2013 Genetic Analysis of Bull Trout in the Baker River Basin, Washington

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Summary

The Baker River Project consists of two hydroelectric generating developments located on the Baker River in Washington State. The Project is currently operated by Puget Sound Energy (PSE) under a new license issued by the Federal Energy Regulatory Commission in October 2008. The new License authorizes PSE to operate the Project for a period of 50 years consistent with the terms and conditions of the new License. New license conditions address the capture and upstream transport of bull trout (*Salvelinus confluentus*) from the Lower Baker River, the capture and downstream transport of bull trout from the Upper Baker reservoir (Baker Lake) and Lower Baker reservoir (Lake Shannon), and the potential capture and transport of bull trout from Lake Shannon to Baker Lake.

Operation of an existing trap and haul facility for bull trout in the Lower Baker River and the downstream transport of bull trout that enter the downstream fish passage facilities provided the opportunity to collect tissue samples from fish in the basin. Additional tissue samples were collected by angling. The geographic origin of captured fish was determined by genotyping the fish and assigning them to a bull trout genetic baseline containing possible in-basin and out-of-basin source populations. Genetic analyses of fish indicated that 3/4 of the adult bull trout captured in the Lower Baker upstream fish trap originated outside the basin, from Downey Creek. This information should be considered in the development of conservation, management, and recovery plans for bull trout in the larger Skagit Basin. Genetic analyses also showed that a minority of adult bull trout captured in Lake Shannon were members of the Upper Baker gene pool, suggesting that bull trout from Baker Lake may have moved down over the Upper Baker

Dam into Lake Shannon during spill events, or are progeny of adults in Lake Shannon that were both of Upper Baker genetic origin.

Background

Bull trout (*Salvelinus confluentus*) are a species of char which express various life history strategies that utilize a wide variety of habitats for spawning, rearing and growth. Bull trout are an obligate cold-water species, requiring water below 9° Celsius for spawning – waters which are generally restricted to headwater streams (USFWS 2004). Their life history expressions are as follows: resident bull trout complete their life cycle within their natal headwater stream, spawning as small resident adults; fluvial bull trout migrate into larger rivers for rearing and growth, returning to their natal tributary to spawn as larger migratory fish; adfluvial bull trout migrate into lakes (or reservoirs) for rearing and growth, achieving still larger sizes with the greater food availability, and return to their natal tributaries to spawn; anadromous bull trout migrate to salt water for rearing and growth and amphidromous bull trout leave their natal basin and traverse salt water en route to other freshwater systems to rear and grow, both forms reversing the journey back to their natal stream to spawn (Brenkman and Corbett 2005). Bull trout populations are connected more or less by straying, forming metapopulations (Rieman and Dunman 2000). Migration is thus an important aspect of bull trout life history and critical to maintaining life history expressions and viability of the species.

Bull trout were formerly distributed in inland and coastal drainages throughout Western North America as far south as California (Dunham et al. 2008). Over the past century their distribution and abundance declined due to land use activities such that in 1999 the U.S. Fish and Wildlife Service listed bull trout as threatened under the U.S. Endangered Species Act (Federal Register 1999). The Draft Recovery Plan (USFWS 2004) outlines bull trout population segments and recovery units throughout Puget Sound in Washington State. In northern Puget Sound, bull trout in the Baker River basin are part of the Lower Skagit core area recovery unit, which includes up to 21 bull trout populations in the Skagit River basin downstream of Seattle City Light's Diablo Dam (Figure 1, see USFWS 2004). Four life forms of bull trout (resident, fluvial, adfluvial, and anadromous or amphidromous) are found in the Skagit basin. In contrast to other portions of the bull trout range, bull trout habitat in the Lower Skagit River is in excellent condition and adult bull trout numbers are estimated to be in the thousands (USFWS 2004).

Despite good habitat condition in the Lower Skagit basin, in the Baker River system bull trout abundance has declined from the historical levels ("great quantities") described in an early U. S. Fish Commission document (1901). Originally, the system consisted of Baker Lake and the mainstem and tributaries beyond the lake in the upper Baker, and mainstem and tributaries below Baker Lake in the lower Baker. We hypothesize that the basin supported all four bull trout life forms. Factors other than habitat are suspected in the decline of bull trout in the Baker system. In particular, barriers presented by the Lower and Upper Baker Dams affect fish movement in the Baker River system and are presumed factors in the decline in abundance of the anadromous life history form of bull trout in the basin. Lower Baker Dam, completed in 1926, blocked access to the system, although a fish ladder was constructed and there was trapping and hauling of fish into Lake Shannon, the reservoir that formed behind the dam (HRA 2000). Migratory fish exited Lake Shannon through the spillway and turbines. In 1959 Baker Lake was enlarged

with the construction of the 312 ft. Upper Baker Lake Dam. Fish trapped below Lower Baker Dam were hauled into Baker Lake, and fish-attracting barges were installed in both lakes for downstream passage (HRA 2000). Prior to the late 1990's, the concern for fishery managers was sockeye production in Baker Lake and trap and haul operations would have included bull trout as incidental fish. Upper Baker River, Bald Eagle Creek, Pass Creek, Crystal Creek, Sulphide Creek, and Swift Creek are known spawning and/or rearing areas for bull trout in the Baker Lake system, while Baker Lake provides primary habitat for foraging and overwintering (Figure 2). Brook trout are known to inhabit the Baker River system (Figure 3) but the level of hybridization appears low (Small et al. 2011). Dolly Varden occupy tributaries above anadromous barriers and are native in the upper Skagit core area but are unconfirmed in the lower Skagit core area (USFWS 2004). Previous work (Small et al. 2009, 2011) found no evidence of genetic interaction (hybridization) between bull trout and Dolly Varden in the Baker system.

Issue

PSE has operated an upstream fish trap and haul fish passage facility in the lower Baker River since 1926. Adult bull trout were collected at the lower Baker River trap and haul facility and, until recently, all bull trout were transported above the dams and released into Baker Lake. Earlier studies showed that these bull trout have a variety of origins: some originated in the upper Baker River basin and were returning to spawn, and some were from other Skagit Basin populations that have dipped into the lower Baker River (Small et al. 2009, 2011). Some bull trout that originated in populations outside the Baker River Basin appear to have reproduced within Upper Baker tributaries after being transported into Baker Lake. This phase of the project continues to explore the origins of adult bull trout and the results of management measures intended to reduce out-of-basin introductions.

In this year's analysis we identify samples (see Table 1a) using the recently expanded Skagit basin bull trout baseline (see Table 1b and Small et al. 2013). The genetic baseline was expanded with data from several bull trout populations throughout the Skagit basin collected by Matt Smith (Smith and Naish 2011) while at University of Washington (UW) under a contract with Seattle City Light (SCL). These data greatly enhance the existing WDFW bull trout population baseline for the Skagit basin and shed additional light on bull trout migration in the Skagit basin. The enhanced genetic baseline includes the original WDFW data (see Table 1b, 14 individuals collected in Lake Shannon that had assigned to Sulphur Creek were added to the Sulphur Creek population to boost the collection size) and additional UW/SCL data from bull trout populations throughout the Skagit basin (see Table 1b for list), as well as Dolly Varden from Diablo Lake in the Upper Skagit and a collection of brook trout from Lake Shannon**.** Reporting groups in the UW/SCL baseline follow Smith and Naish (2011). The enhanced baseline allows us to more precisely identify migratory bull trout adults collected below the Lower Baker River Dam at the Lower Baker River upstream fish trap (LB UFT).

Lake Shannon, formed by the lower Baker Dam, also contains bull trout and they have been observed spawning in one primary tributary, Suphur Creek. Bull trout from Sulphur Creek have been identified as a local population which is genetically distinct from the bull trout population in the upper Baker basin (Small et al. 2009). Genetic analysis in this phase will enhance our understanding of the genetic relationships between bull trout in the upper and lower Baker basin

and will facilitate management objectives that include transporting bull trout based on genetic origins.

In the work described here, we used a suite of 16 microsatellite DNA loci to evaluate the genetic origin of bull trout collected by both active sampling methods, such as angling, and at fish passage facilities located in the Baker River Hydroelectric Project. The objectives of the work were:

- Identify all samples as a bull trout, Dolly Varden, brook trout or hybrid (interspecific or interpopulation) using diagnostic genetic makers;
- Genotype all bull trout collected throughout the Baker River Basin and assign them to population of origin;
- Use population assignment tests and genetic clustering methods to distinguish among bull trout populations inhabiting the Baker River Basin;
- Enter all samples examined in this study into the range-wide bull trout genetic database.

Materials and Methods

Sample Collection

2012-2013 Sampling for Population Assignment

Tissue samples from bull trout in the Baker River Basin were collected from November 8, 2012 through November 7, 2013 by PSE staff and preserved in 100% non-denatured alcohol. Tissue samples were collected from bull trout encountered at the Baker upstream and downstream fish passage facilities and by angling. Collection of tissue samples is ongoing and part of the current management protocol for native char. Tissue samples collected in the Baker River below the Lower Baker River Dam were from adult bull trout at the Lower Baker River upstream fish trap (12AH and 13DW in Table 1a). Tissue samples collected in Lake Shannon were from juveniles, sub-adults and adults and were collected by trapping at the floating surface collector (FSC) and by angling (N = 16) and by angling in the riverine habitat (UB Tailrace) below the Upper Baker Dam (N = 33). Tissue samples collected in Baker Lake (Upper Baker) were from juveniles, sub-adults and adults were collected by trapping in the Upper Baker floating surface collector and by angling (N = 65).

Genotypic Data Collection

DNA was extracted from tissue samples using silica membrane kits (Macherey-Nagel). Fish were genotyped at 16 microsatellite DNA loci (Table 2) that are standardized among labs researching bull trout (Ardren et al. 2011). Microsatellite alleles were PCR-amplified using fluorescently labeled primers (see Table 2 for detailed PCR information). Primers that were fluorescently labeled with a vector tail (V) in our lab are identified in Table 2 by the label "V+a" after the primer (+a refers to a poly-a tail added to the reverse primer) and the concentration for the primer and the vector are given. The other primers were labeled at the factory when primers were constructed. PCRs were conducted in 384 well plates in 5 µl volumes employing 1 µl template with final concentrations of 1.5 mM $MgCl_2$, 200µM of each dNTP, and 1X Promega PCR buffer. After initial two minute denature at 94°, PCR temperature profiles followed a touchdown protocol (see Table 2) where the annealing temperature is lowered after an initial number of cycles. In the touchdown protocol the first four (profile 1) or 10 (profile 2) cycles have 94° denaturing for 30 seconds, 60° annealing for 30 seconds (decrease 1° per cycle) and

extension at 72° for 60 seconds. These are followed by 36 (profile 1) or 30 (profile 2) cycles with the same parameters except for annealing temperature decreases to 50°, and then a final 10-minute extension at 72°. Samples were run on an ABI 3730 automated DNA Analyzer and alleles were sized (to base pairs) and binned using an internal lane size standard (GS500Liz from Applied Biosystems) and GeneMapper software (Applied Biosystems).

