

Microsatellite DNA Study of Population Genetic Structure of Yakima Basin Steelhead

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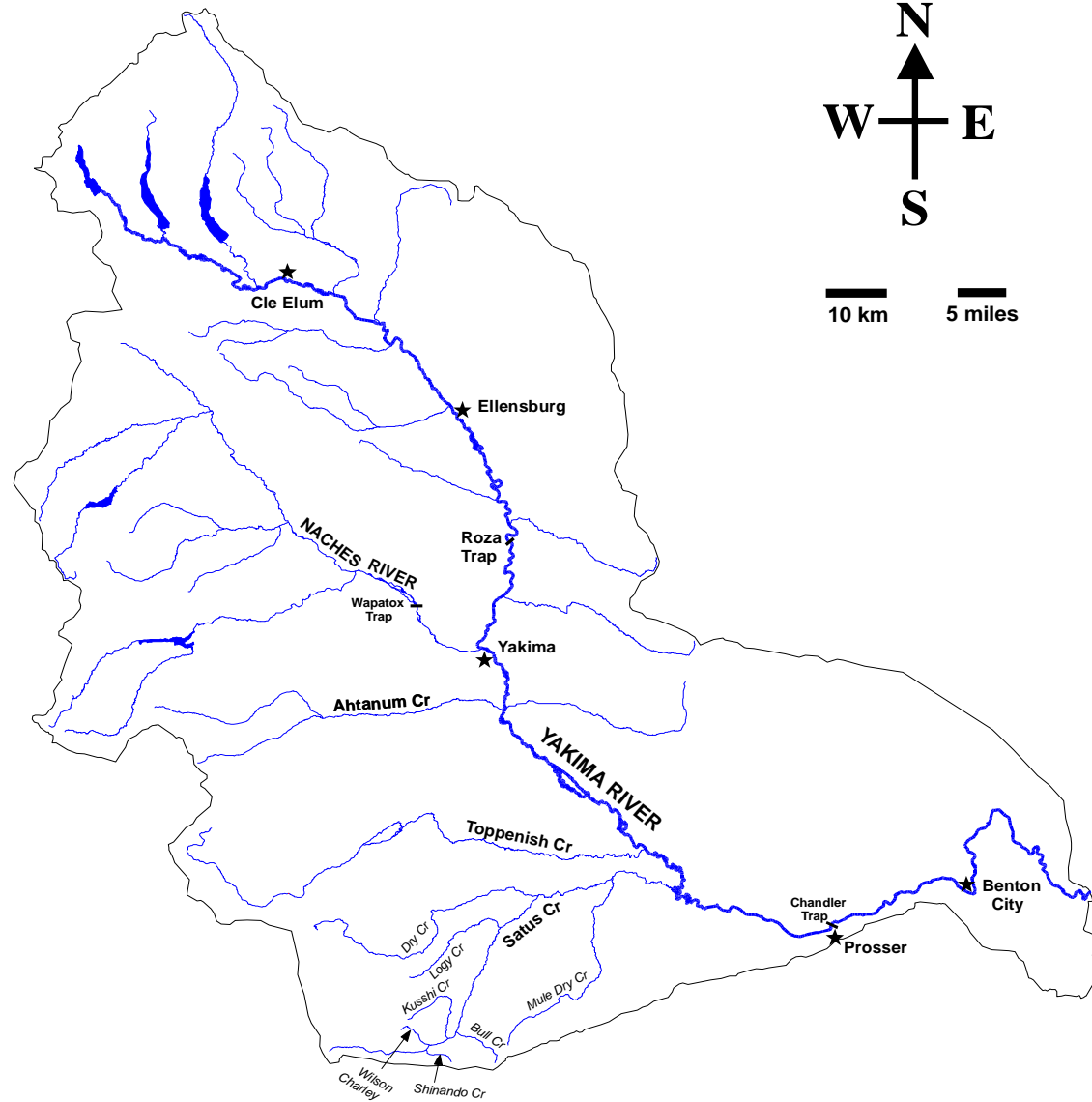


Map of Yakima drainage with tributaries in study

Wild steelhead:
Roza Dam
Naches River
Ahtanum Cr.
Toppenish Cr.
Satus Cr.

