Using DNA Markers To Delineate Populations Of Yakima Basin Steelhead

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Introduction

SH Populations

Roza Dam SH

Resident Trout

Prosser Dam

Conclusions

Presentation Outline

- Background
  - Steelhead population classification
  - Genetic analysis
- Differentiation of Yakima River steelhead
- Analysis of temporally replicated collections from Roza Dam
- Comparison of resident trout to Roza Dam steelhead
- Prospects for identifying steelhead at Prosser Dam
- Conclusions

Yakima Steelhead Population Classification

Federal

Evolutionary Significant Unit (ESU)

- Inland Steelhead – Middle Columbia River

Washington State

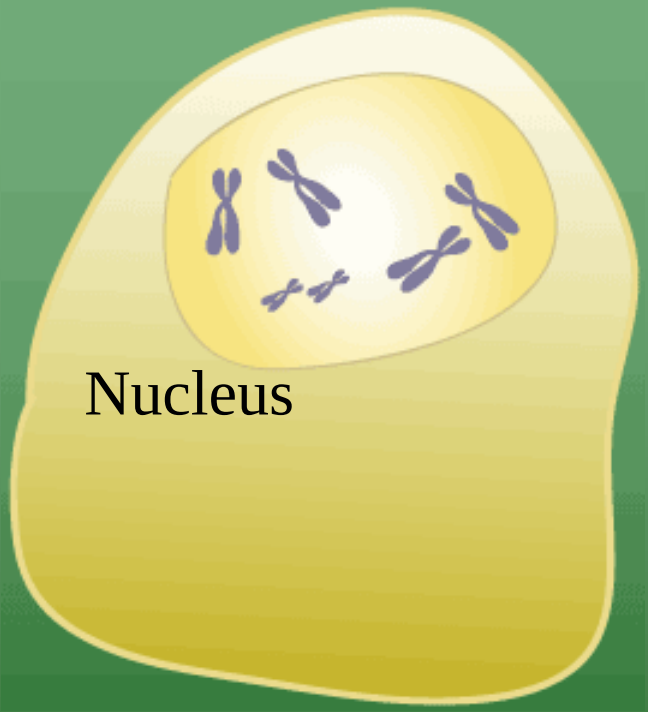
Genetic Diversity Units (GDU)

- Yakima River

Salmonid Stock Inventory (SaSI)