Genetic Analyses

We used assignment tests and exclusion probabilities in the program GeneClass2 (Piry et al. 2004) to identify fish of unknown origin collected in the Baker system to a genetic baseline that included representative population samples from the Baker system and from the greater Skagit basin. Some collections from tributaries within sub-basins were combined into "reporting groups" because they were similar genetically (Table 1b). For instance, the WDFW collection from the Sauk River was combined with the SCL collection from Downey Creek, a tributary of the Sauk River, because they were genetically similar and different from the South Fork Sauk (according to the WDFW database, the 98_04Sauk River collection were adults collected in the mainstem near Darrington). The assignment test assigns fish to the baseline collection in which they have the highest likelihood of occurring, based on the genotype of the fish and allele frequencies of baseline populations. The baseline included the following populations and reporting groups: Suphur, UpperBaker, Bacon, Illabot, South Fork Sauk, Downey, Cascade, Above Gorge Dam, and Goodell, as well as brook trout and Dolly Varden (Table 1b). We used the Rannala and Mountain (1997) algorithm to calculate likelihoods that an individual fish originated in each of the baseline collections based on the genotype of the fish and allele frequencies of the baseline collections. The program calculates a relative likelihood value, which is a ratio of the highest likelihood over the next highest likelihood value and assigns the individual to the baseline collection with the highest relative likelihood value. We used a ratio threshold of 90% as a positive assignment. We also conducted an exclusion analysis to examine whether sampled fish may have originated in a population that was excluded from the baseline, using a Monte Carlo simulation in GeneClass2. The simulation created 10,000 individuals for each baseline collection to simulate the range of genotypes likely to be encountered for that collection. Then it computed assignment likelihoods for simulated individuals and compared the likelihood of the genotype of the fish in question to the distribution of the likelihoods for each simulated baseline collection. If probabilities of coming from each baseline collection are all below a threshold value, here 0.1%, then the individual likely arose from a population outside the baseline. This exclusion test differs from the relative likelihood value, which is a ratio of point estimates for the individual coming from each baseline collection. There is always a likelihood of assignment to each collection but the values may be extremely small for all assignments if the population of origin is absent from the baseline. This may be obscured by the relative likelihood value since an extremely small likelihood value may still be 100 times larger than the sum of the other extremely small likelihood values (e.g., 10^{-51} is 100 times larger than 10^{-53}), yet the individual is 100 times more likely to assign to the collection with a (deceptively) high relative likelihood value.

The baseline still lacks a bull trout collection from the White Chuck River in the Sauk subbasin, which produces many bull trout (Bret Barkdull, WDFW, pers. comm.). Migratory bull trout originating in the White Chuck River are likely to assign to another tributary in the Sauk subbasin for which a baseline sample is available.

We used a Bayesian analysis implemented in STRUCTURE 2.2 (Pritchard et al. 2000) to estimate individual and population ancestry, examine species identities, and identify possible hybrids. STRUCTURE sorts individuals (or portions of individuals if they are hybrids) into a number of hypothetical clusters (K) in order to achieve Hardy-Weinberg equilibrium and linkage equilibrium in the clusters or populations. We compared fish collected 2012-2013 to bull trout collections that were used as the baseline in the assignment analysis described above and set the possible number of clusters at 2 - 14. At a K-value of 2 we expected bull trout and brook trout to cluster separately. At a K-value of 3 we expected bull trout, brook trout and Dolly Varden to cluster separately. At higher K we expected clusters to subdivide according to populations. Analyses were conducted in 5 independent runs that allowed admixture with 50,000 burn-ins and 200,000 iterations. The burn-in runs move the analysis away from the starting conditions to prevent them from influencing the analysis.

Results and discussion

Genotypic data collection

Samples collected in 2012-2013 amplified well and all were included in the study (Table 1a). There were some 100% matches among bull trout in the data set: fish number 13DX0023 matched fish number 13DX0024 and may have been a resampling of 13DX0023 rather than a sample from 13DX0024. They were sampled on the same day (Aug. 28, 2013) but were different sizes. Fish 13DX0024 was eliminated from analyses. There were two other matches of contemporary samples to samples collected last year: 13DY0057 matched 12AJ0046 and 13DY0059 matched 12AJ0071. In these cases the samples collected this year were larger than the samples collected last year and all were collected in Baker Lake, suggesting that the samples this year were resamples of fish collected last year.

Genetic analyses

GeneClass assignments and exclusion tests identified bull trout to their origins (Table 3a and 3b). We used 90% relative likelihood score as the cutoff value for a positive assignment. Most individuals had full genotypes, so there was sufficient assignment power to assign them. The fish collected in 2012 at the upstream fish trap in the Lower Baker River, was from Downey Creek and two of the three fish collected in 2013 were also from Downey Creek and one was from the Baker Basin. In comparison, assignments for fish collected in the adult trap from 2003 through 2012 indicated that the largest proportion of migratory fish came from Cascade (27%) and Downey (20%). This suggests that migratory fish from tributaries beyond the Baker River dip into the lower Baker River en route to spawning or feeding areas at other locations in the Skagit basin or elsewhere in Puget Sound.

More than half of the fish collected in Lake Shannon assigned to the Sulphur Creek population from Lake Shannon and the rest of the fish assigned to the Upper Baker. This suggests that some fish originated in Sulphur Creek and other fish may have moved down from Baker Lake during spill events. Alternatively, fish assigning to Upper Baker may be progeny of adults in Lake Shannon that were both of Upper Baker genetic origin. Individuals with assignment probabilities below the 90% threshold had mixed likelihoods of assignment to Sulphur and Upper Baker in the STRUCTURE analysis (described below) suggesting that they may have had parents from both

populations. Most individuals (56/65) collected in Baker Lake assigned as Upper Baker fish. Three fish from Baker Lake assigned to Sulphur, suggesting that these fish had been transported from the upstream fish trap into Baker Lake or had descended from fish that had originated in Sulphur Creek and were transported to Baker Lake. Two individuals appeared to be from outside the Baker basin (one each assigned to Cascade and Bacon). These two out-of-basin bull trout may have been collected below the dam and transported into Baker Lake. Of the six fish with less than 90% assignment probabilities, STRUCTURE indicated that two were primarily Upper Baker and the other four had mixed ancestry. No brook trout or Dolly Varden ancestry was detected in any fish collected in 2012-2013.

The STRUCTURE analysis supported information from the GeneClass assignment tests. STRUCTURE sorts individuals (or portions of individuals if they are of mixed ancestry) into genetically similar clusters. In this analysis, we used membership in a cluster to identify genetically distinct groups – if most individuals collected from a location (e.g., Sulphur) occupy one cluster, this cluster is identified as the Sulphur cluster and the individuals within comprise the Sulphur population. For fish where the assignment likelihood threshold was below 90% in the GeneClass analysis, we used STRUCTURE to further examine the status of samples of uncertain origin (Table 5). For instance, 13DX0010 was unassigned in GeneClass but had 68% of its ancestry in the Sulphur cluster suggesting that it is a member of the Sulphur population but had some alleles common in Upper Baker population that decreased its assignment likelihood in the GeneClass analysis. In other cases, an individual with mixed ancestry would not assign with high likelihood to a single population in the GeneClass analysis and might assign as mixed ancestry in the STRUCTURE analysis. For instance 13DY0007 was unassigned and appeared to be a mix of Upper Baker, Cascade and Goodell ancestry.

Because the baseline lacks the White Chuck population and is restricted to the Skagit basin, migratory bull trout from the White Chuck or outside the basin would not assign to the baseline and would have misleading ancestry in the STRUCTURE analysis. If the White Chuck population is sufficiently differentiated from other Skagit populations, the exclusion analysis in GeneClass could help identify these individuals but STRUCTURE is limited by cluster number and might be unable to identify these individuals.

Most STRUCTURE results concurred with GeneClass results: individuals clustering within a particular population cluster in the STRUCTURE analysis were assigned to that same population by GeneClass (Figure 5a, 5b). Because no brook trout or Dolly Varden were detected in contemporary collections we only plot bull trout data. At K = 9, each of the baseline collections occupied their own cluster. Individuals collected from the upstream fish trap, Lake Shannon and Upper Baker basin assigned into one of these clusters (see Table 4 for the proportions of membership in each cluster for individuals sampled in 2012). In comparisons to GeneClass, there were a few individuals where STRUCTURE clustered the majority of the individual's ancestry in one population cluster but GeneClass assigned it to a different population. As described in Small et al. (2009), there are differences between the analyses that generate differences in results. In STRUCTURE, the clusters (or populations) are composed of all individuals (or portions of hybrid individuals) that the analysis assigned or grouped into the cluster. This is done using an iterative process to sort an individual's ancestry into clusters in order to achieve Hardy-Weinberg and linkage equilibrium (or minimize disequilibrium) in the

clusters. Data are treated differently in the GeneClass analysis. In GeneClass, the program calculates a likelihood value for the individual arising from each of the baseline collections. Based on the individual's genotype and allele frequencies in the pre-defined baseline collections, GeneClass assigns the individual to a baseline collection. Results from both analyses were mostly congruent but provided different perspectives. For instance, GeneClass can identify migrants and STRUCTURE can identify hybrids as well as hierarchical genetic relationships among population clusters.

STRUCTURE identified some fish with mixed ancestry (over 30% ancestries in more than one cluster) that GeneClass assigned with > 90% likelihood to a single baseline population (Figure 5b, Table 4). For example, STRUCTURE divided 13DW0001 between the Upper Baker and Sulphur clusters but GeneClass assigned it to Upper Baker. Still other fish assigned to different populations with the two analyses. For example GeneClass assigned 13DY0023 to Sulphur and STRUCTURE clustered >86% of its ancestry in Upper Baker. Putative mixed-ancestry fish or differently assigned fish likely had alleles that were common in more than one population such that the STRUCTURE analyses assigned their ancestry to different population clusters. Further, the large size of the dataset (>800 samples), may have decreased the ability of STRUCTURE to partition the data: STRUCTURE performs well with up to around 10 genetic clusters and although we pooled data into reporting groups, there were more than 10 genetic groups in the dataset. However, mixed ancestry signals could also indicate hybridization or introgression from out-of-population fish spawning with local fish that had been introduced through the trap and haul operation.