Hatchery steelhead:
Skamania broodstock

Hatchery rainbow:
Spokane Hatchery
Goldendale Hatchery
South Tacoma Hatchery
Eells Spring Hatchery



[map made from huc maps 17030003, 17030002, and 17030001 from StreamNet]

History

- Drainage once supported large steelhead populations
- Populations declined to 1% of former abundance: harvest and habitat degradation
- Population structure not clear after several years of allozyme work

Questions

What is current population structure?

To what extent have out-of-basin hatchery steelhead (Skamania) and rainbow trout impacted native populations?

Methods

- Genetically characterize wild and hatchery collections
- 10 microsatellite loci
 - Genotype each individual
 - Allele and genotype frequencies for collections
- Collection statistics (HWE)
- Compare allele and genotype frequencies
- Estimate shared ancestry
- Individual assignments

Collections	Abbreviation	N > 5 loci
Steelhead		
Toppenish Creek	00Topp	97
Toppenish Creek	01Topp	98
Ahtanum Creek	00Ahtan	71
Ahtanum Creek	01Ahtan	78
Satus Creek	00Satus	95
Satus Creek	01Satus	97
Roza Dam	00Roza	100
Roza Dam	01Roza	98
Roza Dam	03Roza	99
Naches River	04Naches	84
Skamania Hatchery	01SkamHat	96
Hatchery rainbow		
Goldendale Hatchery	01Gold	48
South Tacoma Hatchery	02STac	50
Eells Springs Hatchery	01Eell	89
Spokane Hatchery	00Spok	96
		1013

Results

- Minimal Hardy-Weinberg disequilibrium: little departure from heterozygosity expected with random mating
 - Ahtanum Cr. mostly negative values: recent outbreeding – not significant over all loci

	00Topp	01Topp	00Ahtan	01Ahtan	00Satus	01Satus	00Roza	01Roza	03Roza	04Naches	01SkamHa
One-102	-0.065	-0.042	0.041	0.024	0.015	0.016	0.000	0.036	0.009	0.070	-0.007
One-114	<u>0.088</u>	0.015	0.029	0.048	0.011	-0.028	0.026	0.043	-0.006	0.017	0.008
Ots-100	0.062	0.070	0.018	-0.014	0.065	0.020	-0.053	0.032	-0.009	0.031	-0.072
One-101	-0.046	<u>0.270</u>	-0.053	-0.109	<u>0.238</u>	<u>0.051</u>	0.098	<u>0.179</u>	0.128	<u>0.418</u>	<u>0.250</u>
One-108	-0.051	-0.004	-0.022	-0.046	0.017	<u>0.008</u>	0.064	0.087	<u>0.142</u>	0.008	0.002
Ots-103	0.151	-0.014	-0.057	-0.021	-0.030	<u>0.010</u>	-0.008	0.136	-0.036	0.093	0.029
Oki-10	<u>0.126</u>	0.064	0.024	-0.044	0.057	-0.095	0.028	0.026	0.042	0.012	-0.034
Omm-1128	0.015	<u>0.068</u>	-0.074	0.046	<u>0.144</u>	0.008	-0.026	0.036	-0.015	<u>0.093</u>	<u>0.135</u>
Omy-1001	0.026	-0.014	-0.031	0.011	0.022	0.007	-0.011	-0.002	-0.037	0.023	0.007
One-18	0.035	0.004	0.031	-0.074	0.105	0.034	<u>0.089</u>	-0.016	0.003	-0.032	0.036
All	<u>0.026</u>	<u>0.040</u>	-0.005	-0.011	<u>0.061</u>	0.001	0.019	<u>0.045</u>	<u>0.022</u>	<u>0.055</u>	<u>0.025</u>
pval	0.048	0.007	0.624	0.787	0.000	0.480	0.065	0.000	0.030	0.000	0.041

Results cont.

