# GENETIC ASSESSMENT OF COLUMBIA RIVER STOCKS

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Jon E. Hess Nathan R. Campbell Andrew P. Matala Daniel J. Hasselman Shawn R. Narum, Columbia River Inter-Tribal Fish Commission (CRITFC), Hagerman, ID, 83332

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## Executive Summary

This project combines four inter-related studies from the Accords Agreement that address the following current and future objectives:

**Objective 1) discover and evaluate SNP markers in salmon and steelhead and other anadromous fishes.** In the fifth year of this project, SNP discovery and evaluation goals were achieved with a total of three projects that included one project each on Chinook salmon, steelhead, and Coho salmon that identified SNP markers using restriction-site associated DNA sequencing (RAD-seq) technology. In addition, we have improved upon the technology for interrogating large sets of SNP loci through the development of GT-seq (genotyping-in-thousands by sequencing) method. The increased efficiency has reduced costs per multi-locus genotype. We now have developed marker panels of 192 SNPs, 293 SNPs, 258 SNPs, 93 SNPs, and 314 SNPs in the GT-seq format for steelhead, Chinook salmon, Coho salmon, Sockeye salmon, and Pacific lamprey, respectively. Using steelhead, we demonstrated how GT-seq can allow rapid genotyping of larger numbers of SNPs at far lower cost than the TaqMan chemistry used previously. These larger numbers of SNPs (~290) increase power for parentage analysis and we demonstrate single parent assignments in Chinook salmon have improved confidence compared to the smaller set of ~90 SNPs that we have relied on for broad scale applications of PBT.

**Objective 2) expand and create genetic baselines for multiple species including Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*O. mykiss*), Sockeye salmon and kokanee (*O. nerka*), and Coho salmon (*O. kisutch*).** There are three GSI baselines that utilize relatively small numbers of SNP loci (<200) and are representative of salmonid populations from the entire Columbia River Basin including Chinook salmon, steelhead, and *O. nerka*. This report includes a description of minor changes (i.e., addition of 5 collections) to the *O. nerka* GSI baseline that utilizes 96 SNP markers. We also describe two RAD-seq projects that are underway and will provide high density geographic coverage of Chinook salmon (N=26) and steelhead (N=51, Fig. 1) populations in the Columbia River Basin. SNPs identified through these latter efforts will be useful in characterizing genetic diversity of hatchery and wild Chinook salmon and steelhead stocks.

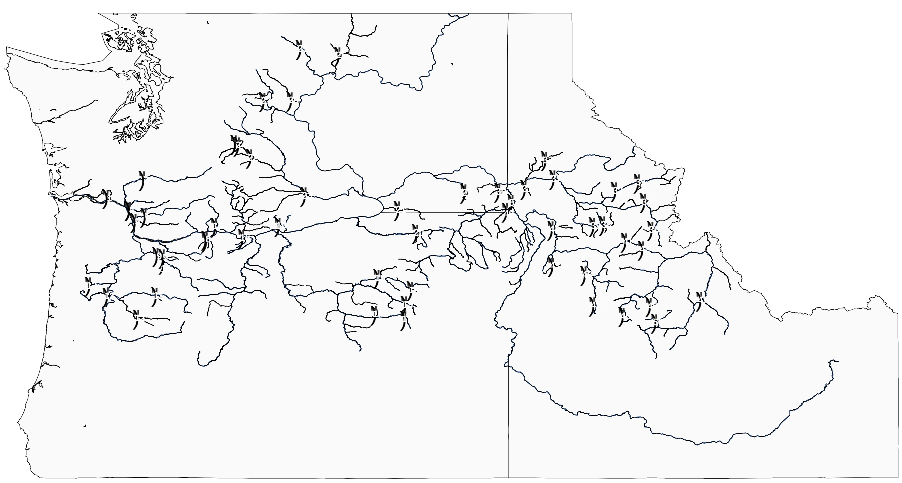


**Figure 1. Map displaying sampled steelhead (*O. mykiss*) populations.** Each numbered population represents a genotyped RAD library identified by number in Section 2, Table 1.

**Objective 3) implement GSI programs for mainstem Chinook salmon, Sockeye salmon, and steelhead fisheries (Fig. 2).** Chinook salmon and steelhead fishery applications of GSI are combined with the Parentage Based Tagging (PBT). Long histories of exogenous stock transfers from specific hatchery programs along with closely related natural stocks often prevents effective application of GSI in assigning origins of hatchery fish. This limitation can be overcome by the use of PBT. Currently PBT allows monitoring of all Snake River hatchery Chinook salmon and steelhead stocks, and does not require adipose fin clipping. The role of PBT continues to expand and beginning with spawn year 2013, most Chinook salmon and steelhead broodstock from hatcheries above Bonneville Dam have been sampled and will begin to be genotyped starting in 2015. GSI will continue to be utilized for determining the stock identity of wild fish and non-tagged hatchery-origin fish.