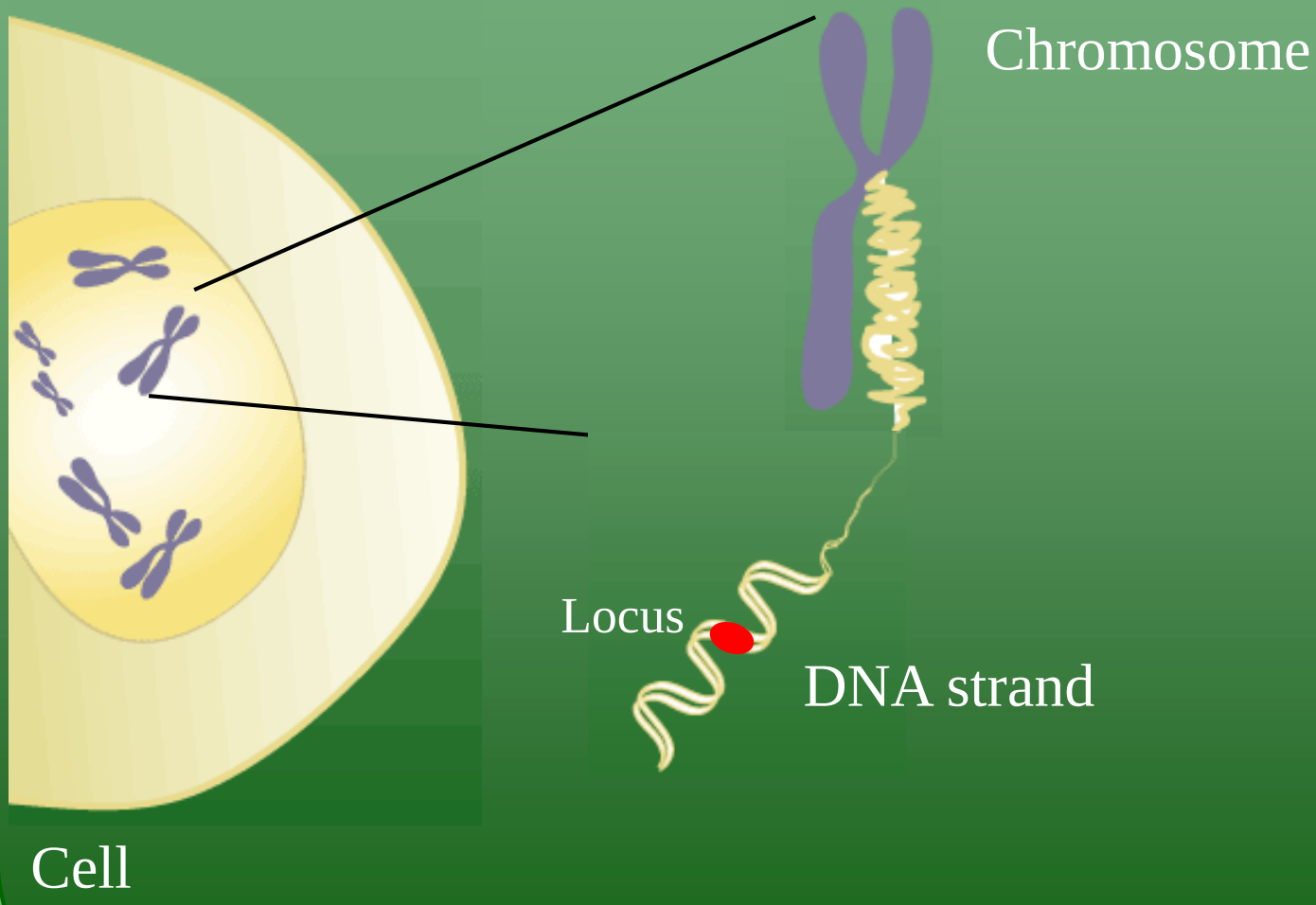
- Satus Creek
- Toppenish Creek
- Naches River
- upper Yakima (above Roza Dam)

Genetic Markers



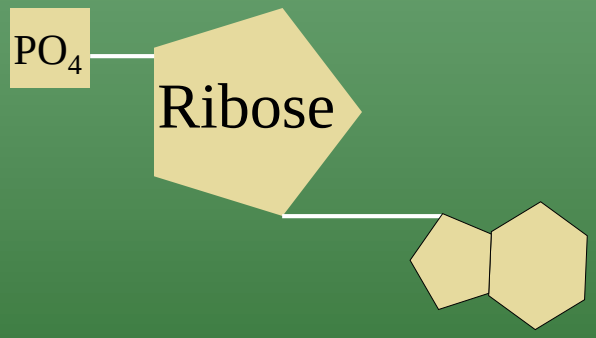
Cell

Genetic Markers



DNA

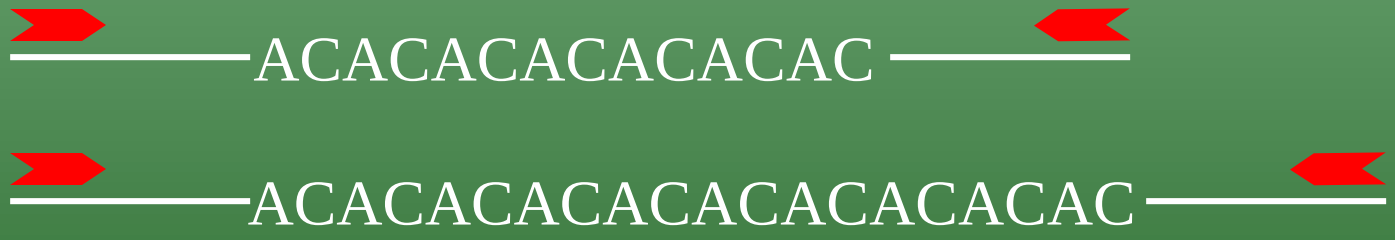
- Linear array of nucleotides



Adenine
Cytosine
Guanine
Thymine

Microsatellite Loci

- Short tandem repeats of DNA nucleotides



Genetic Analyses

Within Collection Analyses

- Heterozygosity
- Hardy-Weinberg Equilibrium
- Linkage Equilibrium (LD)

