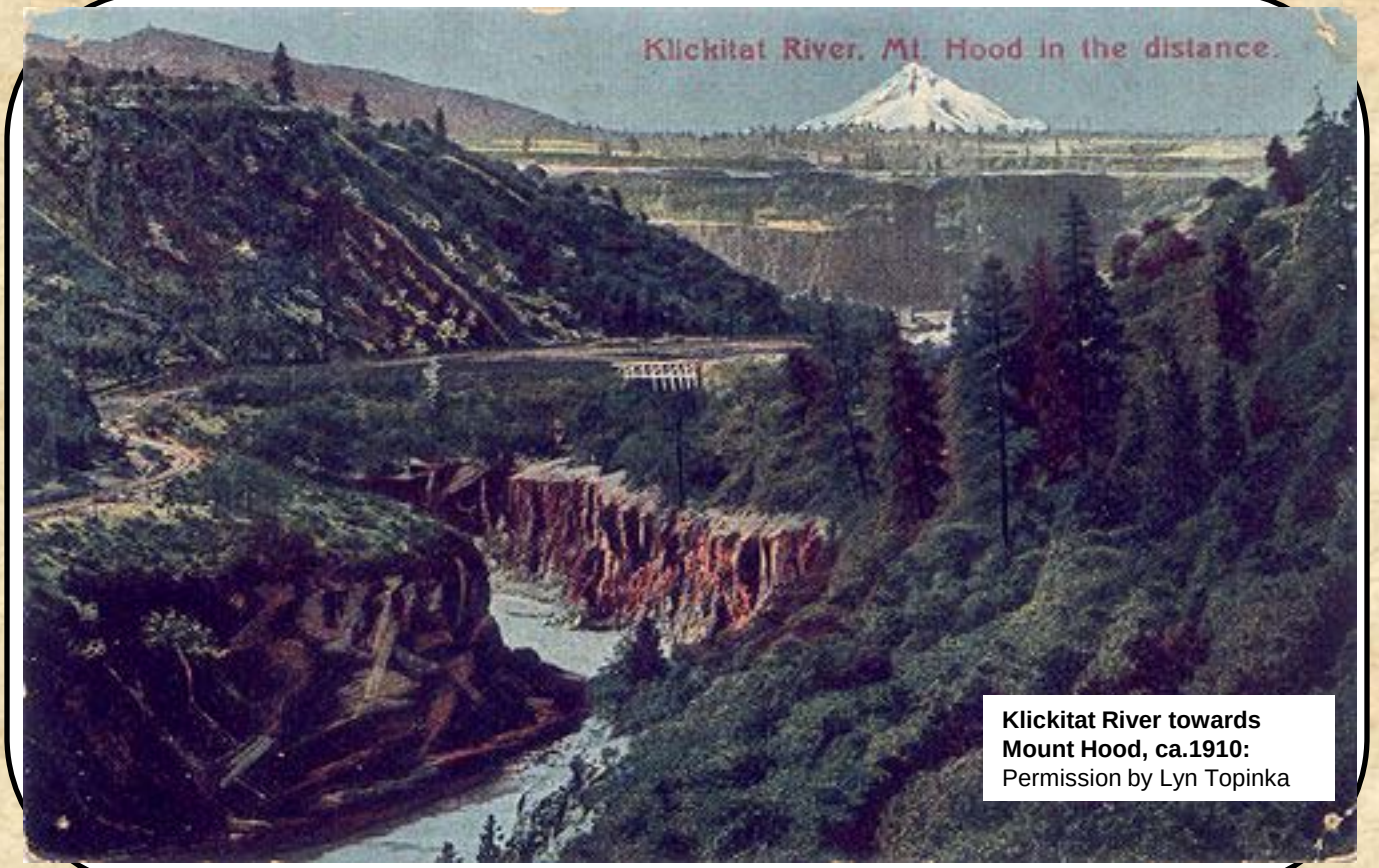
Hatchery practices led to introgressive hybridization between major Columbia River Chinook salmon lineages within the Klickitat river subasin



Klickitat River towards Mount Hood, ca.1910: Permission by Lyn Topinka

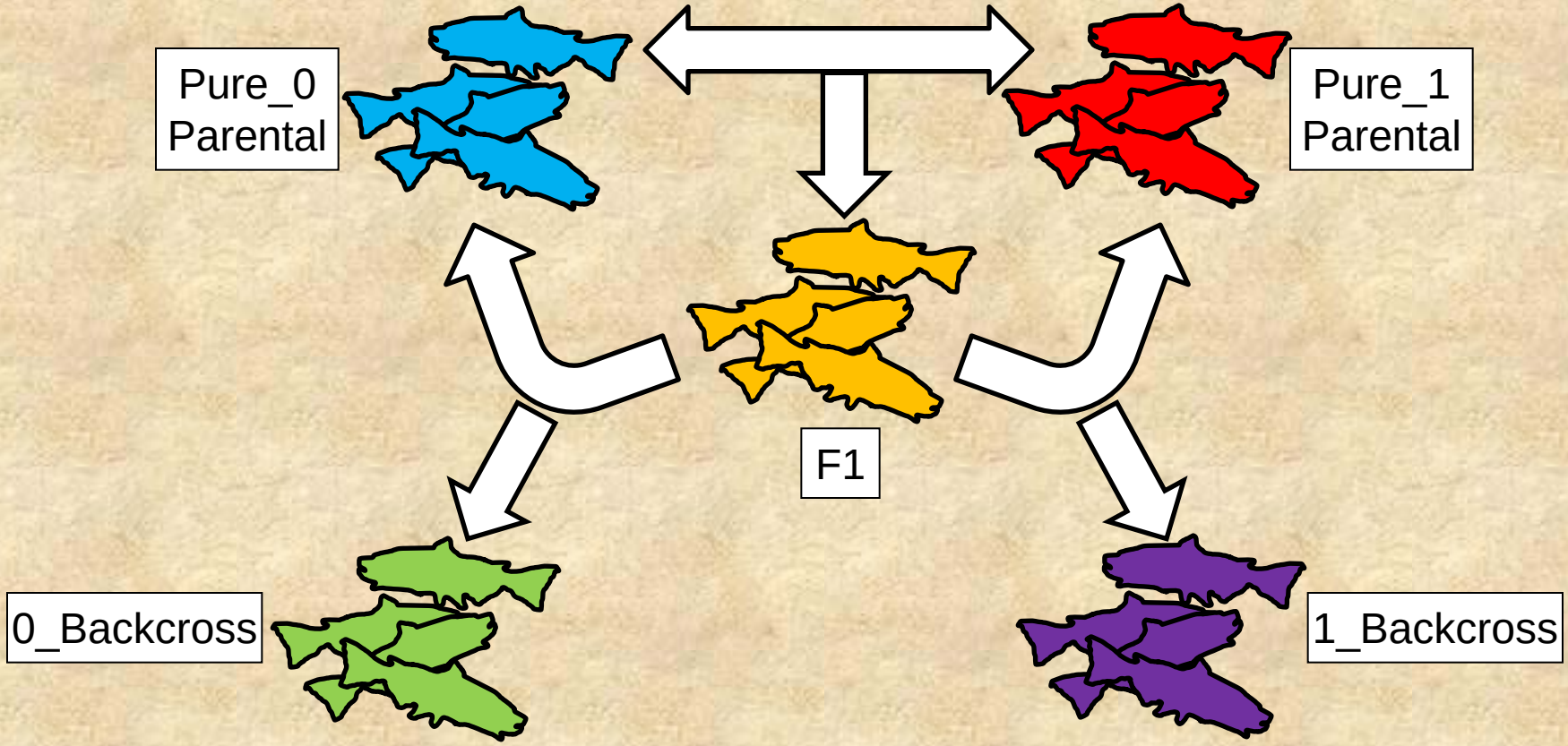
Dr. Jon E. Hess[1], Andrew P. Matala[1], Joe Zendt[2], Chris Frederiksen[2], Bill Sharp[2], and Dr. Shawn R. Narum[1]

Columbia River Inter-Tribal Fish Commission

Yakama Nation Fisheries Program

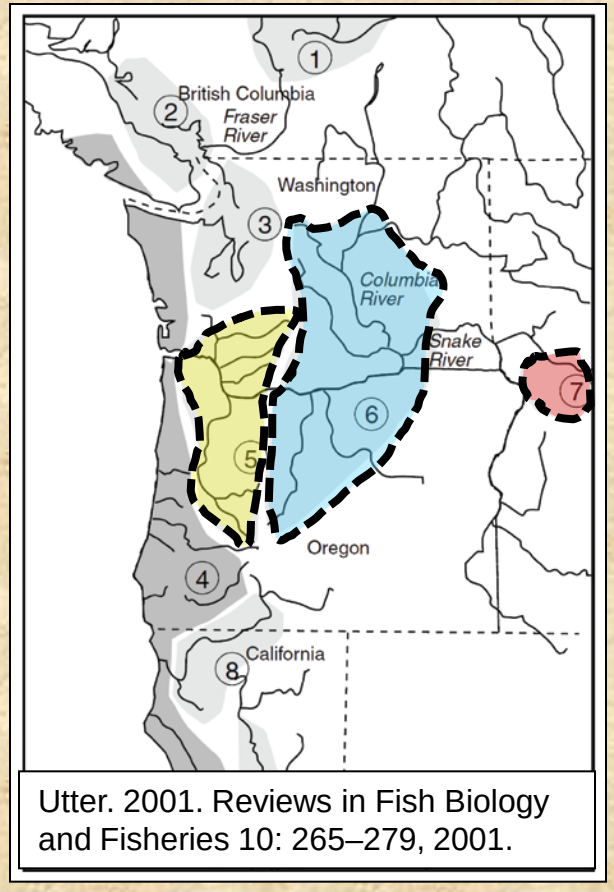
Introgressive hybridization:

two distinct species or populations interbreed and hybrid offspring backcross with parental types.

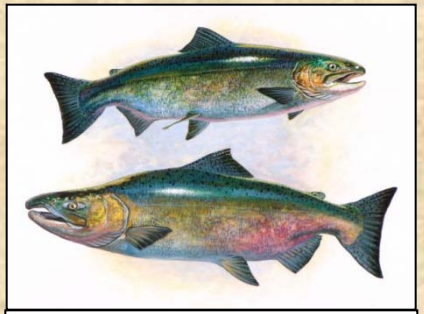


Introgressive hybridization:

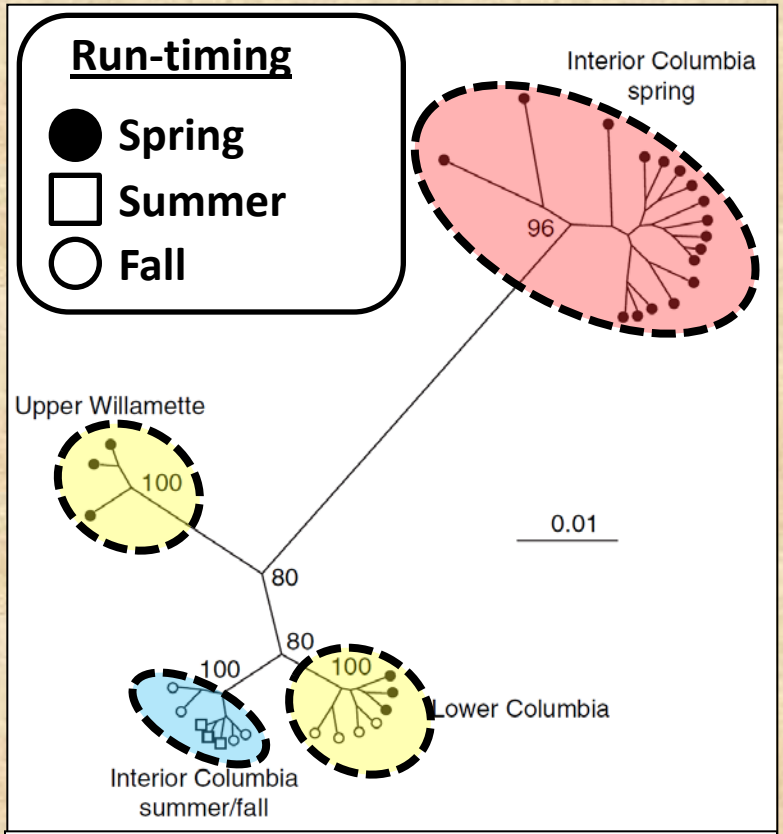
Anadromous salmonids generally are resilient to natural hybridization among major lineages.



