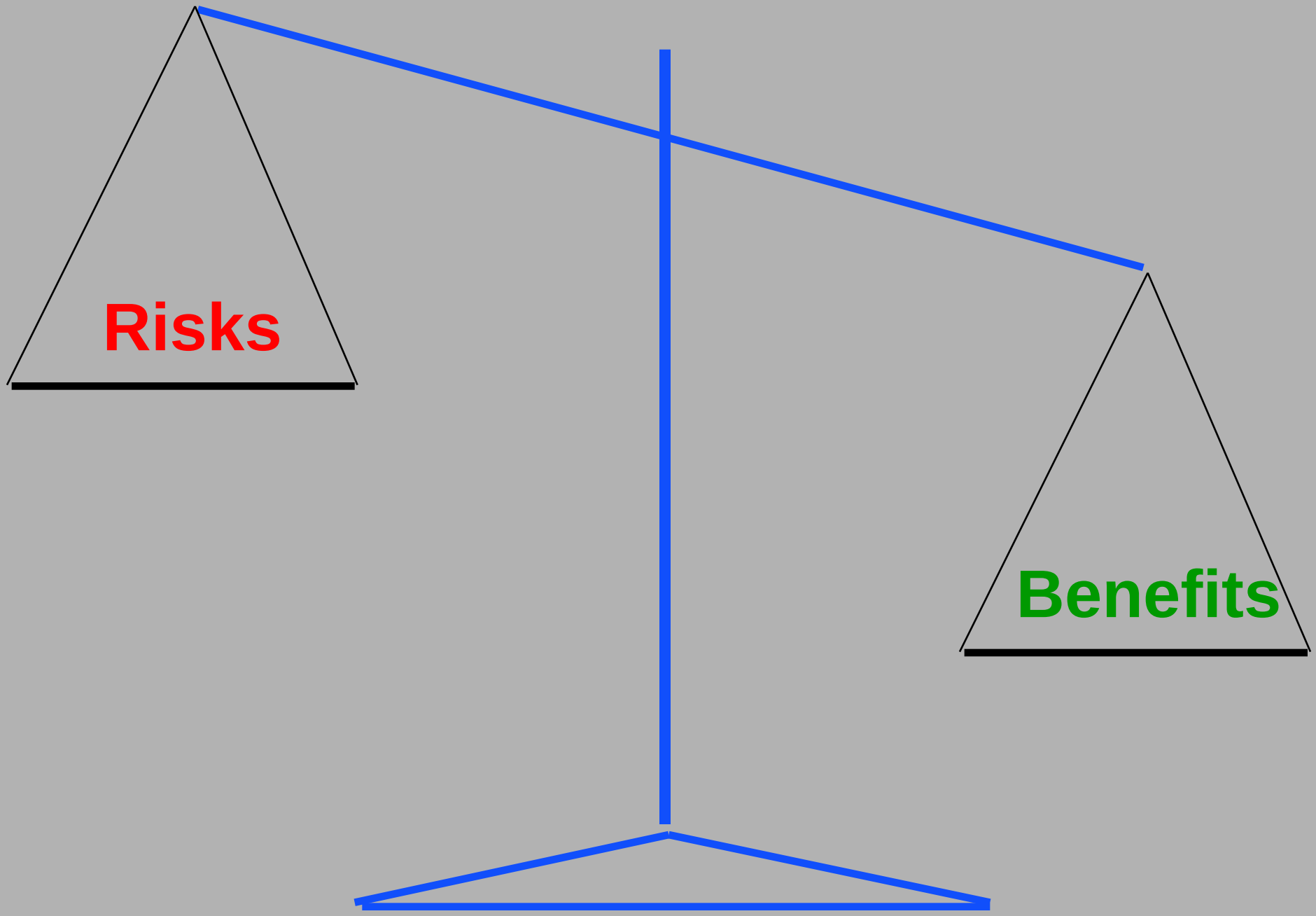


Snake River Chinook hatchery releases (incl presmolts)





T. Cooney, unpublished LSRCP and IDFG data


Risks
Benefits

Types of benefits to be considered

Conservation	General
• Natural pops	• Natural pops • Harvest • Mitigation • Treaty obligations • Public education

Potential benefits of propagation for natural populations

1. Reduce short-term extinction risk
2. Maintain population while habitat problems are addressed
3. Reseed vacant habitat
4. Speed recovery

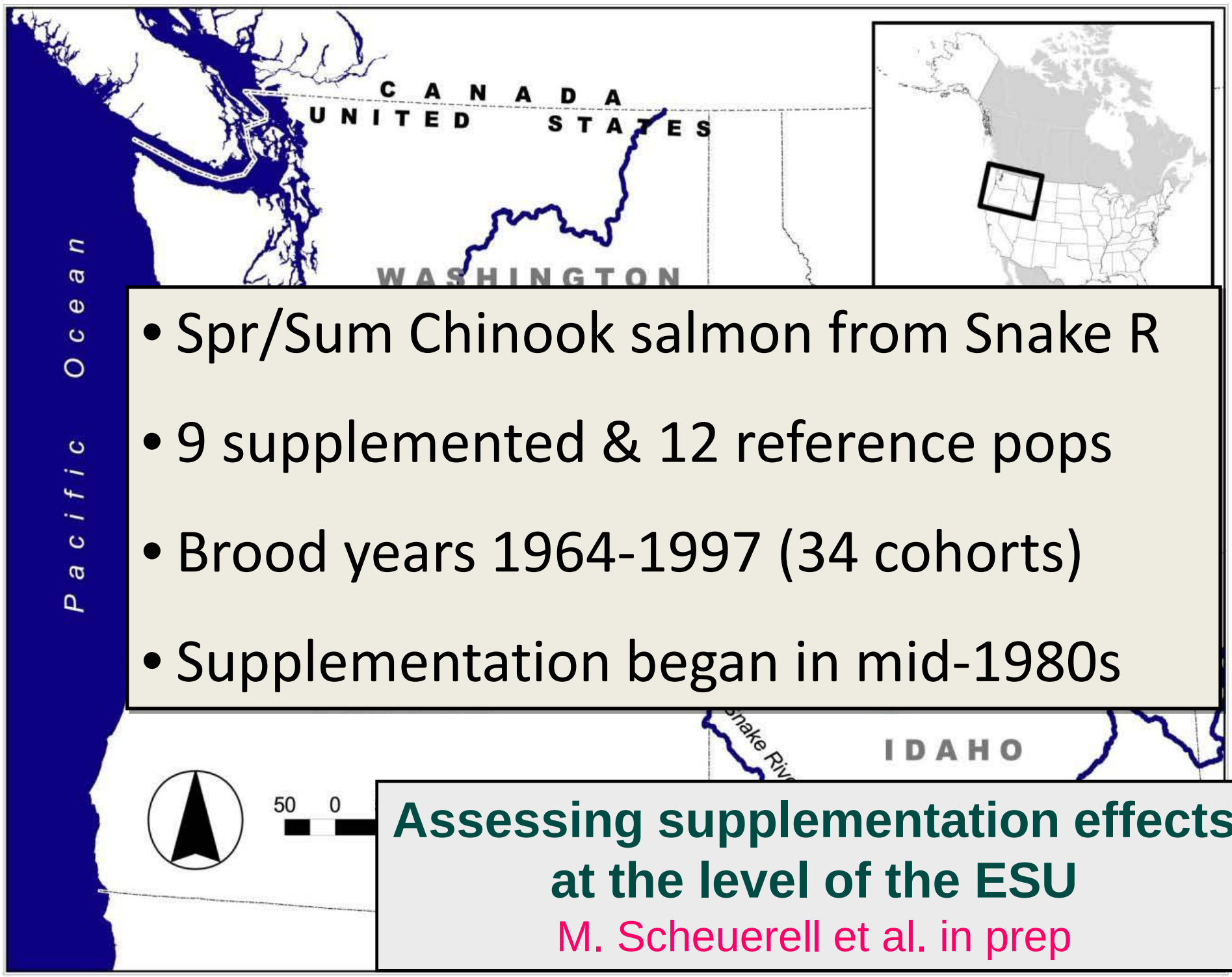
Risks of captive propagation for natural populations

1. Loss of diversity
   - Between populations
   - Within population
2. Loss of fitness
3. Ecological effects
4. Other considerations

Salmon supplementation review

Waples, Ford, Schmitt 2007

Objective	Was it met? Y	N	?
Broodstock collection (representative)			
Age	11	3	8
Run timing	10	2	10
Integrity	17	5	-
Hatchery survival			
Prespawning (90%)	12	6	4
Egg-smolt (70%)	19	2	1
Adult-adult (2x)	12	4	6
Population increase (20%)	8	11	3
Natural spawning (comparable)	1	2	19
Sustainable	-	2	20



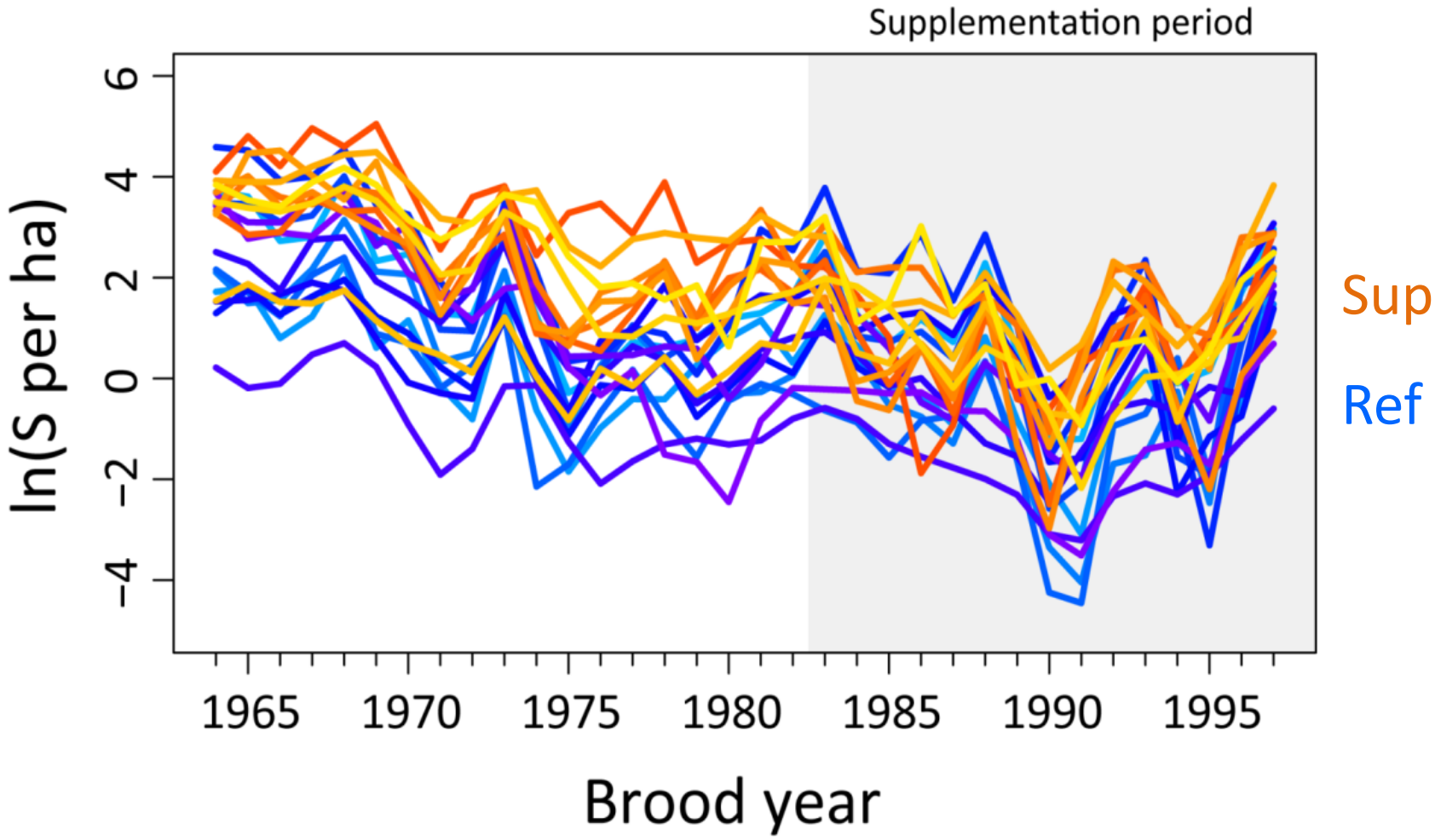
- Spr/Sum Chinook salmon from Snake R
- 9 supplemented & 12 reference pops
- Brood years 1964-1997 (34 cohorts)
- Supplementation began in mid-1980s

Assessing supplementation effects at the level of the ESU

M. Scheuerell et al. in prep

Map by Blake Feist

Time series of wild spawners



M. Scheuerell et al. in prep

Model from the finance world

Advertising effect

State equation

$$x_t = x_{t-1} + \underbrace{\alpha + \beta I_t}_{\text{rate of change in market}} + w_t \qquad w_t \sim N(0,Q)$$

Model for supplementation effect

Supplementation effect

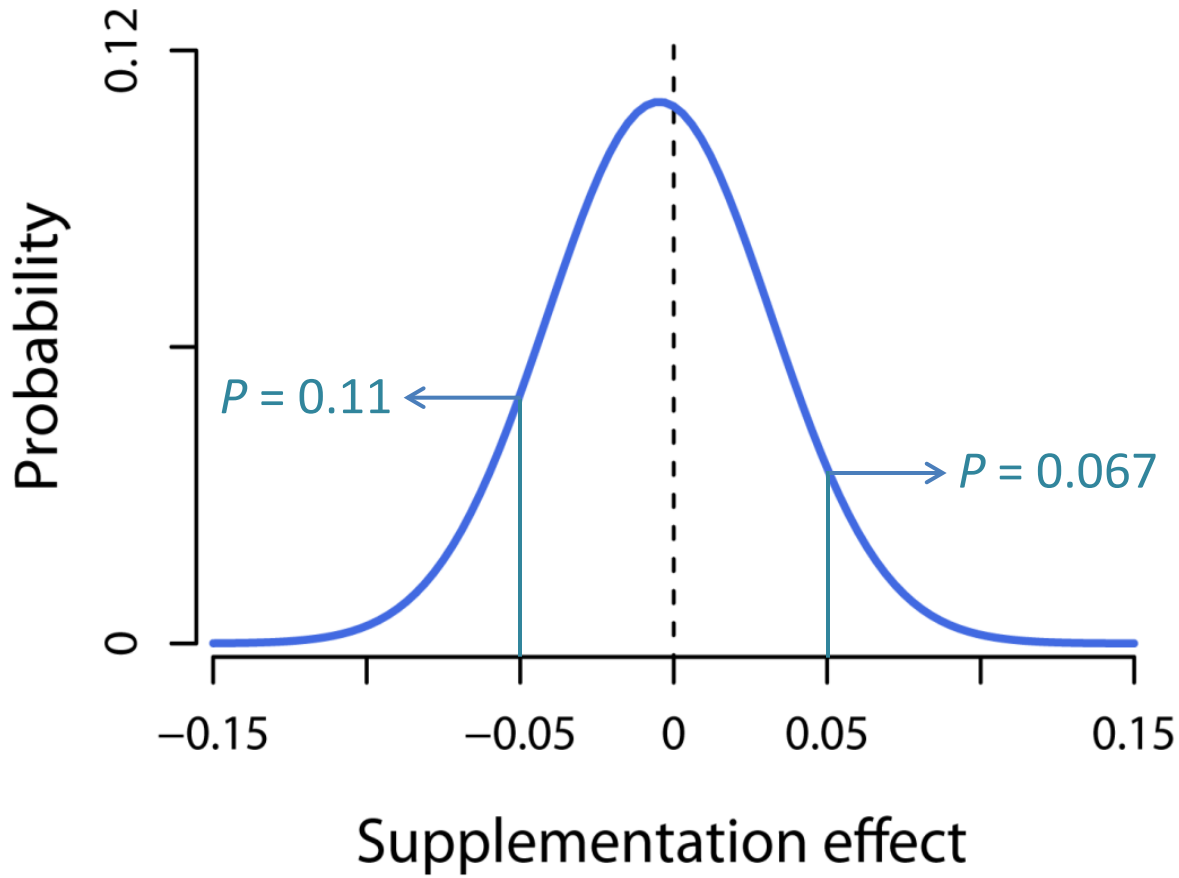
State equation

$$x_t = x_{t-1} + \underbrace{\alpha + \beta I_t}_{\text{rate of change in density}} + w_t \qquad w_t \sim N(0,Q)$$