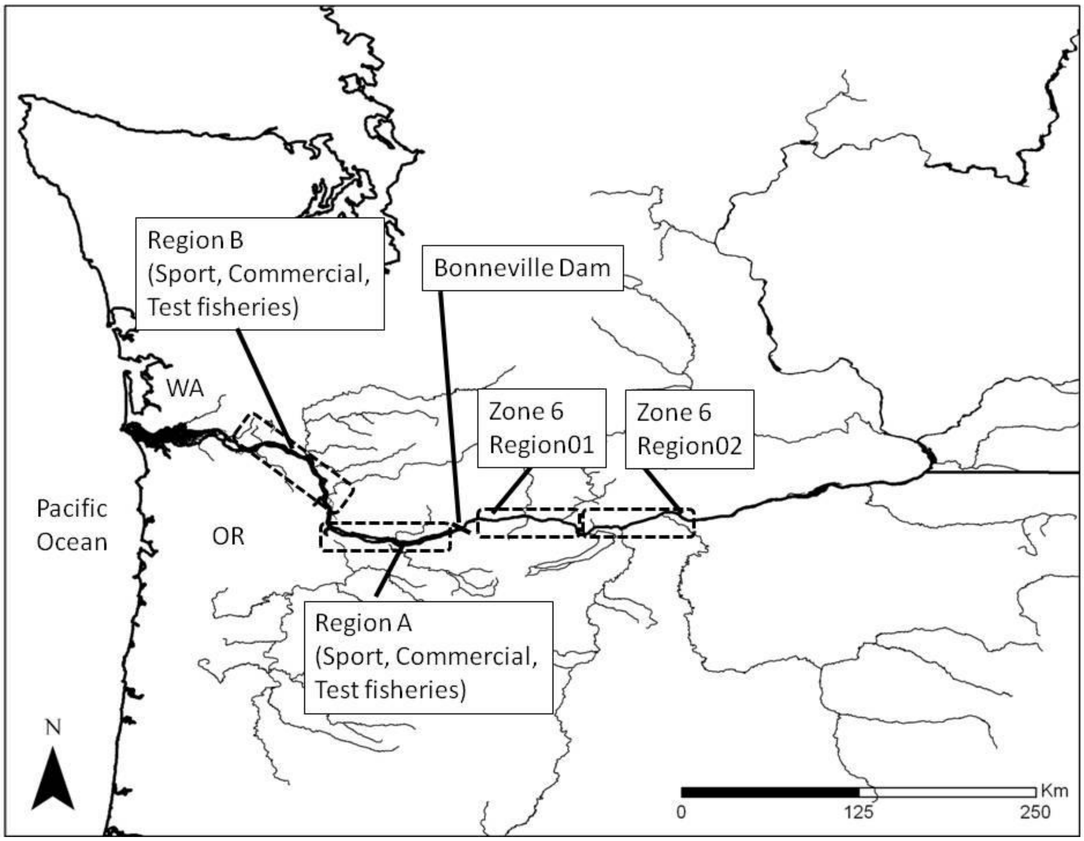


**Figure 2. Sources of fishery mixtures in the lower Columbia River mainstem.**

Using a combination of PBT and GSI approaches we estimated stock composition of several Chinook salmon fisheries and Bonneville Dam sampled during the spring management period (January 1 – June 15). This included: 1) sport, commercial, and tribal bank fisheries below Bonneville Dam, 2) non-lethal interrogation of fish at Bonneville Dam, and 3) a tribal commercial fishery in Zone 6 above Bonneville Dam. Further, we characterized the stock composition of a mark-selective sport fishery from the mouth of the Wind River (above Bonneville Dam) which has recently expanded its fishing boundary into the Columbia River mainstem. These comparisons among fisheries showed that a distinctive characteristic of the Wind River sport fishery is its large proportion of Carson Hatchery/Upper Columbia River hatchery stock ("10_UPCOLSP", Fig. 3). This genetic stock includes Carson Hatchery fish, which is the intended target of this fishery; however, genetic similarity between Carson Hatchery and Upper Columbia River hatcheries and others in the middle Columbia River created

uncertainty regarding the specific stock composition results. An additional distinction of the Wind River harvest was its relatively low proportion of Snake River hatchery fish that were assigned using PBT (Fig. 3).

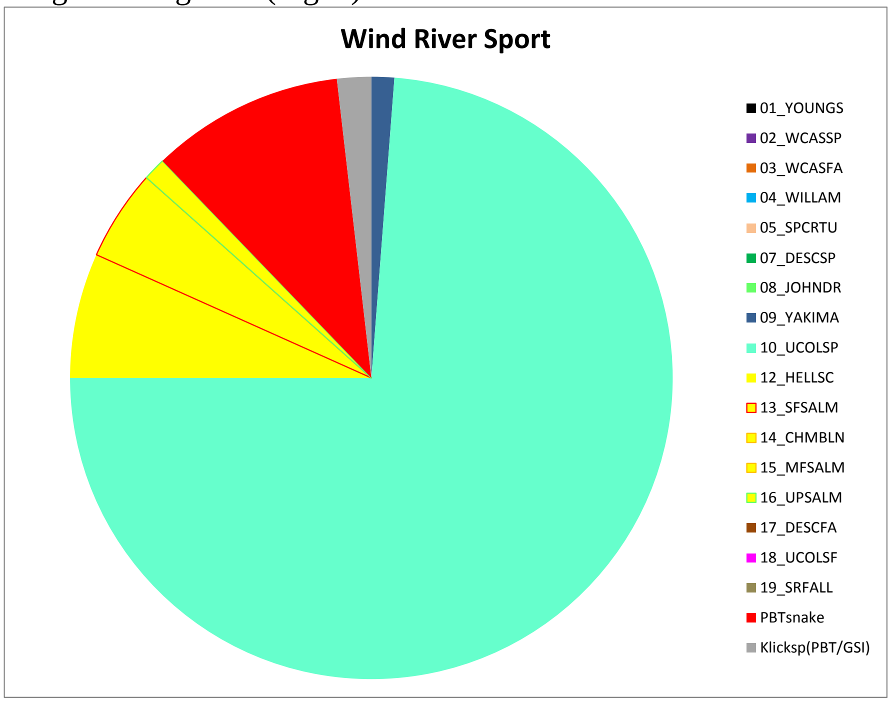



**Figure 3. Genetic stock composition of the Wind River sport harvest in 2014.**

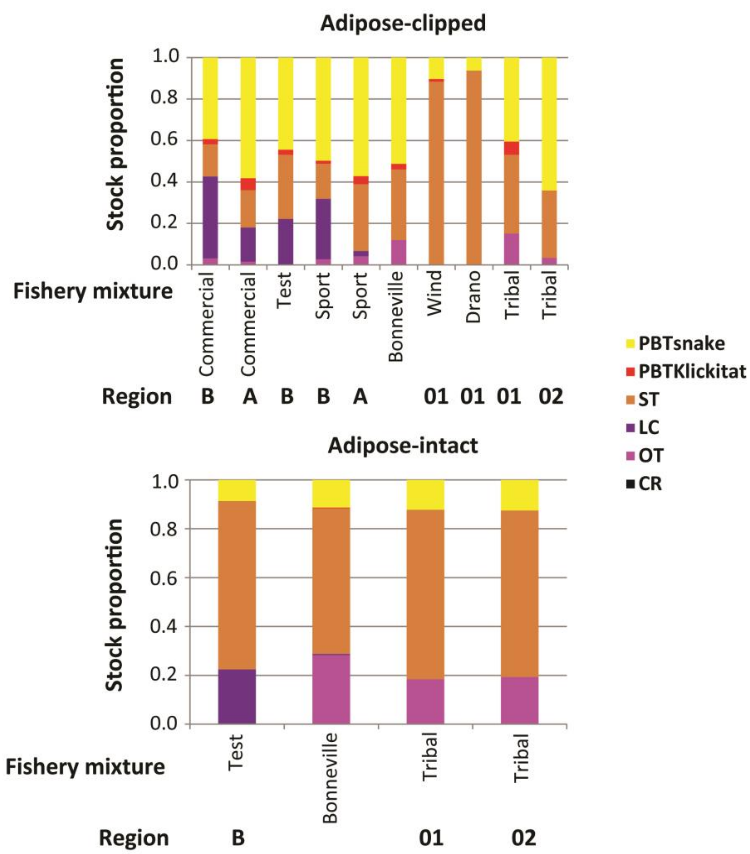



**Figure 4. Stock composition of Chinook salmon harvest mixtures and Bonneville Dam during the spring management period.** Note: “ST” includes upriver spring run and Snake River spring/summer run Chinook salmon stocks, “LC” includes all lower river stocks (e.g. Willamette, Cowlitz, Lewis, and Sandy stocks), “OT” includes upper Columbia summer and upriver fall Chinook salmon stocks, and “CR” denotes Columbia River Rogue stock reared in Youngs Bay net pens. PBT was used to assign Klickitat and Snake River hatchery spring-run Chinook salmon.