Between/Among Collection Analyses

- Genic differentiation
- F_{ST}
- Analysis of Molecular Variance (AMOVA)
- GSI / MSA / Individual ID

Yakima River Steelhead Differentiation

Steelhead Collection	N
2000 Satus Cr.	95
2001 Satus Cr.	97
2000 Toppenish Cr.	97
2001 Toppenish Cr.	98
2000 Ahtanum Cr.	71
2001 Ahtanum Cr.	78
2004 Naches R.	84
2005 Naches R.	102
2000 Roza Dam	100
2001 Roza Dam	98
2003 Roza Dam	99
2005 Roza Dam	94
2001 Skamania H.	96

Rainbow Collection	N
2001 Goldendale H.	48
2002 South Tacoma H.	50
2001 Eells Springs H.	89
2000 Spokane H.	96

Small et al. (2006)

Yakima River Steelhead Differentiation

Results

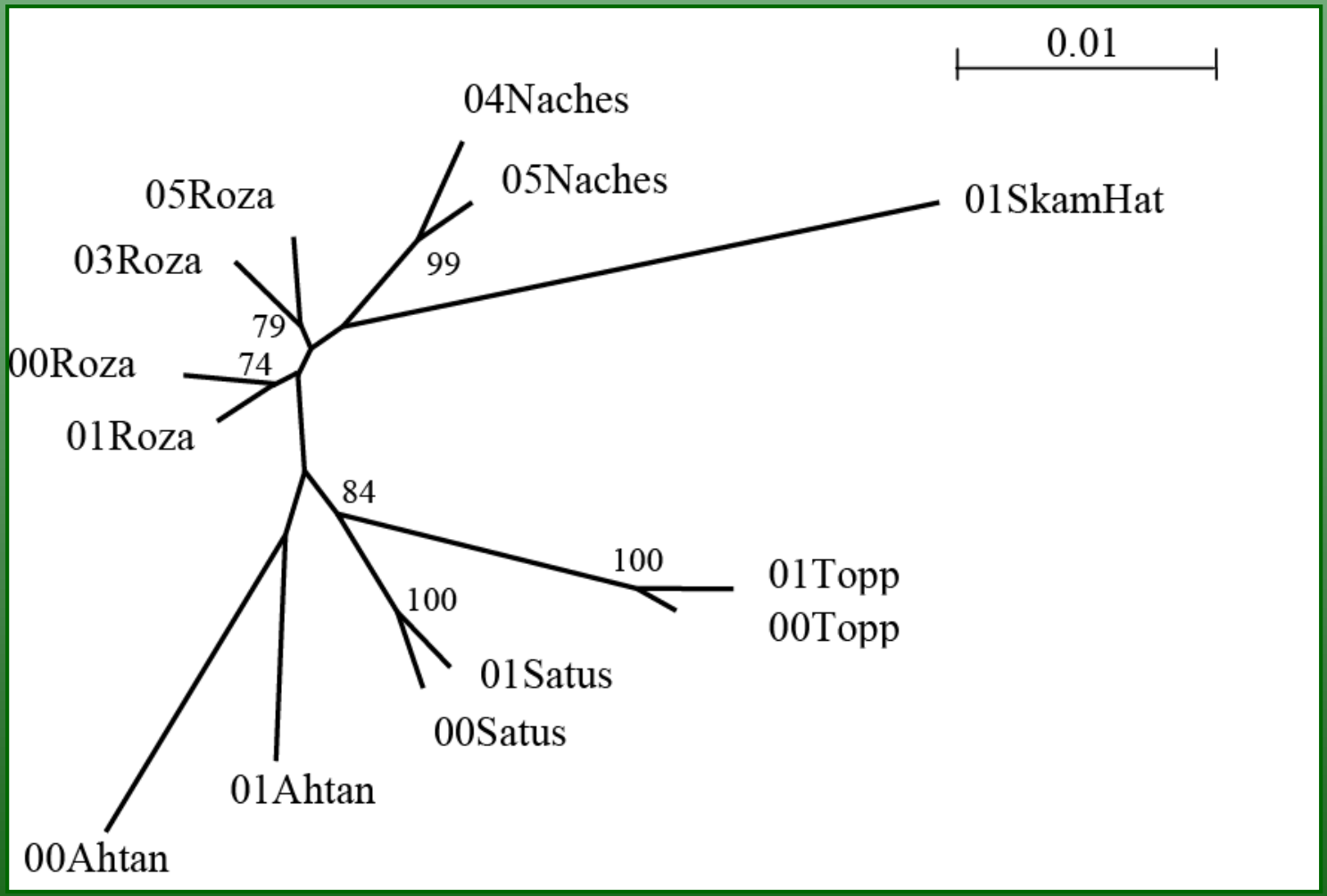
- Multiple collections from a single site tend to be genetically similar