M. Scheuerell et al. in prep

Results: Not much effect overall

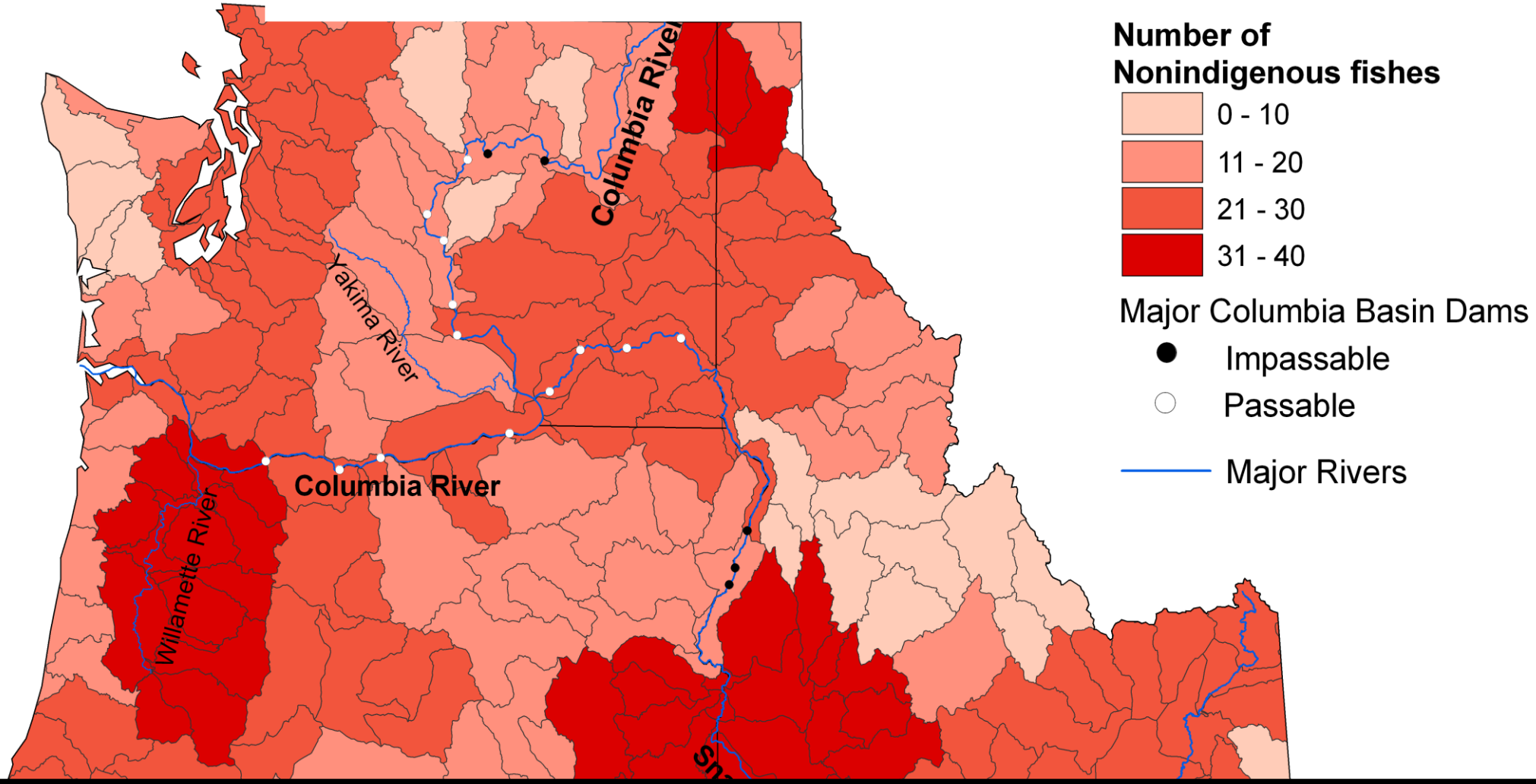
Annual change: $\alpha + \beta I_t$



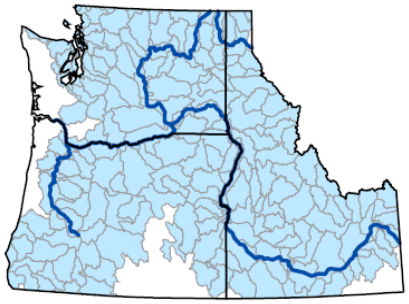
M. Scheuerell et al. in prep

Nonindigenous fish species

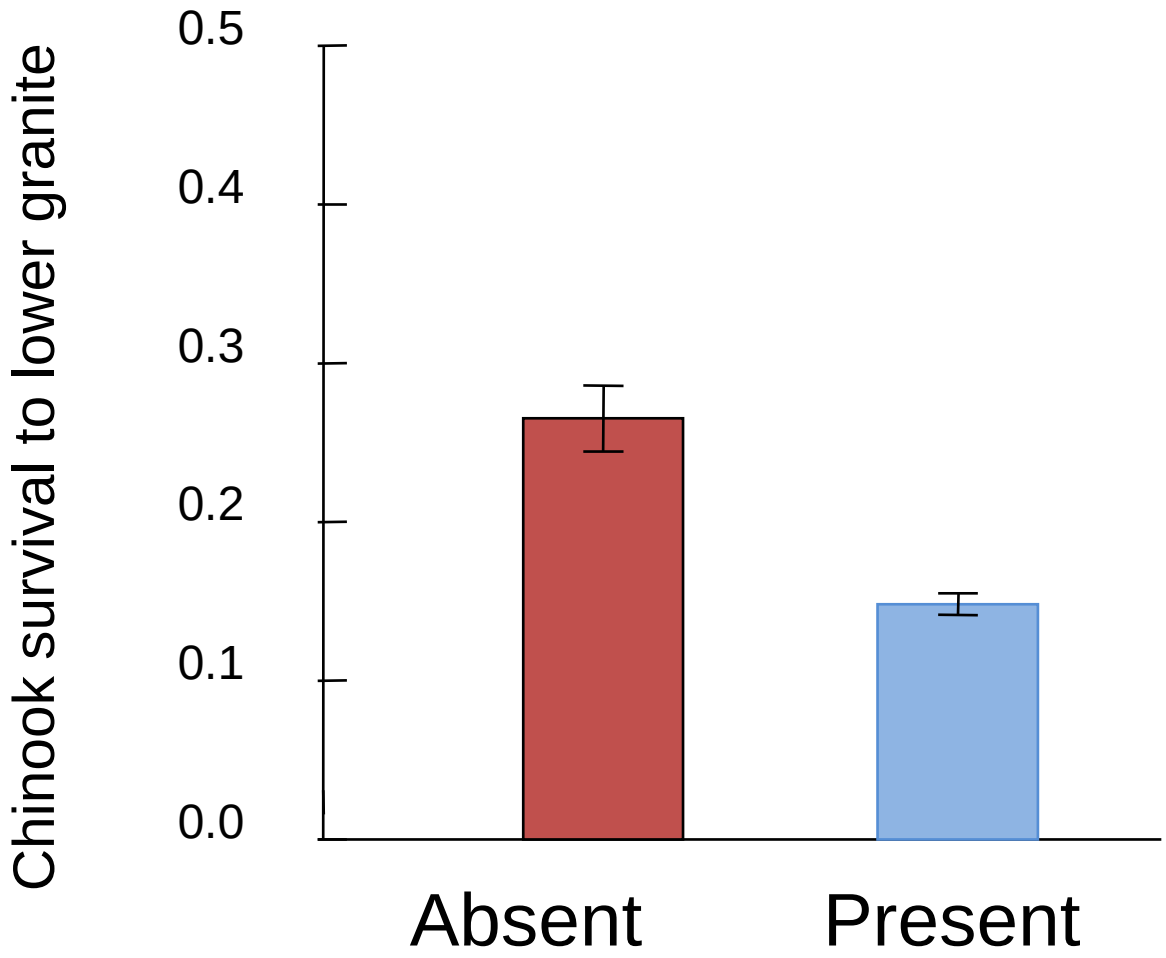
The 5th H



Sanderson, Barnas and Rub 2009

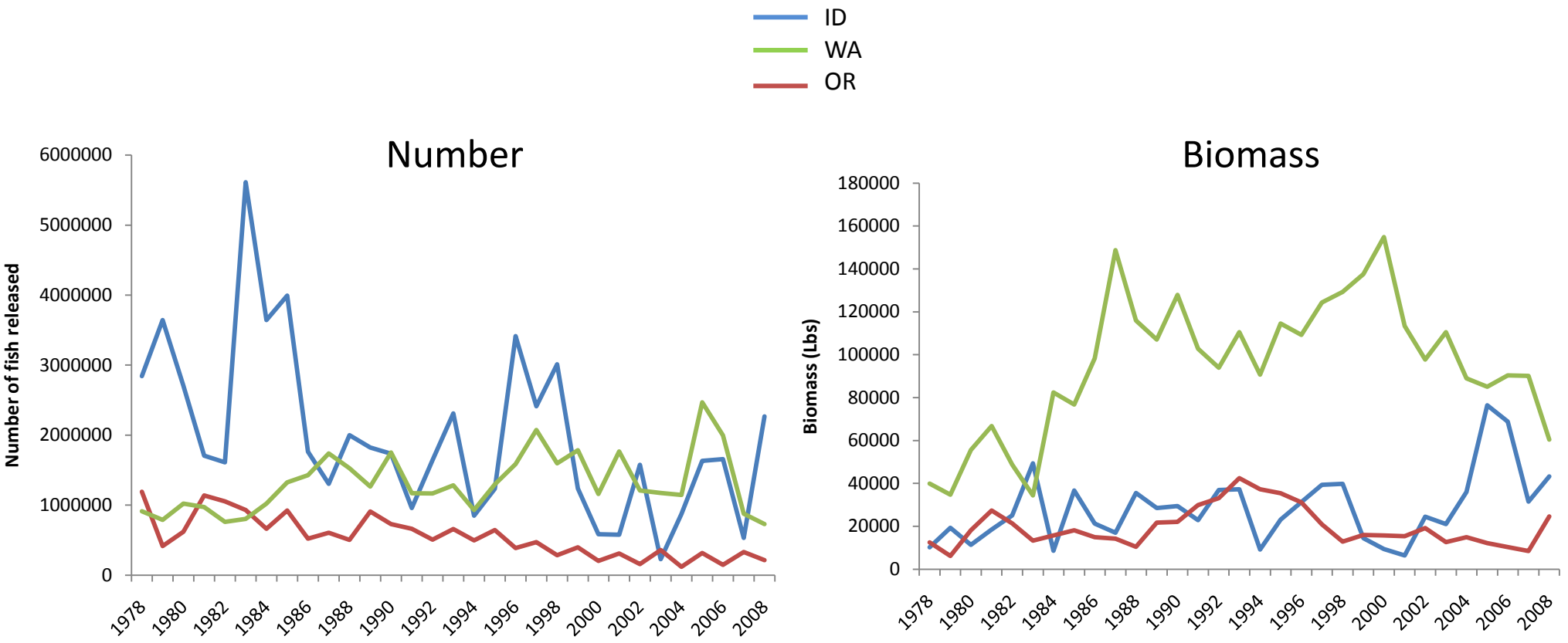


Brook trout



Levin, Achord, Feist,& Zabel. 2001

Nonnative stocking (1978-2008)



B. Sanderson

VIABLE SALMONID POPULATIONS

- Identify population structure within ESUs
- Assess population viability
  - Abundance
  - Productivity
  - Spatial structure
  - Diversity (genetic and life history)
- Assess ESU viability

