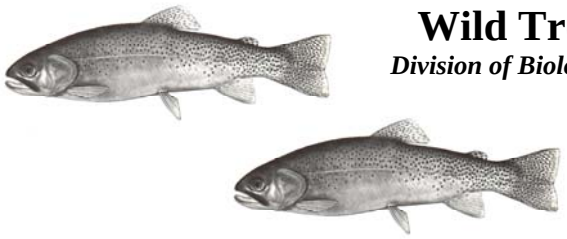

Wild Trout and Salmon Genetics Laboratory

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Jim:

The paired interspersed nuclear DNA elements (PINE) technique has been used to analyze DNA from the following trout samples:

Summary of results.

		a	b	c	d	e	f
Sample #	**Water Name/Location/Collection Date/ Collector**	**N**	**# markers**	**Species ID**	**Power (%)**	**% YCT**	**Individuals**
2956	**Woody Creek** 09S14E25 8/12/2004 Jim Olsen	29	R7W4	YCT X WCT X RBT			mixed population
2957	**Soda Butte Creek** 09S14E26 9/9/2004 Jim Olsen	22	R7W4	YCT X WCT X RBT	98.7X0.6X0.7		xx

[a]Number of samples successfully analyzed. If combined with previous sample (Indicated in "Location" column) number indicates the combined sample size. If present, the number in () is the average number successfully analyzed per locus (some individuals do not amplify for all marker loci).
[b]Number of markers analyzed that are diagnostic for the non-native species (R=rainbow trout, W=westslope cutthroat trout, Y=Yellowstone cutthroat trout).
[c]Codes WCT = westslope cutthroat trout (*Oncorhynchus clarki lewisi*); RBT = rainbow trout (*O. mykiss*); YCT = Yellowstone cutthroat trout (*O. clarki bouvieri*). Only one species code is listed when the entire sample possessed alleles from that species only. However, it must be noted that we cannot definitively rule out the possibility that some or all of the individuals are hybrids. We merely have not detected any non-native alleles at the loci examined because of sampling error (see Power %). Species codes separated by "x" indicate hybridization between those species.
[d]Number corresponds to the percent chance we have to detect 1% hybridization given the number of individuals successfully analyzed and the number of diagnostic markers used. For Example, 25 individuals are required to yield a 97% chance to detect 1% hybridization with rainbow trout or an 87% chance to detect 1% hybridization with westslope cutthroat trout into what once was a Yellowstone cutthroat trout population. Not reported when hybridization is detected.
[e]Indicates the genetic contribution of the hybridizing taxa in the order listed under c to the sample assuming Hardy-Weinburg proportions. This number is reported only if the sample appears to have come from a hybrid swarm. That is, a random mating population in which species markers are randomly distributed among individuals.
[f]Indicates number of individuals with genotypes corresponding to the species code column when the sample can be analyzed on the individual level. This occurs when marker alleles are not randomly distributed among individuals and hybridization appears to be recent and/or if the sample appears to consist of a mixture of populations.

Methods and Data Analysis

The PINE technique uses short synthetically made segments of DNA called primers, in pairs, to search for relatively small segments of organismal DNA flanked by particular, often viral, DNA inserts. During the polymerase chain reaction (PCR), the primers bind to the ends of the inserts and many copies of the organismal DNA between the primers are made. While the DNA from some organisms may have two appropriately spaced inserts to which the primers can attach, the DNA from other organisms may have only one or none of the appropriately spaced inserts in particular regions. During PCR we will fail to copy DNA in the latter two cases. Thus, the PINE technique coupled with PCR is used to search for evidence of genetic variation based on the presence or absence of particular DNA fragments. The fragments are labeled by the primers used to produce them and their length in terms of the number of nucleotides in the fragment.

The fragments are made using dye labeled nucleotides and after PCR are separated from each other via electrophoresis in polyacrylamide gels. Smaller fragments move through the gels at a faster rate than larger fragments. The use of dye labeled nucleotides allows one to visualize the position of the fragments in the gels after electrophoresis using a spectrophotometer and the size of the fragments is determined by comparison to the position of synthetic fragments of known size that were also migrated into the gel.