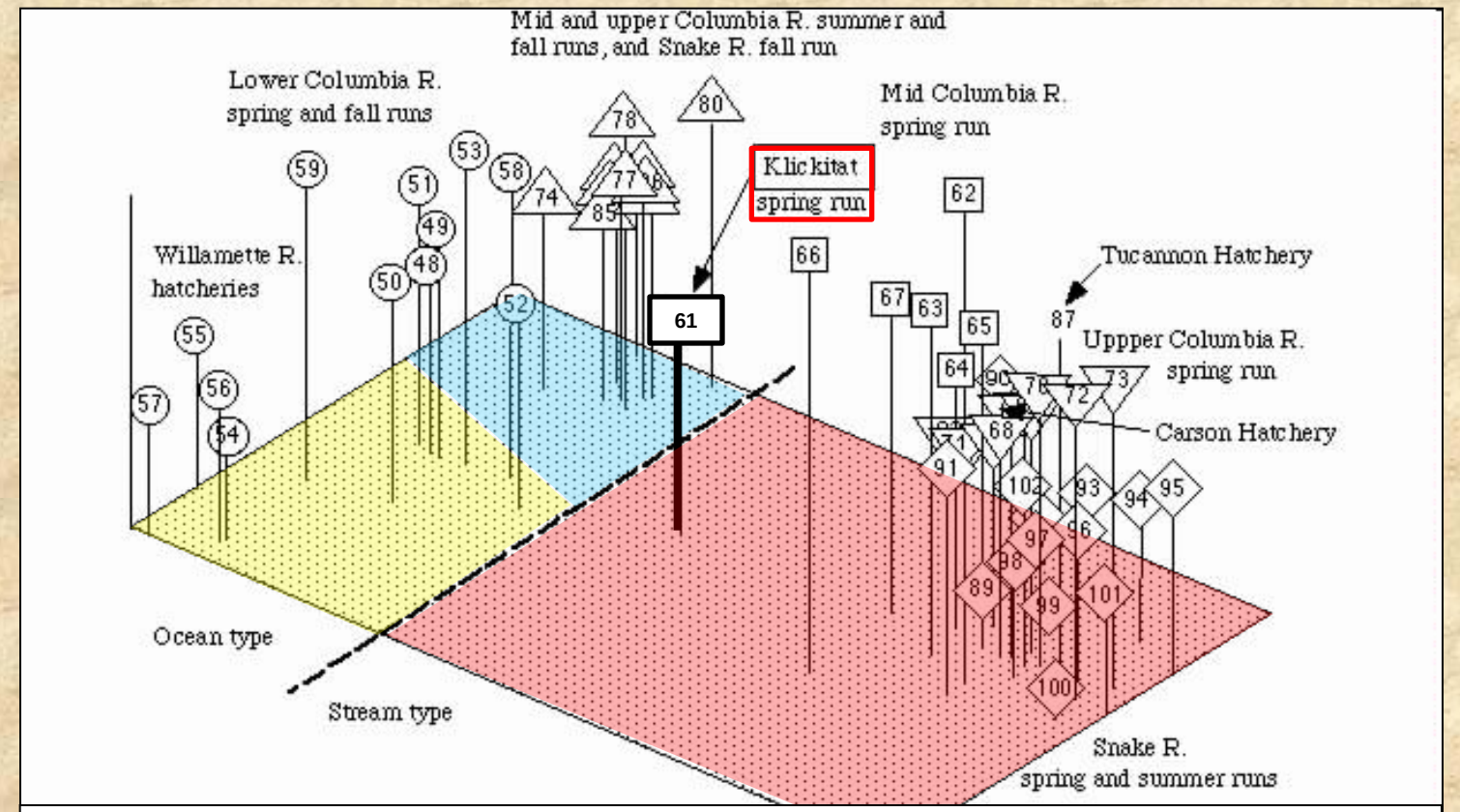
Utter. 2001. Reviews in Fish Biology and Fisheries 10: 265–279, 2001.



Chinook salmon
(Artist: Shari Erickson)

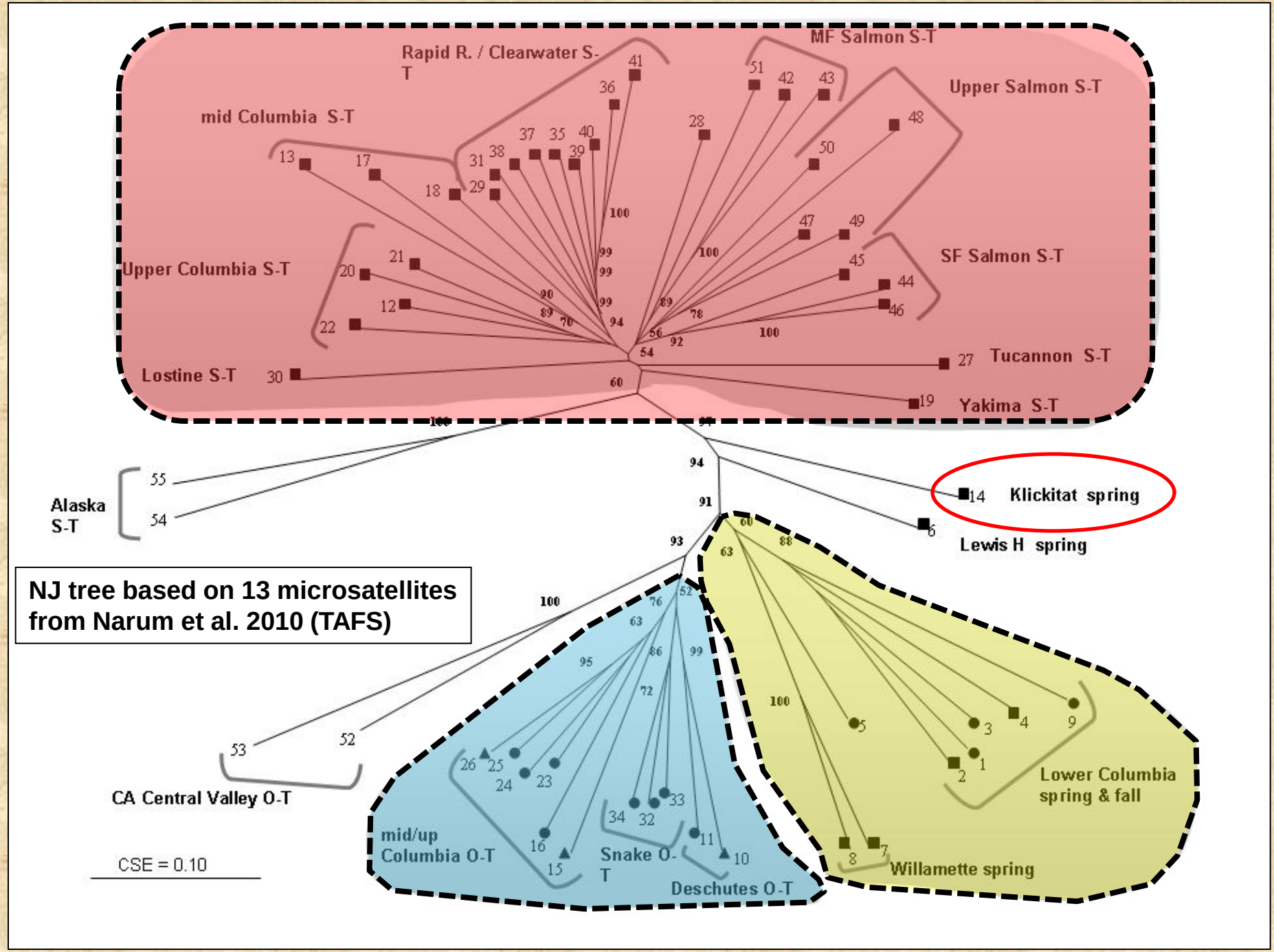


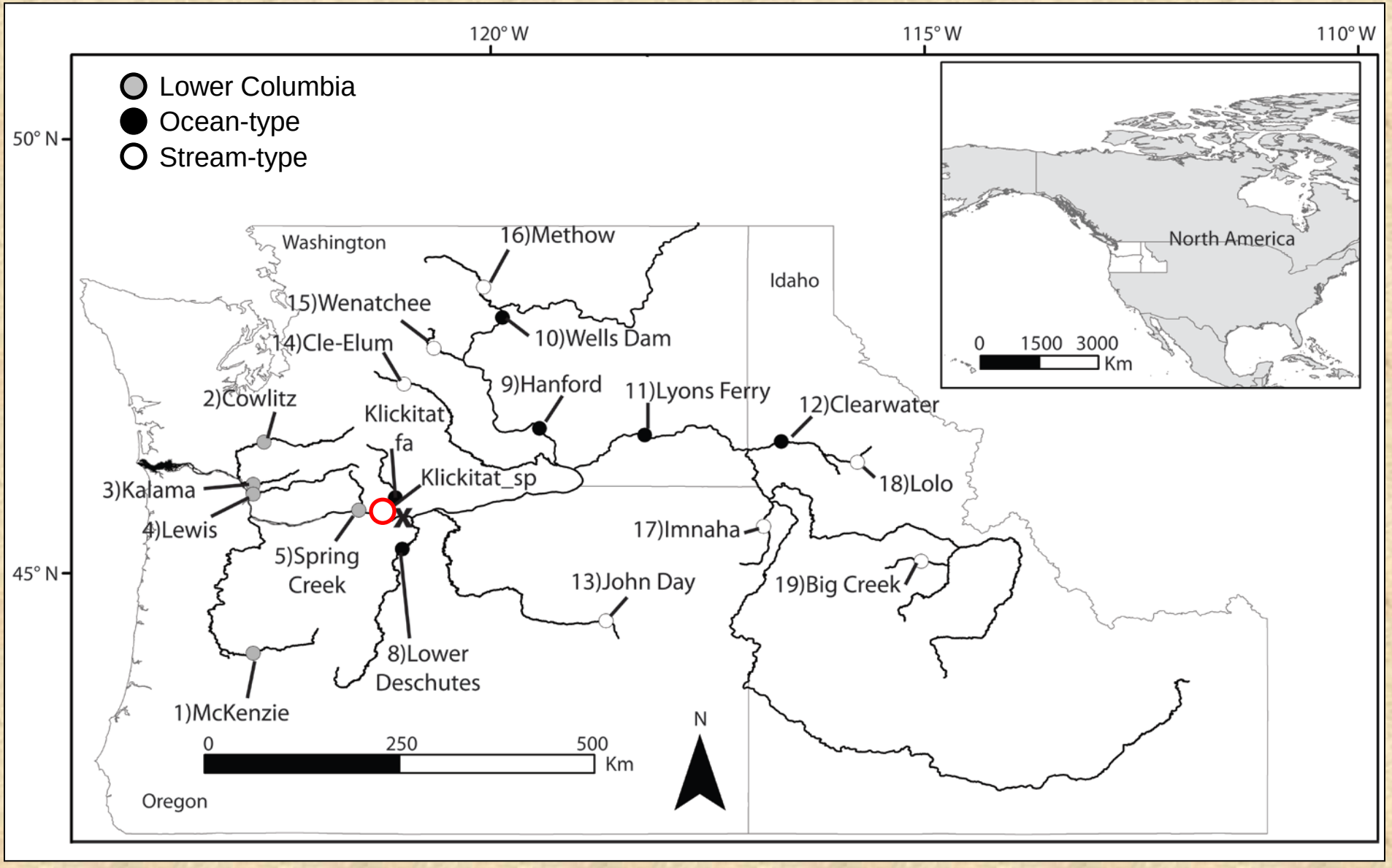
Waples et al. 2008. Evolutionary Applications 1:189-206



Multidimensional scaling of Cavalli-Sforza and Edwards (1967) chord distances based on 31 allozyme loci among Columbia River Chinook salmon populations.

Myers et al. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35, 443 p.