McElhany et al. 2000 *Tech Memo*

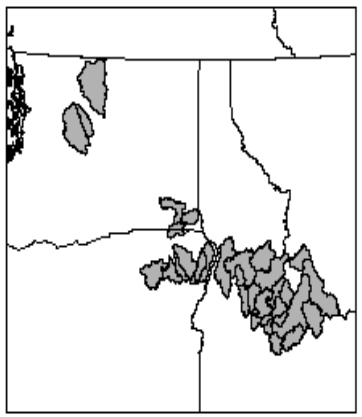
Interior Columbia Spring/Summer Chinook

Number of VSP Impairments

River
1
2
3
4

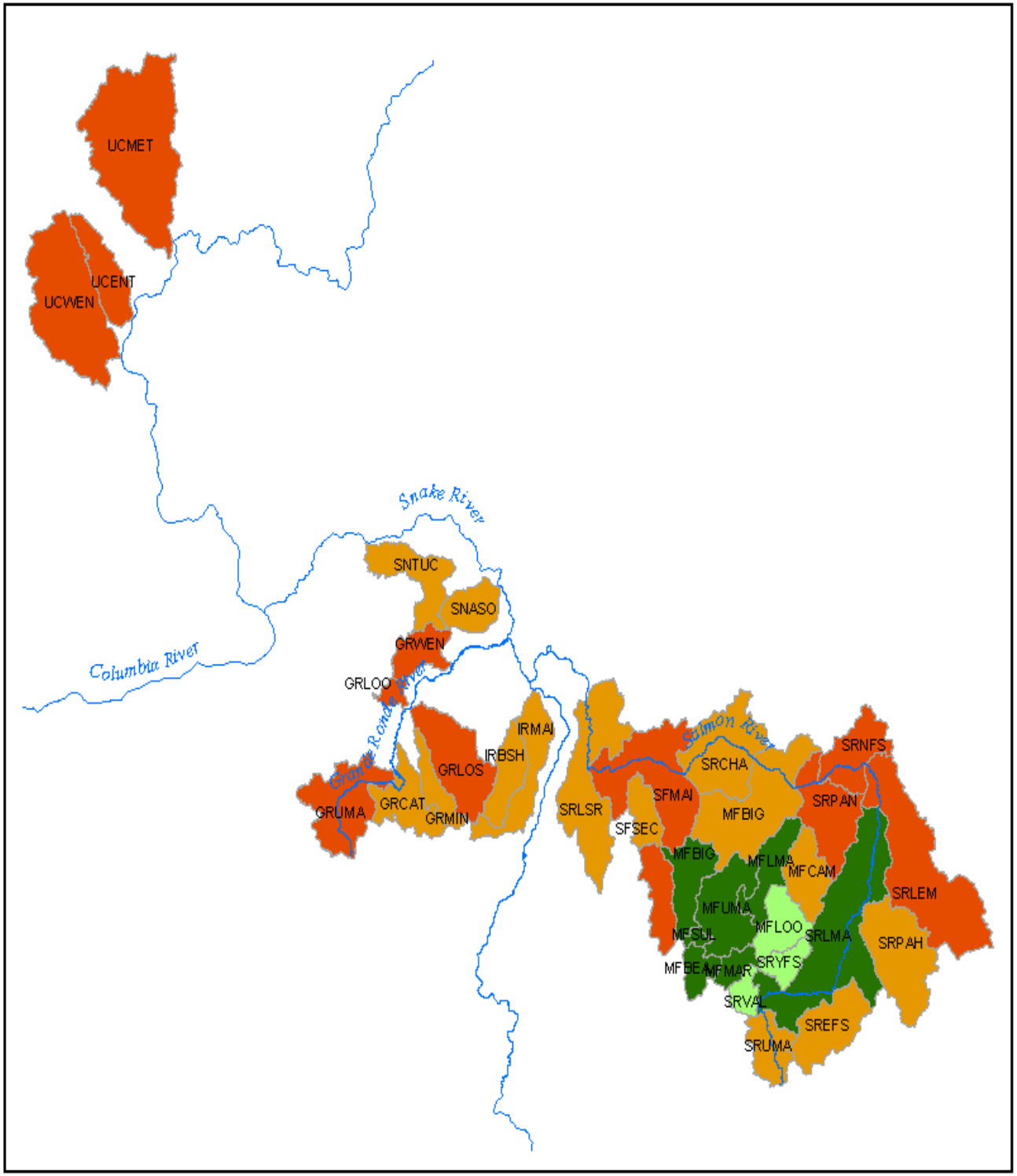
0 37.5 75 150
Kilometers

N

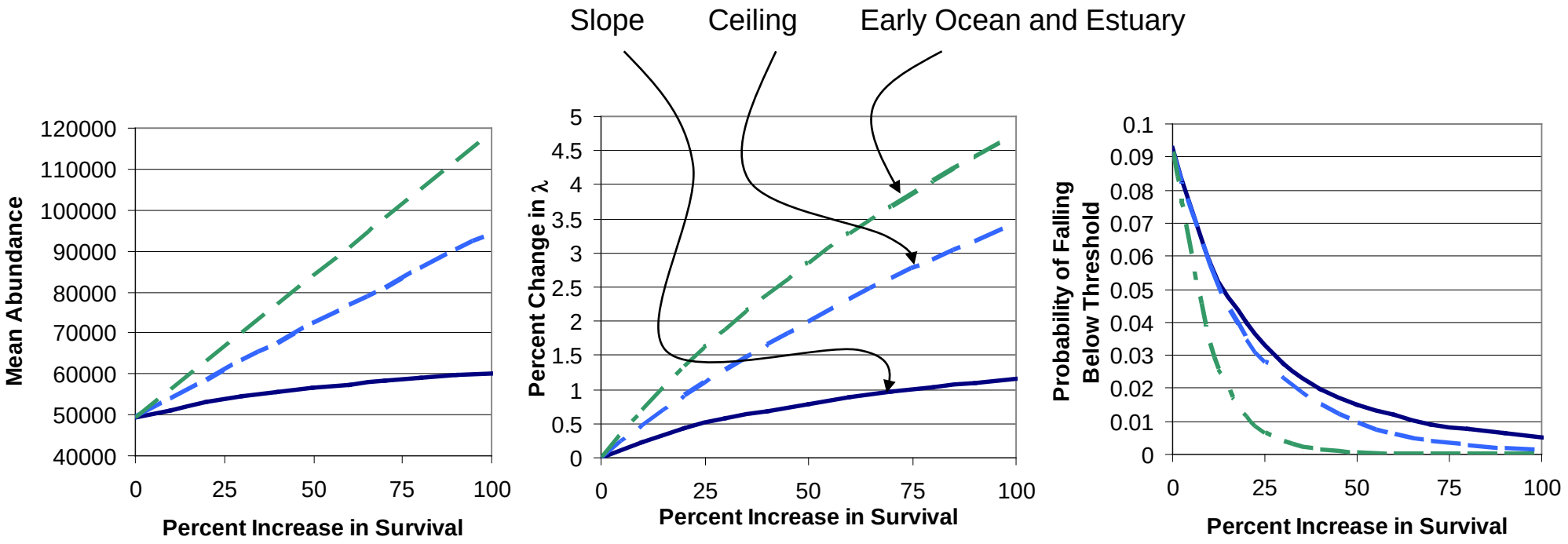


National Oceanic and Atmospheric Administration

National Marine Fisheries Service



Trade-off – freshwater vs. estuary/early ocean (and biological feasibility)

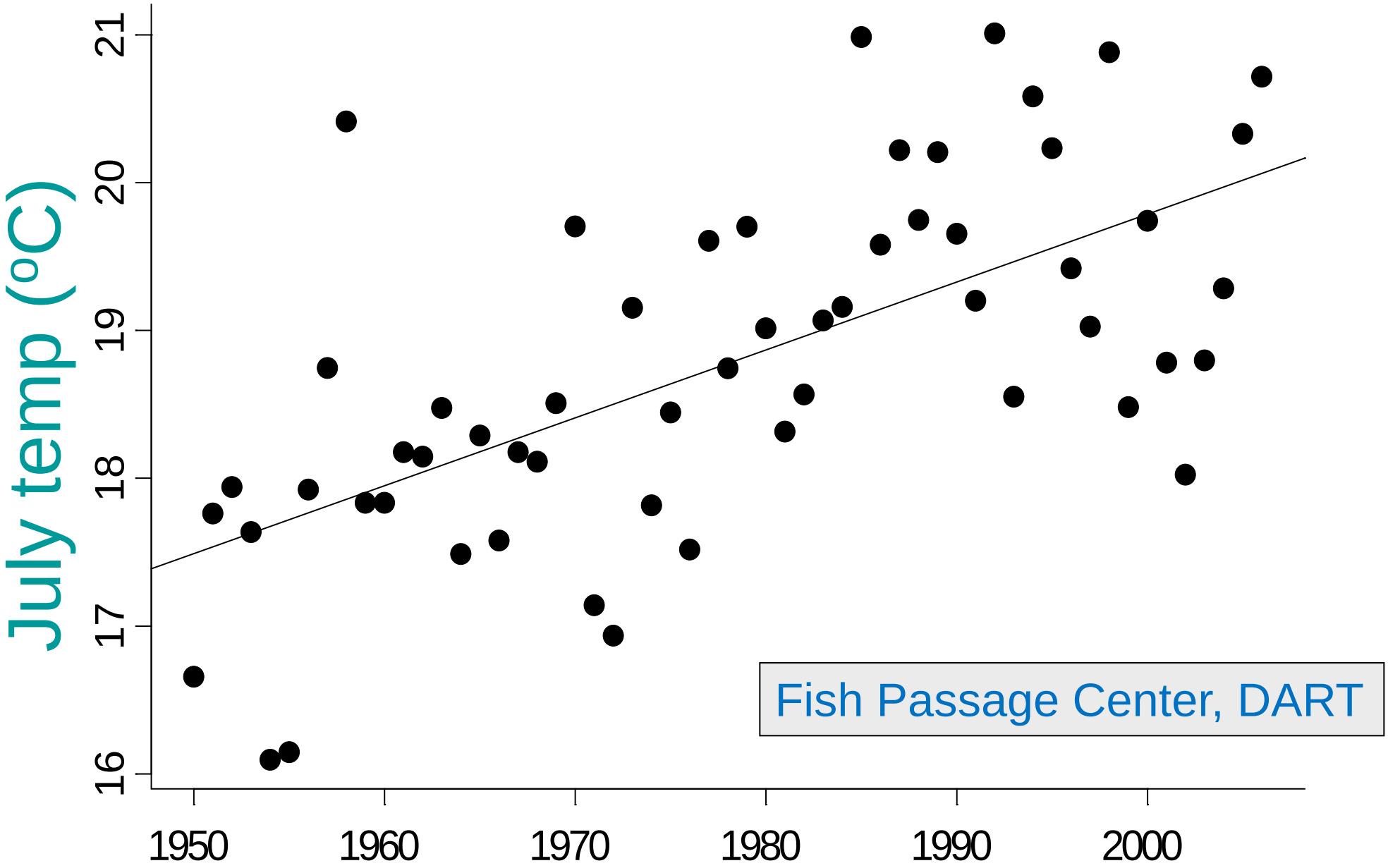


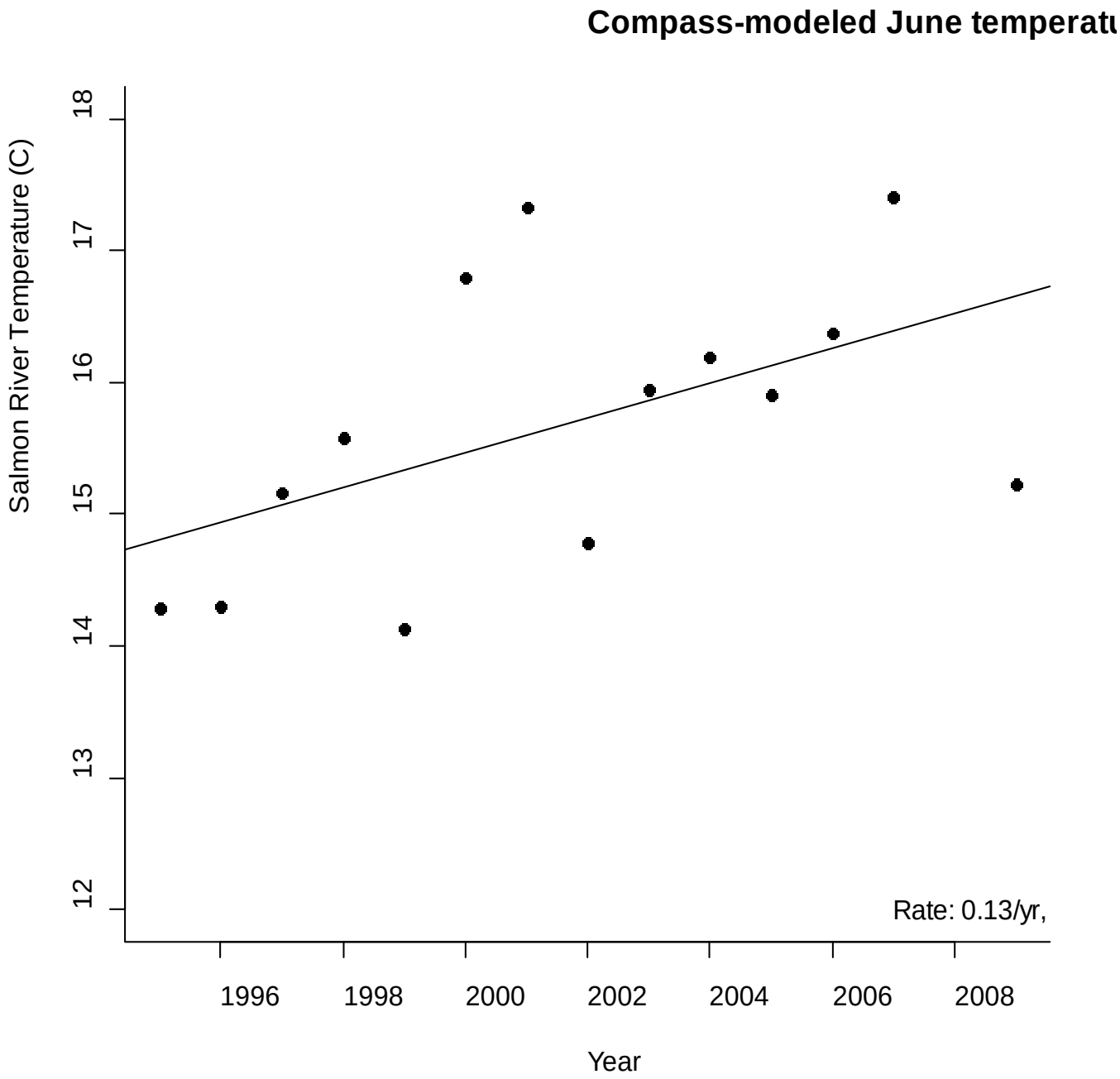
Zabel et al. 2006 *Con Biol.*

What about the future?

- Climate change
- Population growth
- Evolutionary responses to human-modifications to salmon ecosystems