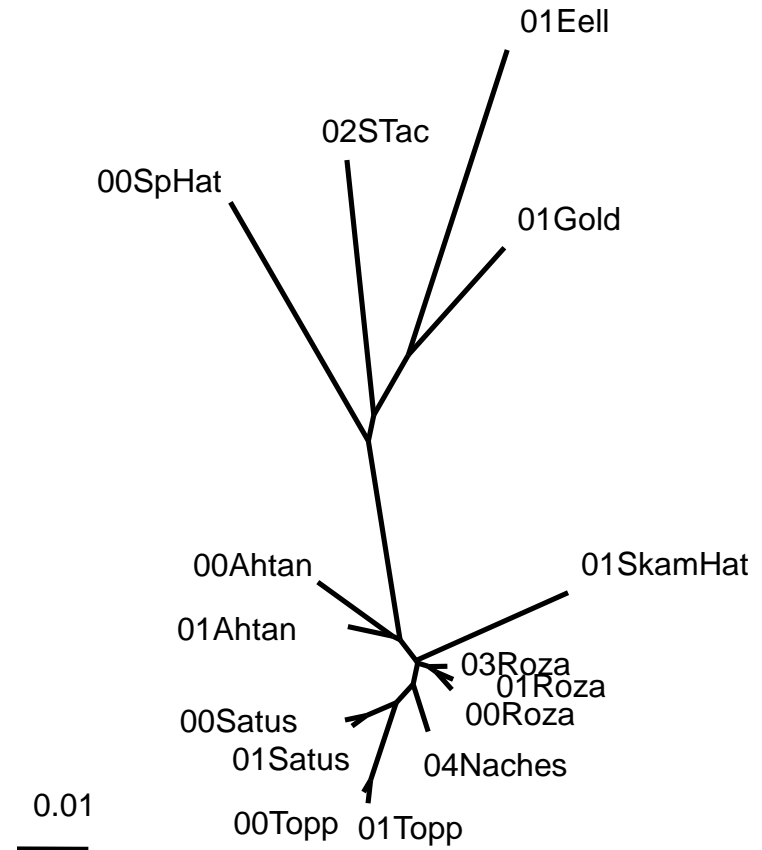
- Heterozygosity (H_e) and allelic richness (rich: number of alleles corrected for sample size) higher in wild collections
- 17 locus pairs linked in Ahtanum Cr. – signal for recent outbreeding



Collections	H_e	rich	link
Steelhead			
Toppenish Creek	0.712	11.02	
Toppenish Creek	0.770	10.39	1
Ahtanum Creek	0.769	11.87	17
Ahtanum Creek	0.732	13.34	1
Satus Creek	0.796	12.27	
Satus Creek	0.752	11.38	1
Roza Dam	0.794	13.99	
Roza Dam	0.768	14.48	
Roza Dam	0.748	14.46	
Naches River	0.802	13.08	
Skamania Hatchery	0.763	12.02	
Hatchery rainbow			
Goldendale Hatchery	0.660	6.32	
South Tacoma Hatchery	0.580	4.60	
Eells Springs Hatchery	0.580	4.24	
Spokane Hatchery	0.7	6.35	1