Rapid R. / Clearwater S-T
MF Salmon S-T
Upper Salmon S-T
mid Columbia S-T
Upper Columbia S-T
SF Salmon S-T
Lostine S-T
Tucannon S-T
Yakima S-T
Alaska S-T
Klickitat spring
Lewis H spring
NJ tree based on 13 microsatellites from Narum et al. 2010 (TAFS)
CA Central Valley O-T
mid/up Columbia O-T
Snake O-T
Deschutes O-T
Lower Columbia spring & fall
Willamette spring
CSE = 0.10


120° W
115° W
110° W
50° N
45° N
Lower Columbia
Ocean-type
Stream-type
Washington
Idaho
Oregon
16)Methow
15)Wenatchee
14)Cle-Elum
10)Wells Dam
9)Hanford
11)Lyons Ferry
12)Clearwater
2)Cowlitz
Klickitat fa
Klickitat_sp
3)Kalama
4)Lewis
5)Spring Creek
17)Imnaha
18)Lolo
13)John Day
19)Big Creek
8)Lower Deschutes
1)McKenzie
0 250 500 Km
N
North America
0 1500 3000 Km

We used a baseline of 32 collections of 2443 fish genotyped for 91 SNP loci to accomplish two goals:

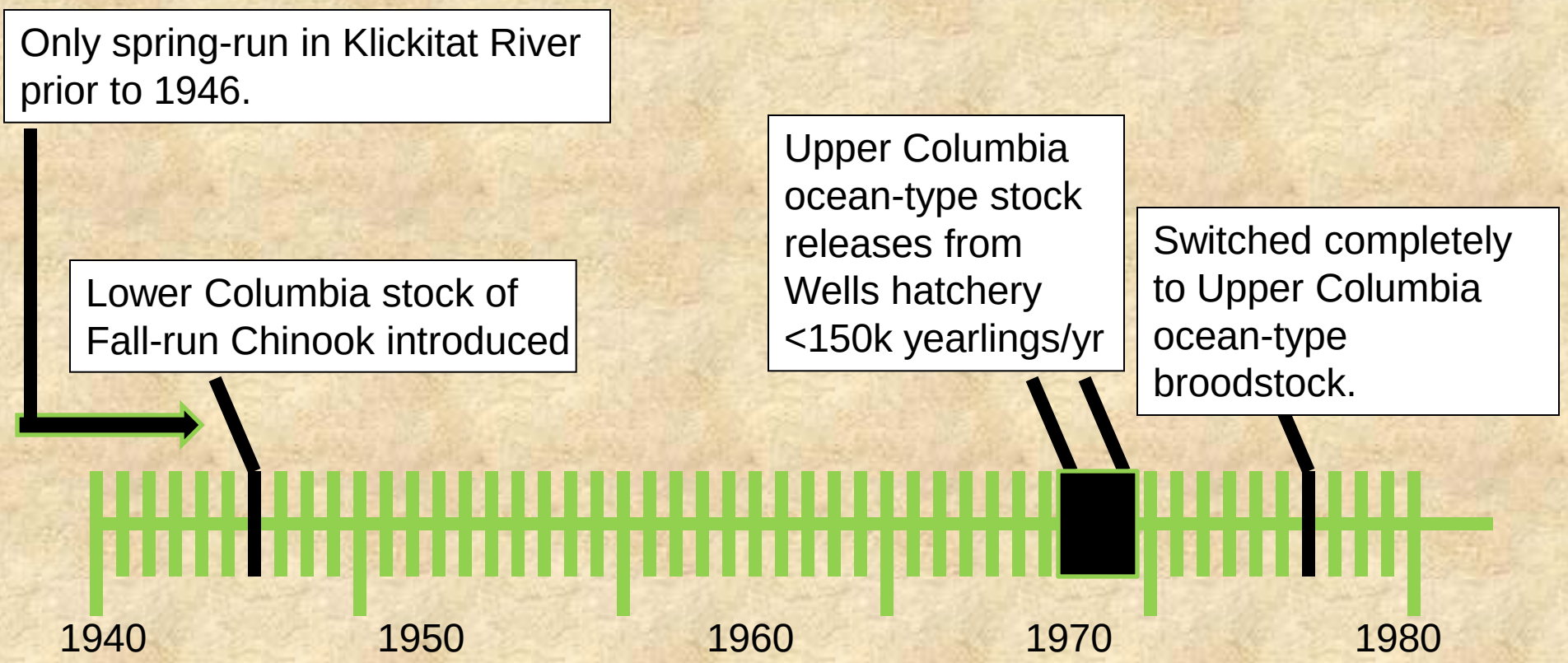
1) to clarify whether the Klickitat spring-run Chinook are more genetically similar to one of the three lineages

2) to determine which process best explains the intermediate genetic relationship of Klickitat spring-run to the three lineages

a) recent admixture (including hatchery influence)
b) historical admixture
c) isolation by distance gene-flow
d) selection

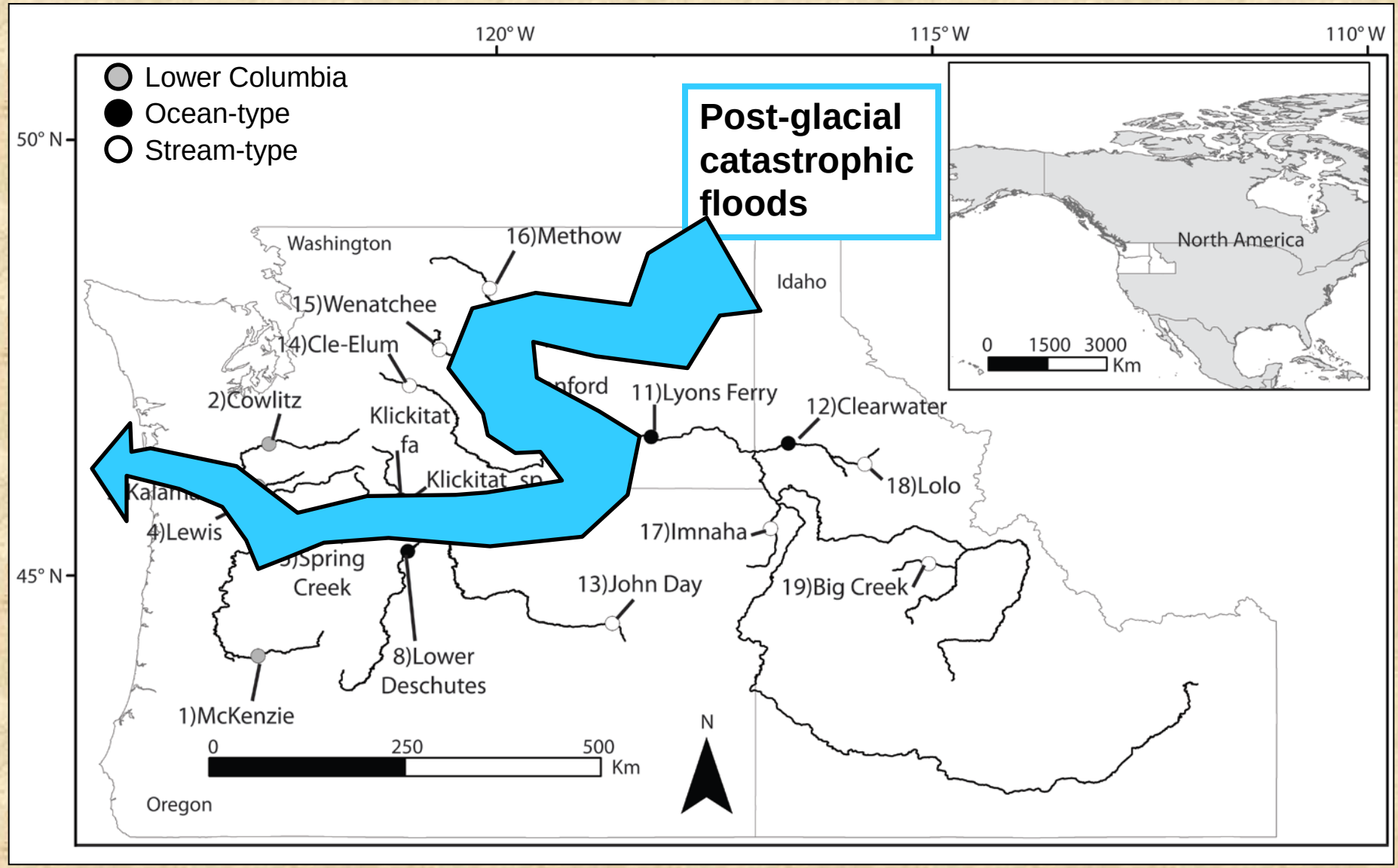
a) recent admixture (hatchery influence)