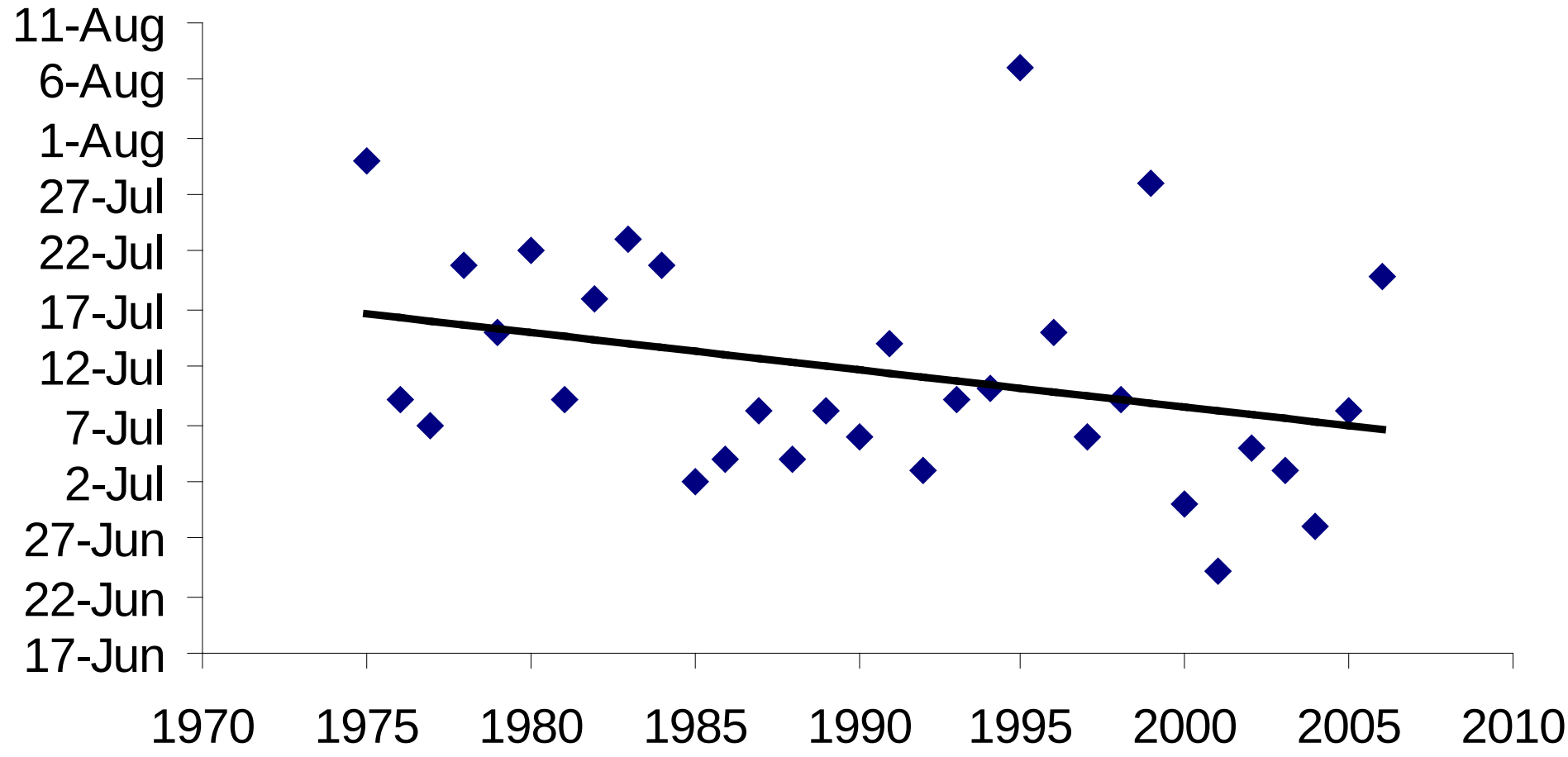
Columbia River at Bonneville



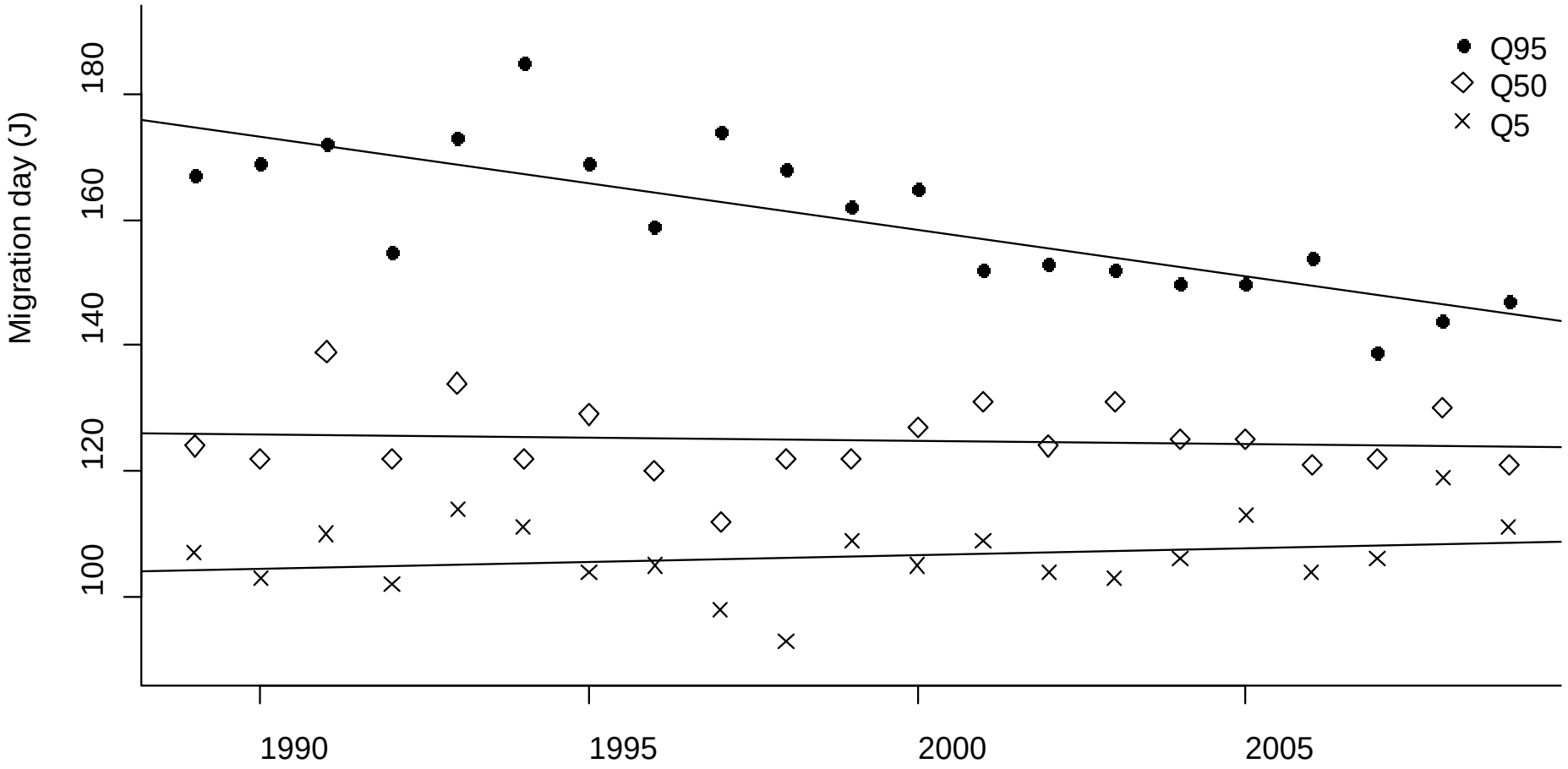


J. Faulkner, unpublished data

Spring/summer adult Chinook passing Lower Granite Dam
95% of the run, with run defined as ending 8/31
rate: -0.32 days/year, p=0.09



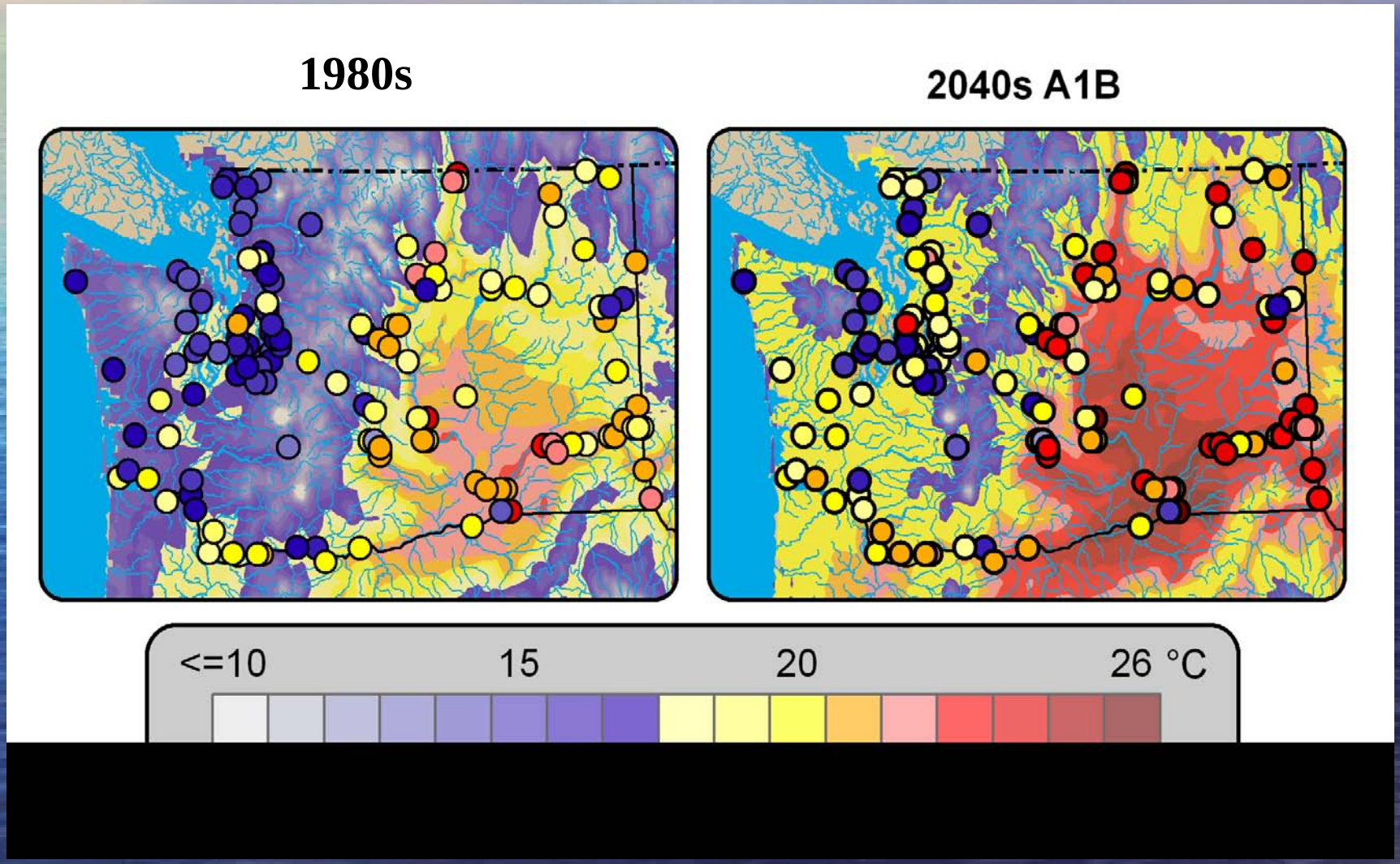
Smolt timing at LGD: upper quantiles now earlier



S. Achord and L. Crozier, unpublished data

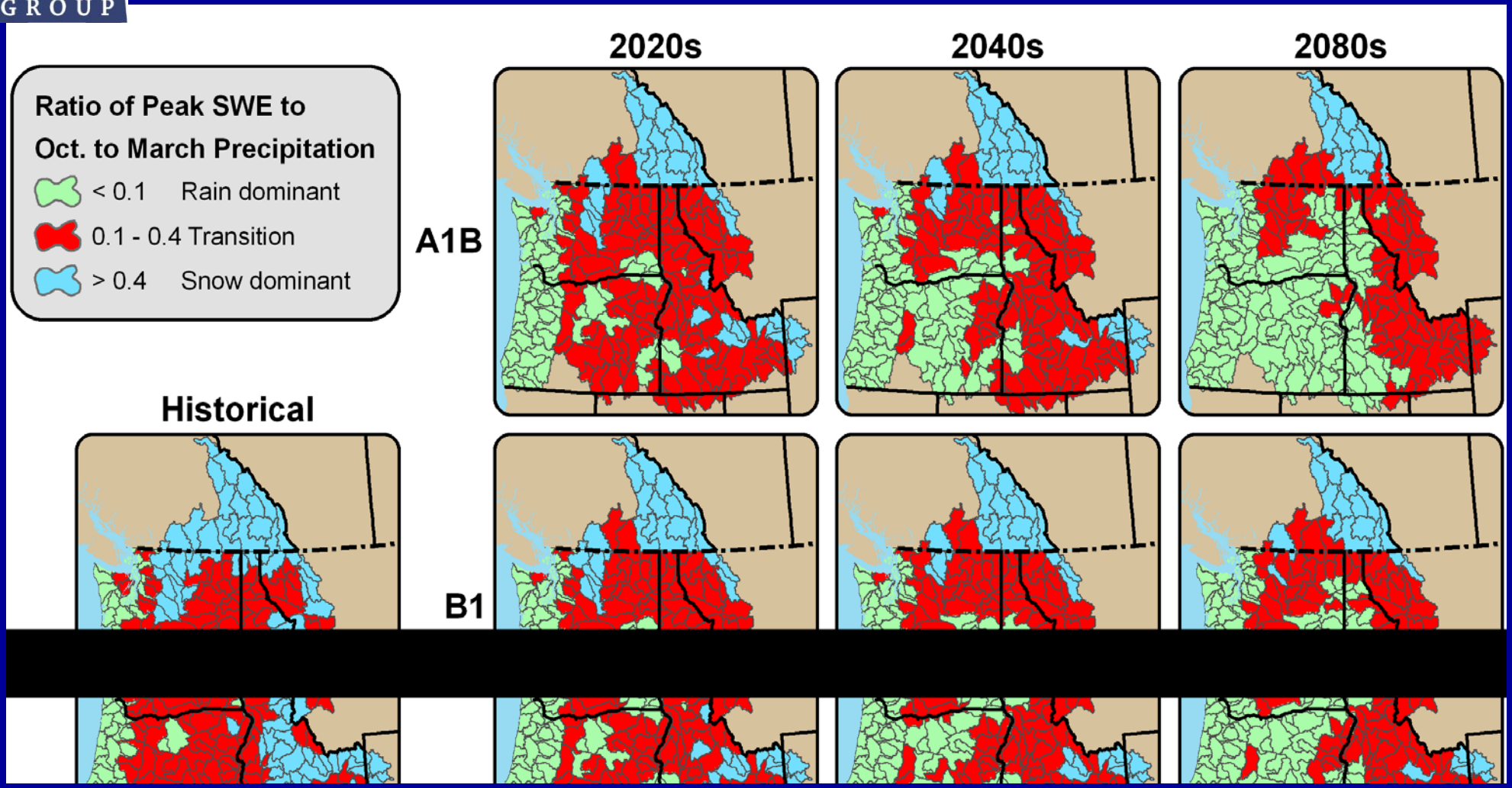
Western Washington: summer climate becomes as warm as today's interior Columbia Basin

Interior Columbia: become as warm as today's Central Valley in California



Mantua et al. 2010: Climatic Change

Transformation From Snow to Rain

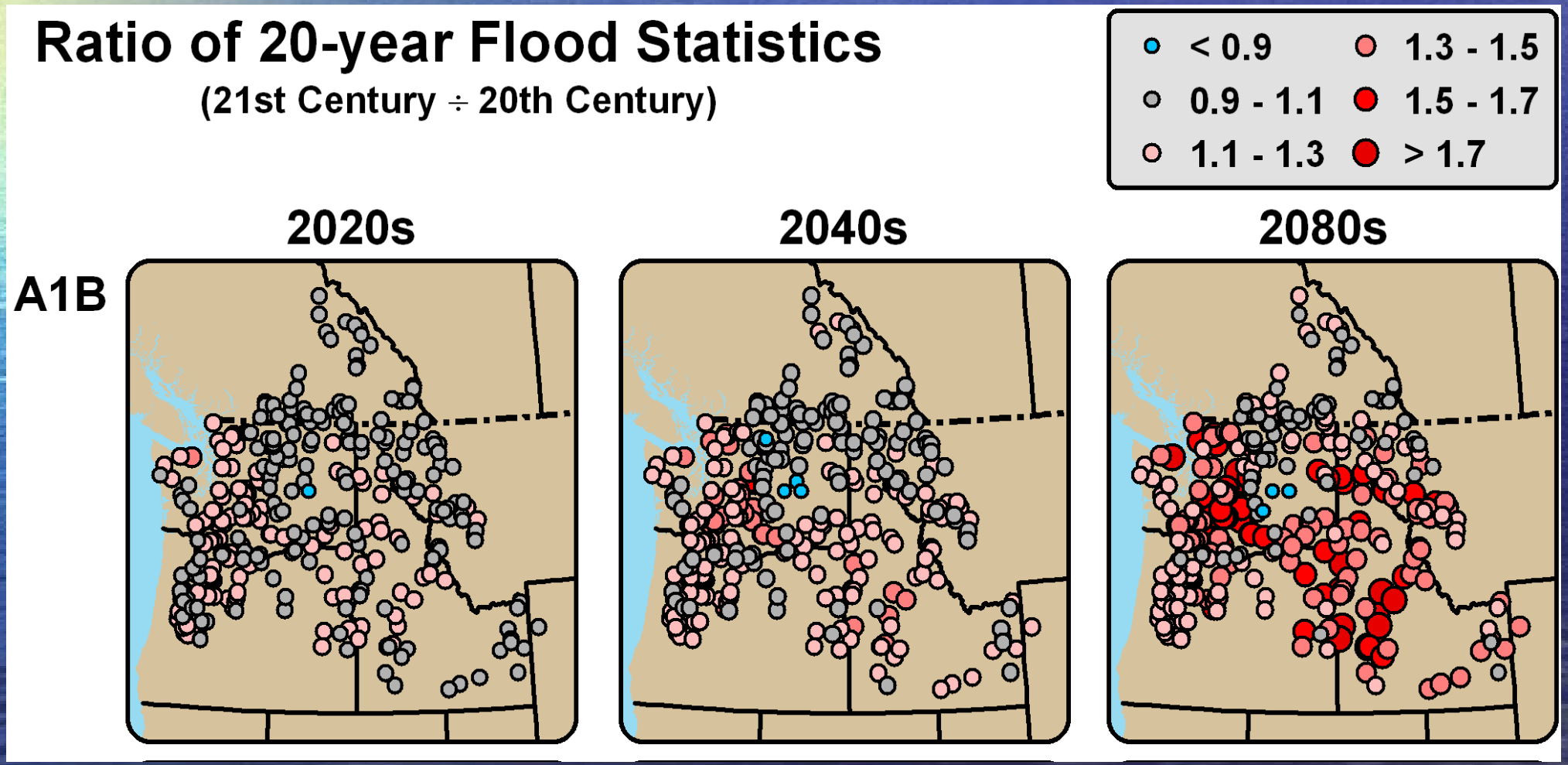


* Based on Composite Delta Method scenarios (multimodel average change in T & P)

Source: Alan Hamlet, Columbia Basin Climate Change Scenarios Project Map: Rob Norheim

Models project **more winter flooding** in sensitive "transient runoff" basins common in eastern OR and Idaho

Would likely reduce survival rates for eggs and parr

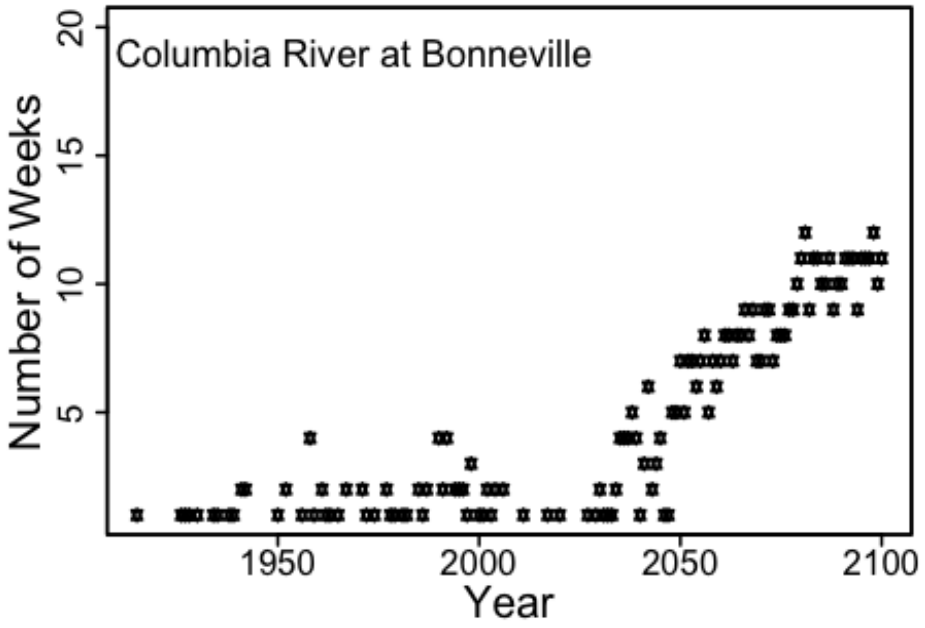


Source: Alan Hamlet, Columbia Basin Climate Change Scenarios Project Map: Rob Norheim