Analysis of adipose-clipped Chinook salmon from multiple fishery mixtures in the spring management period identified relatively larger proportions of lower Columbia River stocks (LC, likely dominated by the Willamette River stock) near the mouth of the Columbia River, such that region B was comprised of a range of 22 – 39% and region A had a range of 3 – 16% of the LC stock in commercial, test, and sport fisheries (Fig. 2, 4). PBT-assignments made it possible to further discriminate fish by their hatchery-of-origin (15 total hatcheries represented), which is a finer scale compared to the larger stock units that are resolved with GSI.  Stream-type stocks (ST, i.e. upriver spring-run and Snake River spring/summer-run Chinook salmon) were in highest proportions upstream of region B.  Analysis of adipose-intact fishery mixtures showed similar patterns (Fig. 4), however the Snake River PBT-assigned stock (hatchery-origin) was estimated in smaller proportions than in adipose-clipped samples as would be expected since PBT identifies hatchery origin fish.

Analysis of Chinook salmon fisheries in the summer management period (June 16 – August 1) addressed the following objectives: 1) estimate stock composition for the mark selective sport fishery and commercial fishery below Bonneville Dam, 2) compare stock composition of adipose-clipped versus adipose-intact fish from the commercial harvest below Bonneville Dam, 3) characterize temporal changes in stock composition across the season.  The percentage of upriver adult and jack spring-run stocks (ST) declined in both harvest and Bonneville Dam mixtures over time, but the commercial harvest may have generally included a lower proportion of this group compared with what actually passes the dam in any given week (Fig. 5).

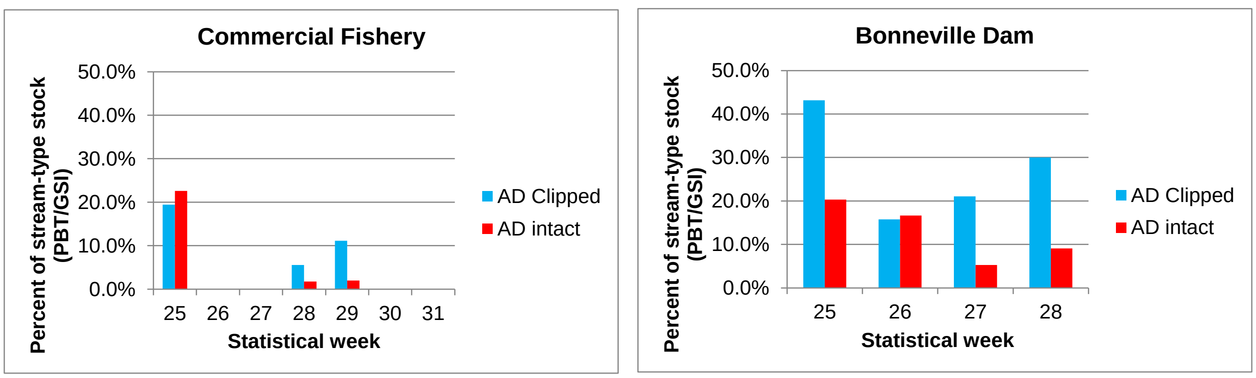
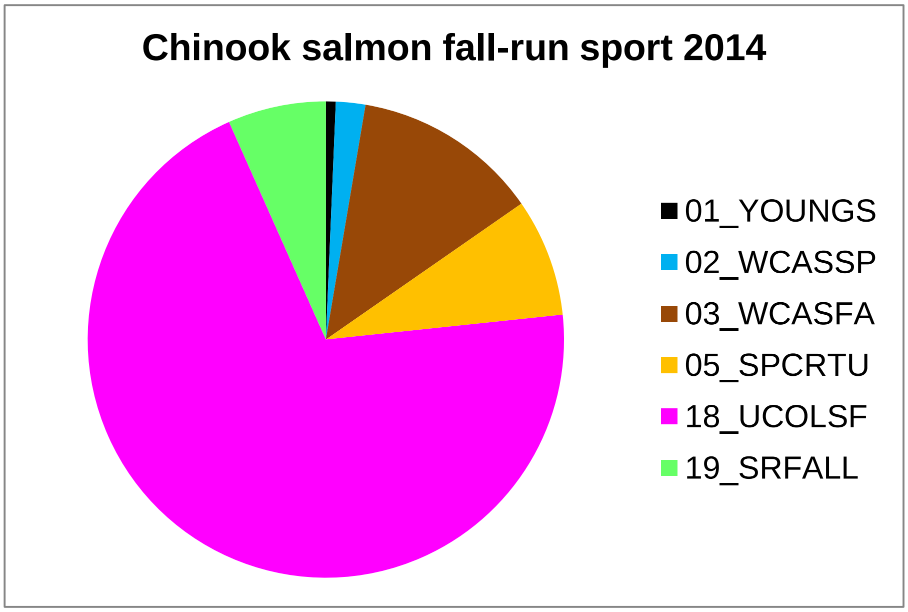



**Figure 5. Temporal patterns of the percent of upriver spring-run stocks (ST) by-catch in adipose-clipped and adipose-intact mixtures of adult and jack Chinook salmon sampled in the lower river commercial fishery and Bonneville Dam during the summer management period in 2014.** Statistical week 25 begins on June 16 and week 31 includes August 1.  The commercial fishery did not occur during weeks 26 and 27.  Sampling at Bonneville Dam was suspended during weeks 29–32 due to high temperatures.




For fall-run Chinook salmon fisheries, we estimated stock composition of the mark selective sport fishery in the lower Columbia River in 2014. A single PBT assignment was observed for a fall Chinook from the Klickitat. Major GSI stocks from greatest to least were: Upper Columbia River su/fa (70%), West Cascade fa (13%), Spring Creek Tule (8%), and Snake River fa (7%, Fig. 6).