Stocking history of fall-run Chinook salmon in the Klickitat River hatchery

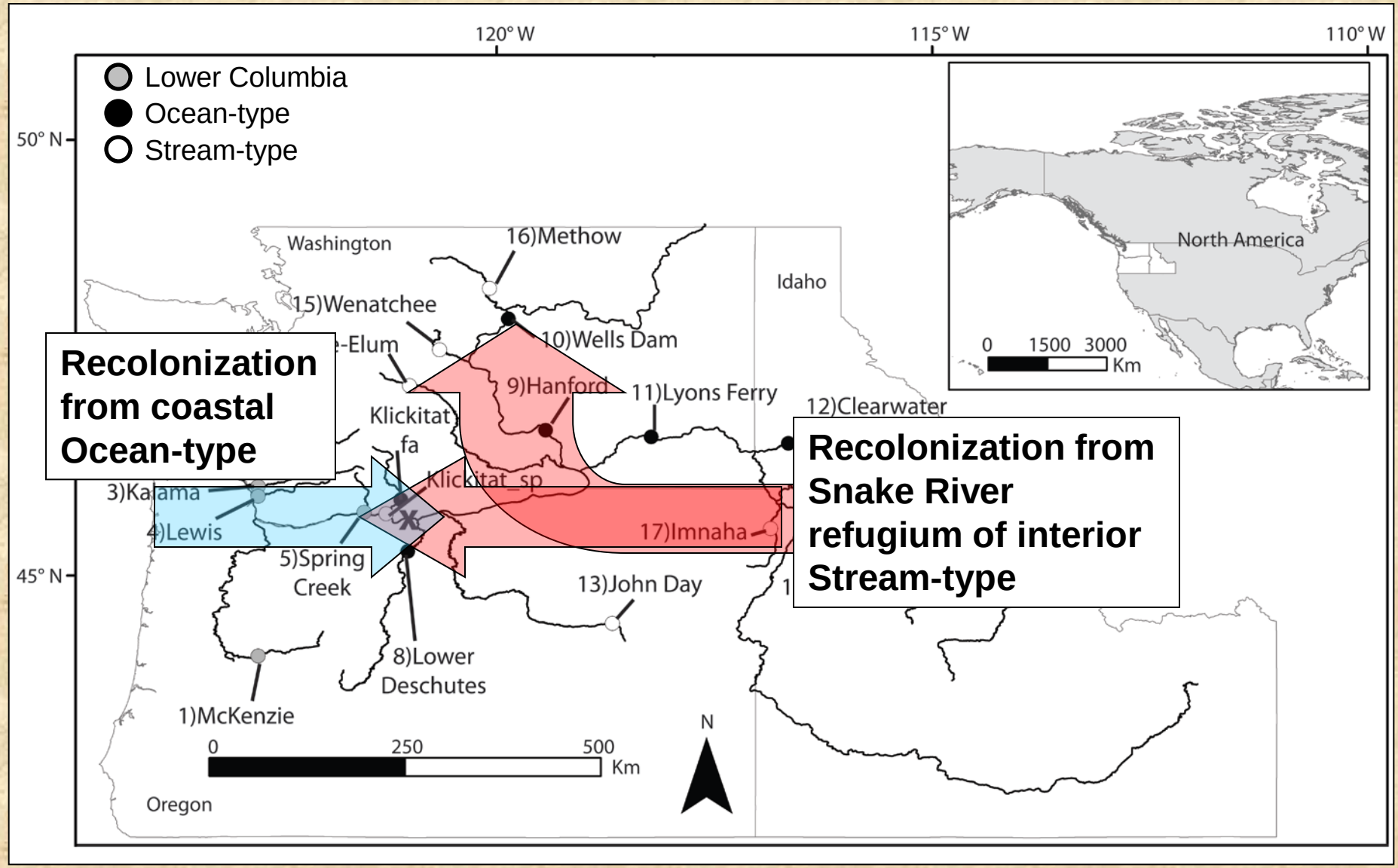


From Marshall *et al*. 1995 WDFW report

b) historical admixture

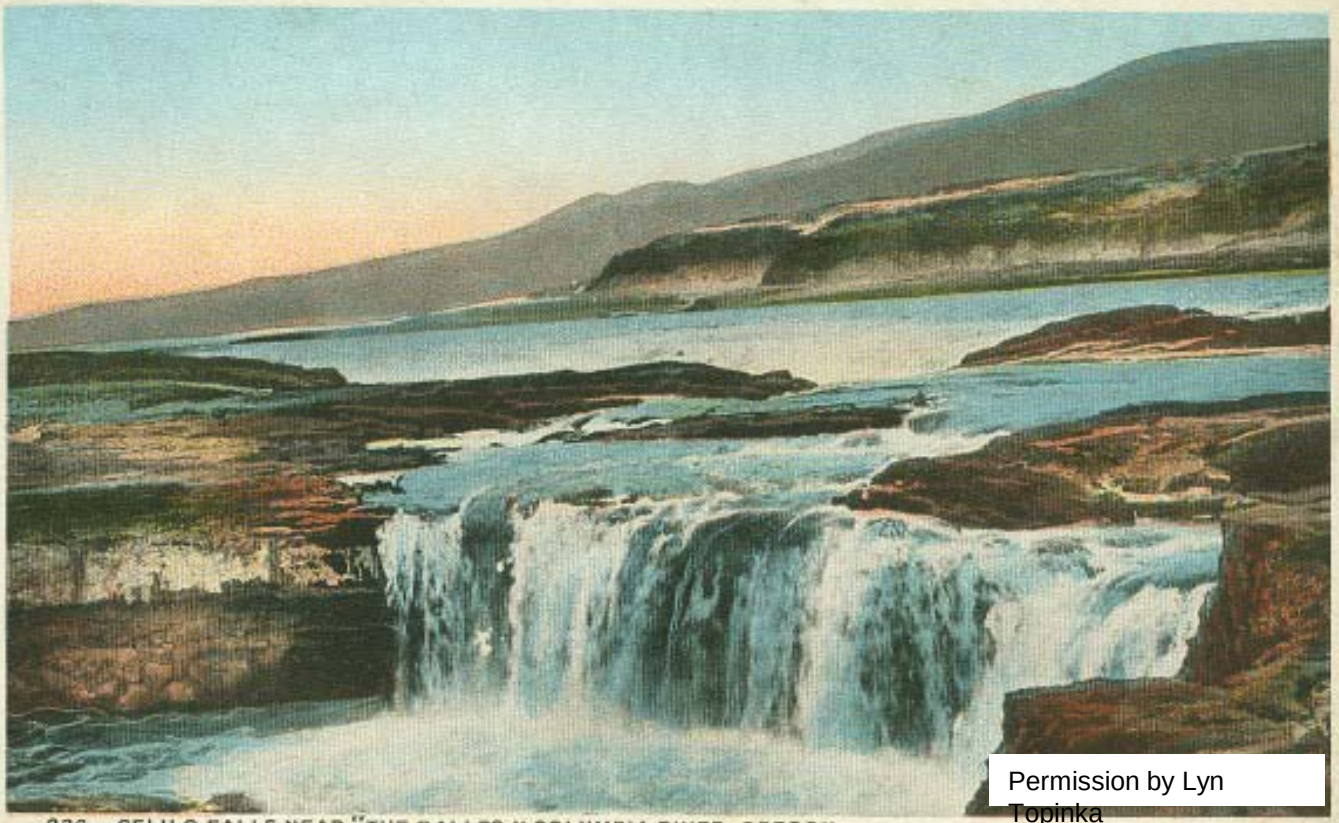


b) historical admixture



Celilo Falls, near The Dalles, ca.1917

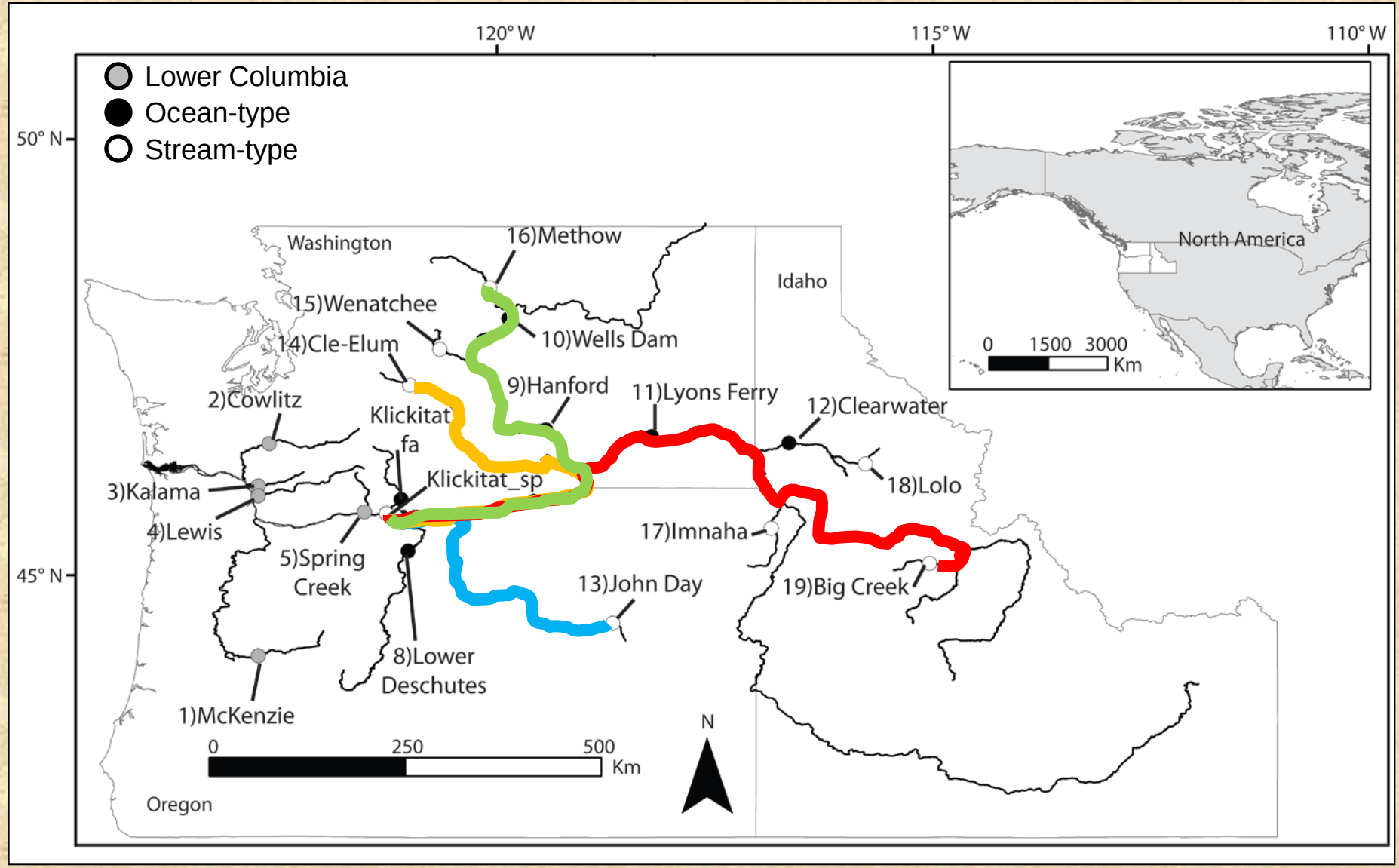
Caption on back reads: "This view shows the falls at low water. When the snow melts in summer in the mountains, the water often rises sixty feet; at that time steamers pass safely over."



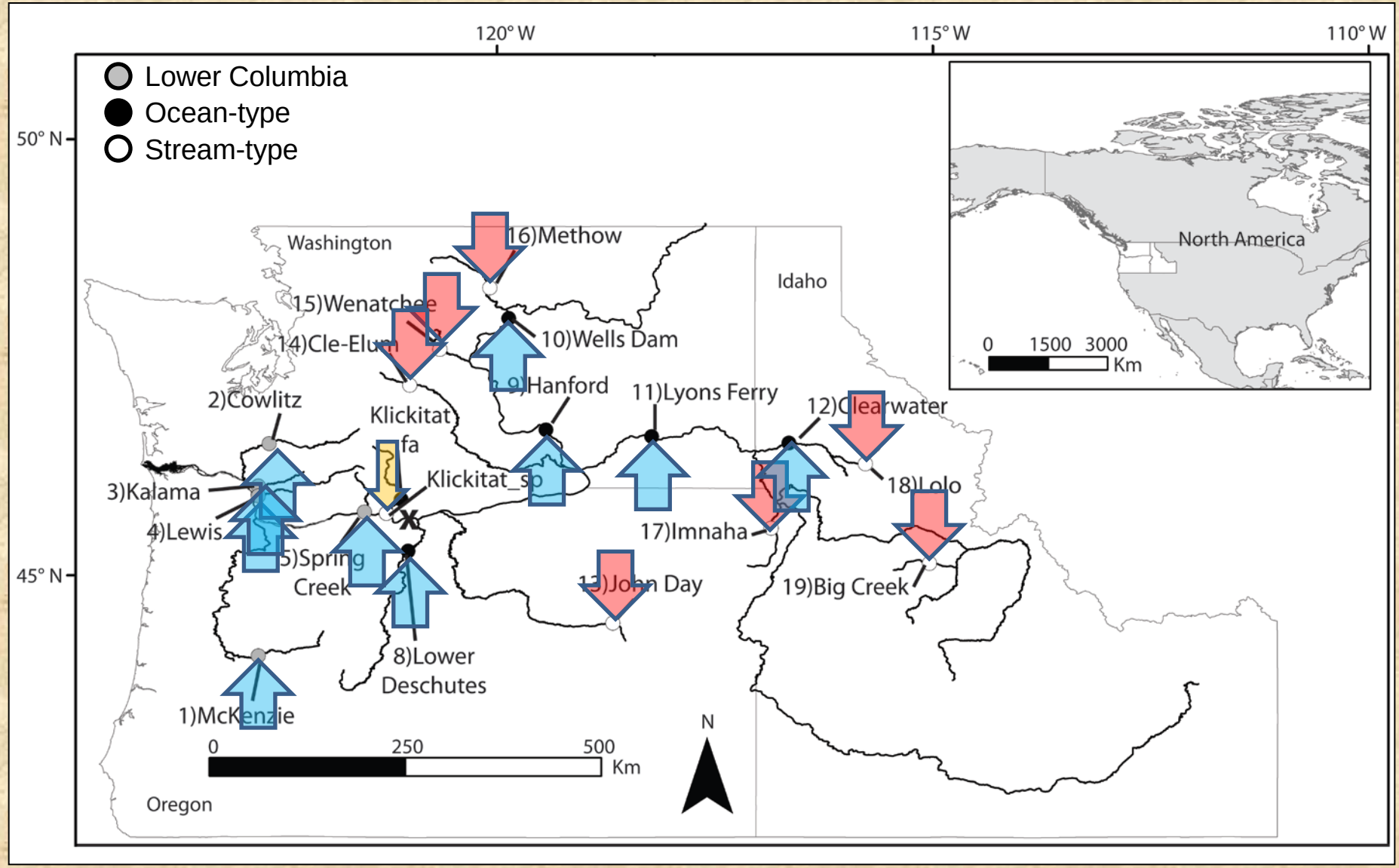
Permission by Lyn Topinka

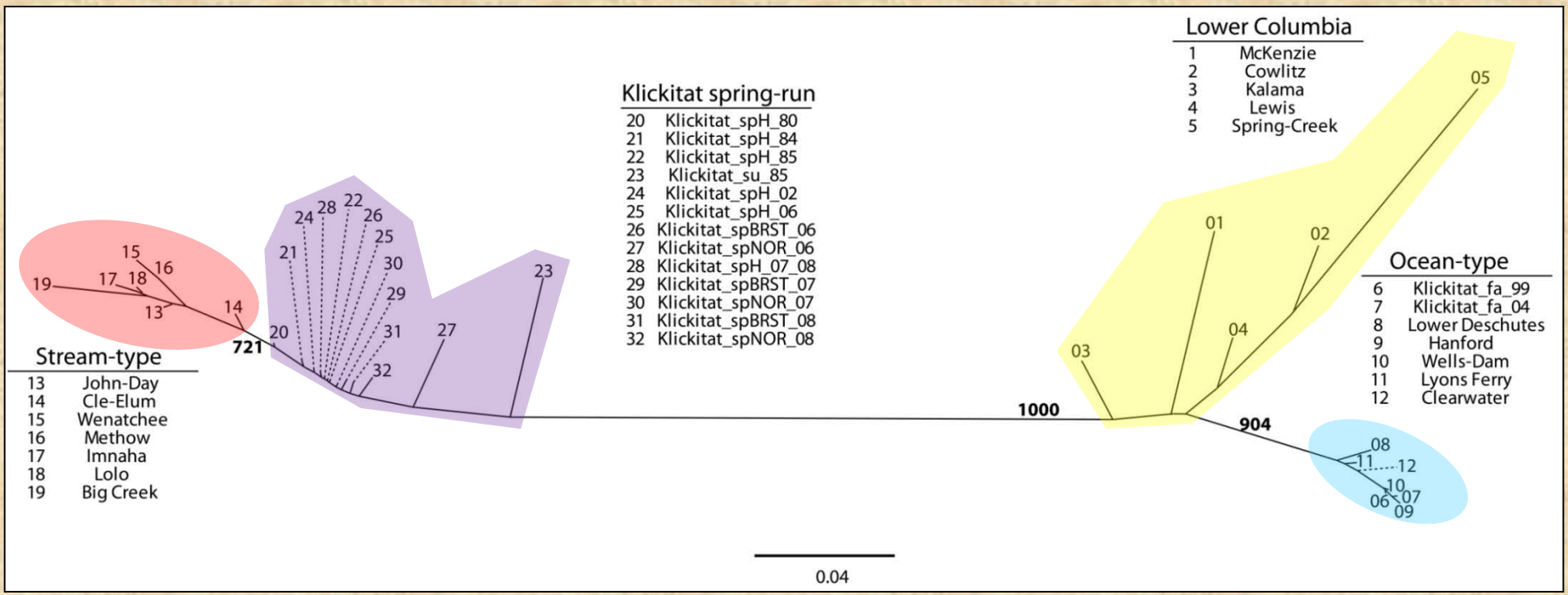
The Dalles Reservoir, ca. 2009
Celilo Falls were inundated after construction of Dalles Dam in 1957.