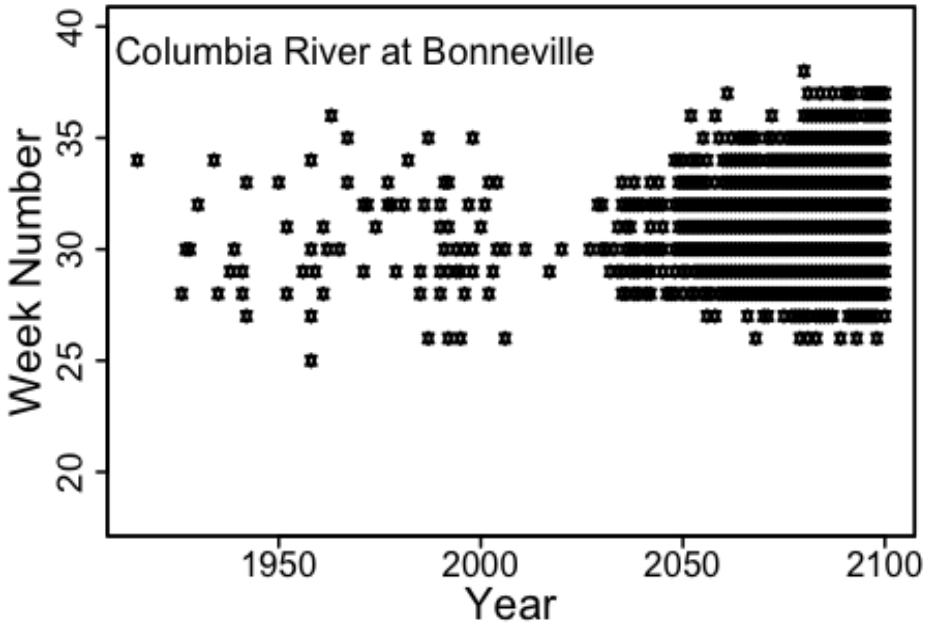
Thermal stress season

Extended periods (up to 12 weeks by 2100) with weekly average water temperatures > 21C

Number of weeks T > 21C



Weeks with T > 21C

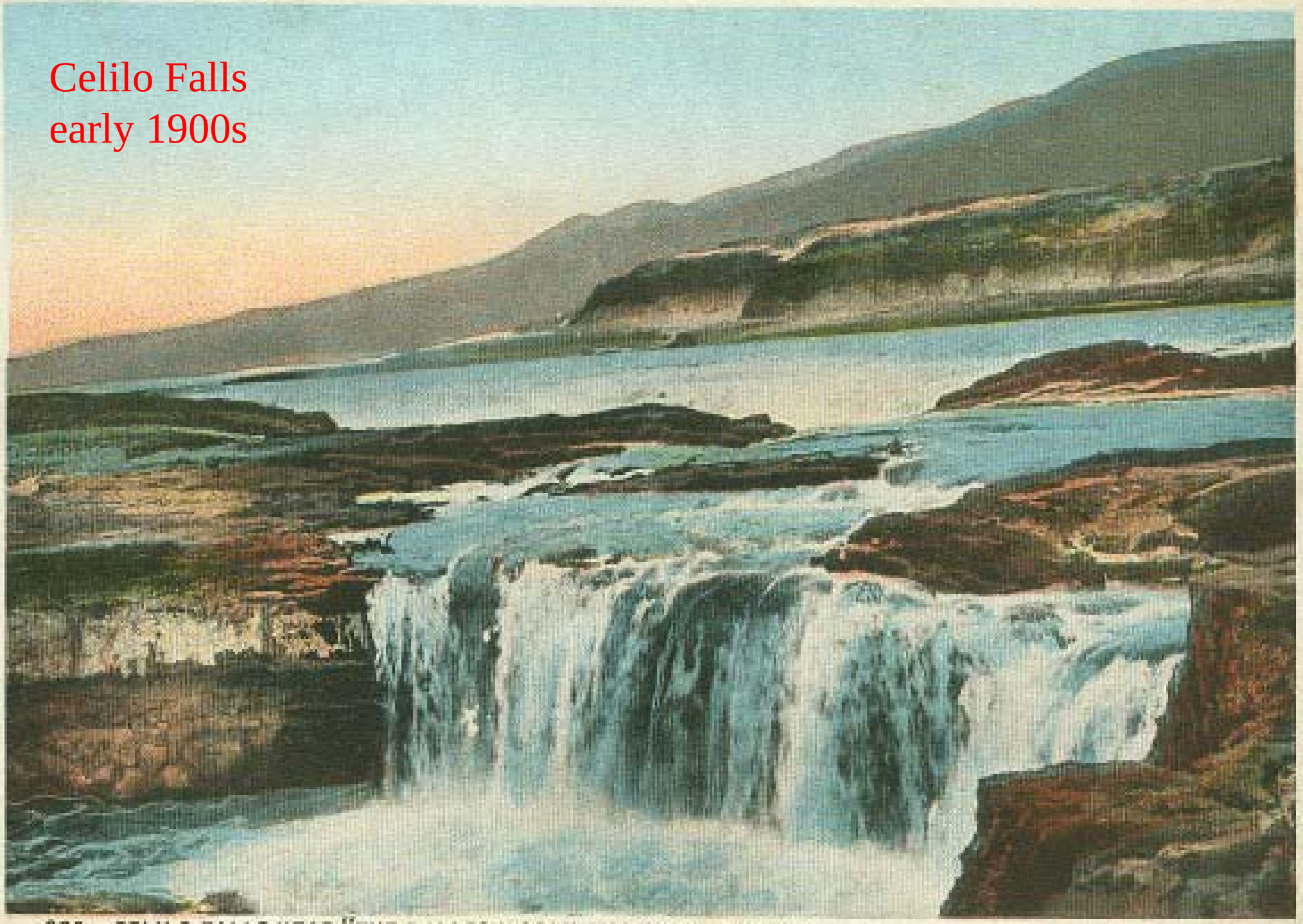


Mantua et al. 2010: Climatic Change

It's not only *how many* fish survive,

but *which* ones survive

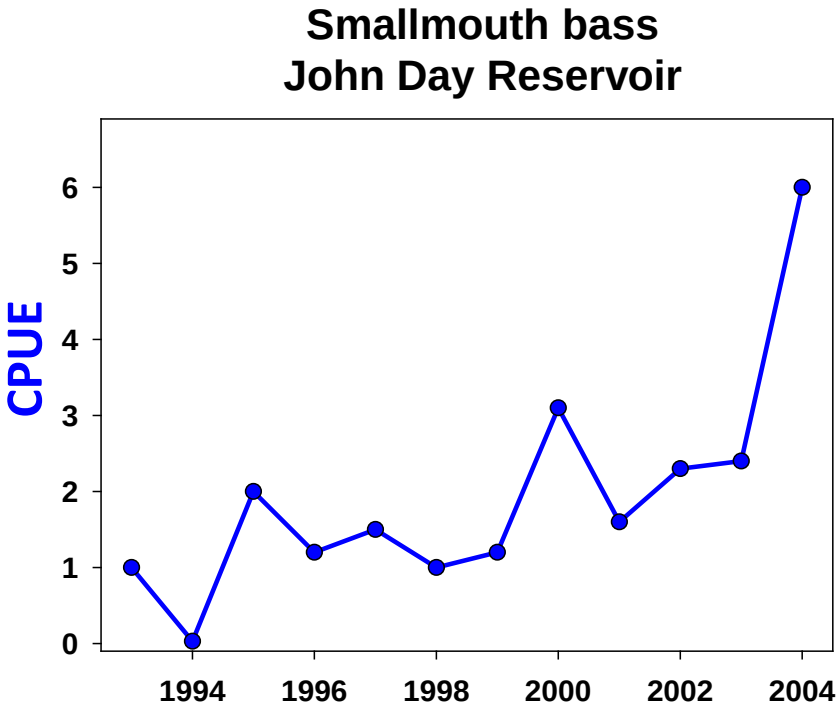
A sympo

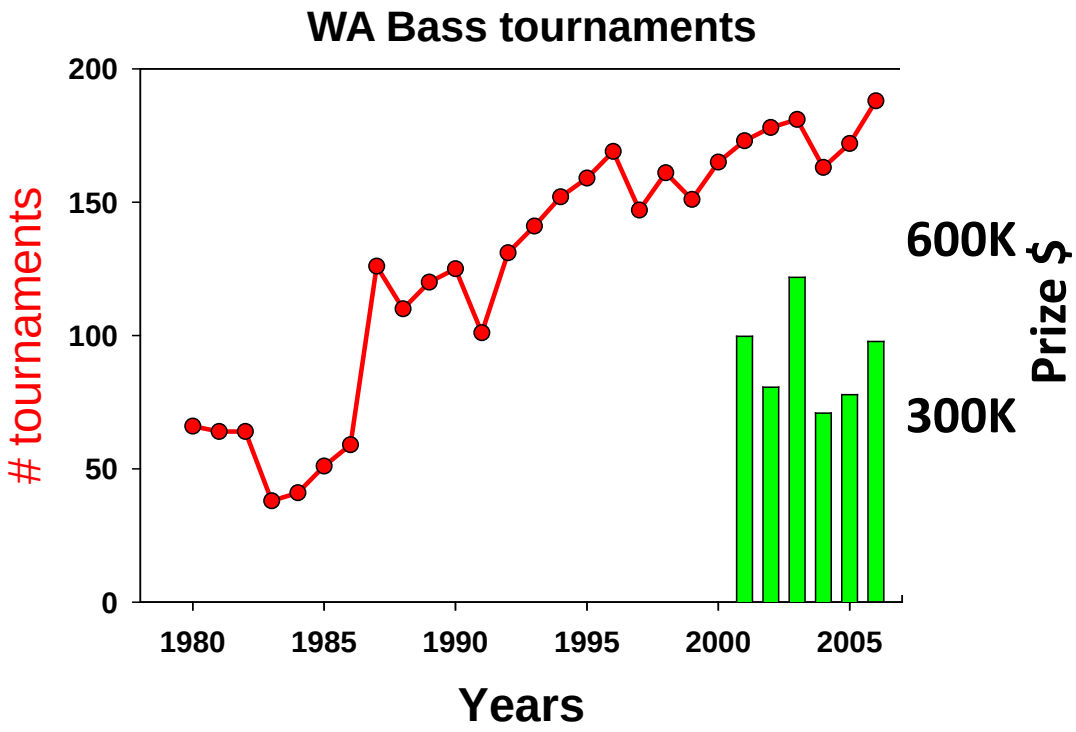

Celilo Falls
early 1900s
236. CELILO FALLS NEAR "THE DALLES," COLUMBIA RIVER, OREGON.

The Dalles Dam

John Day Dam
Fish ladder

19.3 lb walleye From McNary pool





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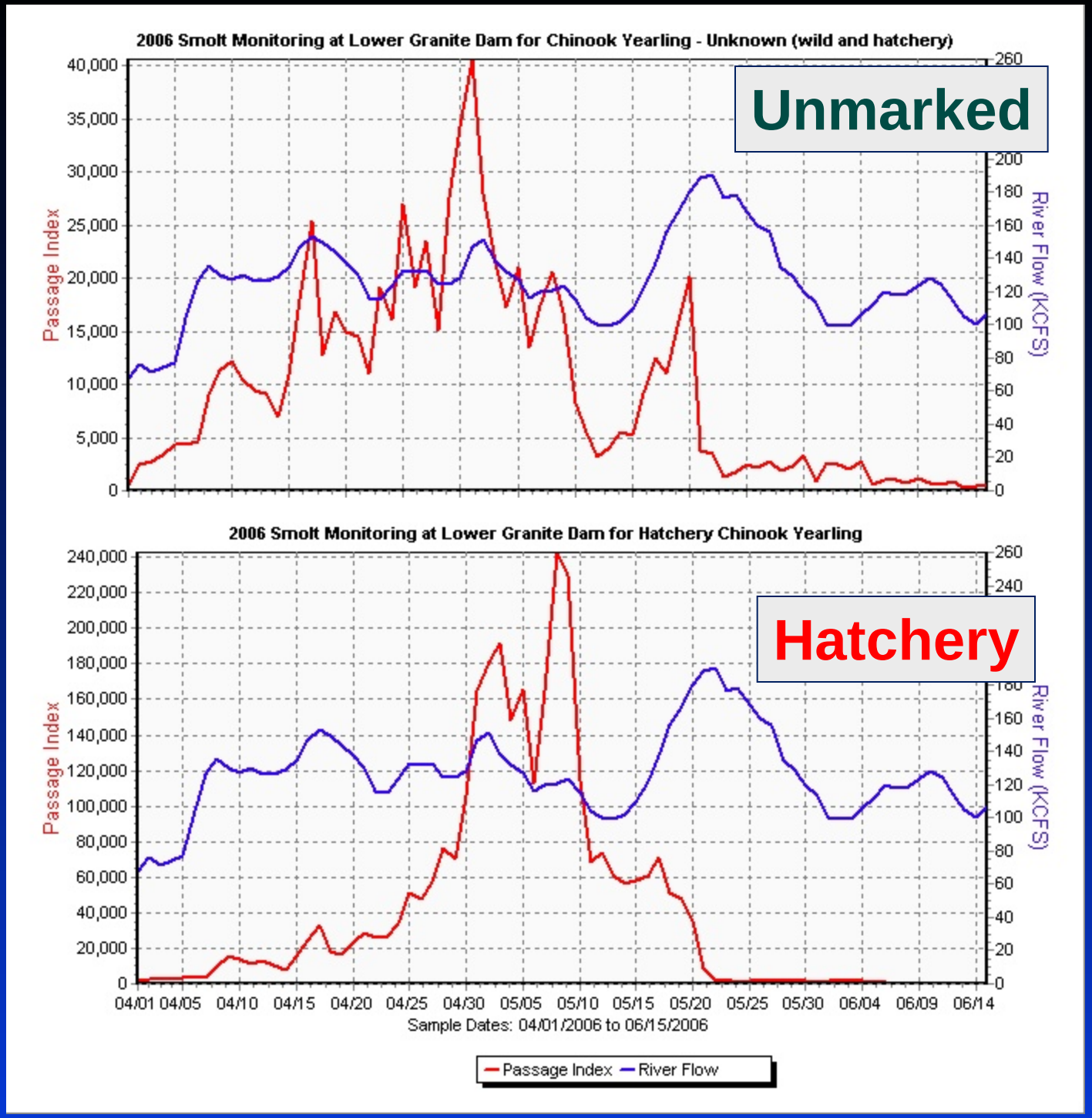
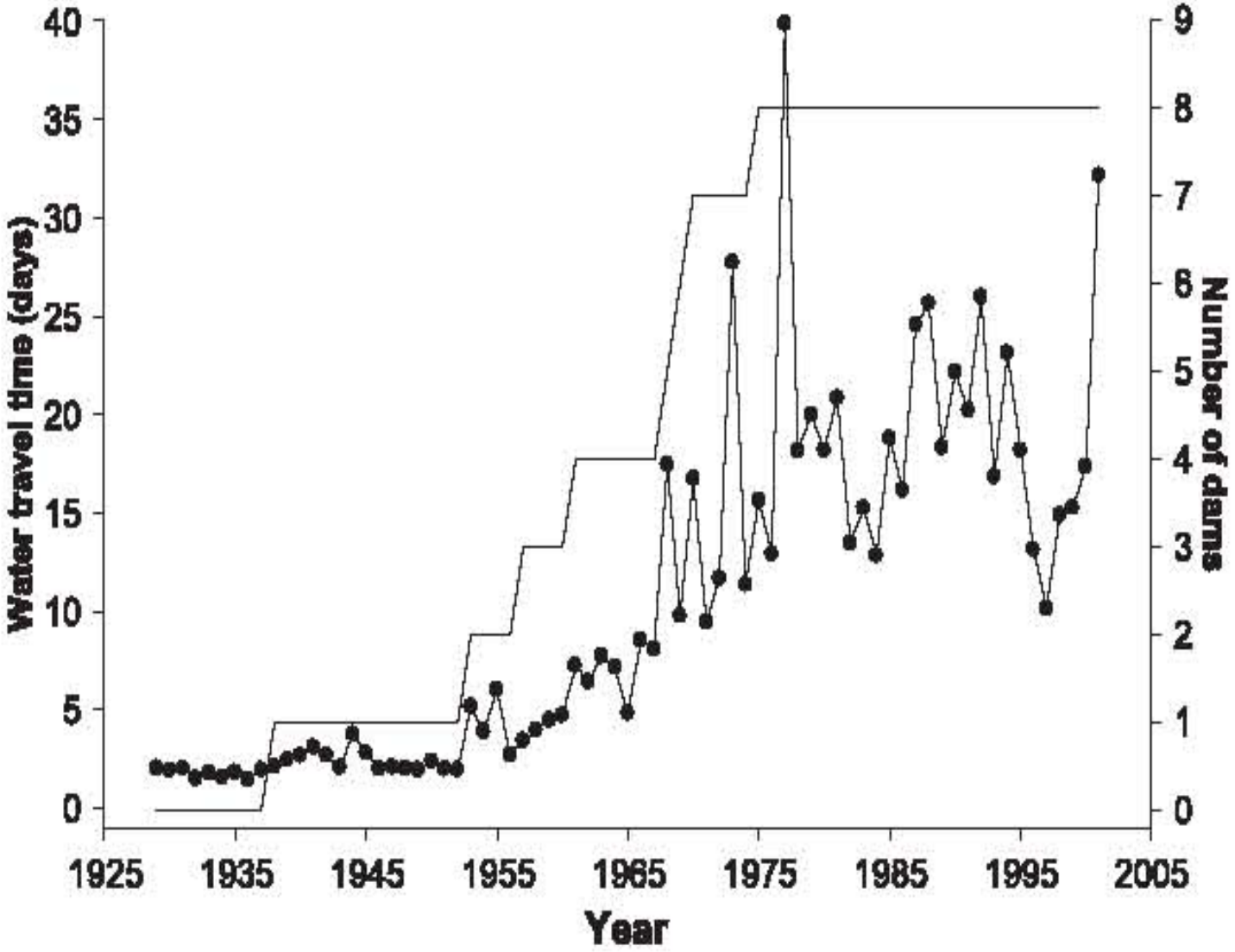