In summary:

- Three out of four adult bull trout collected at the Lower Baker River upstream fish trap originated outside the Baker basin in the greater Skagit basin (Downey Creek).
- Of bull trout analyzed from the Lower Baker River upstream fish trap, the only bull trout with origins in the Baker basin was an Upper Baker origin adult collected in July.
- Fifty-two percent of the bull trout collected in Lake Shannon assigned to Sulphur Creek, 42% assigned to the Upper Baker basin, and 6% were unassigned.
- Eighty-three percent of the bull trout captured by angling from or collected in the Upper Baker downstream fish passage facility (Upper Baker FSC) had ancestry in the Upper Baker River basin, 5% assigned to Sulphur Creek, 9% were unassigned, and one each had ancestry in the Bacon and Cascade populations.

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References

Angers, B. and L. Bernachez. (1996). Usefulness of heterologous microsatellites obtained from brook charr, *Salvelinus fontinalis* Mitchill, in other *Salvelinus* species. Molecular Ecology 5(2):317–319.

Ardren, W. R., P. W. DeHaan, P. Spruell, C. Bettles, R. Taylor, C. Cegelski, M. Campbell, P. Tamkee. (in preparation). Bull trout locus and allele standardization.

Belkhir, K., P. Borsa, L. Chikhi, N. Raufaste, and F. Bonhomme. 2004. GENETIX, logiciel sous WindowsTM pour la génétique des populations. Laboratoire Génome, Populations, Interactions CNRS UMR 5000, Université de Montpellier II, Montpellier (France). Available at http://www.univ-montp2.fr/~genetix/ genetix/genetix.htm

Brenkman, S. J. and C. Corbett (2005) Extent of anadromy in bull trout and implications for conservation of a threatened species. North American Journal of Fish Management 25: 1073-1081.

Crane, P. A., C. J. Lewis, E. J. Kretschmer, S. J. Miller, W. J. Spearman, A. L. DeCicco, M. J. Lisac, and J. K. Wenburg. (2004). Characterization and inheritance of seven microsatellite loci from Dolly Varden, *Salvelinus malma*, and cross-species amplification in Arctic char, *S. alpinus*. Conservation Genetics 5(5):737-741.

DeHaan P. W. and W. R. Ardren. (2005). Characterization of 20 highly variable tetranucleotide microsatellite loci for bull trout (*Salvelinus confluentus*) and cross amplification in other *Salvelinus* species. *Mol. Ecol. Notes* 5(3):582-585.

Dunham J. and 12 co-authors. 2008 Evolution, ecology and conservation of Dolly Varden, white-spotted char, and bull trout. Fisheries 33(11): 537-550.

Historical Research Associates (HRA). 2000. Salmon on the Baker River, A history of fisheries management at Puget Sound Energy's Baker River Project. Prepared by Historical Research Associates, Inc., Seattle Washington. Prepared for Puget Sound Energy, Bellevue, Washington. p.155

Paetkau, D., R. Slade, M. Burden, and A. Estoup (2004) Genetic assignment methods in direct, real-time estimation of migration rate: a simulation-based exploration of accuracy and power. Molecular Ecology 13:55-65.

Piry, S., A. Alapetite, J. –M. Cornuet, D. Paetkau, L. Baudouin, and A. Estoup. (2004) GeneClass2: a software for genetic assignment and first-generation migrant detection. Journal of Heredity 96(6):536-539.

Pritchard, J. K., M. Stephens, and P. Donnelly. (2000). Inference of population structure using multilocus genotype data. Genetics 155:945-959.

Rannala B, Mountain JL (1997) Detecting immigration by using multilocus genotypes. Proceedings of the National Academy of Sciences 94:9197-9201.

Rexroad, C. E. III, R. L. Coleman, A. M. Martin, W. K. Hershberger, and J. Killefer. 2001. Thirty-five polymorphic microsatellite markers for rainbow trout (*Oncorhynchus mykiss*). Animal Genetics 32:317-319.

Rieman, B. E. and J. B. Dunman (2000) Metapopulations and salmonids: a synthesis of life history patterns and empirical observations. Ecology of Freshwater Fishes 9:51-64.

Small, M. P., C. Bowman, and D. Hawkins. 2007. Microsatellite DNA analysis of char population genetic structure in the Pacific Northwest. Unpublished report from WDFW Genetics Lab. 51 pp.

Small, M.P., W.A. Ardren, P.J. Hilgert, and J.F. Von Bargen. 2009. Genetic Analysis of Bull Trout in the Baker River Basin, Washington. Prepared by Washington Department of

Fish and Wildlife, Olympia Washington; prepared for Puget Sound Energy, Bellevue, Washington.

Small, M.P., N. Overman, P.J. Hilgert and E. Martinez. 2011. Genetic Analysis of Bull Trout in the Baker River Basin, Washington. Prepared by Washington Department of Fish and Wildlife, Olympia Washington; prepared for Puget Sound Energy, Bellevue, Washington.

Small, M.P., N. Overman, E. Martinez, and S. Bell. 2013. 2012 Genetic Analysis of Bull Trout in the Baker River Basin, Washington. Prepared by Washington Department of Fish and Wildlife, Olympia Washington; prepared for Puget Sound Energy, Bellevue, Washington.

Smith, M and K. Naish. 2010 Population structure and genetic assignment of bull trout (*Salvelinus confluentus*) in the Skagit River Basin. Report from UW to SCL.

U.S. Fish and Wildlife Service. 2004. Draft Recovery Plan for the Coastal-Puget Sound Distinct Population Segment of Bull Trout (*Salvelinus confluentus*). Volume I (of II) Puget Sound Management Unit. Portland, Oregon. 389 + xvii pp.

U.S. Fish Commission. 1901. Report of the Commissioner. Baker Lake, Washington. H.H. Buck, superintendent. pp. 83-84.

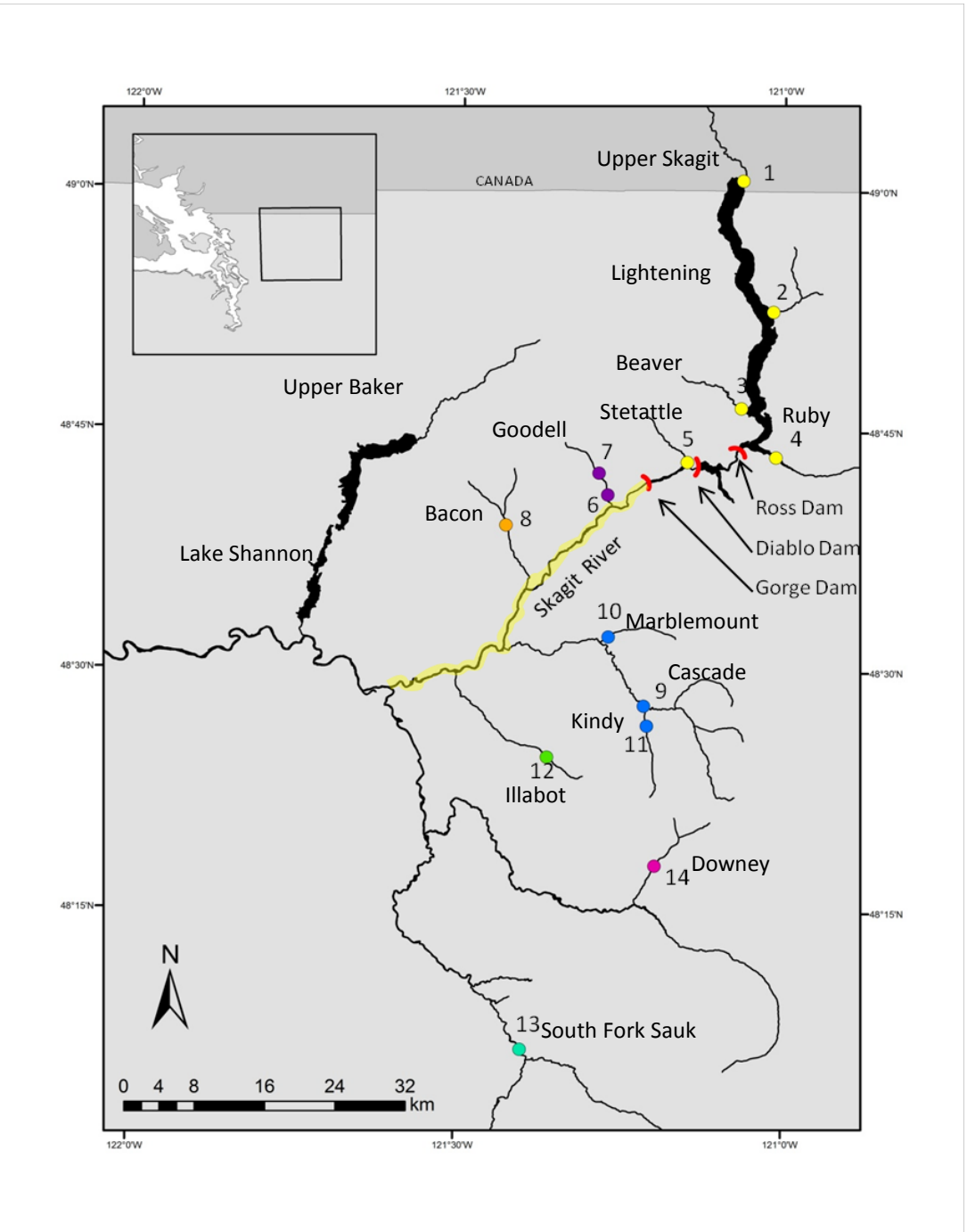

Figure 1. Skagit basin map from Smith and Naish 2010.