c) isolation-by-distance gene-flow

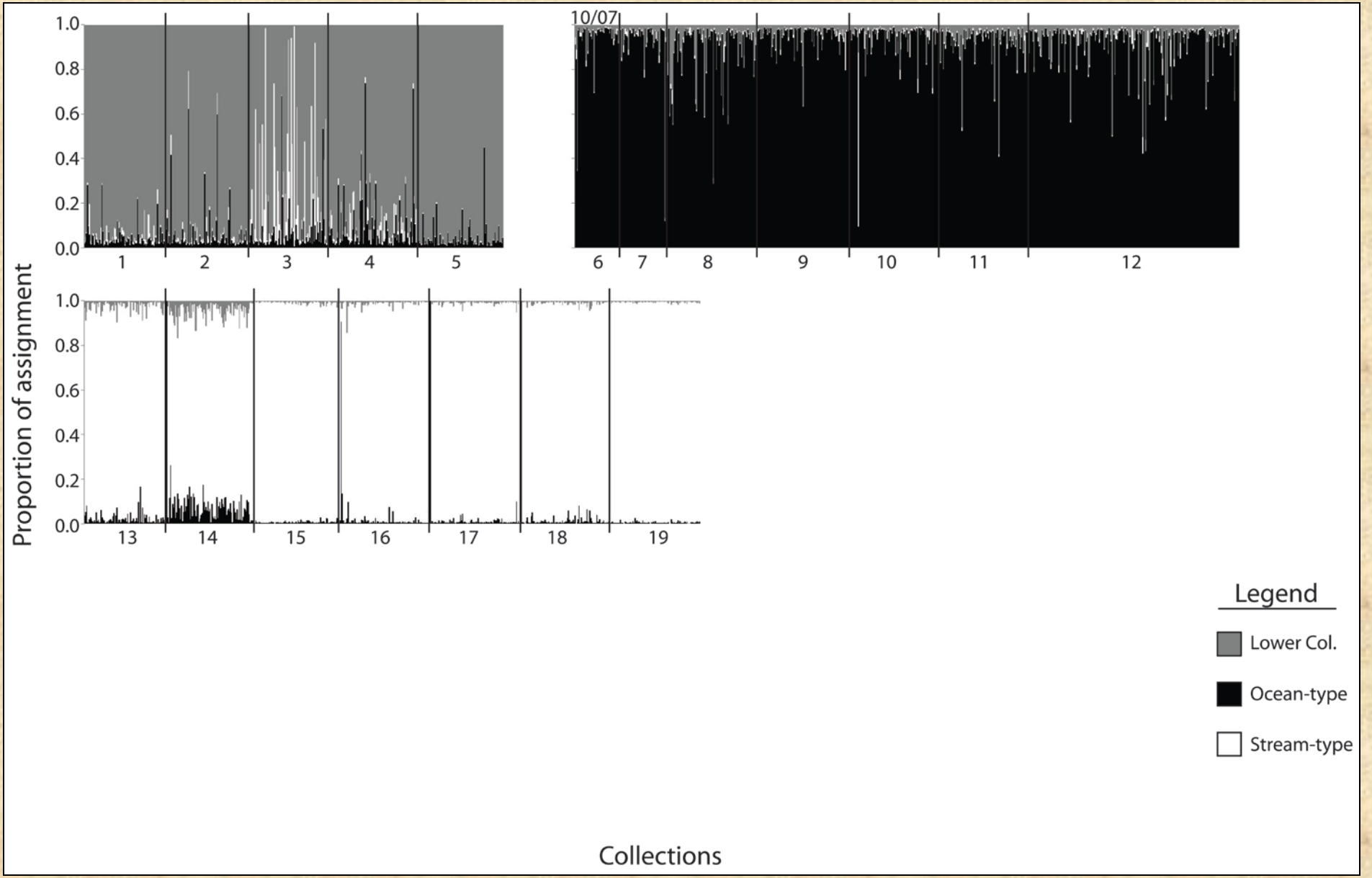


d) natural selection

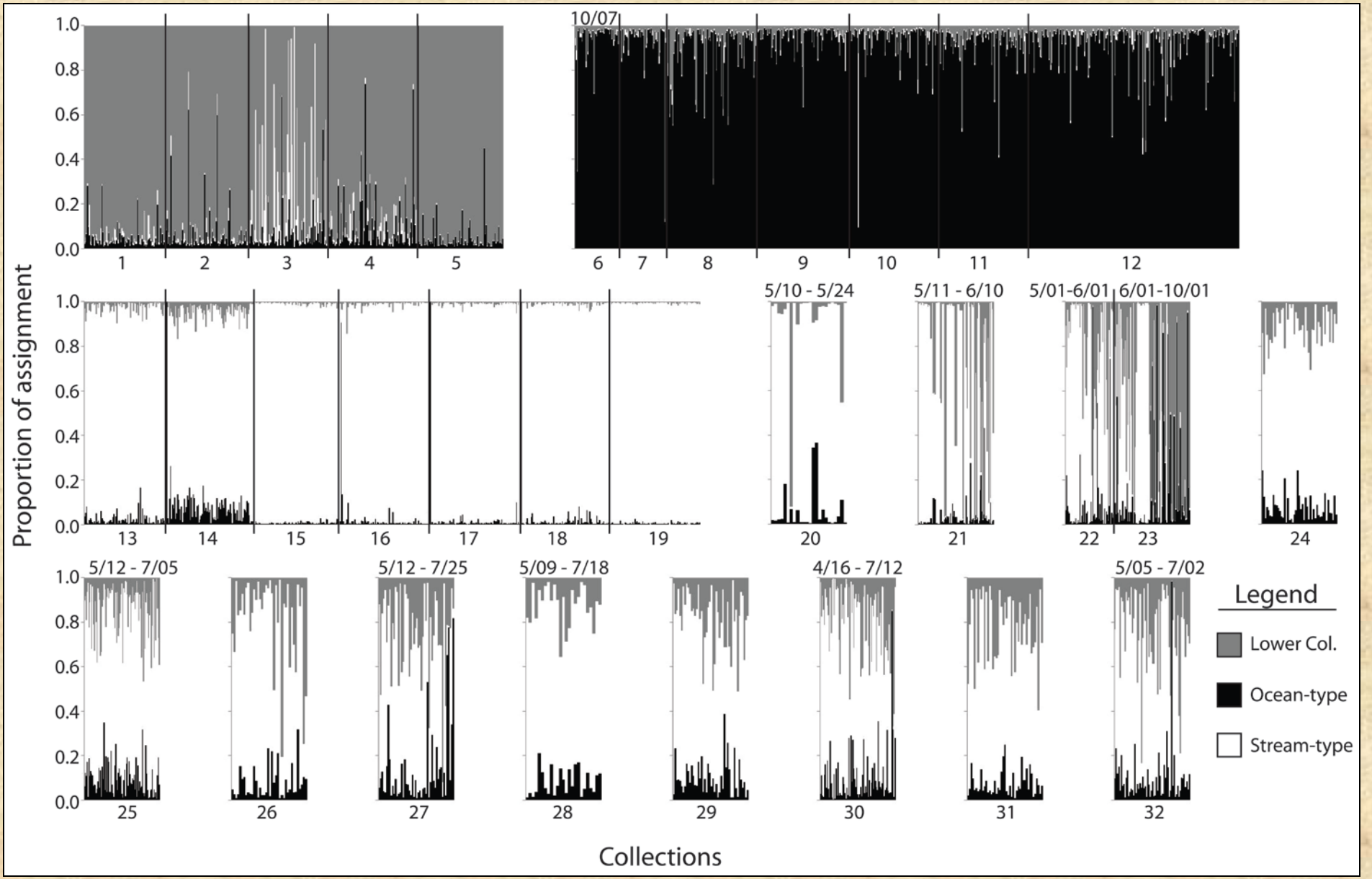




Neighbor joining tree based on pairwise F_{ST} for 91 SNP loci



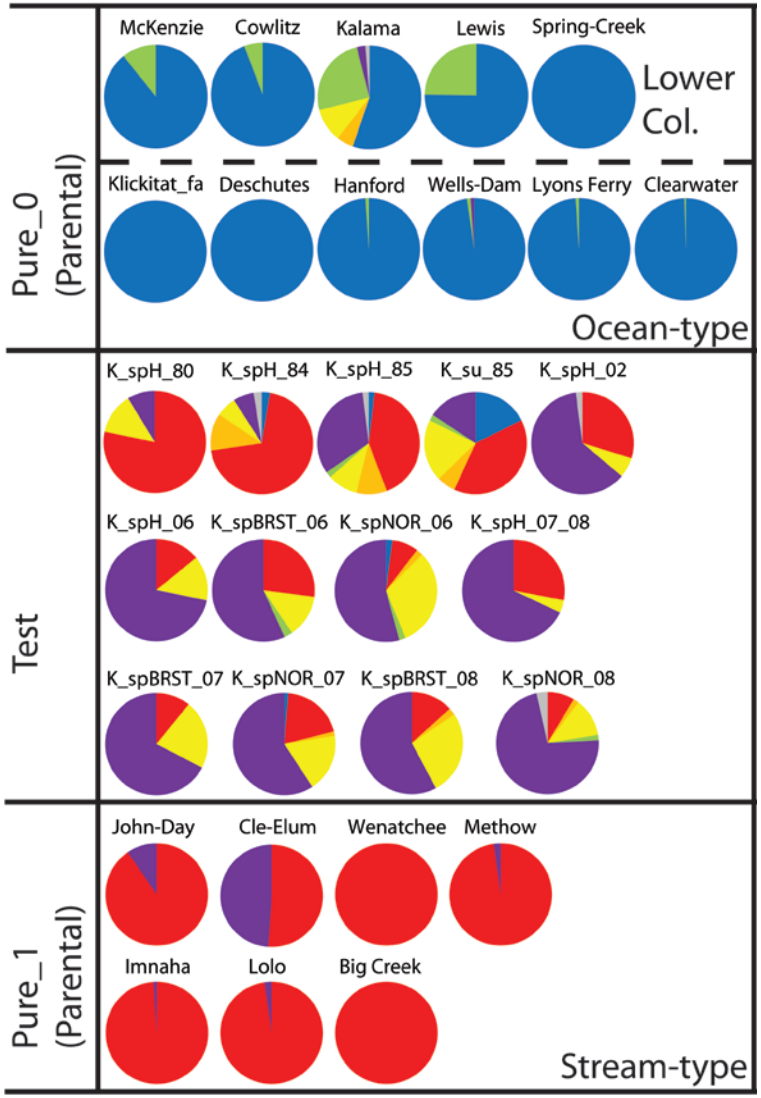
STRUCTURE results for 91 SNP loci



STRUCTURE results for 91 SNP loci

NEWHYBRIDS input

Lower Col./Ocean-type versus Stream-type



Legend

Pure_0 Pure_1 F1 F2 0_Backcross 1_Backcross Other

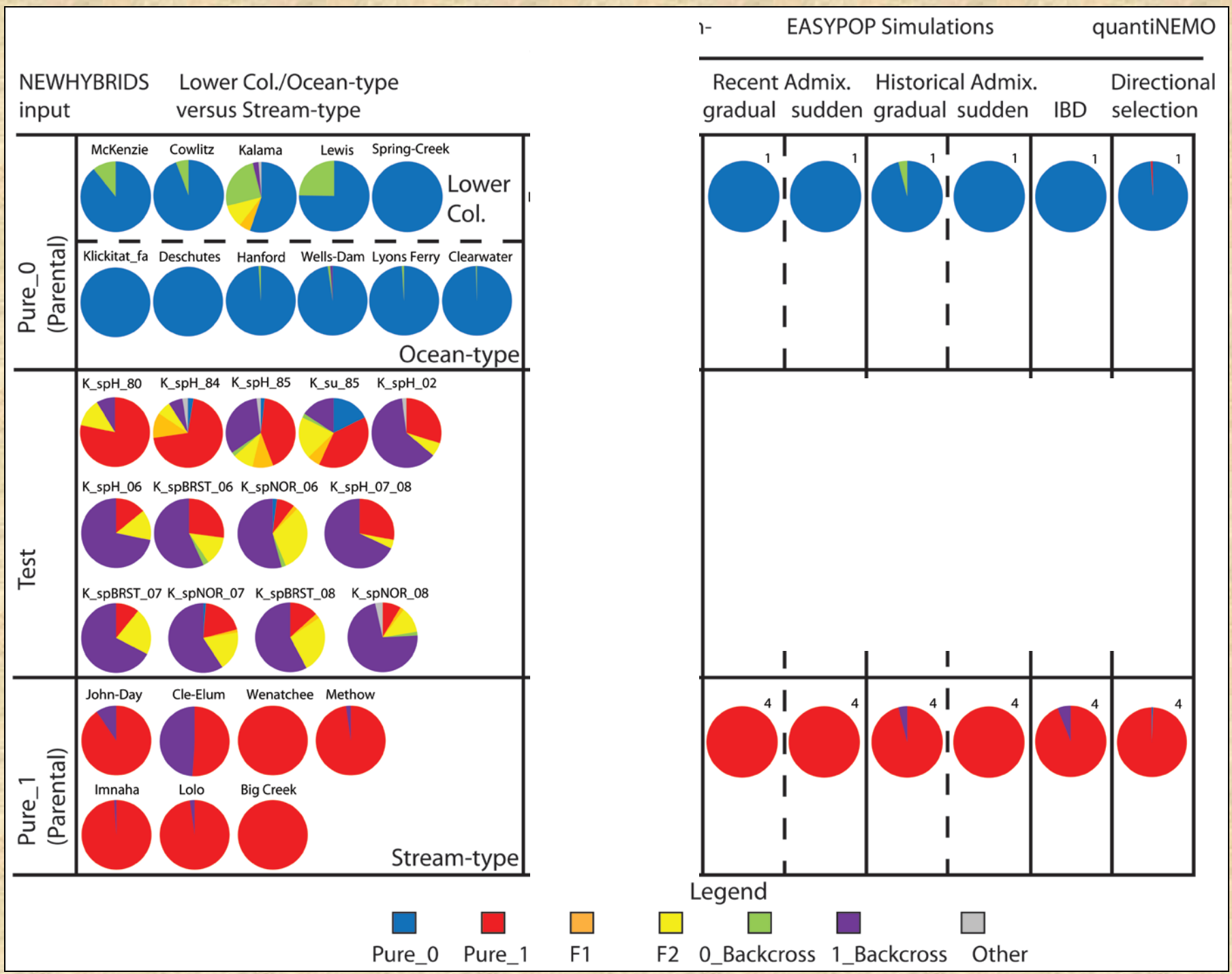
Computer simulations to test four main scenarios:

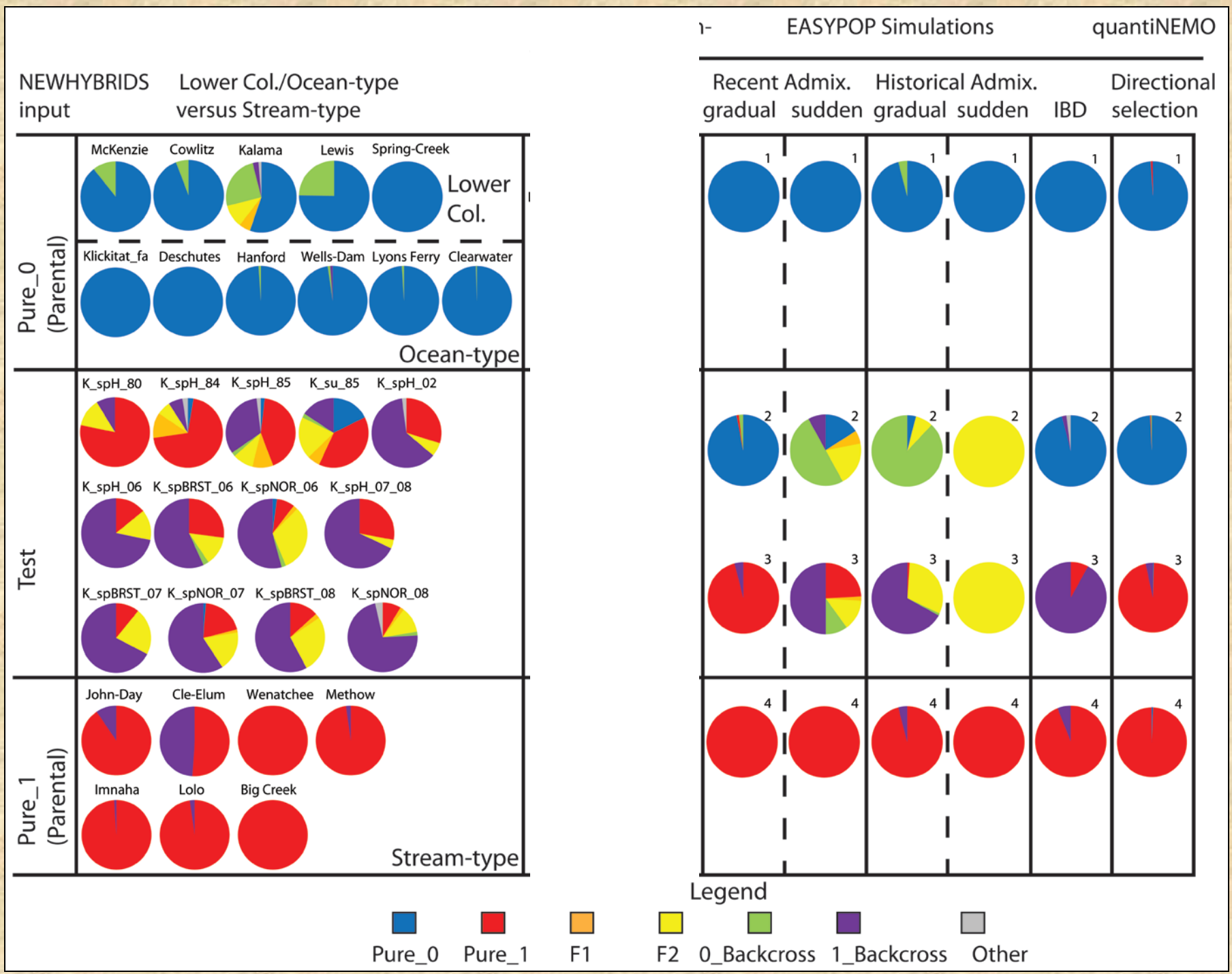
a)Recent admixture (~5 generations)
- **i)Sudden**
- **ii)Gradual**