2006 Snake R spr/sum CK at LGD

Fish Passage Center/J. Williams

Columbia River water travel time vs # dams

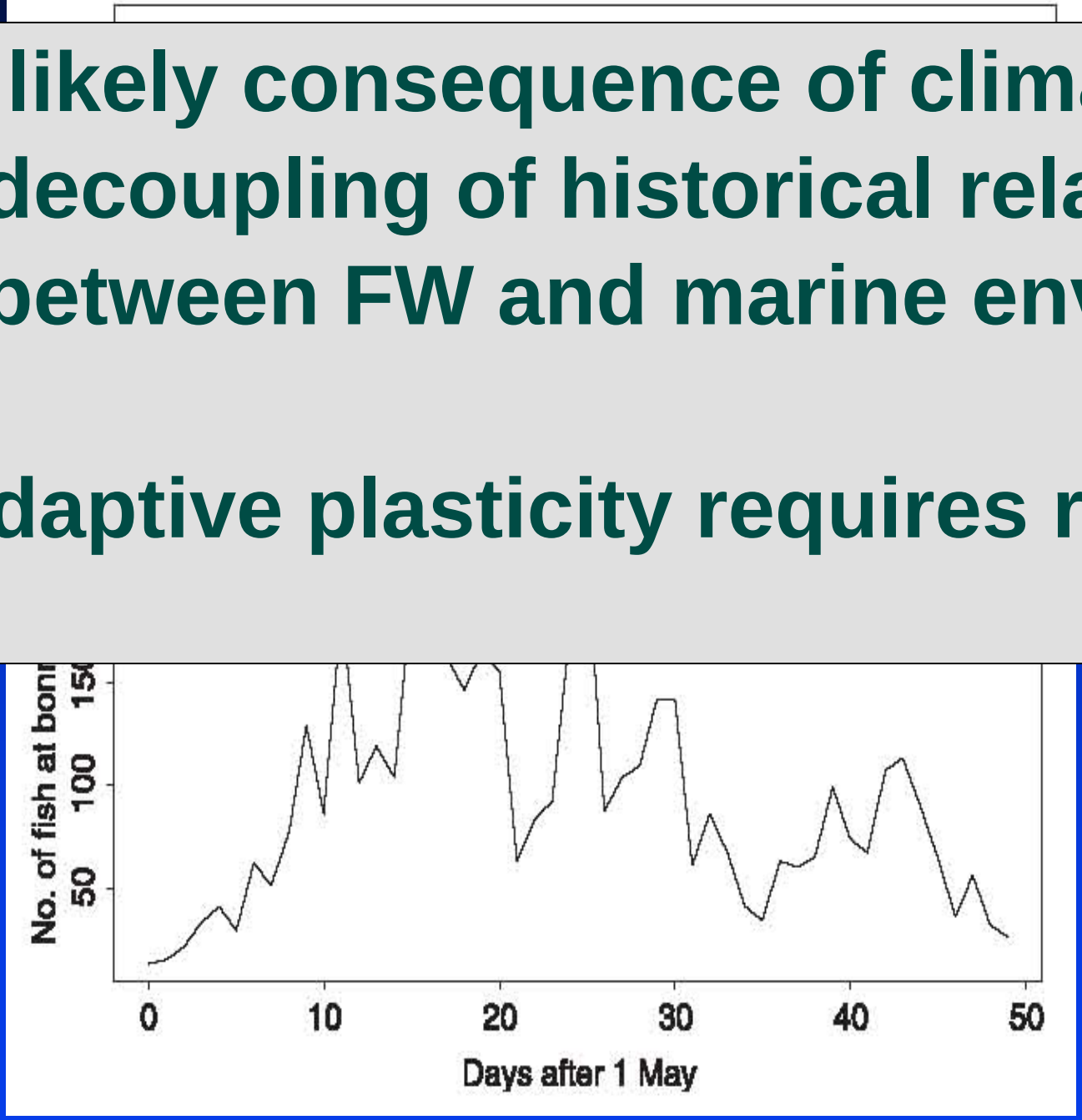


Waples, Zabel, Scheuerell, Sanderson 2008 Mol Ecol

Mismatch between smolt arrival time and optimal arrival time for marine survival

A likely consequence of climate change is decoupling of historical relationships between FW and marine environments

Adaptive plasticity requires reliable cues



Waples, Zabel, Scheuerell, Sanderson 2008 Mol Ecol

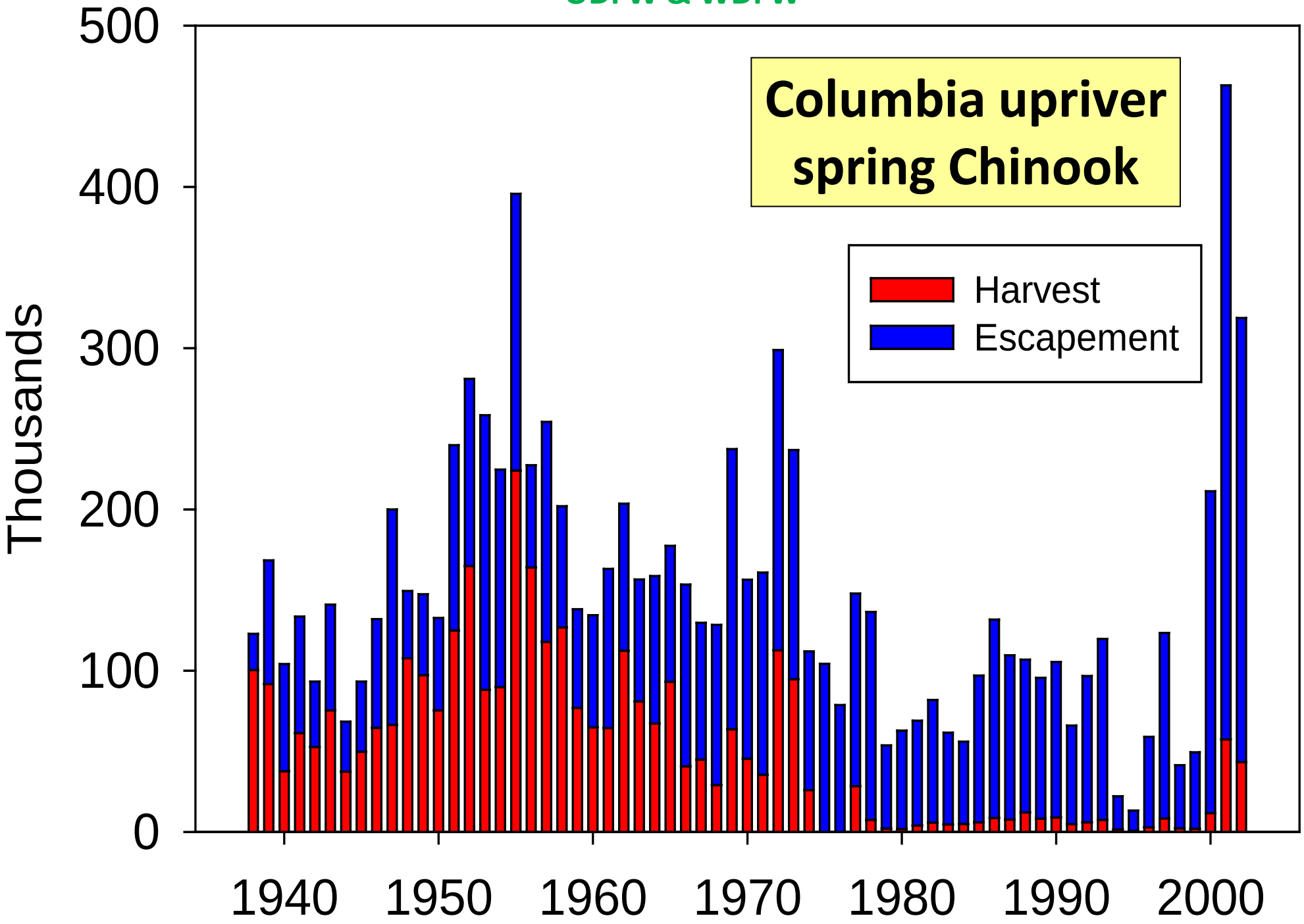
Thanks

Steve Achord, Tim Beechie, Craig Busack, Tom Cooney, Lisa Crozier, Nate Mantua, Beth Sanderson, Mark Scheuerell, John Williams

Rich Carmichael

LSRCP folks

Source: Status Report, Columbia River Fish Runs and Fisheries, 1938-2002. ODFW & WDFW