**Figure 6. Genetic stock composition of the lower Columbia River fall-run Chinook salmon sport harvest in 2014.**

Analysis of stock composition of sockeye salmon fisheries included those from the lower Columbia River below Bonneville Dam in sport and commercial fisheries and the Zone 6 tribal fishery. The overall composition of the three stocks of sockeye salmon in the commercial fishery were Okanagan at 75%, Wenatchee at 25%, and Snake = 0%. The overall composition of the three stocks of sockeye salmon in the sport fishery were Okanagan 80%, Wenatchee at 18%, and Snake at 2%. The Zone 6 fishery proportions were Okanogan = 69%, Wenatchee at 29%, and Snake = 2%. For context, the composition of these stocks at Bonneville for the same time period (weeks 24-31) was Okanagan 80%, Wenatchee 20%, and Snake 1%. The proportion of each stock of sockeye salmon varied over time, most notably for the Wenatchee stock (Fig. 7).

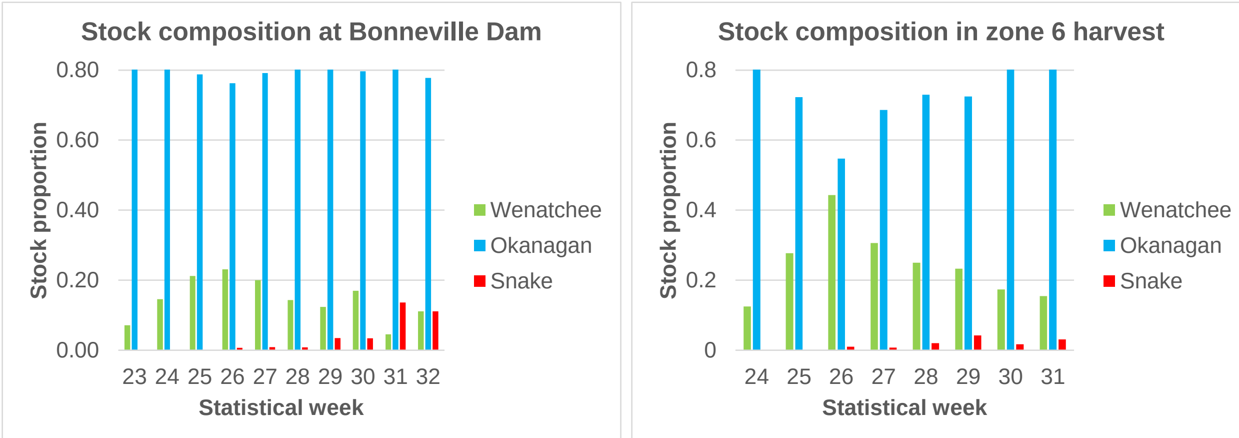



**Figure 7. Stock composition at Bonneville Dam and the Zone 6 sockeye harvest on a weekly basis.** Statistical week 23 begins on June 2 and week 32 ends on August 10.

Finally, objective 3 concluded with a stock composition analysis of unclipped steelhead harvested in the summer and fall tribal fishery in Zone 6. Despite, the absence of an adipose mark, PBT assignments were used to identify 19% and 11% of the sampled harvest in Drano Lake and Zone 6, respectively, as unclipped Snake River hatchery-origin (Fig. 8). These fish are likely to be primarily from supplementation releases that were not adipose-clipped and mis-clipped fish from other hatchery programs.

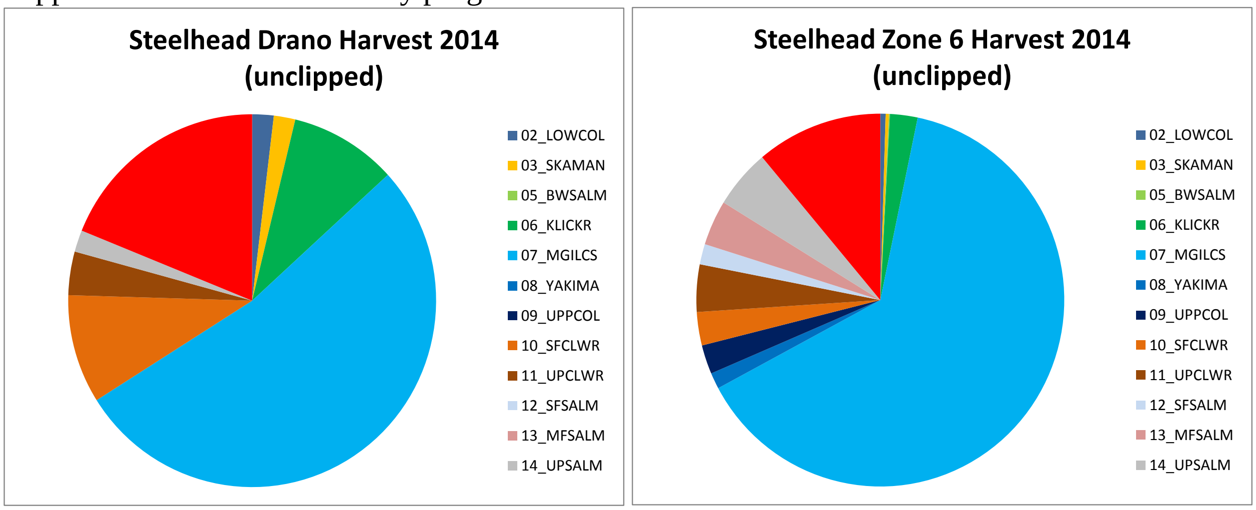



**Figure 8. Stock composition of adipose-intact steelhead harvested in 2014 from summer and fall fisheries in Zone 6.** Twelve Columbia River Basin stocks were represented: Lower Columbia "LOWCOL", Skamania "SKAMAN", Big White Salmon "BWSALM", Klickitat "KLICKR", MGILCS, Yakima "YAKIMA", upper Columbia "UPPCOL", S.F. Clearwater "SFCLWR", upper Clearwater "UPCLWR", S.F. Salmon "SFSALM", M.F. Salmon "MFSALM", and upper Salmon "UPSALM". The MGILCS is a large group of closely related stocks that includes the following Snake River stocks: George Cr, Asotin Cr, Alpowa Cr, and Tucannon R as well as the stocks from the Grande Ronde, Imnaha, Lower Clearwater and Lower Salmon R.; and all other middle Columbia River stocks that were not listed above.