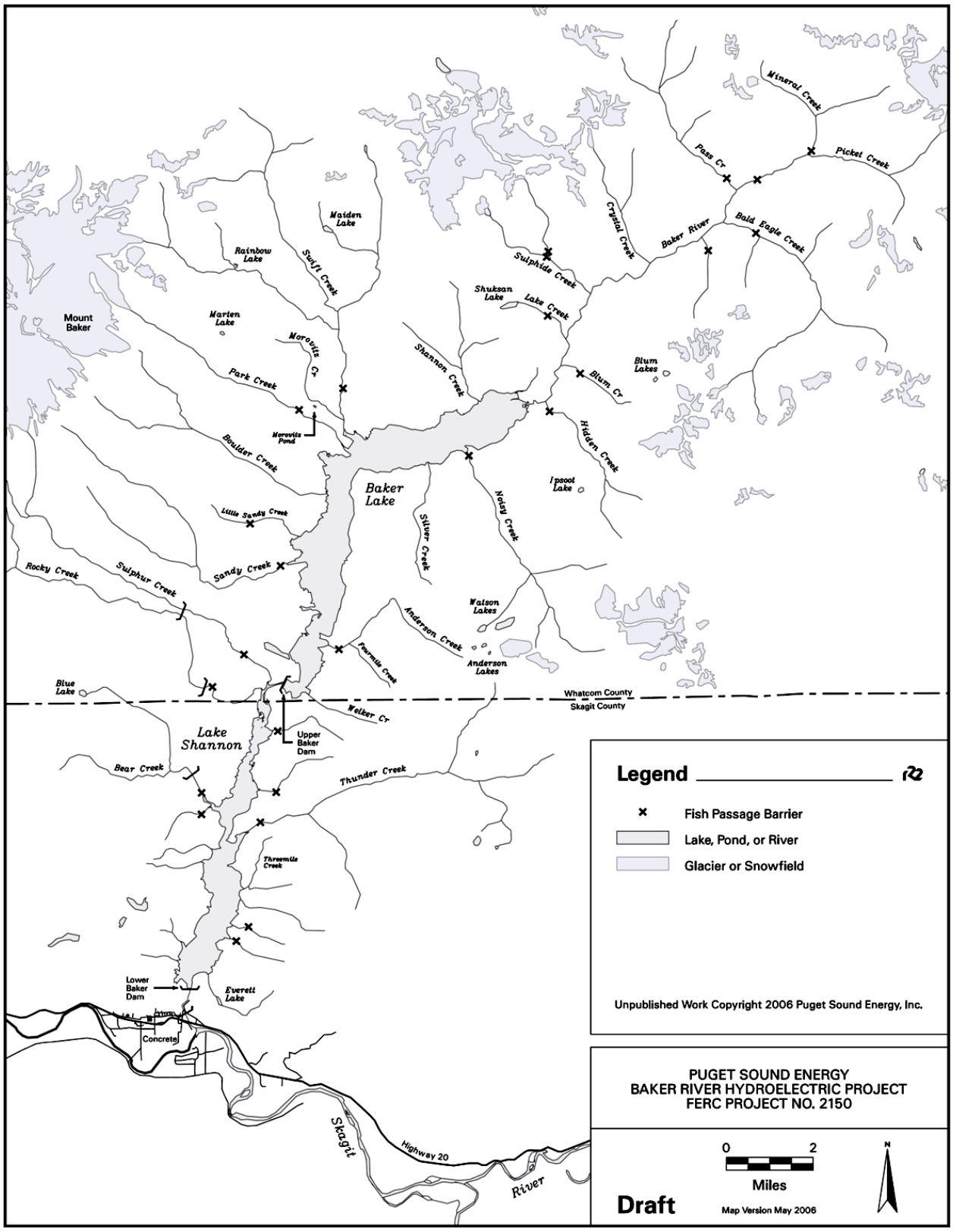

Figure 2. Baker River Hydroelectric Project and Baker River Basin.

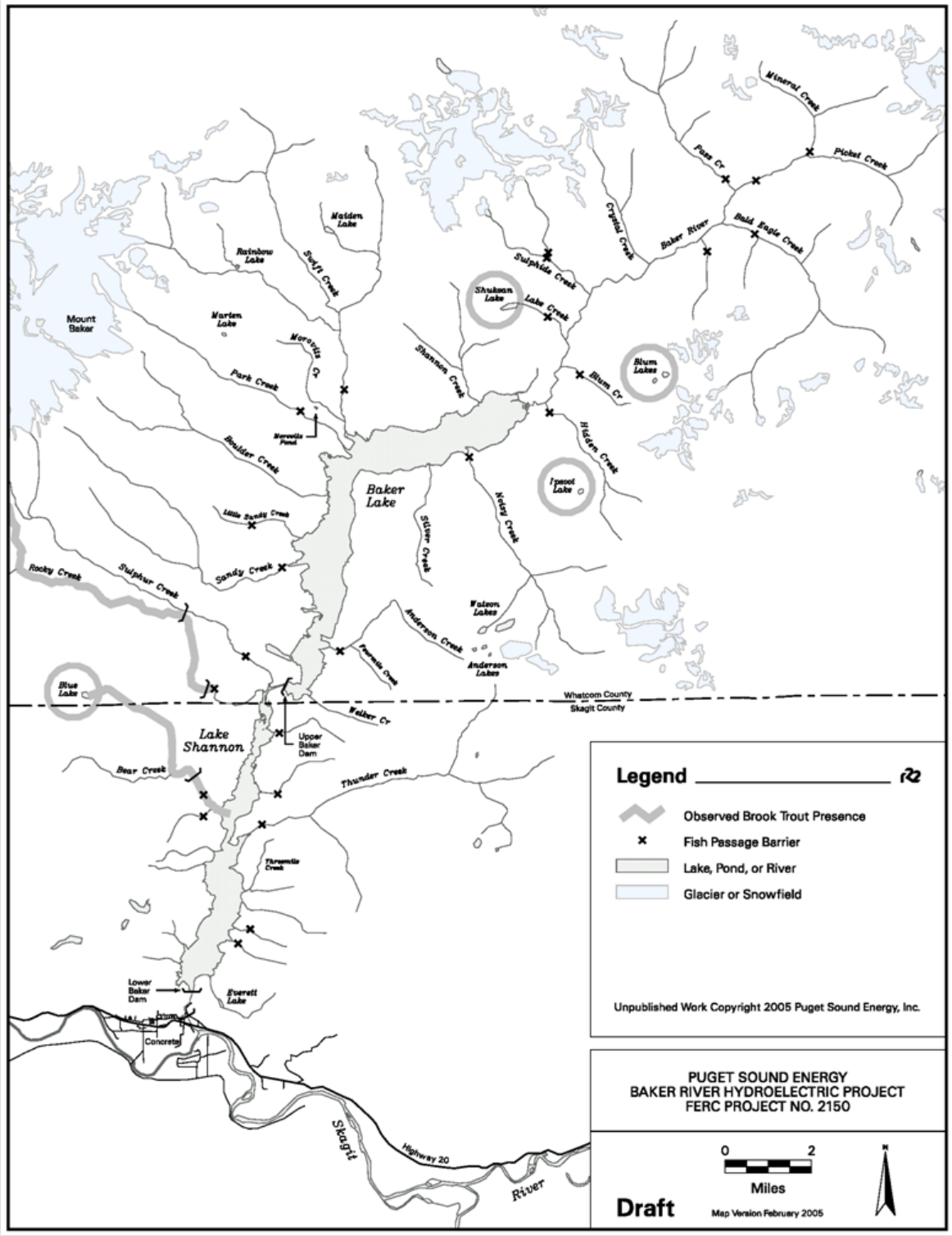

Figure3. Brook trout distribution in the Baker River Basin.

Figure 5a. Individual ancestry values from STRUCTURE for K = 9 including the expanded Skagit basin baseline. Each cluster (genetic group or population) has an associated color (e.g. blue for Sulphur population from Lake Shannon in the Lower Baker River); and single color for an individual suggests pure ancestry and multiple colors suggest mixed ancestry (ancestry in more than one cluster). See Figure 5b for details of bull trout collected in 2013. Table 4 has percentage of ancestry values (percentage of color) in numerical format for the 2013 data. Baseline collections include tributaries of the Upper Baker River (UpBakerBase), Sulphur population in the Lower Baker River (SulphurBase), Bacon River, tributaries above Gorge Dam (Beaver, Stetattle, Ruby, and Upper Skagit), tributaries in the Cascade basin (Cascade, Kindy, and Marblemount), Downey, Sauk mainstem, Illabot, Upper and Lower Goodell, and the South Fork Sauk River.

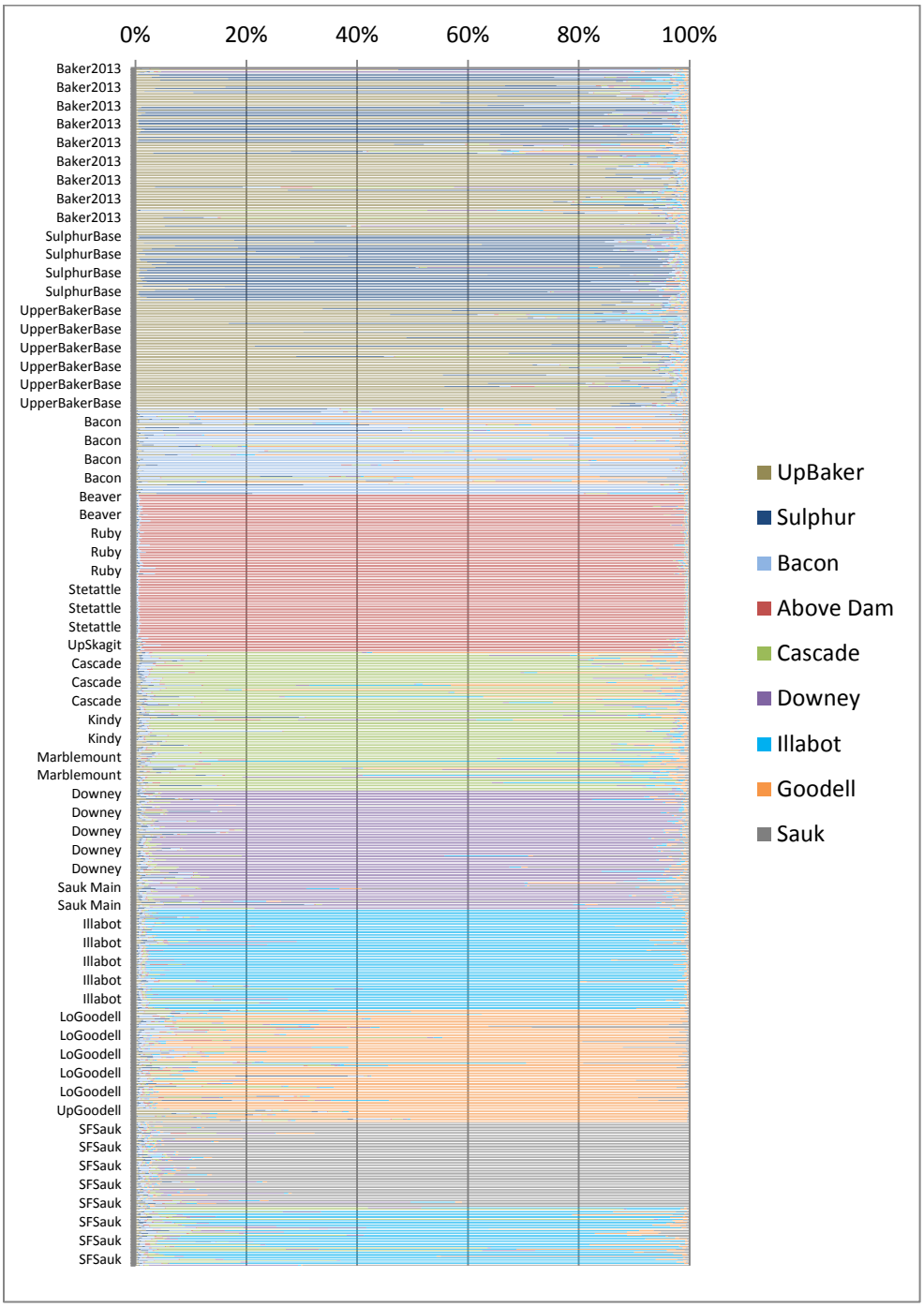

Figure 5b. Expansion of the STRUCTURE plot in Figure 5a for the samples collected in 2013 in the Baker basin for the Baker River bull trout project. Individual sample codes identify each fish (see Table 4 for numerical ancestry proportions and comparisons to GeneClass assignments).