  Exceptions:
  1) Two Ahtanum collections slightly different
  2) Naches R. and Roza Dam similar

- Populations are differentiated based on geography

Small et al. (2006)

Yakima River Steelhead Differentiation



Small et al. (2006)

Yakima River Steelhead Differentiation

Results

- Multiple collections from a single site tend to be genetically similar

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  1) Two Ahtanum collections slightly different
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- Populations are differentiated based on geography

  •Ahtanum a distinct stock

- Evidence suggests little introgression from hatchery steelhead

Small et al. (2006)

Roza Dam Steelhead

Project Objectives

1) Compare a 2006 collection from Roza Dam to the previous collections from the upper Yakima

Why?

★ Inferences about population dynamics based on genetic data rely on accurately estimating allele frequencies

Possible explanations for temporal instability are:

1) The population is experiencing genetic drift
2) There is gene flow from a differentiated stock
3) The collection itself is not a valid population sample

Roza Dam Steelhead

Project Objectives

1) Compare a 2006 collection from Roza Dam to the previous collections from the upper Yakima

Analysis

- Randomization chi-square test
- AMOVA

Roza Dam Steelhead

Project Objectives

1) Compare a 2006 collection from Roza Dam to the previous collections from the upper Yakima

Results

- Allele frequencies for five replicated Roza Dam collections are quite similar, and in most cases statistically equivalent.
- The AMOVA test that grouped all replicated Roza Dam collections together minimized the proportion of variance partitioned among collections – within groups (0.43%)

Roza Dam Steelhead

Project Objectives

2) Determine if collections from Roza Dam constitute a population mixture

Why?

- Roza Dam has excellent collection facilities, but Roza Dam is located fairly far downstream of upper Yakima steelhead spawning areas
- It is important to determine if there are multiple populations upstream of Roza Dam

Roza Dam Steelhead

Project Objectives

2) Determine if collections from Roza Dam constitute a population mixture

Analysis

- Hardy-Weinberg Equilibrium
- Linkage Disequilibrium
- F_{ST}

Roza Dam Steelhead

Project Objectives

2) Determine if collections from Roza Dam constitute a population mixture

Results

- 2000 and 2001 Roza Dam collections were consistent with HWE expectations, and the 2003, 2005 and 2006 had slight deviation
- Linkage disequilibrium minimal
- $F_{ST} = 0.001$, not statistically different from zero

Roza Dam Steelhead

Project Objectives

3) Identify if resident trout samples collected above Roza Dam are different genetically from the steelhead collections from Roza Dam

Why?

- Considerable attention recently has focused on the reproductive interactions between resident rainbow trout and steelhead
- If interbreeding is extensive, then the two forms should be similar genetically

Roza Dam Steelhead

Project Objectives

3) Identify if resident trout samples collected above Roza Dam are different genetically from the steelhead collections from Roza Dam

Analysis

- Individual resident trout samples were compared to a genetic baseline containing reference steelhead population samples from Satus Creek, Toppenish Creek, Ahtanum Creek, Naches River, Roza Dam, and Skamania Hatchery.