**Objective 4) use GSI to estimate stock composition of fish passage at Bonneville Dam (steelhead, Sockeye salmon, and Chinook salmon) and juvenile Pacific lamprey passage at Lower Granite Dam.** Fish were sampled as they migrated past Bonneville Dam. We sampled adult and jack Chinook and adult steelhead during the spring, summer, and fall management periods. We used a combination of GSI and PBT to estimate run-timing distributions and relative abundance of hatchery and wild Chinook salmon and steelhead stocks in 2014. We observed more than 13,000 natural-origin and 10,000 hatchery-origin fish assigned to spring-run Chinook salmon reporting groups (mostly Snake River origin) that return during the summer management period (June 16 – July 31) based on our estimates. Some jack aged spring and Snake River spring/summer Chinook salmon stocks are known from PIT tag data to have a very late run timing and in fact approximately 75% of the 8,900 Snake River hatchery spring/summer stocks that arrived in the summer management period were jacks. Some run-timing results were consistent with those from previous analyses, e.g. Salmon River spring-run Chinook salmon have relatively late runs compared to other spring stocks.

There were eleven wild and five hatchery steelhead stocks with an estimated relative abundance greater than 1000 fish passing Bonneville Dam in 2014. Managers have historically grouped

steelhead stocks into management periods and we observed that the run-timing of genetic stocks appears to correspond relatively well. Historically, managers have defined an early Skamania summer-run, an intermediate run-timing category that contains most wild and hatchery steelhead stocks, and a late run-timing category that arrived after August $25^{th}$. While managers do not utilize the August 25 date break anymore, the overall trends of stocks tend to segregate into this historic pattern. The latter timed group includes South Fork Clearwater R., upper Clearwater R., and South Fork and Middle Fork Salmon R. stocks. However, this pattern was not exclusive as these three stocks also had some earlier returning fish, and late returning fish were also comprised of other stocks.

We combined PIT-tag (adults tagged at Bonneville Dam) and genetic analyses to estimate relative abundances and median run-timing dates of the following three extant anadromous sockeye salmon stocks: Okanagan (488,813; Jun. 30th), Wenatchee (119,971; Jun. 29th), and Snake River (5,136; Jul 5th). The estimated median date for Snake River sockeye calculated by this method differs slightly from estimates based on PIT tagged juveniles which were 50% complete at Bonneville by July 7 and were 75% complete by July 11. However, the sample size for fish assigned to Snake River with PIT-tag data and GSI was very small as only 17 fish were identified from Bonneville Dam and thus limits precise estimates of run-timing. A comparison of dam counts in the Snake River compared to dam counts at Priest Rapids would suggest about 1 in 255 sockeye salmon in the basin were Snake River stock (approximately 0.4% of the total run). The low abundance of this stock makes it challenging to estimate with the methods in this study given current restrictions on numbers of fish that can be sampled at Bonneville Dam at the Adult Fish Facility (AFF) trap. Further, low sample numbers of the Snake River stock in the harvest make it difficult to estimate stock proportions with narrow confidence intervals and preclude determination of whether harvest proportions were significantly higher than the estimate for this stock at Bonneville, which was 0.8% (95% C.I. 0.4% – 1.4%) of the sockeye run during this fishing period. Possible explanations for differences among the estimates of this stock could owe to the sampling protocols at Bonneville Dam (Fig. 7), which may have higher representation of young fish as compared to harvest mixtures.

This study also utilized a genetic baseline of adult lamprey that were translocated throughout the Snake River basin in the year 2007 and examined whether they could be assigned as parents to any Pacific lamprey juveniles collected as mortalities on the screens of turbine units at Lower Granite Dam (LGR) in 2014. A previous parentage analysis identified a cohort of translocation-offspring (broodyear 2007) as 5-, 6-, and 7-year-olds that were exiting their home-tributary (Newsome Creek) during 2012 – 2014. Of the 377 lamprey in the sample, there was a single LGR juvenile that assigned to the translocated adults, representing the very first detection of a 7-year-old Pacific lamprey macropthalmia (juvenile ocean migrant life stage) derived from the Newsome Creek 2007 translocation event. All prior testing of earlier samples from 2011-2013 had failed to identify even a single assignment to translocated adults. Estimation of the effective number of spawners represented by the 2014 collection of LGR juveniles yielded 508 (95%CI 441–595). This number is extremely low given that it represents the effective spawner abundance of nearly the entire Snake River Basin.

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## Introduction

This project combines four inter-related studies from the Fish & Wildlife Program Accords that address the following current and future objectives: 1) discover and evaluate SNP markers in salmon, steelhead, and lamprey; 2) expand and create genetic baselines for multiple species (Chinook, steelhead, sockeye, and coho); 3) implement Genetic Stock Identification (GSI) sampling programs for mainstem Chinook salmon, sockeye salmon, and steelhead fisheries and 4) GSI of fish passing Bonneville Dam (salmon and steelhead). These four projects are highly related since SNP markers are needed to complete species-specific baselines, and these baselines are requisite to complete GSI. The results of these four objectives address needs for distinguishing specific stocks, determining genetic diversity, stock specific run timing, and estimating stock composition which can provide information for fisheries management.

*Objective 1) SNP Discovery*

One of the highest priorities in the full-scale implementation of SNPs for salmon genetics is the discovery and development of a sufficient number of markers to characterize population variability. These DNA sequence polymorphisms represent the most abundant variation in the genome of most organisms, and are spread throughout the entire genome at high density (Morin et al. 2004). Thus SNPs can be discovered through sequencing known regions of DNA and converted to high throughput assays (e.g., Campbell and Narum 2008a), and more recently SNP discovery has become even more efficient for rapid identification of thousands of SNPs using genotyping-by-sequencing technology (e.g., Hess et al. 2013). Mutation rates, mutation models and error rates for SNPs are generally well understood, providing a foundation for estimating genetic divergence between populations. SNP markers offer a more cost-effective and less error-prone alternative to previous genetic marker technology such as microsatellite markers. Over the past few years, our lab has contributed to the increasing numbers of SNP markers that are available for salmonids and lampreys, and we have reached a point where rigorous stock composition and assessment goals for timely management of fisheries and highly accurate, precise stock assignments can be achieved using one or two panels of 96 SNP markers independently of any other marker-type.

*Objective 2) Baseline Expansion*

Currently, genetic baselines of microsatellite markers are in place for Chinook salmon across the coastwide range (Seeb et al. 2007), steelhead (Blankenship et al. 2011), and *O. nerka* (including kokanee) in the interior Columbia River Basin. Despite large, representative sample sizes from many populations and high microsatellite allelic diversity, the resolution of specific stocks and populations in these baselines is limited in some cases. For example, Upper Columbia summer and upriver fall Chinook salmon in the Columbia River are closely related and remain impossible to distinguish even with a powerful set of 13 microsatellite markers. Several other closely related populations in the Chinook salmon baseline are similarly difficult to distinguish and thus have been pooled into a single reporting unit for GSI applications. In some cases (e.g., mainstem Columbia River Chinook fisheries) a finer level of stock discrimination is necessary to match data utilized by managers such as information provided by CWTs. Additional SNP loci will increase stock assignment reliability where greater resolution is desired. Given the difficulty and expense of inter-laboratory standardization, additional microsatellite markers are not the most efficient choice. In

this regard, SNP markers are the preferred option for additional loci since they offer many beneficial characteristics that make them amenable to adding loci to existing baselines.