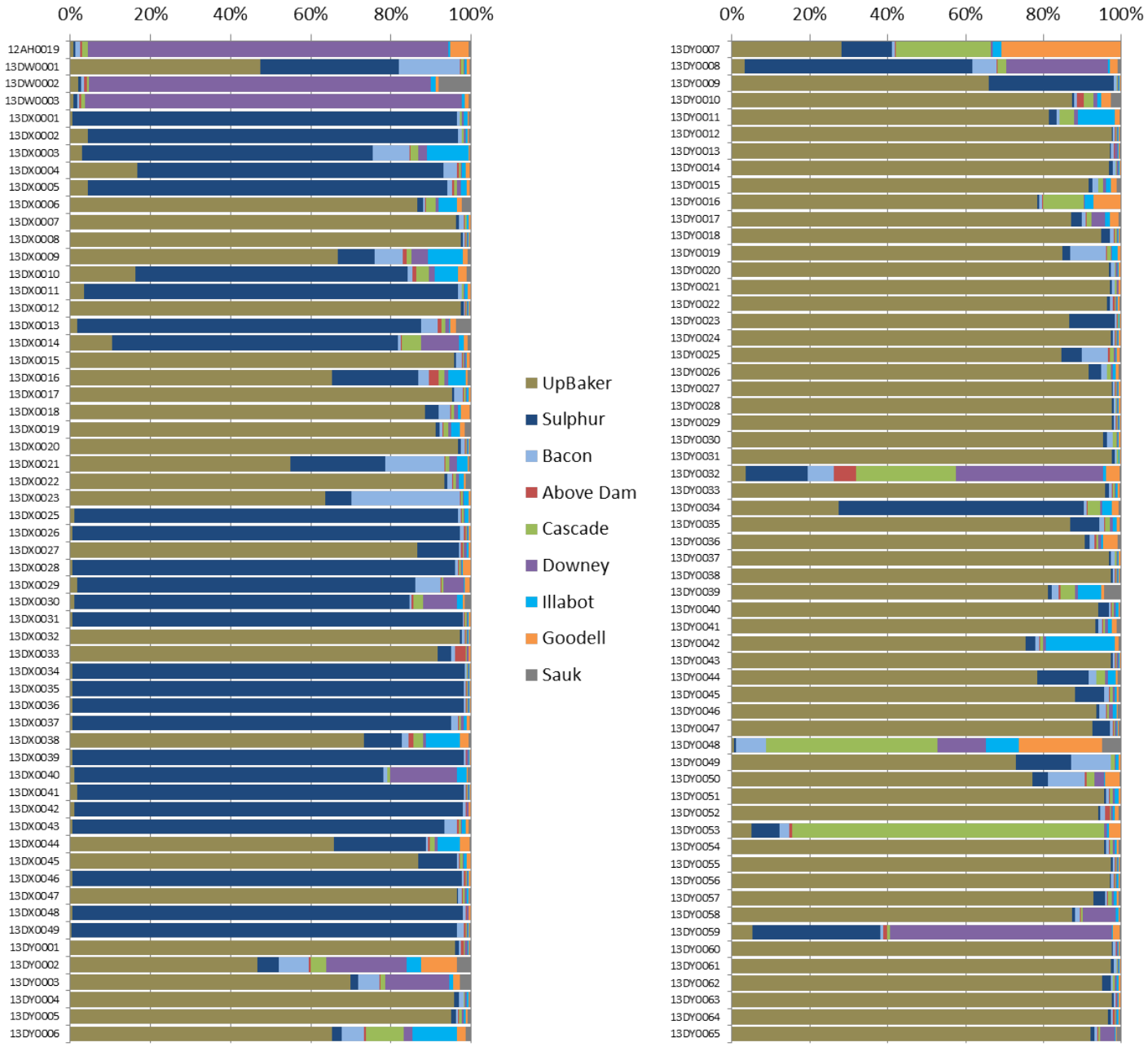

Table 1a. Baker basin collection table with collection locations and WDFW collection codes assigned to each collection. The number of samples analyzed is under N.

notes	Collection Name	WDFW Code	N
1 processed in 2013, collected in 2012	2012Lower Baker R. @ Upstream fish trap	12AH	1
	2013Lower Baker R. @ Upstream fish trap	13DW	3
	2013 Lake Shannon Floating surface collector, angling	13DX	49
	2013 Upper Baker Floating surface collector, angling	13DY	65

Table 1b. List of collections from WDFW and UW that comprise the expanded Skagit basin bull trout genetic baseline.

Subbasin	Capture location	WDFW code	N
WDFW archive baseline			
Lower Baker	05Sulphur Creek / Lake Shannon	05OF	4
	06Sulphur Creek / Lake Shannon	06JQ	25
Upper Baker	06Near Sulphide Cr. 5C, RM 25.5	06JT	11
	06U/s Crystal Creek RM 26.0-26.2	06JU	2
	06D/s Bald Eagle, RM 26.8-26.9	06JN	2
	06Pass Creek RM 0.0-0.25	06JP	27
	06D/s Pass Creek RM 26.8-26.9	06JO	10
	06Bald Eagle Creek RM 0.0-0.9	06JS	2
	06U/s Pass Creek RM 27.8 - 28.1	06JR	15
	06Near Pass Cr Rm 27.7	06JW	5
Out of basin	Sauk River mainstem	98AG, 04EU	26
	Illabot River	06DG, 97CK, 98EP	40
UW/SCL data-enhanced Skagit River baseline baseline			
Reporting group			
Above Dam (Gorge)	Upper Skagit River		16
	Big Beaver Creek		21
	Ruby Creek		43
	Stetattle Creek		56
Goodell	Lower Goodell Creek		59
	Upper Goodell Creek		19
Bacon	Bacon Creek		61
Cascade	Cascade River		39
	Marble Creek		28
	Kindy Creek		30
Illabot	Illabot Creek		70
SF Sauk	South Fork SF Sauk River		58
Downey	Downey Creek		58

Table 2. Information for multiplexes and loci including annealing temperature (°C) and primer and vector concentration. Annealing profiles are detailed below table. References for primer sequences are under Citation. The +a indicated a poly-a tail on the primer.

Multiplex	Locus	Anneal profile	conc [uM]	Citation
Sco-E	Omm-1128 +a	1	0.14	Rexroad et al. (2001)
	Sco-105 +a	1	0.08	WDFW unpublished data
Sco-1.1	Sco-218 V1+a	2	0.16	DeHaan and Ardren (2005)
	V1		0.08	
	Sco-202 V2+a	2	0.13	DeHaan and Ardren (2005)
	V2		0.06	
	Sco-200 V4+a	2	0.21	DeHaan and Ardren (2005)
	V4		0.1	
Sco-1.2	Sco-220 V3+a	2	0.12	DeHaan and Ardren (2005)
	V3		0.06	
Sco-J	Sco-216 V2+a	2	0.16	DeHaan and Ardren (2005)
	V2		0.08	
	Sco-215 V4+a	2	0.11	DeHaan and Ardren (2005)
	V4		0.05	
Sco-K	Sco-109 +a	2	0.26	WDFW unpublished data
	Sfo-18 V3 +a	2	0.14	Angiers and Bernachez (1996)
	V3		0.07	
	Smm-22 V4 +a	2	0.17	Crane et al. (2004)
	V4		0.08	
Sco-L	Sco-106 +a	1	0.14	WDFW unpublished data
	Sco-102 +a	1	0.07	WDFW unpublished data
	Omm-1130 +a	1	0.15	Rexroad et al. (2001)
Sco-M	Sco-212 V2 +a	1	0.16	DeHaan and Ardren (2005)
	V2		0.08	
	Sco-107 +a	1	0.13	WDFW unpublished data

Anneal profile 1: 4 cycles 94º for 30 sec, 60º anneal for 30 sec (decrease 1° per cycle), 72º for 60 sec then 36 cycles with 50º anneal (no decrease)

Anneal profile 2: 10 cycles 94º for 30 sec, 60º anneal for 30 sec (decrease 1° per cycle), 72º for 60 sec then 30 cycles with 50º anneal (no decrease)

Table 3a. Summary of GeneClass assignment test results for all bull trout samples from the Baker River basin assigned to expanded Skagit basin baseline (see Table 3b for individual assignments). The Lower Baker upstream fish trap is abbreviated as "UFT" and floating surface collector is abbreviated as "FSC".

>90%	UpBaker	Sulphur	Bacon	Cascade	Downey	unassign	Grand Total
UFT	1				3		4
Lake Shannon		1					1
Upper Baker Tailrace	14	17					31
Lower Baker FSC	6	7				3	16
Upper Baker FSC	54	3	1	1		6	65

highest	UpBaker	Sulphur	Bacon	Cascade	Downey	Goodell	Grand Total
UFT	1				3		4
Lake Shannon		1					1
Upper Baker Tailrace	14	17					31
Lower Baker FSC	7	8		1			16
Upper Baker FSC	56	3	2	2	1	1	65

Table 3b. Biological and capture data associated with GeneClass assignment test results for all bull trout samples from the Baker River basin assigned to expanded Skagit basin baseline. Baker sample names are in second column and WDFW sample names are in third column (see Table 1 for sample codes) with their putative origin under "> 90%" preceded by their relative likelihood score (under Relative %). Pink cells highlight relative likelihood scores below 90. The "N loci" is the number of loci in an individual's genotype.