When DNA from Yellowstone cutthroat trout, *Oncorhynchus clarki bouvieri*, and rainbow trout, *O. mykiss*, is compared with PINE analysis and four different pairs of primers 12 fragments are characteristic of Yellowstone cutthroat trout and seven fragments are usually characteristic of rainbow trout (Table 1). Likewise, when DNA from Yellowstone and westslope cutthroat trout, *O. c .lewisi*, is compared using the same procedure five fragments are characteristic of Yellowstone cutthroat trout and four fragments are characteristic of westslope cutthroat trout (Table 1).

Fragments produced from the DNA of one taxon and not another are commonly termed diagnostic or marker loci because they can be used to help determine whether a sample came from a non-hybridized population of one of the taxa or a population in which hydridization between them has or is occurring. Individuals from a non-hybridized population will possess fragments characteristic of only that taxon. In contrast, since half the DNA of first generation hybrids comes from each of the parental taxa the DNA from such individuals will yield all the fragments characteristic of the two parental taxa. In later generation hybrids, the amount and particular regions of DNA acquired from the parental taxa will vary among individuals. Thus, DNA from later generation hybrid individuals will yield only a subset of the parental fragments and the particular subset will vary among individuals. In a sample from a random mating hybrid swarm, that is a population in which the genetic material (i.e. fragments) of the parental taxa is randomly distributed among individuals such that essentially all of them are of hybrid origin, the frequency of the fragment producing allele from the non-native taxon is expected to be nearly equal among the diagnostic loci since their presence can all be traced to a common origin or origins. Thus, if a sample contains significant variation at only a single marker locus where the presence of the fragment is usually characteristic of a non-native taxon and lacks such fragments at all other markers this is probably not indicative of hybridization. Rather, it much more likely represents the existence of genetic variation for the presence or absence of the fragment within this particular population of the native taxon.

An important aspect of PINE marker loci is that individuals homozygous for the presence allele (*pp*) or heterozygous (*pa*) will both yield the fragment. That is, *p* is dominant to *a*. Thus, in order to estimate the genetic contribution of the native taxon to a hybrid swarm we concentrate on the marker loci at which the *p* allele is characteristic of the non-native taxon. Furthermore, we must assume that genotypic distributions in the population reasonably conform to expected random mating proportions. Under this assumption the frequency of the native *a* allele is approximately the square root of the frequency of individuals in the population lacking the fragment (*aa).* The frequency of the non-native allele then is one minus this value. We focus on the *p* alleles

characteristic of the non-native taxon because with low levels of hybridization it is the presence of these alleles that are likely to provide evidence of hybridization. With low levels of hybridization, it is likely all individuals in the sample will genotypically be *pp* or *pa* where the *p* allele is characteristic of the native taxon. Thus, like in non-hybridized populations all individuals in the sample will yield the fragment providing no evidence of hybridization.

Failure to detect evidence of hybridization in a sample does not necessarily mean the population is non-hybridized because there is always the possibility that we would not detect evidence of hybridization because of sampling error. In order to assess the likelihood the population is non-hybridized, we determine the chances of not detecting as little as a one percent genetic contribution of a non-native taxon to a hybrid swarm. This is simply 0.99^{2NX} where N is the number of fish in the sample and X is the number of marker loci where the *p* allele is characteristic of the non-native taxon.

In samples showing evidence of hybridization, that is fragments characteristic of a non-native taxon were detected at two or more marker loci, we used two approaches to determine if the population appeared to be a hybrid swarm. First, contingency table chi-square analysis was used to test for heterogeneity of allele frequencies among the marker loci. Next, we compared the observed distribution of the number of loci per individual at which non-native fragments were detected to the expected random binomial distribution based on the estimated native and non-native genetic contributions to the population. If both analyses were non-significant we concluded the population came from a hybrid swarm.

Heterogeneity of allele frequencies among marker loci can arise in very old hybrid swarms as the frequencies over time diverge from each other due to genetic drift. In this case, however, the non-native fragments will still be randomly distributed among individuals.

There are two likely reasons why a non-random distribution of non-native fragments may be observed among individuals in a sample. It may contain individuals from genetically divergent populations with different amounts of hybridization or hybridization may have only recently occurred in the population. Based on genetic data alone, these two situations will generally be difficult to distinguish from each other. Regardless of the explanation, when the non-native fragments are not randomly distributed among individuals in a sample estimating a mean level of hybridization has little, if any, biological meaning and, therefore, is often not estimated.