*Objectives 3 & 4) Genetic Stock Identification*

Genetic Stock Identification (GSI) methods have proven to be effective in determining the proportion of stock origin in several mixed stock applications (Narum et al. 2008b, Hess et al. 2011, Hess and Narum 2011). This study includes two GSI projects that will utilize genetic baselines: 1) GSI to provide information about harvest; and 2) GSI of fish passing Bonneville Dam.

This study includes GSI analysis of Chinook salmon and Sockeye salmon collected from commercial, recreational, and tribal fisheries in the Columbia River and GSI analysis of steelhead collected from the tribal fishery above Bonneville Dam. Subsequent years of the study may include other species such as coho salmon. Implementation of GSI technology could make monitoring individual production units in mixed stock areas possible. Tissues will be sampled annually from fisheries with existing programs in place with Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), Yakama Nation Fisheries Program (YNFP) and Confederated Tribes of the Warm Springs of Oregon (CTWSRO). We plan to genotype representative samples from fisheries of primary interest. The GSI estimates may help fill information gaps on wild fish with a different resolution than can be estimated using methods such as CWTs.

The second application of GSI analysis in this study includes sampling unknown origin salmon and steelhead at Bonneville Dam for genetic analysis. Samples will be collected over the entire length of the run on a weekly basis, and genetic baselines will be utilized to determine the stock composition of these runs. Few studies have been able to determine the extent of overlap among life history types of salmon and steelhead, but GSI of each life history type will allow us to determine the stock composition of the different runs through Bonneville Dam which can be compared to other methods such as using fish PIT tagged as juveniles. Population genetic methods and statistical assignment models have advanced dramatically in recent years, and estimating stock composition is now possible using either Bayesian or Maximum Likelihood methods (Anderson et al. 2008). Therefore, we plan to estimate stock composition of multiple species passing Bonneville Dam and provide this information on a timely basis to fisheries managers in the form of an annual report.

Finally, we continue to utilize a new genetic technology, parentage based tagging (PBT), in combination with GSI to help augment and refine our stock identification results. PBT is an efficient approach for mass-tagging of fish. The method is carried out by first genotyping a set of potential parents which then provides the opportunity to assign a set of genotyped offspring to their true parent pair. PBT is currently being utilized on a broad scale in the Columbia River Basin to tag all Snake River Chinook salmon and steelhead hatchery broodstocks (Steele et al. 2011) and we will soon have a baseline that includes most Chinook salmon and steelhead hatcheries located above Bonneville Dam. This application has effectively tagged all Snake River hatchery Chinook salmon and steelhead starting with the 2008 brood years. When parent pairs of a Snake River hatchery fish are identified with PBT, we can provide accurate information including age of the fish and the source hatchery in which its parents were spawned.

We can now use PBT in both Chinook salmon and steelhead GSI applications to identify all Snake River hatchery-origin fish, and then we estimate stock-of-origin of all other hatchery fish that were not assigned with PBT (i.e. non-Snake River hatchery-origin) and all wild fish using GSI. In this way PBT and GSI are complimentary, and using them in combination takes full advantage of the strengths of each method, while resolving or minimizing limitations. Exogenous stock transfers by hatcheries have made hatchery-origin fish challenging to assign with GSI and represents a main limitation that is addressed with PBT. Applications of PBT have been initiated in other species such as Pacific lamprey, and are being used to monitor translocations of lamprey throughout the interior of the Columbia River.

*Report Structure*

This report is divided into four sections, one for each of the objectives of the study. The first section reports on SNP discovery efforts and the second section on genotyping SNP markers in Chinook salmon, steelhead, and *O. nerka* to create genetic baselines. The third section contains stock composition estimates of Chinook salmon, Sockeye salmon and steelhead sampled in mainstem fisheries in 2014. The fourth section includes analysis of run-timing distributions and estimated abundance of adult Chinook salmon, Sockeye salmon, and steelhead stocks migrating over Bonneville Dam in 2014.

## Section 1: SNP Discovery

### Introduction

Through the analysis of genetic variation among individuals of a species, biological insights into the population dynamics of that species can be gained. Metrics such as reproductive success rate, effective number of breeders, population size, relative stock abundance, and exploitation rates for specific stocks can all be gathered using well established methods of genetic analysis. However, in order for these methods to be accurately utilized, genotype data from a sufficiently informative panel of genetic markers must first be collected from a suitably large collection of individual samples. The identification of a sufficient number of informative genetic variations had previously been a barrier to the study of some species by population genetics. Advances in sequencing technologies have now made the identification of genetic variants much easier and more cost effective. Techniques such as RAD-seq (Restriction Site Associated DNA sequencing: https://www.monitoringmethods.org/Method/Details/4144) allow for the de-novo identification and genotyping of thousands of SNP variants (Single Nucleotide Polymorphisms) among a set of samples.

With identified SNP variants now abundant for most species of interest (Hess et al. 2015), we turned our attention to adapting the power of Next Generation Sequencing (NGS) for high throughput genotyping of selected panels of SNP loci. Through a series of experiments a SNP genotyping method based on multiplex amplicon sequencing (GT-seq: Genotyping in Thousands by Sequencing) was developed which allowed for the collection of targeted SNP genotypes at less than ¼ the cost of the previously used method (TaqMan™ 5' exonuclease assays). The GT-seq method was refined further and a paper describing the technique was published (Campbell *et al.* 2015: https://www.monitoringresources.org/Document/Method/Details/5446). This technique produces high quality SNP genotypes (100 to 1,000 SNP loci) for 1,000 to 4,000 individual samples per Illumina HiSeq lane. Implementation of GT-seq for high throughput genotyping for most all of our study species has been ongoing and is delivering faster, more powerful, and more cost-effective data sets for population genetic analyses. To date, GT-seq primer pools have been developed in our laboratory for 5 of our study species (Steelhead [*O. mykiss*], Chinook [*O. tshawytscha*], Coho [*O. kisutch*], Sockeye [*O, nerka*], and Pacific Lamprey [*E. tridentata*]).