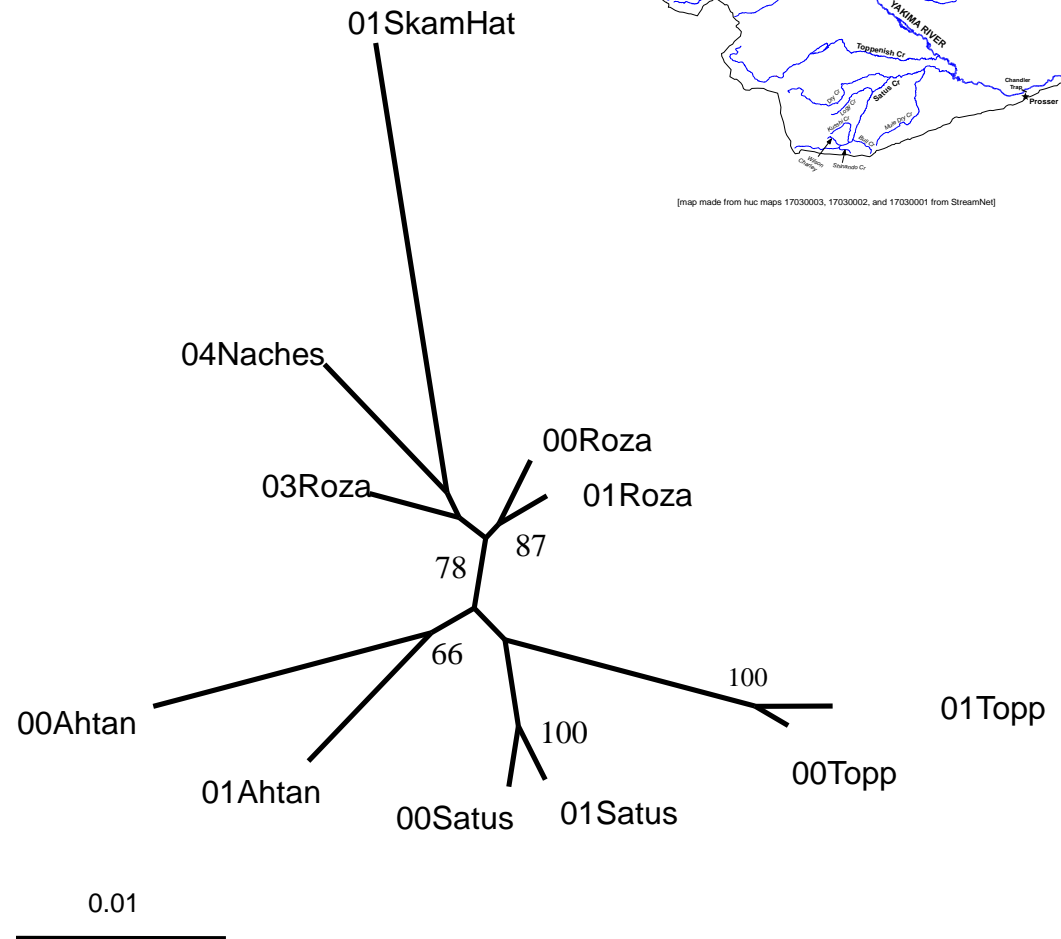
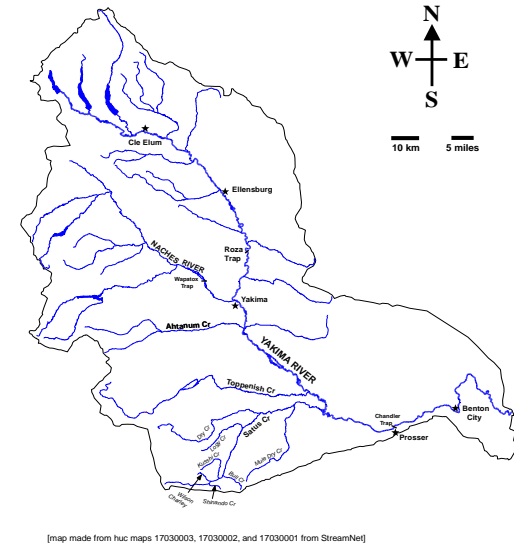
Results: hatchery rainbow and steelhead collections

- Neighbor-joining tree of genetic distances among collections
- Hatchery rainbow had little to no impact on steelhead populations