b)Historical admixture (~200 generations)
- **i)Sudden**
- **ii)Gradual**

c)Isolation by distance (IBD) gene flow

d)Natural selection


EASYPOP Simulations
quantiNEMO
NEWHYBRIDS input
Lower Col./Ocean-type versus Stream-type
Recent Admix.
gradual
sudden
Historical Admix.
gradual
sudden
IBD
Directional selection
Pure_0 (Parental)
McKenzie
Cowlitz
Kalama
Lewis
Spring-Creek
Lower Col.
Klickitat_fa
Deschutes
Hanford
Wells-Dam
Lyons Ferry
Clearwater
Ocean-type
Test
K_spH_80
K_spH_84
K_spH_85
K_su_85
K_spH_02
K_spH_06
K_spBRST_06
K_spNOR_06
K_spH_07_08
K_spBRST_07
K_spNOR_07
K_spBRST_08
K_spNOR_08
Pure_1 (Parental)
John-Day
Cle-Elum
Wenatchee
Methow
Imnaha
Lolo
Big Creek
Stream-type
1
4
Legend
Pure_0
Pure_1
F1
F2
0_Backcross
1_Backcross
Other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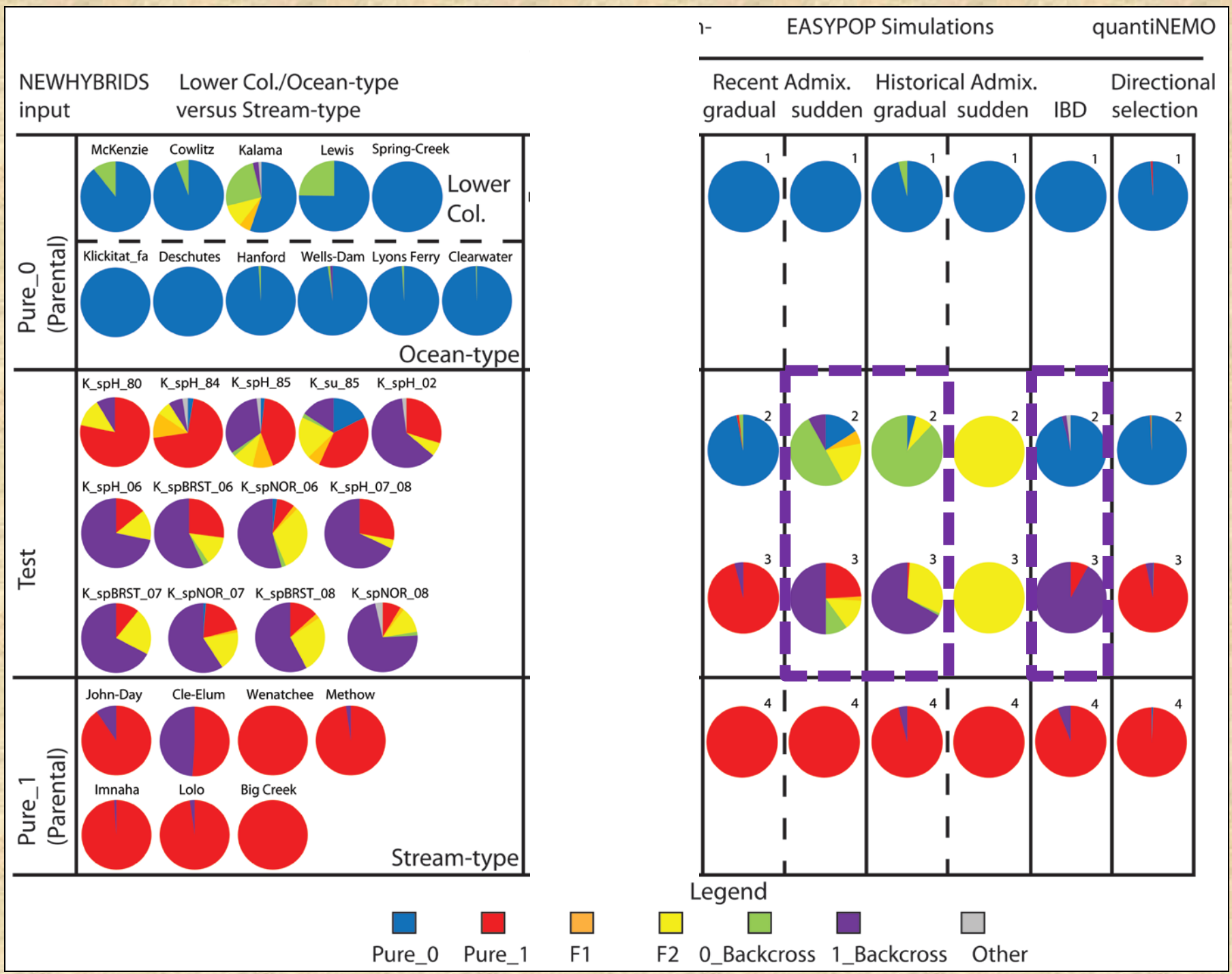
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Pure_1
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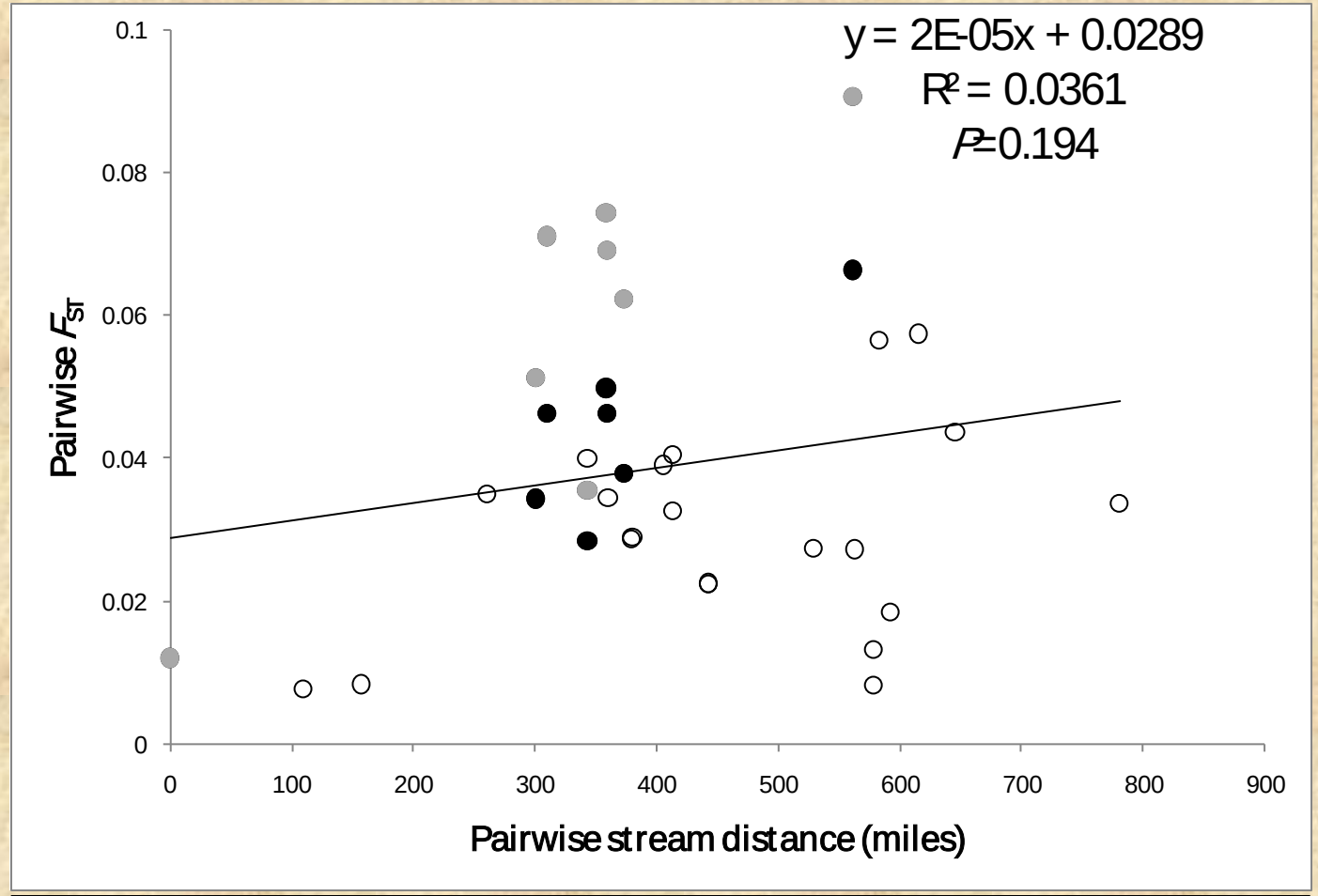
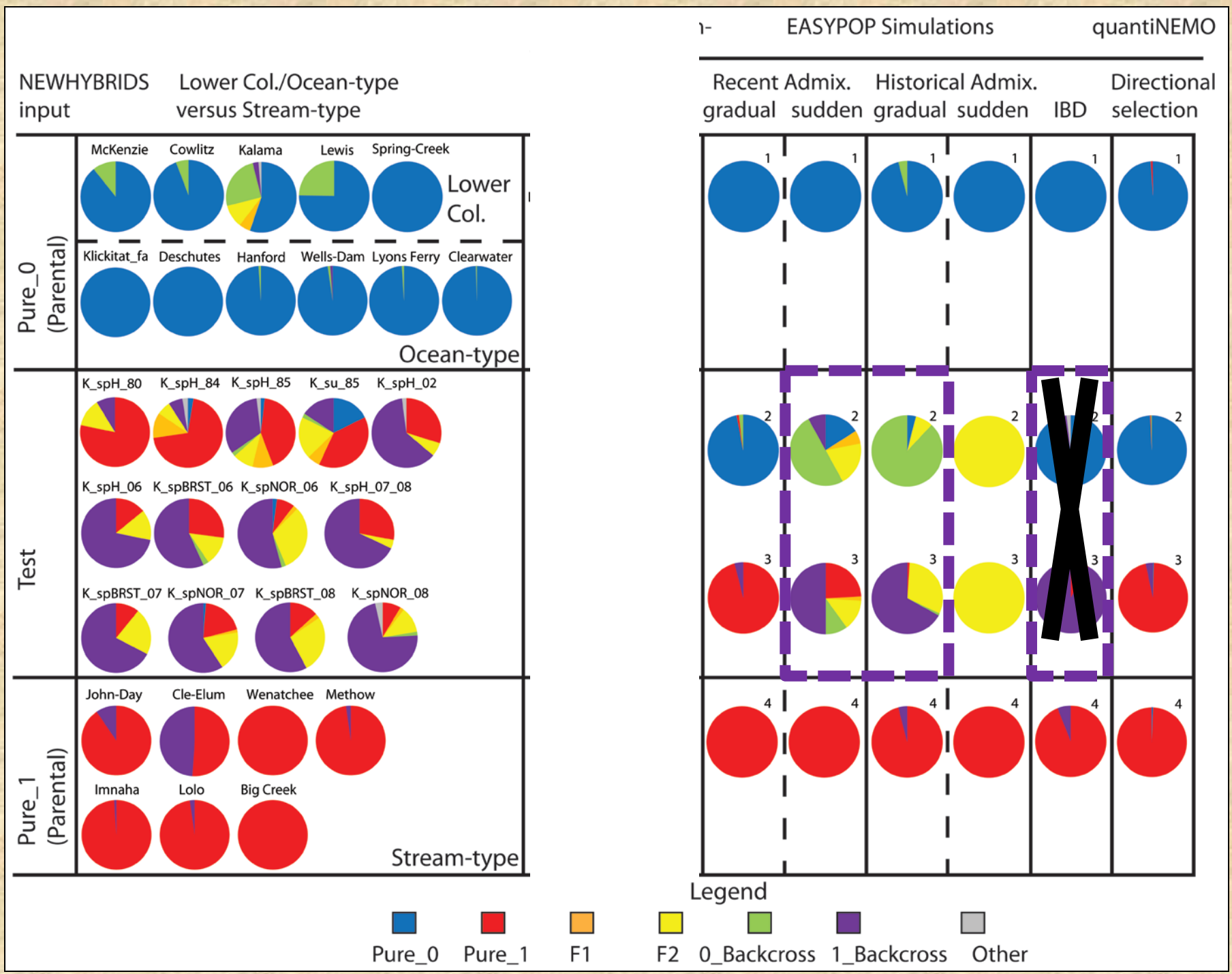
F2
0_Backcross
1_Backcross
Other

c)Isolation by distance (IBD) gene flow?



Mantel test to examine isolation-by-distance gene-flow among stream-type (Klickitat River spring-run collections included).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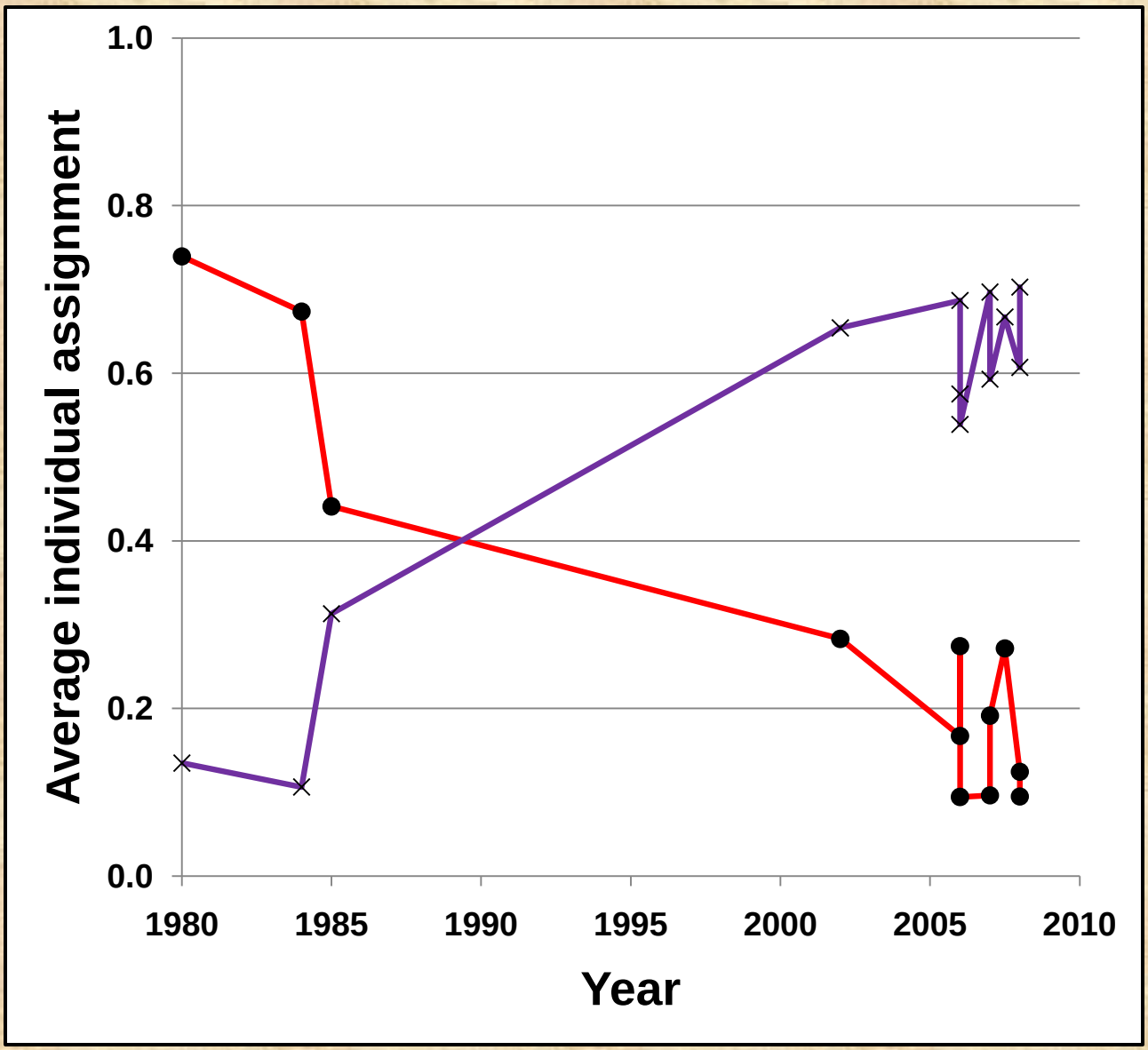
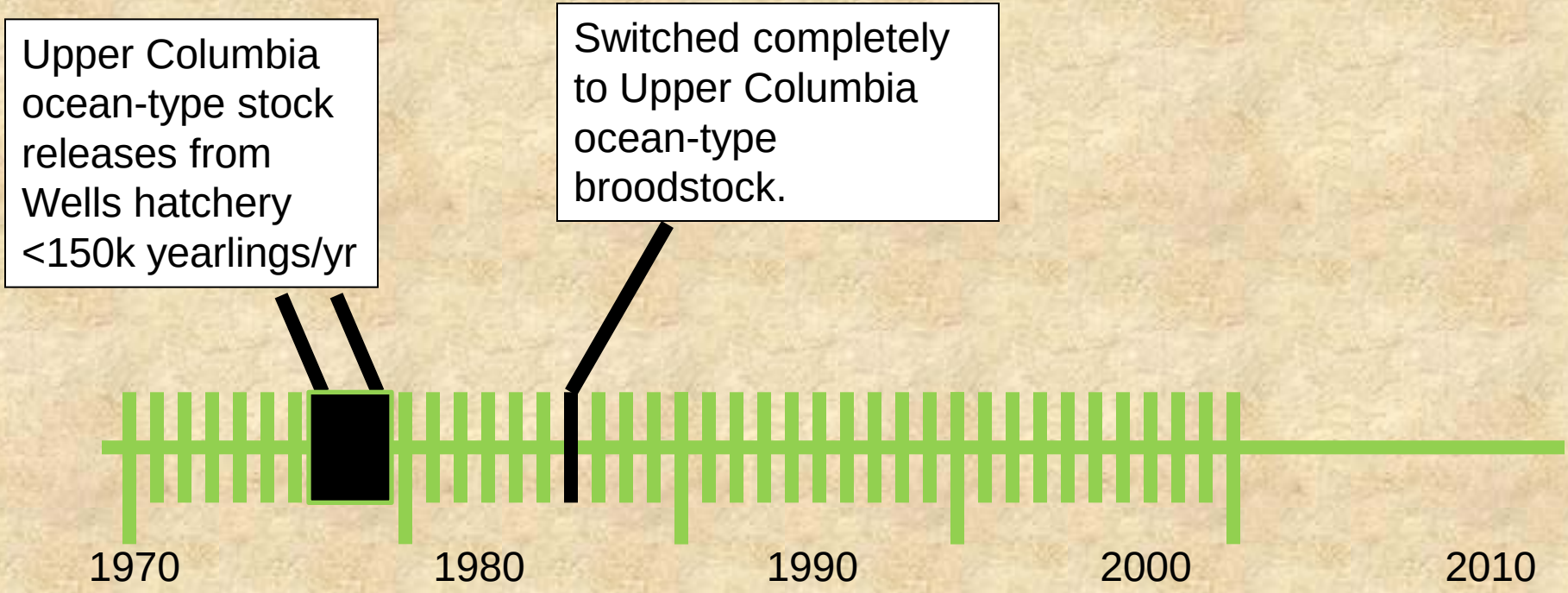
Temporal shift in genetic composition of Klickitat spring-run Chinook salmon



a) recent admixture (hatchery influence)