### Methods

For each species, all current SNP loci used for genotyping, as well as some additional SNP loci, were targeted for inclusion in PCR primer pools for GT-seq. For SNP loci which were already being genotyped using TaqMan™ assays, the existing flanking primers were simply modified to include the Illumina sequencing primer sites. For novel SNP loci, the program Primer3 (Rozen and Skaletsky 2000) was used to design flanking primers (product size range: 60-120 bases,

optimal annealing temperature: 60°C, primer size range: 18-24 bases, optimal GC content: 50%) which were tagged with Illumina sequencing primers as per Campbell *et al.* 2015). Ninety-six well plates of primers were ordered from Integrated DNA Technologies (IDT) at a 25 nmole synthesis scale resuspended at 200µM concentration. Test primer pools were created by combining equal volumes of each primer such that the concentration of each primer was 0.25µM. The primer mixture was used to prepare small test libraries containing 96 samples each using the GT-seq protocol (Campbell *et al.* 2015). The test libraries were "spiked" into the same Illumina HiSeq flowcell lane as other sequencing libraries such that each test library produced 5-10 million reads. Sequencing reads from each of the test libraries were analyzed for primer hetero-dimers using perl scripts supplied on GitHub (https://github.com/GTseq/GTseq-Pipeline/) and primers contributing to large numbers of sequence artifacts were identified and eliminated from the primer pools. In some cases primers were modified in order to avoid primer heterodimers rather than dropped from the panel. Following this step, another test library was created and evaluated for each new modified primer pool. At this point the primer pools each performed well enough to produce genotypes at most loci and only minor modifications to the primer mix and input files were necessary.

## Results

GT-seq primer pools for high throughput SNP genotyping have been developed for 5 target species (Steelhead [*O. mykiss*]-261 SNP loci plus sex determination marker, Chinook [*O. tshawytscha*]-298 SNP loci plus sex determination marker, Coho [*O. kisutch*]-257 SNP loci, Sockeye [*O. nerka*]-93 SNP loci, and Pacific Lamprey [*E. tridentata*]-308 SNP loci) after filtering for primers producing large numbers of artifact sequences and loci which genotype poorly using the method (Table 1). Each of these primer sets have been tested for their ability to produce high quality SNP genotypes using the GT-seq method with between 1,000 and 2,000 samples per Illumina HiSeq lane. These resources have now been used to genotype over 100,000 individual samples (Figure 1) at a far lower cost than the previously used method (TaqMan genotyping assays).

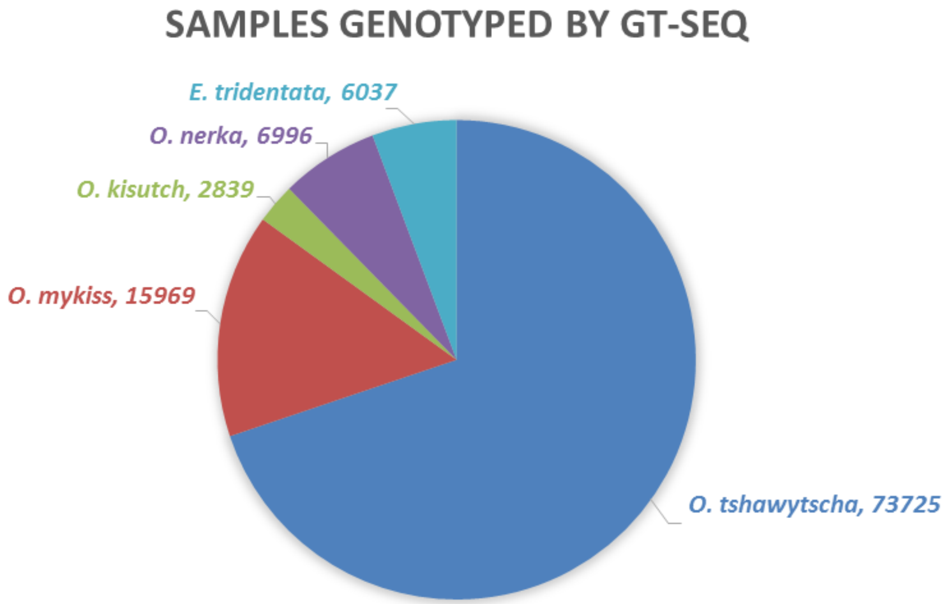


**Figure 1:** Summary of Columbia River fish samples genotyped using GT-seq.

**Discussion**

The GT-seq SNP genotyping method has many advantages over the previously used TaqMan™ genotyping method. For instance, all loci are amplified simultaneously within the same PCR reaction for each sample rather than each locus in a separate reaction as is necessary with all types of 5' exonuclease assay. A second PCR step then adds a unique combination of 6 base barcode sequences to each amplified fragment to allow PCR products to be assigned to a specific sample after sequencing. This allows the amplified target loci from all samples to be combined in a single sequencing run and makes it unnecessary to use microfluidic chips, which constituted a substantial portion of the genotyping costs using TaqMan™ assays. Library preparation requires only common laboratory equipment (multi-channel pipettes, a plate centrifuge, and 96-well thermal cyclers) and, once DNA has been extracted, sequencing libraries can be prepared very quickly. Once the libraries have been sequenced, genotypes are generated much more efficiently than was previously possible since many more samples are genotyped simultaneously and allele ratios generated from sequencing data are much more predictable than those generated using fluorescent probes (Campbell *et al.* 2015). Overall, GT-seq has become a cost effective, flexible, efficient, and powerful tool for genetic monitoring of Columbia River fishes.

## References

Campbell NR, Harmon SA, Narum SR. 2015. Genotyping-in-Thousands by sequencing (GT-seq): A cost effective SNP genotyping method based on custom amplicon sequencing. *Molecular Ecology Resources* **15**, 855-867.

Hess, J.E., N.R. Campbell, A.P. Matala, S.R. Narum. 2015. 2013 Annual Report: Genetic Assessment of Columbia River Stocks. U.S. Dept. of Energy Bonneville Power Administration Report Project #2008-907-00. - See more at: http://www.critfc.org/reports/2013-annual-report-genetic-assessment-of-columbia-river-stocks/#sthash.m8gGahg7.dpuf

Rozen S, Skaletsky H. 2000. Primer3 on the WWW for general users and for biologist programmers. In: Krawetz S, Misener S, editors. *Bioinformatics Methods and Protocols*. Totowa, NJ: Humana Press p. 365-386.

**Table 1:** Primer sequences, in-silico probe sequences for each allele, and correction values for each allele for each SNP locus included in each GT-seq primer pool. Each forward primer is modified with a 5 prime "small RNA" sequencing primer site (CGACAGGTTCAGAGTTCTACAGTCCGACGATC) and each reverse primer is modified with a 5 prime standard paired-end sequencing primer site (GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCT).