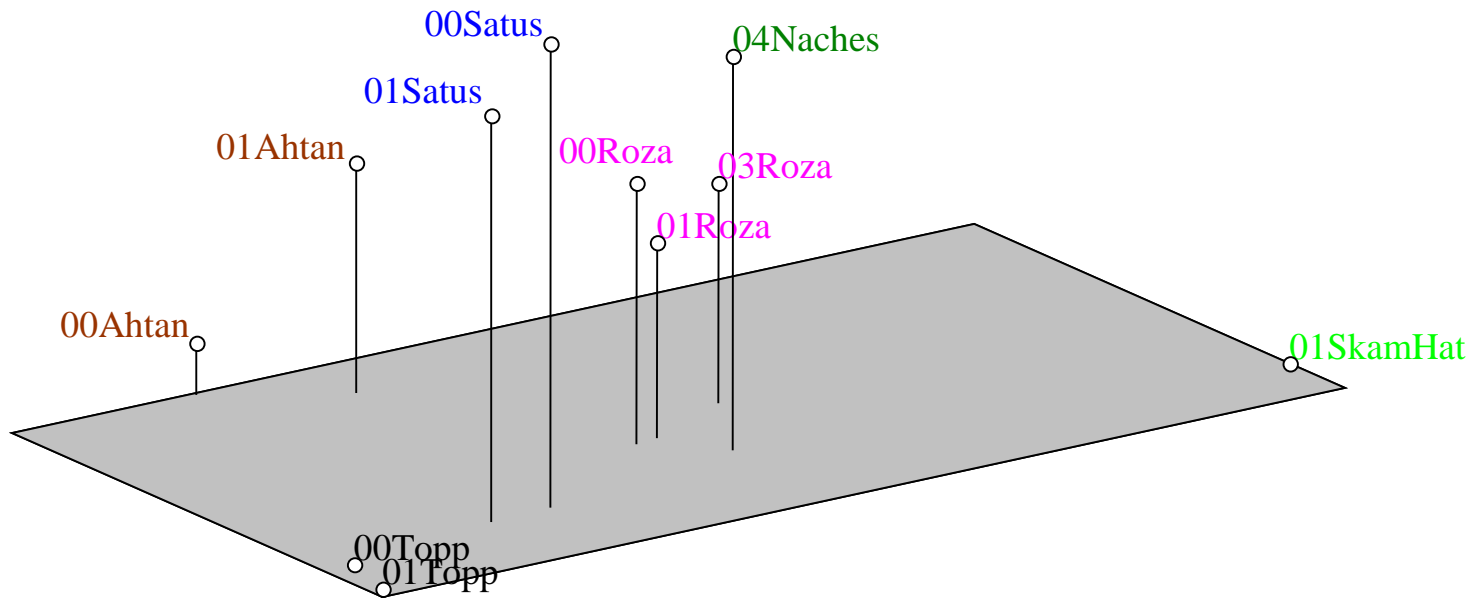
Results: hatchery steelhead and steelhead collections

- Consensus neighbor-joining tree of genetic distances among collections
- Numbers at nodes are percentage of 10,000 trees in which collections grouped together
- Year classes group by tributary
- Skamania hatchery steelhead distant from all populations but most closely related to Roza Dam and Naches River



Multi-dimensional scaling plot of genetic distances: year classes group by tributary, Skamania Hatchery genetically distant

Stress = 0.142





Results cont.

- Pairwise genotypic and F_{ST} tests – are populations reproductively isolated:
 - Genotypic: are genotypic frequencies significantly different
 - F_{ST} : what is magnitude of differences



Results: pairwise tests

- Tests were concordant (bold values significant)
 - Year classes not significantly different within Toppenish, Satus and 00,01Roza Dam (although 03Roza Dam differences small)
 - Significant differences between tributaries and between hatchery and wild fish

	00Topp	01Topp	00Ahtan	01Ahtan	00Satus	01Satus	00Roza	01Roza	03Roza	04Naches	01SkamHat
00Topp	-	0.42024	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
01Topp	0.0041	-	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
00Ahtan	0.0537	0.0583	-	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
01Ahtan	0.0445	0.0513	0.0286	-	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
00Satus	0.0504	0.0473	0.0414	0.0339	-	0.53227	0.00002	0.00002	0.00002	0.00002	0.00002
01Satus	0.0344	0.033	0.0379	0.0316	0.0023	-	0.00002	0.00002	0.00002	0.00002	0.00002
00Roza	0.035	0.0431	0.0326	0.0224	0.025	0.0184	-	0.19135	0.00002	0.00002	0.00002
01Roza	0.0351	0.0411	0.0306	0.019	0.0217	0.017	0.0007	-	0.00002	0.00002	0.00002
03Roza	0.0401	0.0469	0.0321	0.0198	0.0323	0.0268	0.0041	0.004	-	0.00002	0.00002
04Naches	0.0463	0.0512	0.0329	0.027	0.0221	0.0206	0.017	0.0173	0.0192	-	0.00002
01SkamHat	0.0684	0.0746	0.0654	0.0547	0.0721	0.067	0.0382	0.0373	0.0295	0.0526	-