								GeneClass		
Capture Date	**Baker ID**	**WDFW ID**	**Location**	**Method**	**Length**	**Life Stage**	**Rel like**	**>90 assign**	**highest**	**N loci**
11/8/2012	2012UFT019	12AH0019	UFT	TRAP	445	ADULT	100.00	Downey		16
07/16/13	2013UFT001	13DW0001	UFT	TRAP	570	ADULT	100.00	UpBaker		16
09/17/13	2013UFT002	13DW0002	UFT	TRAP	365	ADULT	100.00	Downey		16
11/07/13	2013UFT003	13DW0003	UFT	TRAP	526	ADULT	100.00	Downey		13
03/13/13	2013LB001	13DX0001	Lower Baker FSC	Trap	132	juvenile	100.00	Sulphur		16
03/18/13	2013LB002	13DX0002	Lower Baker FSC	Trap	177	sub-adult	100.00	Sulphur		16
03/19/13	2013LB003	13DX0003	Lower Baker FSC	Trap	94	juvenile	86.60	unassign	Cascade	16
03/22/13	2013LB004	13DX0004	Lower Baker FSC	Trap	71	juvenile	98.07	Sulphur		16
04/09/13	2013LB005	13DX0005	Lower Baker FSC	Trap	110	juvenile	99.37	Sulphur		16
04/15/13	2013LB006	13DX0006	Lower Baker FSC	hook and line	415	adult	100.00	UpBaker		16
04/25/13	2013LB007	13DX0007	Lower Baker FSC	hook and line	505	adult	100.00	UpBaker		16
04/25/13	2013LB008	13DX0008	Lower Baker FSC	Trap	435	adult	99.98	UpBaker		16
4/30/2013	2013LB009	13DX0009	Lower Baker FSC	Trap	102	juvenile	43.38	unassign	Bacon	16
05/04/13	2013LB010	13DX0010	Lower Baker FSC	Trap	94	juvenile	80.13	unassign	Sulphur	16
05/05/13	2013LB011	13DX0011	Lower Baker FSC	Trap	357	adult	100.00	Sulphur		16
05/10/13	2013LB012	13DX0012	Lower Baker FSC	Trap	435	adult	100.00	UpBaker		16
05/23/13	2013LB013	13DX0013	Lower Baker FSC	hook and line	415	adult	100.00	Sulphur		16
05/23/13	2013LB014	13DX0014	Lower Baker FSC	hook and line	420	adult	100.00	Sulphur		16
06/12/13	2013LB015	13DX0015	Lower Baker FSC	TRAP	340	ADULT	100.00	UpBaker		16
06/19/13	2013LB016	13DX0016	Lower Baker FSC	TRAP	115	JUV	99.96	UpBaker		16
06/25/13	2013LB017	13DX0017	Upper Baker Tailrace	ANGLE	385	ADULT	100.00	UpBaker		16
06/25/13	2013LB018	13DX0018	Upper Baker Tailrace	ANGLE	425	ADULT	99.85	UpBaker		16
06/25/13	2013LB019	13DX0019	Upper Baker Tailrace	ANGLE	495	ADULT	100.00	UpBaker		16
07/09/13	2013LB020	13DX0020	Upper Baker Tailrace	ANGLE	340	ADULT	100.00	UpBaker		16
07/09/13	2013LB021	13DX0021	Upper Baker Tailrace	ANGLE	445	ADULT	99.94	UpBaker		16
08/06/13	2013LB022	13DX0022	Upper Baker Tailrace	ANGLE	450	ADULT	100.00	UpBaker		16

Capture Date	Baker ID	WDFW ID	Location	Method	Length	Life Stage	Rel like	GeneClass >90 assign	GeneClass highest	N loci
08/28/13	2013LB023	13DX0023	Upper Baker Tailrace	ANGLE	410	ADULT	100.00	UpBaker		16
08/28/13	2013LB024	13DX0024	Upper Baker Tailrace	ANGLE	505	ADULT				16
08/28/13	2013LB025	13DX0025	Upper Baker Tailrace	ANGLE	415	ADULT	100.00	Sulphur		16
08/28/13	2013LB026	13DX0026	Upper Baker Tailrace	ANGLE	415	ADULT	100.00	Sulphur		15
08/28/13	2013LB027	13DX0027	Upper Baker Tailrace	ANGLE	440	ADULT	99.73	UpBaker		16
08/28/13	2013LB028	13DX0028	Upper Baker Tailrace	ANGLE	440	ADULT	100.00	Sulphur		16
08/28/13	2013LB029	13DX0029	Upper Baker Tailrace	ANGLE	295	sub-ADULT	100.00	Sulphur		15
08/28/13	2013LB030	13DX0030	Upper Baker Tailrace	ANGLE	278	sub-ADULT	100.00	Sulphur		16
08/28/13	2013LB031	13DX0031	Upper Baker Tailrace	ANGLE	420	ADULT	100.00	Sulphur		16
08/28/13	2013LB032	13DX0032	Upper Baker Tailrace	ANGLE	482	ADULT	100.00	UpBaker		16
08/28/13	2013LB033	13DX0033	Upper Baker Tailrace	ANGLE	428	ADULT	100.00	UpBaker		16
09/12/13	2013LB034	13DX0034	Upper Baker Tailrace	ANGLE	510	ADULT	100.00	Sulphur		16
09/12/13	2013LB035	13DX0035	Upper Baker Tailrace	ANGLE	485	ADULT	100.00	Sulphur		16
09/12/13	2013LB036	13DX0036	Upper Baker Tailrace	ANGLE	515	ADULT	100.00	Sulphur		16
09/12/13	2013LB037	13DX0037	Upper Baker Tailrace	ANGLE	445	ADULT	100.00	Sulphur		16
09/25/13	2013LB038	13DX0038	Upper Baker Tailrace	ANGLE	530	ADULT	94.61	UpBaker		16
09/25/13	2013LB039	13DX0039	Upper Baker Tailrace	ANGLE	440	ADULT	100.00	Sulphur		16
09/25/13	2013LB040	13DX0040	Upper Baker Tailrace	ANGLE	405	ADULT	100.00	Sulphur		16
09/25/13	2013LB041	13DX0041	Upper Baker Tailrace	ANGLE	570	ADULT	99.99	Sulphur		16
09/25/13	2013LB042	13DX0042	Upper Baker Tailrace	ANGLE	565	ADULT	100.00	Sulphur		16
09/25/13	2013LB043	13DX0043	Upper Baker Tailrace	ANGLE	395	ADULT	100.00	Sulphur		15
09/25/13	2013LB044	13DX0044	Upper Baker Tailrace	ANGLE	495	ADULT	98.75	UpBaker		15
09/25/13	2013LB045	13DX0045	Upper Baker Tailrace	ANGLE	425	ADULT	99.88	UpBaker		15
09/25/13	2013LB046	13DX0046	Upper Baker Tailrace	ANGLE	418	ADULT	100.00	Sulphur		15
09/25/13	2013LB047	13DX0047	Upper Baker Tailrace	ANGLE	438	ADULT	100.00	UpBaker		15
09/25/13	2013LB048	13DX0048	Upper Baker Tailrace	ANGLE	500	ADULT	100.00	Sulphur		15
09/26/13	2013LB049	13DX0049	Lake Shannon	ANGLE	365	ADULT	100.00	Sulphur		15
03/01/13	2013UB001	13DY0001	Upper Baker FSC	Trap	298	sub-adult	100.00	UpBaker		16
03/01/13	2013UB002	13DY0002	Upper Baker FSC	Trap	134	juvenile	99.53	Bacon		16
03/11/13	2013UB003	13DY0003	Upper Baker FSC	Trap	143	juvenile	96.31	UpBaker		16
03/18/13	2013UB004	13DY0004	Upper Baker FSC	Trap	411	adult	100.00	UpBaker		16
03/25/13	2013UB005	13DY0005	Upper Baker FSC	Trap	79	juvenile	100.00	UpBaker		16
04/03/13	2013UB006	13DY0006	Upper Baker FSC	Trap	129	juvenile	99.74	UpBaker		16
04/11/13	2013UB007	13DY0007	Upper Baker FSC	Trap	170	sub-adult	71.26	unassign	Cascade	16
04/17/13	2013UB008	13DY0008	Upper Baker FSC	Trap	74	juvenile	86.96	unassign	Downey	16
04/22/13	2013UB009	13DY0009	Upper Baker FSC	Trap	140	juvenile	99.49	UpBaker		16
04/26/13	2013UB010	13DY0010	Upper Baker FSC	Trap	115	juvenile	100.00	UpBaker		16
04/27/13	2013UB011	13DY0011	Upper Baker FSC	Trap	430	adult	100.00	UpBaker		16
04/28/13	2013UB012	13DY0012	Upper Baker FSC	Trap	438	adult	100.00	UpBaker		16
04/29/13	2013UB013	13DY0013	Upper Baker FSC	Trap	229	sub-adult	100.00	UpBaker		16
04/29/13	2013UB014	13DY0014	Upper Baker FSC	Trap	274	sub-adult	98.81	UpBaker		16
05/01/13	2013UB015	13DY0015	Upper Baker FSC	Trap	119	juvenile	100.00	UpBaker		16
05/01/13	2013UB016	13DY0016	Upper Baker FSC	Trap	193	sub-adult	100.00	UpBaker		16
05/08/13	2013UB017	13DY0017	Upper Baker FSC	hook and line	415	adult	100.00	UpBaker		16
05/08/13	2013UB018	13DY0018	Upper Baker FSC	hook and line	462	adult	99.98	UpBaker		16
05/08/13	2013UB019	13DY0019	Upper Baker FSC	hook and line	405	adult	100.00	UpBaker		16
05/08/13	2013UB020	13DY0020	Upper Baker FSC	hook and line	415	adult	100.00	UpBaker		16
05/08/13	2013UB021	13DY0021	Upper Baker FSC	hook and line	430	adult	100.00	UpBaker		16
05/08/13	2013UB022	13DY0022	Upper Baker FSC	hook and line	397	adult	100.00	UpBaker		16
05/08/13	2013UB023	13DY0023	Upper Baker FSC	hook and line	445	adult	91.57	Sulphur		16
05/08/13	2013UB024	13DY0024	Upper Baker FSC	hook and line	382	adult	100.00	UpBaker		16
05/08/13	2013UB025	13DY0025	Upper Baker FSC	hook and line	445	adult	100.00	UpBaker		16
05/08/13	2013UB026	13DY0026	Upper Baker FSC	hook and line	400	adult	100.00	UpBaker		16
05/08/13	2013UB027	13DY0027	Upper Baker FSC	hook and line	408	adult	100.00	UpBaker		16
05/08/13	2013UB028	13DY0028	Upper Baker FSC	hook and line	495	adult	100.00	UpBaker		16
05/08/13	2013UB029	13DY0029	Upper Baker FSC	hook and line	515	adult	100.00	UpBaker		16
05/15/13	2013UB030	13DY0030	Upper Baker FSC	hook and line	408	adult	99.99	UpBaker		16
05/15/13	2013UB031	13DY0031	Upper Baker FSC	hook and line	400	adult	98.39	UpBaker		16