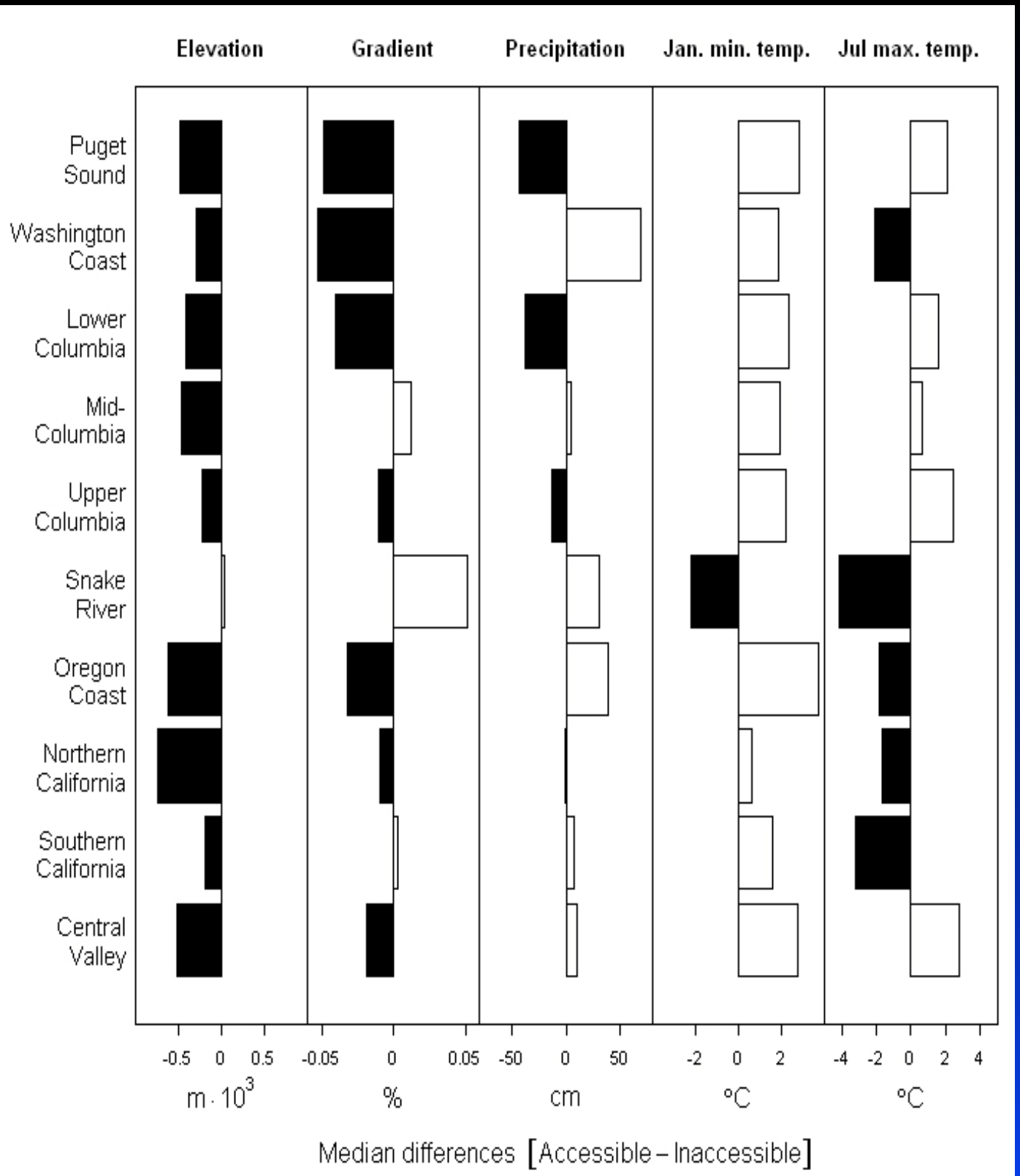
Spatial Structure and Diversity

Spatial Structure

- Spatial Distribution of fish and habitat
- Spatial patterns through time

Diversity

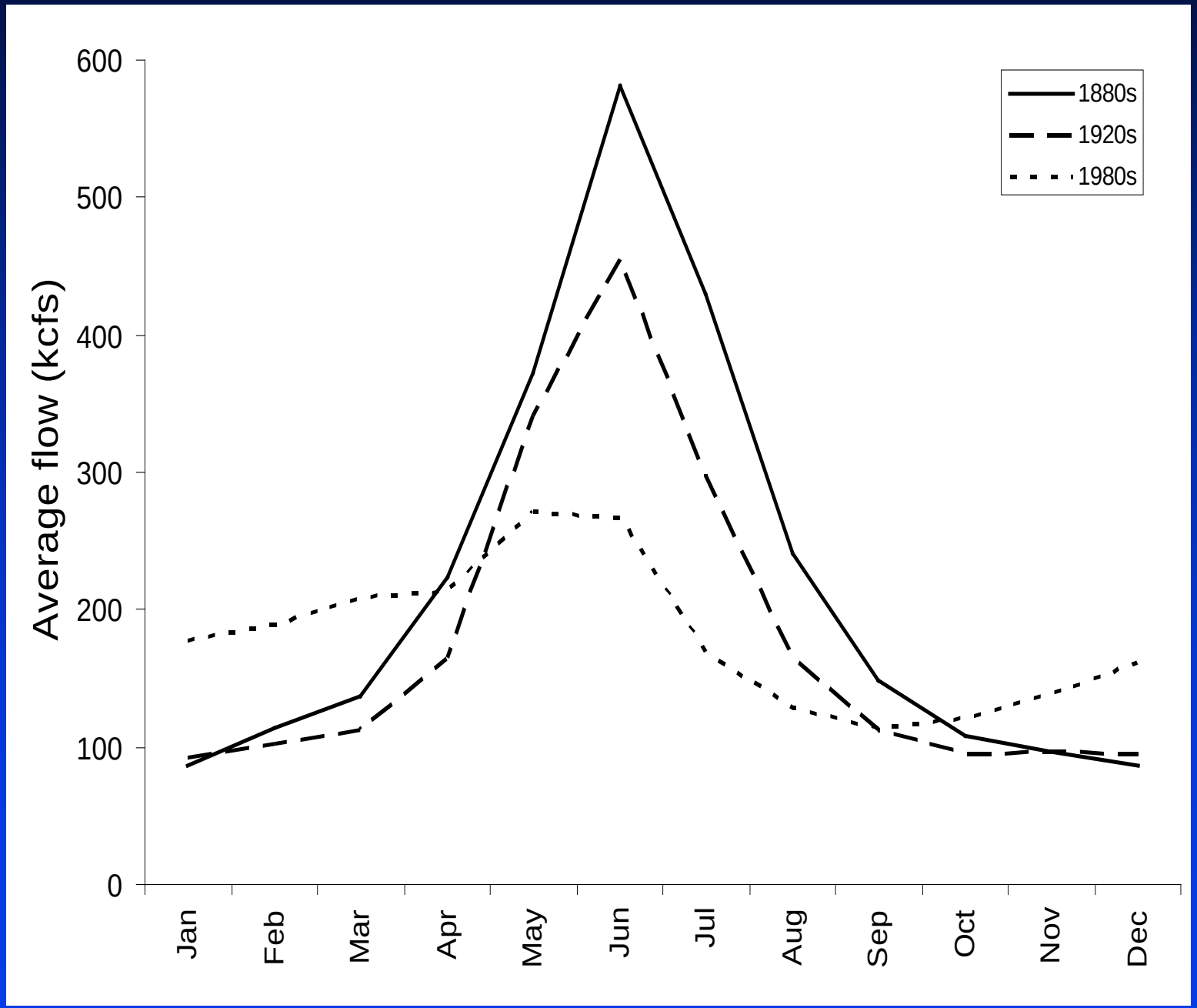
- Life history changes
- Selective pressures (e.g. domestication)
- Habitat diversity



Selective loss of habitat

McClure et al. 2008 Evol Apps

Monthly average flow of the Columbia River, The Dalles



Waples, Zabel, Scheuerell, Sanderson 2008 Mol Ecol

Spatial Structure Guidelines

- Balance between creation and loss of habitat
- Promote natural processes of connectivity
- Don’t ignore currently unoccupied habitat
- Maintain source subpopulations

Summary – Life cycle modeling

- Needed improvements may be biologically feasible (note that BiOp-required improvements are not final)
- Achievable increases in estuarine/near-shore ocean dependent on proportion of mortality occurring in estuary
- Increasing ceiling and slope of B-H relationship can yield similar increases to estuarine/near-shore ocean increases

Estuary – some outcomes

- Operations of hydropower system directly affects some characteristics of estuarine habitat, especially amount and quality of shallow water habitat which is most important to certain life history strategies.
- Flow, toxics and habitat primarily affect fry, fingerling and subyearling strategies. Those ESUs and portions of ESUs that produce these strategies are most vulnerable to changes in these factors
- Tern predation primarily affects yearlings. Those ESUs and portions of ESUs that produces yearlings are most vulnerable to this factor.

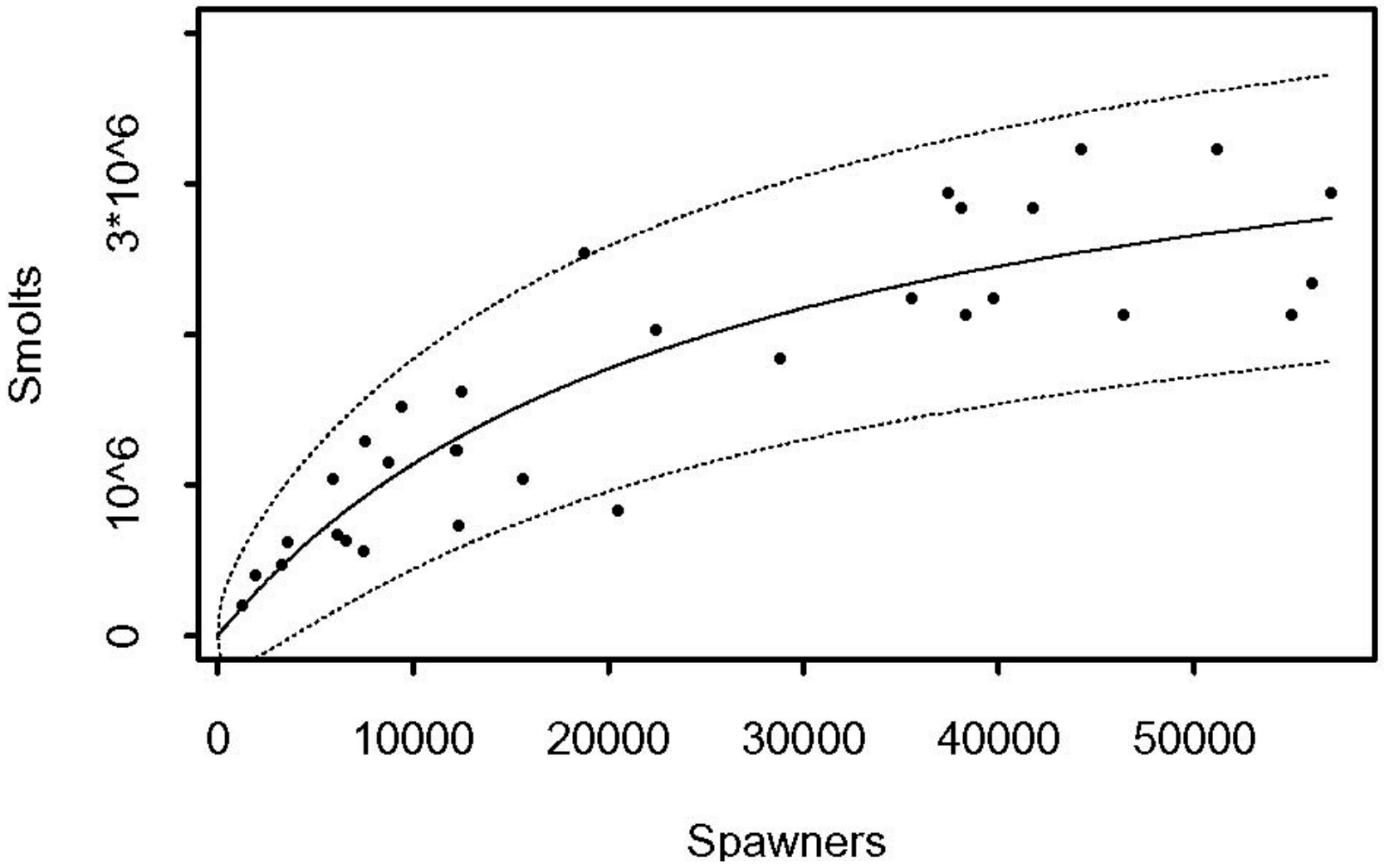
Summary -- habitat

- Tributary habitat of variable quality
  - Mid-Columbia, portions of Grande Ronde, Upper Salmon and Upper Columbia especially compromised
  - Middle Fork Salmon notably low in habitat impairment
- Estuarine impacts dependent on life history strategy

Summary – fish population status

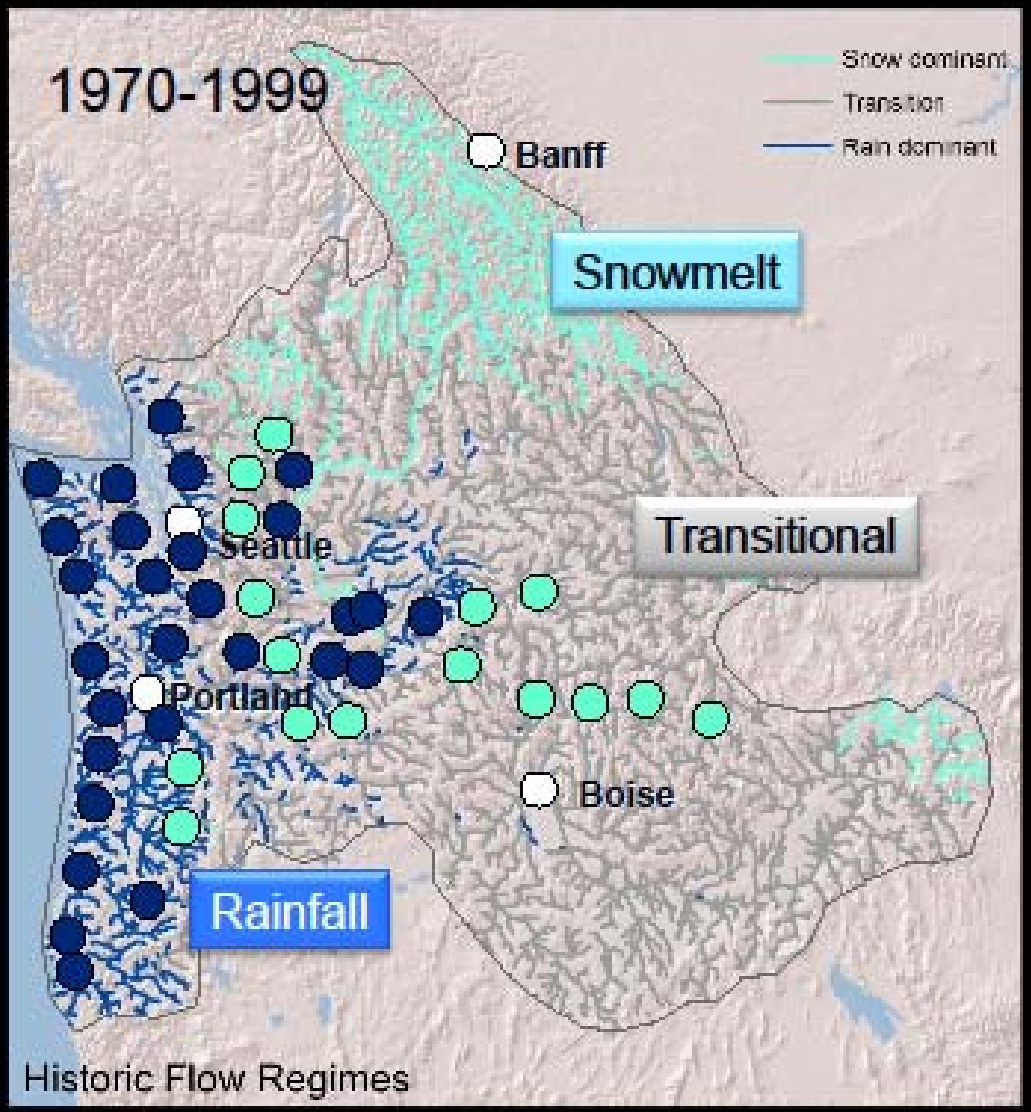
- Scores may be refined
  - modification to intrinsic potential analysis
- Data availability issues
- Overall, all populations with some capacity for improvement
- Population in Middle Fork Salmon, portions of Clearwater and John Day “least bad”
- Upper Columbia, Walla Walla/Umatilla and chum populations in especially poor status

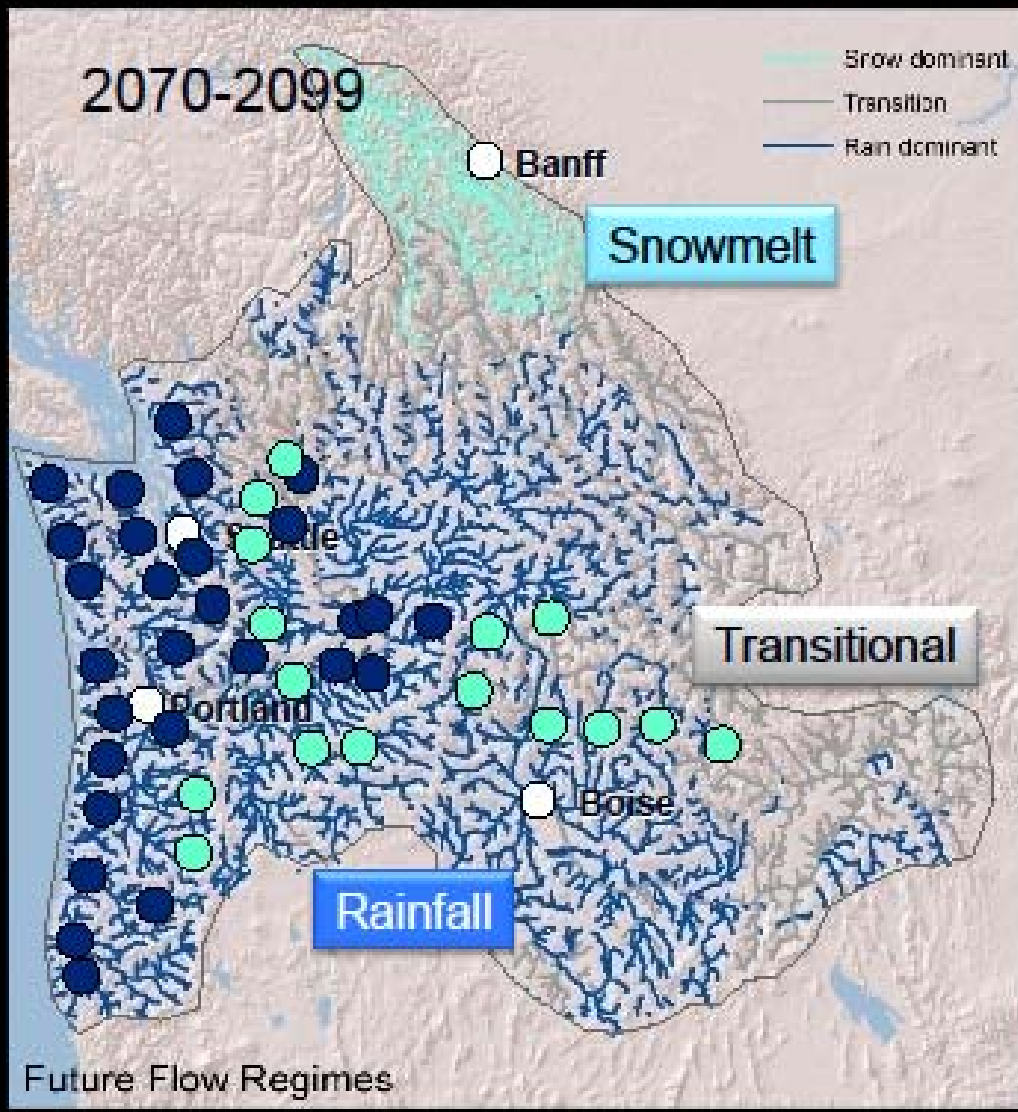
Beverton-Holt
Lower Granite Dam
Spring/summer chinook