Bayesian ancestry analysis: what

proportion of ancestry is shared among collections – organizes genotypes in groups to minimize Hardy-Weinberg disequilibrium, number of groups hypothesized based on tree

- Collections share most ancestry within tributary
- Upper Yakima and Naches share more ancestry
- Upper Yakima and Naches share slightly more ancestry with Skamania Hatchery

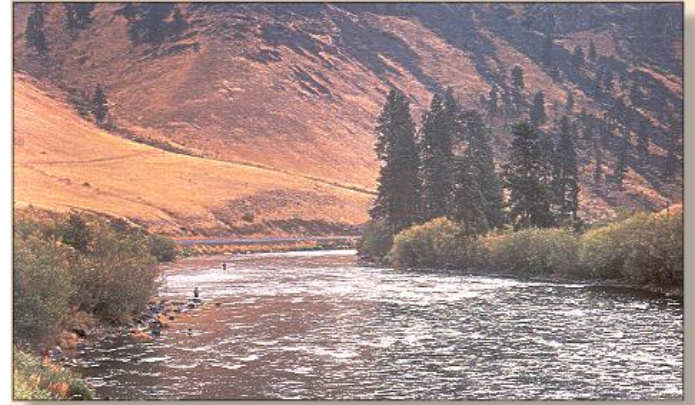
Pop	1	2	3	4	5	6	Individuals
00Topp	0.712	0.067	0.081	0.069	0.046	0.025	97
01Topp	0.777	0.050	0.058	0.041	0.035	0.040	98
00Ahtan	0.117	0.629	0.069	0.115	0.040	0.030	71
01Ahtan	0.064	0.525	0.064	0.211	0.102	0.034	78
00Satus	0.036	0.064	0.607	0.072	0.184	0.038	95
01Satus	0.084	0.055	0.582	0.058	0.196	0.025	97
00Roza	0.052	0.089	0.116	0.416	0.264	0.063	100
01Roza	0.051	0.124	0.140	0.396	0.213	0.077	98
03Roza	0.032	0.072	0.083	0.522	0.203	0.088	99
04Naches	0.050	0.085	0.117	0.100	0.575	0.072	84
01SkamHat	0.018	0.022	0.022	0.043	0.030	0.864	96

Assignment test

- Based upon an individual's genotype – which collection was it most likely to have originated from
 - High self-assignment = genetic distinction
- Collections assigned well within tributary
- Few individuals assigned as hatchery steelhead indicating little impact or contribution by hatchery fish

	00Topp	01Topp	00Ahtan	01Ahtan	00Satus	01Satus	00Roza	01Roza	03Roza	04Naches	01SkamHa
00Topp	47	30	1	3		4	1	2	1	3	
01Topp	38	58		2		3	1	1			
00Ahtan	1	1	51	7			4	5	5	4	1
01Ahtan	2	1	8	48	2	2	4	6	1	1	
00Satus	1			3	42	31	2	4	2	5	
01Satus	2	5		4	35	47	8	6	4	3	
00Roza	1		2	1	5	5	34	23	13	1	1
01Roza	2	1	3	5	3	3	20	35	12	4	
03Roza			3	4	2		15	8	48	8	3
04Naches	3		3		5	2	8	8	13	54	1
01SkamHat		2		1	1		3			1	90
Total	97	98	71	78	95	97	100	98	99	84	96
correct	47	58	51	48	42	47	34	35	48	54	90
% correct	48.45	59.18	71.83	61.54	44.21	48.45	34.00	35.71	48.48	64.29	93.75
Trib correct		173		114		155		208			
% Trib correct		88.72		76.51		80.73		70.03			

Conclusions



- Hatchery rainbow and hatchery steelhead seem to have had little impact on wild steelhead populations
- Discrepancy between microsatellite and allozyme results regarding hatchery impacts?
- Year class collections within tributaries are more closely related to each other, indicating reproductive isolation from populations in other tributaries
- Population structure of upper basin still unclear, and needs further resolution

Acknowledgements

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