Results and Discussion

Soda Butte Creek 2957

PINE fragments characteristic of Yellowstone cutthroat trout and rainbow trout were detected at two of the seven diagnostic loci between these species that were analyzed in the sample. The frequency of rainbow trout alleles was statistically homogeneous among the marker loci ($P>0.50$) and the rainbow trout markers were randomly distributed among the fish in the sample.

One fish in the sample possessed a fragment characteristic of westslope cutthroat trout at one of the four diagnostic loci analyzed between Yellowstone and westslope cutthroat trout. This could indicate a small amount of hybridization with westslope cutthroat trout or it could simply be Yellowstone cutthroat trout genetic variation that is electrophoretically indistinguishable from that characteristic of westslope cutthroat trout. In this situation, we strongly favor the former interpretation. A previous sample collected from Soda Butte Creek in 1989 about 2.5 miles downstream (T9S R14E S33; col. 9/7/89; N=25) from this sample, based on allozyme analysis, appeared to have come from a Yellowstone-westslope cutthroat trout hybrid swarm with about a 12% westslope cutthroat trout genetic contribution. Thus, considering both samples it appears the fish in Soda Butte Creek are hybridized with westslope cutthroat trout and the westslope cutthroat trout genetic contribution tends to decrease as one proceeds upstream.

Overall, therefore, the data indicate the latest Soda Butte Creek sample came from a Yellowstone cutthroat-westslope cutthroat-rainbow trout hybrid swarm.

It is highly unlikely (P=0.007) we would not have detected as little as a one percent rainbow trout genetic contribution to the 1989 Soda Butte Creek sample. Thus, in contrast to the westslope cutthroat trout genetic contribution to the Soda Butte Creek fish, the rainbow trout genetic contribution appears to proportionally increase as one proceeds upstream.

Woody Creek 2956

PINE fragments characteristic of Yellowstone cutthroat and rainbow trout were detected in the sample at two of the seven diagnostic loci between these species that were analyzed. Although the allele frequencies were statistically homogenous among the diagnostic loci ($P>0.5$), the rainbow trout markers were not randomly distributed ($P<0.01$) among the fish in the sample as they were detected in only one individual.

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PINE fragments characteristic of Yellowstone and westslope cutthroat trout were detected at two of the four diagnostic loci between these fishes that were analyzed in the sample. Like the rainbow trout markers, the allele frequencies were statistically homogeneous ($P>0.05$) among these diagnostic loci but, the westslope cutthroat trout fragments were not randomly distributed ($P<0.001$) among the fish in the sample. Rather, they were detected in only two fish with one possessing the westslope cutthroat trout marker at one locus and the other at two loci.

Woody Creek is a tributary to Soda Butte Creek that enters the creek about 1.5 miles upstream from the most recent Soda Butte Creek sample. There are no known barriers preventing fish movement between Woody and Soda Butte Creek. Considering all the data, it appears the Woody Creek sample probably contains individuals from at least two genetically different populations; migrants of hybrid origin from Soda Butte Creek and individuals from Woody Creek. The Woody Creek population may be non-hybridized Yellowstone cutthroat trout or slightly hybridized. With the available data we cannot distinguish between these possibilities. Because of the low frequency of non-native alleles in the fish of hybrid origin in the Woody Creek sample and in the Soda Butte Creek fish just downstream, determining whether a fish in Woody Creek is or is not non-hybridized will be extremely problematic. Thus, from a practical perspective Woody Creek should simply be considered to contain fish of hybrid origin with a Yellowstone cutthroat-westslope cutthroat-rainbow trout genetic contribution.

Sincerely,

Ben Wright
Robb Leary

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TABLE 1

Diagnostic PINE markers for westslope cutthroat, Yellowstone cutthroat, and rainbow trout. **X** indicates the fragment is present in the particular taxon.

Markers	Yellowstone	Westslope	Rainbow
Hpa1 5'/Hpa1 3'			
232	x		
153		x	
72	x	x	
70			x
69	x	x	
66			x
Fok1 5'/Tc1			
369			x
366	x	x	
230			x
159	x		
138	x		
110		x	
Hpa1 5'/33.6+2			
395			x
388	x	x	
266			x
248	x		
148	x	x	
Fok1 5'/Hpa1 3'			
323	x		
242		x	
173	x	x	
170	x		
162		x	
144			x