WDFW Baker Bull Trout 2013

Capture Date	Baker ID	WDFW ID	Location	Method	Length	Life Stage	Rel like	GeneClass >90 assign	GeneClass highest	N loci
05/15/13	2013UB032	13DY0032	Upper Baker FSC	hook and line	450	adult	59.82	unassign	Bacon	16
05/15/13	2013UB033	13DY0033	Upper Baker FSC	hook and line	455	adult	67.68	unassign	UpBaker	14
05/15/13	2013UB034	13DY0034	Upper Baker FSC	hook and line	415	adult	98.06	Sulphur		16
05/15/13	2013UB035	13DY0035	Upper Baker FSC	hook and line	440	adult	99.95	UpBaker		16
05/15/13	2013UB036	13DY0036	Upper Baker FSC	hook and line	376	adult	100.00	UpBaker		15
05/15/13	2013UB037	13DY0037	Upper Baker FSC	hook and line	405	adult	100.00	UpBaker		13
05/15/13	2013UB038	13DY0038	Upper Baker FSC	hook and line	408	adult	100.00	UpBaker		16
05/18/13	2013UB039	13DY0039	Upper Baker FSC	Trap	435	adult	87.43	unassign	UpBaker	16
05/19/13	2013UB040	13DY0040	Upper Baker FSC	Trap	407	adult	99.87	UpBaker		16
05/21/13	2013UB041	13DY0041	Upper Baker FSC	Trap	405	adult	100.00	UpBaker		16
05/22/13	2013UB042	13DY0042	Upper Baker FSC	hook and line	505	adult	100.00	UpBaker		16
05/22/13	2013UB043	13DY0043	Upper Baker FSC	hook and line	395	adult	100.00	UpBaker		16
05/22/13	2013UB044	13DY0044	Upper Baker FSC	hook and line	458	adult	100.00	UpBaker		16
05/22/13	2013UB045	13DY0045	Upper Baker FSC	hook and line	435	adult	95.56	UpBaker		16
05/22/13	2013UB046	13DY0046	Upper Baker FSC	hook and line	431	adult	100.00	UpBaker		16
05/22/13	2013UB047	13DY0047	Upper Baker FSC	hook and line	448	adult	99.99	UpBaker		16
05/22/13	2013UB048	13DY0048	Upper Baker FSC	hook and line	412	adult	51.30	unassign	Goodell	16
05/22/13	2013UB049	13DY0049	Upper Baker FSC	hook and line	420	adult	100.00	UpBaker		16
05/22/13	2013UB050	13DY0050	Upper Baker FSC	hook and line	411	adult	99.05	UpBaker		16
05/22/13	2013UB051	13DY0051	Upper Baker FSC	hook and line	400	adult	100.00	UpBaker		16
05/22/13	2013UB052	13DY0052	Upper Baker FSC	hook and line	466	adult	100.00	UpBaker		16
05/29/13	2013UB053	13DY0053	Upper Baker FSC	hook and line	466	adult	100.00	Cascade		16
05/29/13	2013UB054	13DY0054	Upper Baker FSC	hook and line	474	adult	100.00	UpBaker		16
05/29/13	2013UB055	13DY0055	Upper Baker FSC	hook and line	392	adult	100.00	UpBaker		16
05/29/13	2013UB056	13DY0056	Upper Baker FSC	Trap	204	sub-adult	100.00	UpBaker		16
06/05/13	2013UB057	13DY0057	Upper Baker FSC	ANGLE	420	ADULT	100.00	UpBaker		15
06/05/13	2013UB058	13DY0058	Upper Baker FSC	ANGLE	495	ADULT	100.00	UpBaker		16
06/12/13	2013UB059	13DY0059	Upper Baker FSC	ANGLE	440	ADULT	99.98	Sulphur		16
06/12/13	2013UB060	13DY0060	Upper Baker FSC	ANGLE	450	ADULT	100.00	UpBaker		16
06/12/13	2013UB061	13DY0061	Upper Baker FSC	ANGLE	410	ADULT	100.00	UpBaker		16
06/12/13	2013UB062	13DY0062	Upper Baker FSC	ANGLE	405	ADULT	100.00	UpBaker		16
06/29/13	2013UB063	13DY0063	Upper Baker FSC	ANGLE	420	ADULT	100.00	UpBaker		16
06/29/13	2013UB064	13DY0064	Upper Baker FSC	TRAP	160	JUV	100.00	UpBaker		16
7/15/2013	2013UB065	13DY0065	Upper Baker FSC	TRAP	153	JUV	99.99	UpBaker		16

Table 4. STRUCTURE ancestry values illustrated in Figure 5b in comparison to GeneClass assignments and the relative likelihood of assignment (rel like). Colored cells under STRUCTURE columns had at least 20% ancestry in that cluster. Clusters were labeled for the dominant baseline population in the clusters displayed in Figure 5a (e.g. most bull trout from Upper Baker were in cluster 1 and cluster 1 is labeled UpBaker cluster).

	STRUCTURE clusters									GeneClass		
	UpBaker	Sulphur	Bacon	Above Dam	Cascade	Downey	Illabot	Goodell	Sauk	**Rel like**	**>90 assign**	**highest**
12AH0019	0.008	0.004	0.013	0.003	0.015	0.899	0.006	0.045	0.007	100.00	Downey	
13DW0001	0.474	0.345	0.154	0.002	0.006	0.004	0.003	0.008	0.004	100.00	UpBaker	
13DW0002	0.020	0.006	0.007	0.008	0.005	0.853	0.012	0.007	0.081	100.00	Downey	
13DW0003	0.008	0.008	0.007	0.003	0.011	0.941	0.008	0.009	0.006	100.00	Downey	
13DX0001	0.004	0.961	0.007	0.002	0.004	0.005	0.009	0.004	0.005	100.00	Sulphur	
13DX0002	0.043	0.924	0.008	0.001	0.006	0.004	0.005	0.002	0.006	100.00	Sulphur	
13DX0003	0.029	0.726	0.090	0.002	0.020	0.021	0.104	0.004	0.003	86.60	unassign	Cascade
13DX0004	0.167	0.766	0.032	0.005	0.005	0.004	0.009	0.009	0.004	98.07	Sulphur	
13DX0005	0.044	0.895	0.012	0.005	0.008	0.009	0.016	0.007	0.003	99.37	Sulphur	
13DX0006	0.867	0.013	0.006	0.002	0.024	0.008	0.046	0.010	0.024	100.00	UpBaker	
13DX0007	0.963	0.008	0.011	0.003	0.004	0.002	0.004	0.004	0.002	100.00	UpBaker	
13DX0008	0.975	0.005	0.005	0.001	0.003	0.002	0.003	0.002	0.004	99.98	UpBaker	
13DX0009	0.668	0.093	0.071	0.010	0.011	0.041	0.088	0.012	0.008	43.38	unassign	Bacon
13DX0010	0.162	0.678	0.013	0.010	0.030	0.016	0.058	0.020	0.012	80.13	unassign	Sulphur
13DX0011	0.035	0.930	0.009	0.002	0.003	0.004	0.006	0.007	0.002	100.00	Sulphur	
13DX0012	0.974	0.007	0.004	0.001	0.002	0.004	0.003	0.002	0.003	100.00	UpBaker	
13DX0013	0.016	0.859	0.041	0.011	0.009	0.009	0.003	0.015	0.037	100.00	Sulphur	
13DX0014	0.104	0.712	0.008	0.002	0.047	0.095	0.012	0.009	0.009	100.00	Sulphur	
13DX0015	0.957	0.004	0.016	0.001	0.004	0.004	0.003	0.007	0.003	100.00	UpBaker	
13DX0016	0.652	0.215	0.027	0.025	0.014	0.010	0.042	0.006	0.008	99.96	UpBaker	
13DX0017	0.953	0.004	0.023	0.003	0.004	0.003	0.004	0.004	0.002	100.00	UpBaker	
13DX0018	0.884	0.033	0.031	0.002	0.007	0.010	0.006	0.023	0.003	99.85	UpBaker	
13DX0019	0.912	0.010	0.007	0.002	0.014	0.007	0.020	0.013	0.016	100.00	UpBaker	
13DX0020	0.967	0.007	0.011	0.001	0.003	0.003	0.003	0.002	0.003	100.00	UpBaker	
13DX0021	0.548	0.236	0.147	0.002	0.010	0.021	0.026	0.002	0.006	99.94	UpBaker	
13DX0022	0.933	0.006	0.012	0.004	0.007	0.006	0.012	0.005	0.014	100.00	UpBaker	
13DX0023	0.636	0.066	0.271	0.002	0.006	0.002	0.011	0.005	0.002	100.00	UpBaker	
13DX0025	0.010	0.958	0.006	0.004	0.003	0.004	0.009	0.003	0.003	100.00	Sulphur	
13DX0026	0.005	0.967	0.010	0.004	0.003	0.003	0.003	0.003	0.002	100.00	Sulphur	
13DX0027	0.866	0.104	0.005	0.005	0.003	0.005	0.006	0.004	0.002	99.73	UpBaker	
13DX0028	0.004	0.957	0.008	0.002	0.004	0.003	0.003	0.018	0.002	100.00	Sulphur	
13DX0029	0.018	0.843	0.064	0.002	0.005	0.050	0.004	0.012	0.003	100.00	Sulphur	
13DX0030	0.010	0.836	0.006	0.003	0.025	0.084	0.015	0.006	0.015	100.00	Sulphur	
13DX0031	0.004	0.976	0.004	0.002	0.003	0.003	0.003	0.004	0.002	100.00	Sulphur	
13DX0032	0.973	0.005	0.007	0.002	0.003	0.003	0.003	0.002	0.003	100.00	UpBaker	
13DX0033	0.916	0.034	0.010	0.027	0.003	0.003	0.002	0.003	0.002	100.00	UpBaker	
13DX0034	0.005	0.979	0.004	0.002	0.002	0.002	0.002	0.002	0.002	100.00	Sulphur	
13DX0035	0.005	0.977	0.004	0.004	0.002	0.002	0.002	0.002	0.002	100.00	Sulphur	
13DX0036	0.006	0.977	0.004	0.002	0.002	0.003	0.002	0.002	0.002	100.00	Sulphur	
13DX0037	0.006	0.945	0.017	0.002	0.005	0.007	0.007	0.007	0.004	100.00	Sulphur	
13DX0038	0.734	0.094	0.016	0.014	0.022	0.009	0.085	0.020	0.007	94.61	UpBaker	
13DX0039	0.005	0.977	0.003	0.002	0.002	0.004	0.002	0.002	0.002	100.00	Sulphur	
13DX0040	0.010	0.773	0.008	0.001	0.007	0.168	0.024	0.002	0.008	100.00	Sulphur	
13DX0041	0.016	0.965	0.004	0.003	0.003	0.002	0.002	0.002	0.002	99.99	Sulphur	
13DX0042	0.009	0.970	0.006	0.002	0.002	0.003	0.002	0.003	0.002	100.00	Sulphur	
13DX0043	0.006	0.927	0.032	0.004	0.006	0.003	0.008	0.007	0.007	100.00	Sulphur	
13DX0044	0.659	0.230	0.006	0.004	0.013	0.007	0.054	0.025	0.004	98.75	UpBaker	
13DX0045	0.869	0.097	0.004	0.002	0.007	0.004	0.007	0.008	0.002	99.88	UpBaker	
13DX0046	0.004	0.974	0.006	0.003	0.003	0.003	0.003	0.003	0.002	100.00	Sulphur	
13DX0047	0.965	0.004	0.010	0.002	0.005	0.005	0.004	0.003	0.003	100.00	UpBaker	
13DX0048	0.005	0.976	0.006	0.002	0.002	0.003	0.002	0.003	0.002	100.00	Sulphur	
13DX0049	0.003	0.960	0.017	0.006	0.003	0.002	0.003	0.002	0.003	100.00	Sulphur	