M. McClure

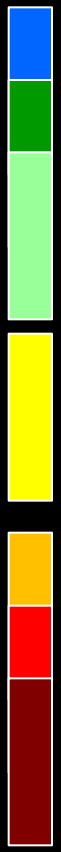
Flow regime and Chinook life history



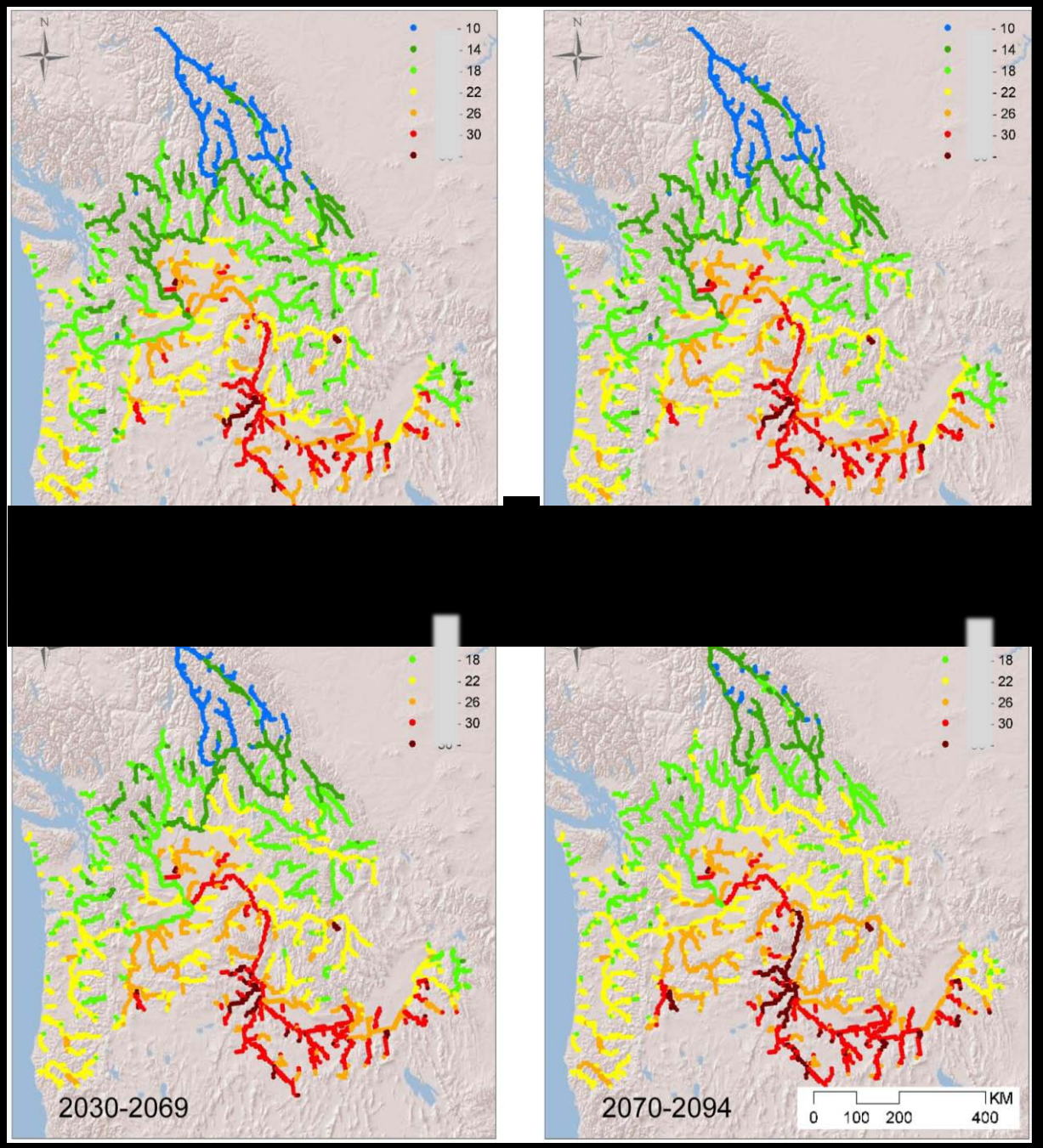


Data source: http://www.hydro.washington.edu/2860/report/

Summer rearing sensitivity

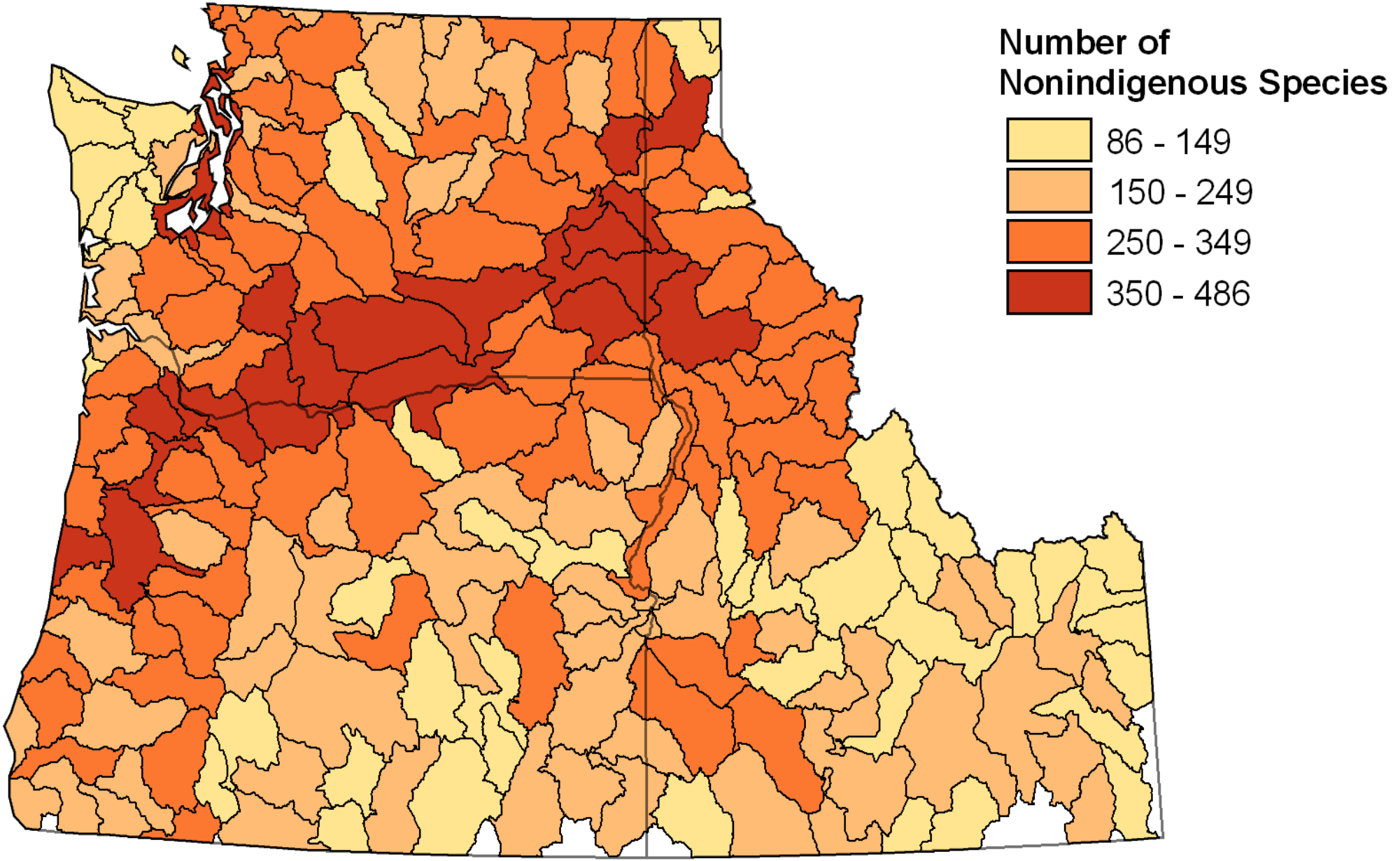


Average increase in stream temperature ~1.5°C



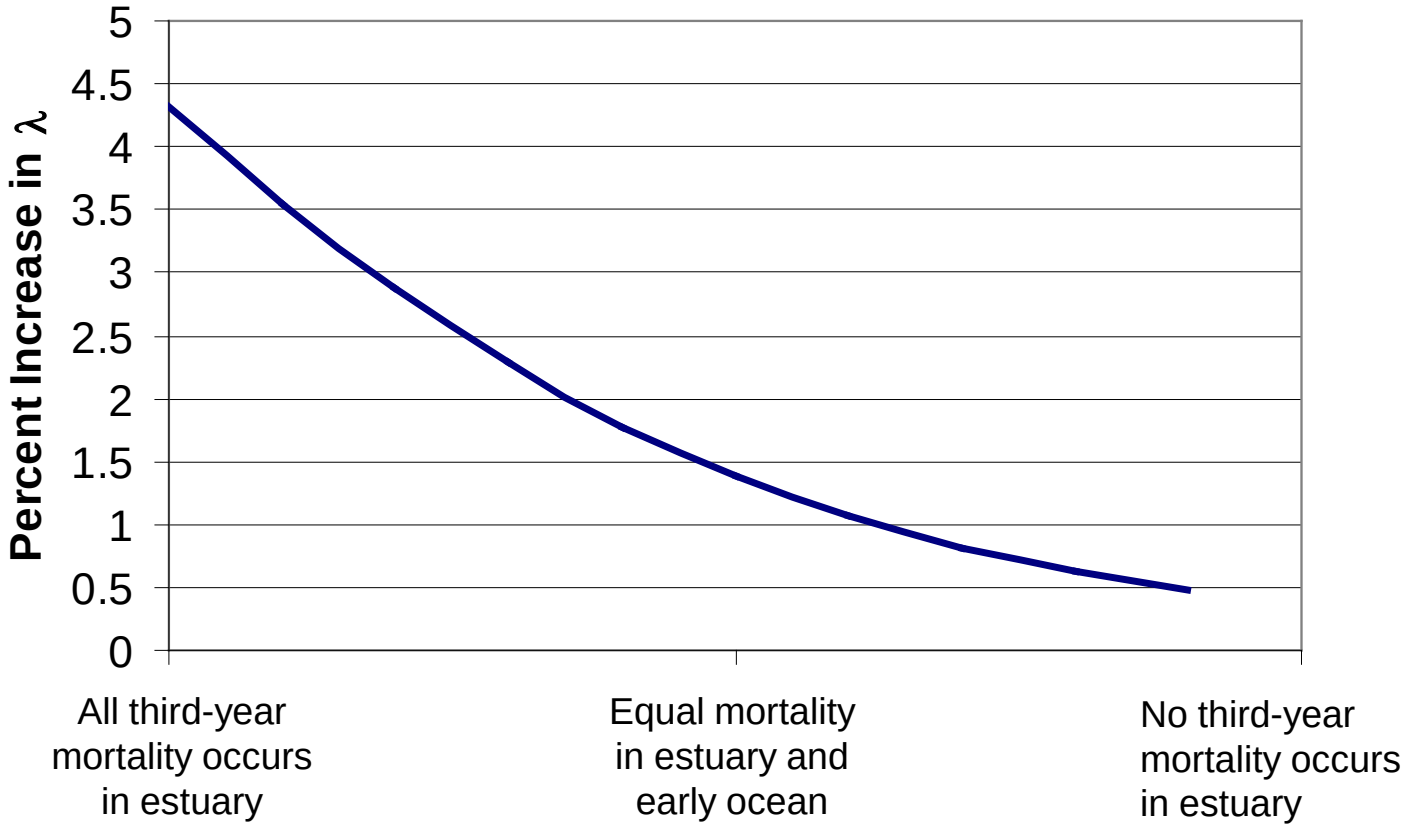
Nonindigenous species

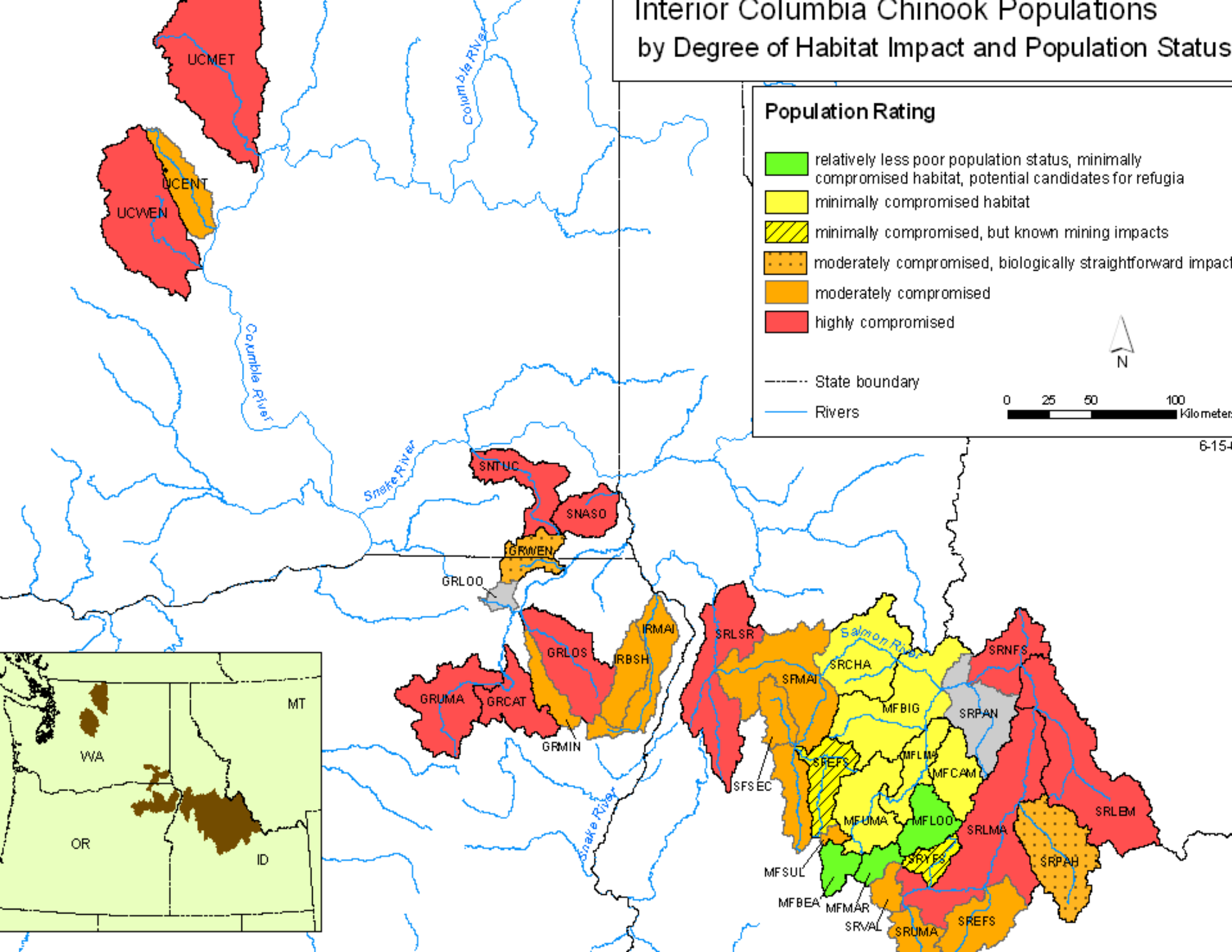
The 5th H



Sanderson, Barnas and Rub 2009

Bounds to improvement in estuary




Interior Columbia Chinook Populations
by Degree of Habitat Impact and Population Status
Population Rating
relatively less poor population status, minimally compromised habitat, potential candidates for refugia
minimally compromised habitat
minimally compromised, but known mining impacts
moderately compromised, biologically straightforward impact
moderately compromised
highly compromised
State boundary
Rivers
N
0 25 50 100
Kilometers
6-15-
Columbia River
Columbia River
Snake River
Snake River
Salmon River
UCMET
UCENT
UCWEN
SNTUC
SNASO
GRWEN
GRLOO
GRLOS
IRMAI
IRBSH
GRUMA
GRCAT
GRMIN
SRLSR
SRMAI
SRCHA
SRNFS
MFBIG
SRPAN
SREFS
MFLMA
MFCAM
SFSEC
MFUMA
MFLOO
SRLMA
SRLBM
SRYFS
SRPAH
MFSUL
MFBEA
MFMAR
SRVAL
SRUMA
SREFS
MT
WA
OR
ID