Stocking history of fall-run Chinook salmon in the Klickitat River hatchery

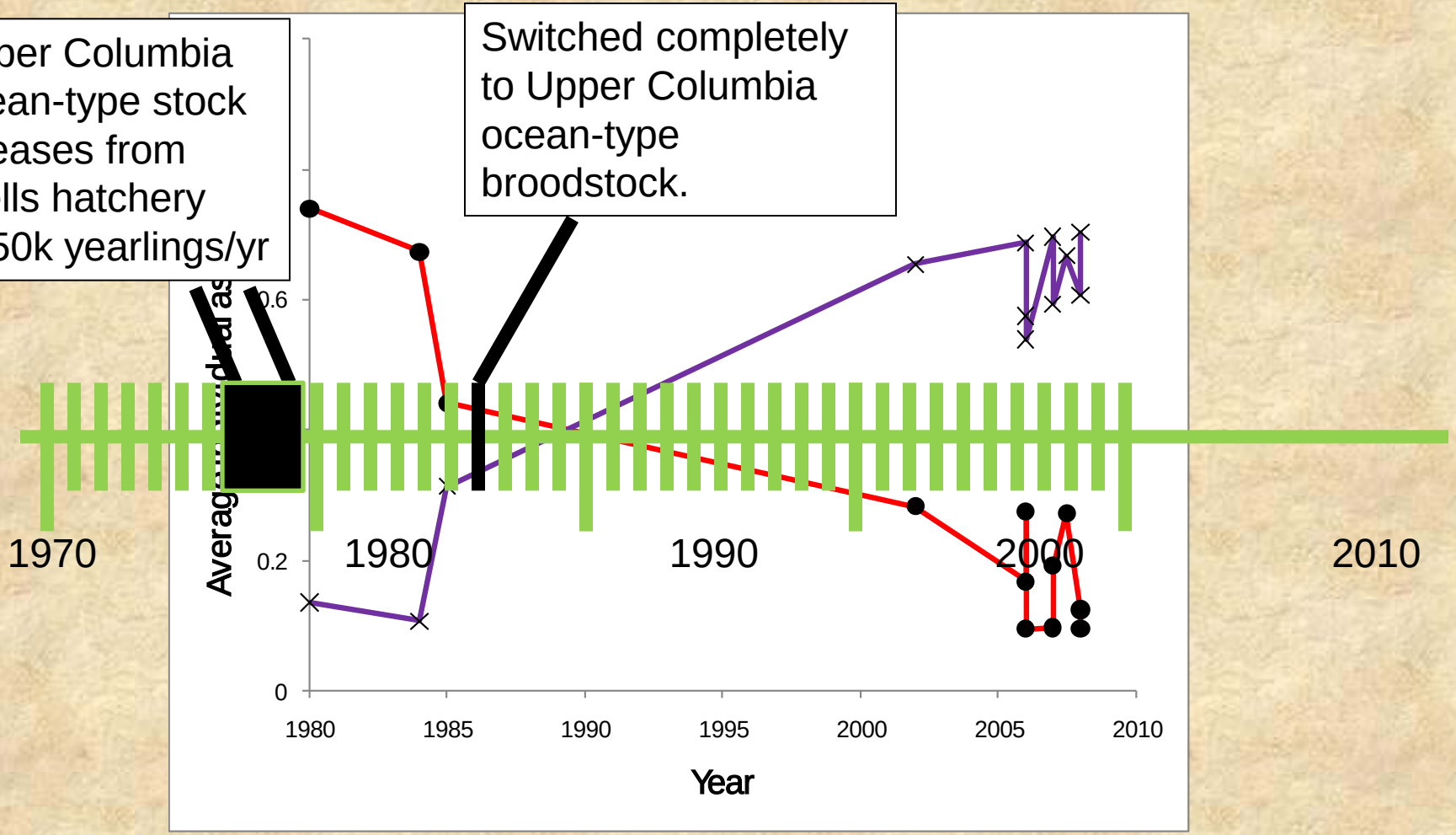


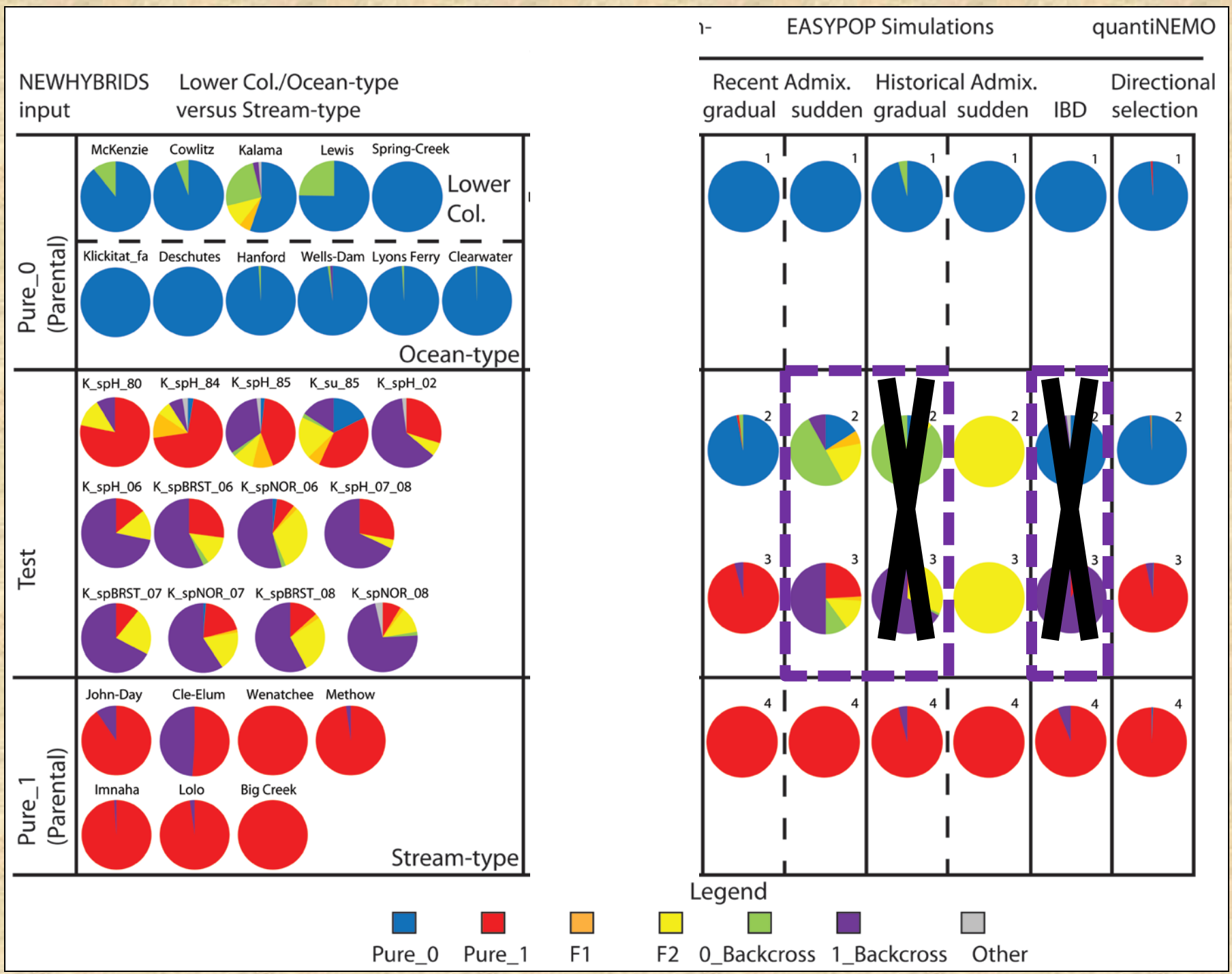
a) recent admixture (hatchery influence)

Stocking history of fall-run Chinook salmon in the Klickitat River hatchery

Upper Columbia ocean-type stock releases from Wells hatchery <150k yearlings/yr

Switched completely to Upper Columbia ocean-type broodstock.

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Pure_1
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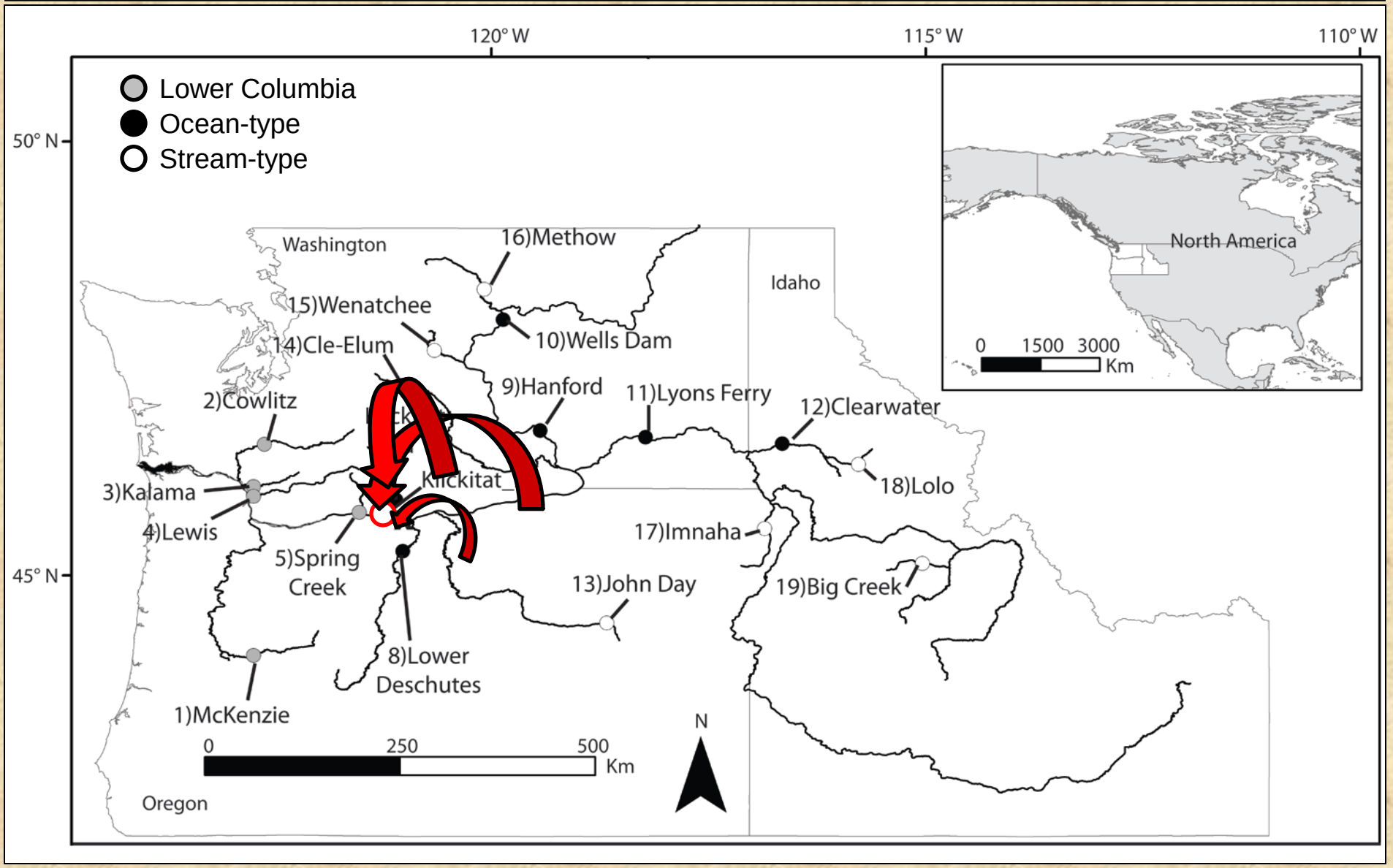
1_Backcross
Other

Possible strategy to mitigate potential long-term negative effects: incorporate “pure” stream-type fish from adjacent subbasin into Klickitat River Hatchery broodstock



Acknowledgements

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Jason Allen

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