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	STRUCTURE clusters									GeneClass		
	UpBaker	Sulphur	Bacon	Above Dam	Cascade	Downey	Illabot	Goodell	Sauk	**Rel like**	**>90 assign**	**highest**
13DY0001	0.960	0.010	0.004	0.006	0.004	0.007	0.002	0.003	0.003	100.00	UpBaker	
13DY0002	0.467	0.054	0.074	0.005	0.039	0.201	0.036	0.090	0.035	99.53	Bacon	
13DY0003	0.699	0.020	0.053	0.002	0.011	0.161	0.010	0.016	0.028	96.31	UpBaker	
13DY0004	0.956	0.011	0.012	0.001	0.003	0.004	0.005	0.003	0.003	100.00	UpBaker	
13DY0005	0.949	0.013	0.005	0.001	0.007	0.006	0.005	0.005	0.008	100.00	UpBaker	
13DY0006	0.653	0.023	0.057	0.003	0.094	0.024	0.111	0.021	0.013	99.74	UpBaker	
13DY0007	0.281	0.130	0.007	0.003	0.244	0.006	0.023	0.305	0.003	71.26	unassign	Cascade
13DY0008	0.032	0.586	0.063	0.002	0.021	0.263	0.004	0.020	0.010	86.96	unassign	Downey
13DY0009	0.659	0.320	0.008	0.001	0.002	0.002	0.002	0.003	0.002	99.49	UpBaker	
13DY0010	0.874	0.005	0.007	0.018	0.025	0.010	0.009	0.025	0.027	100.00	UpBaker	
13DY0011	0.815	0.020	0.006	0.001	0.038	0.009	0.096	0.011	0.005	100.00	UpBaker	
13DY0012	0.975	0.003	0.006	0.001	0.003	0.002	0.003	0.002	0.005	100.00	UpBaker	
13DY0013	0.969	0.004	0.006	0.002	0.002	0.007	0.002	0.003	0.004	100.00	UpBaker	
13DY0014	0.967	0.012	0.006	0.001	0.002	0.005	0.002	0.002	0.003	98.81	UpBaker	
13DY0015	0.917	0.009	0.015	0.001	0.011	0.007	0.014	0.013	0.013	100.00	UpBaker	
13DY0016	0.783	0.006	0.007	0.002	0.105	0.003	0.021	0.069	0.003	100.00	UpBaker	
13DY0017	0.872	0.027	0.010	0.004	0.011	0.034	0.013	0.023	0.007	100.00	UpBaker	
13DY0018	0.948	0.022	0.011	0.002	0.004	0.003	0.003	0.003	0.004	99.98	UpBaker	
13DY0019	0.848	0.020	0.092	0.002	0.012	0.002	0.014	0.007	0.003	100.00	UpBaker	
13DY0020	0.967	0.007	0.008	0.001	0.003	0.005	0.003	0.004	0.002	100.00	UpBaker	
13DY0021	0.971	0.005	0.006	0.002	0.004	0.004	0.002	0.003	0.003	100.00	UpBaker	
13DY0022	0.964	0.006	0.009	0.003	0.003	0.003	0.003	0.004	0.005	100.00	UpBaker	
13DY0023	0.865	0.116	0.006	0.002	0.002	0.002	0.002	0.002	0.002	91.57	Sulphur	
13DY0024	0.974	0.004	0.006	0.001	0.004	0.002	0.003	0.003	0.003	100.00	UpBaker	
13DY0025	0.850	0.050	0.069	0.005	0.009	0.005	0.003	0.007	0.005	100.00	UpBaker	
13DY0026	0.917	0.033	0.013	0.002	0.008	0.006	0.007	0.007	0.008	100.00	UpBaker	
13DY0027	0.976	0.003	0.005	0.002	0.002	0.003	0.003	0.003	0.003	100.00	UpBaker	
13DY0028	0.975	0.004	0.005	0.001	0.003	0.002	0.003	0.003	0.003	100.00	UpBaker	
13DY0029	0.975	0.005	0.006	0.002	0.003	0.002	0.003	0.002	0.002	100.00	UpBaker	
13DY0030	0.954	0.009	0.015	0.002	0.009	0.003	0.003	0.003	0.003	99.99	UpBaker	
13DY0031	0.974	0.008	0.004	0.002	0.003	0.002	0.002	0.002	0.002	98.39	UpBaker	
13DY0032	0.035	0.159	0.068	0.058	0.255	0.380	0.007	0.035	0.004	59.82	unassign	Bacon
13DY0033	0.957	0.011	0.007	0.003	0.004	0.003	0.005	0.005	0.005	67.68	unassign	UpBaker
13DY0034	0.275	0.628	0.007	0.003	0.033	0.005	0.025	0.017	0.007	98.06	Sulphur	
13DY0035	0.868	0.075	0.012	0.002	0.014	0.008	0.009	0.008	0.004	99.95	UpBaker	
13DY0036	0.905	0.013	0.014	0.003	0.007	0.007	0.005	0.037	0.009	100.00	UpBaker	
13DY0037	0.967	0.007	0.008	0.002	0.004	0.002	0.003	0.004	0.003	100.00	UpBaker	
13DY0038	0.974	0.005	0.004	0.002	0.003	0.002	0.004	0.002	0.004	100.00	UpBaker	
13DY0039	0.812	0.009	0.018	0.004	0.039	0.006	0.060	0.008	0.044	87.43	unassign	UpBaker
13DY0040	0.939	0.029	0.005	0.002	0.005	0.005	0.007	0.003	0.004	99.87	UpBaker	
13DY0041	0.934	0.007	0.010	0.002	0.005	0.009	0.010	0.012	0.012	100.00	UpBaker	
13DY0042	0.754	0.026	0.008	0.004	0.008	0.006	0.178	0.009	0.007	100.00	UpBaker	
13DY0043	0.974	0.006	0.006	0.002	0.003	0.003	0.003	0.002	0.003	100.00	UpBaker	
13DY0044	0.786	0.132	0.018	0.001	0.021	0.008	0.021	0.004	0.010	100.00	UpBaker	
13DY0045	0.881	0.074	0.013	0.002	0.008	0.004	0.004	0.007	0.006	95.56	UpBaker	
13DY0046	0.936	0.009	0.016	0.002	0.006	0.010	0.010	0.003	0.009	100.00	UpBaker	
13DY0047	0.925	0.045	0.007	0.004	0.003	0.004	0.002	0.004	0.006	99.99	UpBaker	
13DY0048	0.004	0.005	0.077	0.002	0.438	0.126	0.083	0.215	0.049	51.30	unassign	Goodell
13DY0049	0.730	0.140	0.102	0.002	0.009	0.003	0.007	0.004	0.003	100.00	UpBaker	
13DY0050	0.771	0.039	0.096	0.003	0.021	0.025	0.003	0.036	0.005	99.05	UpBaker	
13DY0051	0.957	0.005	0.006	0.003	0.008	0.005	0.011	0.004	0.002	100.00	UpBaker	
13DY0052	0.941	0.004	0.013	0.011	0.004	0.005	0.004	0.009	0.008	100.00	UpBaker	
13DY0053	0.050	0.073	0.025	0.006	0.802	0.007	0.006	0.028	0.003	100.00	Cascade	
13DY0054	0.957	0.005	0.007	0.002	0.008	0.005	0.005	0.004	0.008	100.00	UpBaker	
13DY0055	0.971	0.005	0.005	0.002	0.002	0.004	0.002	0.002	0.005	100.00	UpBaker	
13DY0056	0.971	0.003	0.006	0.002	0.004	0.003	0.003	0.003	0.005	100.00	UpBaker	
13DY0057	0.928	0.030	0.006	0.001	0.010	0.006	0.006	0.006	0.007	100.00	UpBaker	
13DY0058	0.873	0.008	0.011	0.002	0.007	0.084	0.006	0.003	0.005	100.00	UpBaker	

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	STRUCTURE clusters									GeneClass		
	UpBaker	Sulphur	Bacon	Above Dam	Cascade	Downey	Illabot	Goodell	Sauk	**Rel like**	**>90 assign**	**highest**
13DY0059	0.053	0.328	0.008	0.010	0.007	0.569	0.004	0.017	0.004	99.98	Sulphur	
13DY0060	0.976	0.003	0.007	0.002	0.002	0.002	0.002	0.003	0.004	100.00	UpBaker	
13DY0061	0.974	0.007	0.006	0.001	0.002	0.003	0.002	0.003	0.002	100.00	UpBaker	
13DY0062	0.950	0.022	0.005	0.002	0.003	0.007	0.003	0.005	0.003	100.00	UpBaker	
13DY0063	0.974	0.006	0.005	0.001	0.002	0.002	0.003	0.003	0.003	100.00	UpBaker	
13DY0064	0.967	0.006	0.005	0.005	0.003	0.004	0.003	0.004	0.004	100.00	UpBaker	
13DY0065	0.920	0.010	0.007	0.002	0.005	0.038	0.002	0.003	0.012	99.99	UpBaker	