Roza Dam Steelhead

Project Objectives

3) Identify if resident trout samples collected above Roza Dam are different genetically from the steelhead collections from Roza Dam

Results

Resident	Satus	Toppenish	Ahtanum	Naches	Roza	Skamania
1	-	-	-	0.83	0.17	-
2	-	-	-	0.90	0.10	-
3	-	-	-	-	1.00	-
4	-	-	-	0.36	0.64	-
5	-	-	-	-	1.00	-
6	-	-	-	-	1.00	-

Roza Dam Steelhead

Project Objectives

3) Identify if resident trout samples collected above Roza Dam are different genetically from the steelhead collections from Roza Dam

Results

- There are no private alleles observed in the resident trout samples
- The observed allele frequencies of the 2006 resident trout collection are equivalent to the Roza Dam steelhead collections
- Variance partitioned among collection-within group is minimized when the Roza Dam collections, including the 2006 resident trout sample, is defined as a group

Steelhead Capture At Prosser Dam

Can individual steelhead be identified to Yakima Basin population of origin from mixed collections at Prosser Dam?

Individual assignment method

- Jack-knife assignment of all Yakima River steelhead present in reference baseline

- Assignment precision is assessed by observing the correct and incorrect assignments back to population of origin

    - Type-1 error: individuals not assigned to population of origin
    - Type-2 error: individuals falsely assigned to a population

Steelhead Capture At Prosser Dam

All Steelhead Assigned

Aggregate	Correctly assigned	Incorrectly assigned	Unassigned	Confidence (1-alpha)	Power (1-beta)
Satus	135	52	0	0.72	0.73
Toppenish	168	25	0	0.87	0.87
Ahtanum	105	39	0	0.73	0.73
Naches	102	78	0	0.57	0.65
Roza	388	88	0	0.82	0.77
Skamania	76	16	0	0.83	0.88

Steelhead Capture At Prosser Dam

Minimum Probability Criterion

Aggregate	Correctly assigned	Incorrectly assigned	Unassigned	Confidence (1-alpha)	Power (1-beta)
Satus	68	8	111	0.89	0.96
Toppenish	127	5	61	0.96	0.96
Ahtanum	81	11	52	0.88	0.92
Naches	41	13	126	0.76	0.77
Roza	239	19	218	0.93	0.89
Skamania	67	2	23	0.97	0.96

Conclusions

- Yakima Basin steelhead genetically differentiated by watershed
  - Although Naches River and upper Yakima similar
- Evidence suggests limited hatchery introgression into natural populations
- Allele frequencies for replicated Roza Dam collections are temporally stable
- Genetic dataset for five replicated collections from Roza Dam should be combined to form a single genetic baseline sample
- Roza Dam data are consistent with the presence of a single steelhead population above Roza Dam

Conclusions

- Resident trout sampled are more similar to Naches River and Roza Dam steelhead than they are to any other steelhead in the reference baseline

- Resident trout samples appear genetically undifferentiated from the steelhead collections

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Broodstock capture at Prosser Dam

All Steelhead Assigned

Aggregate	Total	Unassigned	Satus	Topp	Ahtanum	Naches	Roza	Residents	Ska
Satus	187	0	135	7	6	13	25	1	0
Toppenish	193	0	5	168	4	6	9	0	1
Ahtanum	144	0	4	4	105	6	25	0	0
Naches	180	0	15	6	5	102	49	1	2
Roza	476	0	25	8	20	22	388	6	7
Residents	6	0	0	0	0	2	4	0	0
Skamania	92	0	0	0	3	5	7	1	76

Broodstock capture at Prosser Dam

Minimum Probability Criterion

Aggregate	Total	Unassigned	Satus	Topp	Ahtanum	Naches	Roza	Residents	Ska
Satus	187	111	68	0	0	3	5	0	0
Toppenish	193	61	0	127	1	0	4	0	0
Ahtanum	144	52	0	0	81	1	10	0	0
Naches	180	126	2	2	1	41	6	0	2
Roza	476	218	1	3	5	8	239	1	1
Residents	6	3	0	0	0	0	3	0	0
Skamania	92	23	0	0	0	0	2	0	67