***O. mykiss* GT-seq panel (261 loci plus sex determination marker)**

| Assay: | A1: | A2: | FWD: | REV: | A1-Probe: | A2-Probe: | Allele Corrections: |
|---|---|---|---|---|---|---|---|
| Ocl_gshpx-357 | T | G | GAGATCCTGAGGTCCCTGAAGTAT | AAGTGGAAATTTGGGCTCAAAGC | ATCCGTCCAGGAAATG | TCCGTCCCGGAAATG | 0,0 |
| Omy_myclarp404-111 | T | G | GCTGTGGTGCTCATGGGTAAA | CCAGGGCAGGGTTGTTCTC | CAAAGCCATACGTGGCC | AAGCCATCCGTGGCC | 0,0 |
| Omy_Omyclmk438-96 | A | C | CCCGACTCTACTTCACTACTTTCCT | GGCCTAGGACAATAGGACTGAAC | TACGCAAATTAGGTTTAAA | CGCAAATTAGGGTTAAA | 0,0 |
| M09AAC.055 | C | T | GTCTCCGACGTGTGGCT | TGGAACGAACCTGAGAACATAAGG | ACCTCCACGCTGTCC | ACCTCCACACTGTCC | 0,0 |
| OMGH1PROM1-SNP1 | A | T | TCAAACTGCATTTGATGGAAACAAACAT | AGGACAATTCTAAGTGACCTCAAACTG | TAGTGTTCACTGACTTCA | TAGTGTACACTGACTTCA | 0,0 |
| OMS00003 | T | G | GTGCCACTGATGAGGATGAGATC | GTAATAAAGCCCTTTTGTGAGGAAAAACTAAT | CTTTACTGTCGACATTTTA | TACTGTCGCCATTTTA | 0,0 |
| OMS00008 | A | T | CCCTTTAAGGAGGATTTTAAATATGTGAGATAGAA | GGATACAGCGTTTTGGAATGAAACT | CTTCAAATATCCATAATTATATC | TCAAATATCCATAATAATATC | 0,0 |
| OMS00013 | A | G | GCCTTTGTTCTCCTTGGTGGTTA | AGAAAAGTGTGGACTGAGGTTGAG | CTTCTTTTCCCTTGCTACTC | CTTTTCCCTCGCTACTC | 0,0 |
| OMS00014 | T | C | CTTACACACAAGGGCTTCATTCTG | GATGTCTCTGGGTGGTTGTCA | TGATTTGATGAATTAAACTTC | TTGATGAATTGAACTTC | 0,0 |
| OMS00015 | A | T | TCAGACCCTATTTTTGGCACAAGT | GTCTAACTGATCCCACTTCTGCAT | CAAGTCACACTTTTAATGAA | CAAGTCACACTTATAATGAA | 0,0 |
| OMS00017 | A | G | ATTAAGTTCATACAAAAGTTCATCATAAATATTTTCCTTT | GGAGAACAAAGGGAAAGAGAAGACA | TAGACCTCGGTGCTGTAG | CCTCGGCGCTGTAG | 0,0 |
| OMS00018 | T | G | AGAGTACATGTGTGGCTGCAA | GTCATAAATCAACACAATTATCTTCTTCACAGAA | AACCACATAATTAATAATTC | CCACATAATTCATAATTC | 0,0 |
| Omy_cd28-130 | T | C | CACAACTCCACAGAGACAGTGA | GAGGACAAAACTGACCGTATGGT | CCTGTTCATTCACCC | CTGTTCGTTCACCC | 0,2.7 |
| OMS00030 | T | G | CCTCGTGACTACAGAGCTATACAAC | GATCTGATCGGTCGGGAGAGA | ATGAGGGTCCCTATACAGG | ATGAGGGTCCCTCTACAGG | 0,0 |
| OMS00048 | T | C | GGAAGAGCTGGAGAACAACGT | TGCAGTTGACAGAGGCTTTCTTT | CAGCTAAACTCAGCAAAA | AGCTAAACTCGGCAAAA | 0,0 |
| OMS00052 | T | G | TGCGTTTTTCATCCCAATCATTCAC | GGCATCAGGCTCTTCTTCCT | CTTCCTTTTGAGAATAAT | CCTTTTGCGAATAAT | 0,0 |
| OMS00056 | T | C | TCAGGAAGTAAACTGAAAATTCCAATGTATGA | CCCCAACCATGCTTGTTATTGAAC | TAGCTTGACCAAATAGCA | CTTGACCGAATAGCA | 0,0 |
| OMS00061 | T | C | AAGTGGAGGCTGACCTGTTG | GCTGATGGCACCTGACAGTTAATT | CATTGCCATTTACAGACTT | TGCCATTTGCAGACTT | 0,0 |
| OMS00092 | A | C | TCTCCAGGTGTATCTTGAGAAGGT | AGGGTTCACACAGGGAAGATATCAT | CAGCTGAGAATAGGTTC | AGCTGAGAAGAGGTTC | 0,0 |
| OMS00096 | T | G | CATGAGAATGGATCAGTCTCCACAA | GATGAAATCTGAATGTGTTGACACTACAG | AAAGAGGAAGAGTCTCG | AAAGAGGAAGCGTCTCG | 0,0 |
| OMS00087 | A | G | GCAAATTTCACCCTTAACGTGGTTT | GATTTGATGTGTGTGTATTACCTCCTCTA | GTTA[CA]AACTGACAAAGTGTG | GTTA[CA]AGCTGACAAAGTGT | 0,0 |
| OMS00119 | A | T | AGCGGCAGTTGTGTTAATGAGA | CTTCCTAAAGCCTGACAGTCTGT | CCACACAGCTGCCTGT | CACACAGCAGCCTGT | 0,0 |
| OMS00129 | C | G | GGAGATGATGAAATAAAAATTGAGGAAAAGATGA | TGTCTGGTGAATTATCGCAAATAACCA | TTGAACAACAAGAAAAA | TTGAACAACAACAAAAA | 0,0 |
| OMS00133 | A | G | GACCACTTCACTCATTCCTCCTTTT | TCCGGTTTACACACTTCATGCA | CGCCTCCATCTTTGTGGT | CGCCTCCATCTCTGTGGT | 0,0 |
| OMS00138 | T | G | TCGGACCACATGAGCAGTTC | GTTCAACAGGTGCCCACAC | CTAACAATAACCAAAGACTG | CTAACAATAACCACAGACTG | 0,0 |
| OMS00149 | T | G | GGCATCATTGTTCTTGCTCTGTTTA | CCTGGGAGGGTTTATATCGGAGTAT | GCTAAATGCACAG | GCTAAAGGCACAG | 0,0 |
| OMS00151 | A | G | CTAACGTCTTCCCAATGATATTTCACAAGATA | ACCGTGGAAATACAATTTTTTATGCCAAT | TCATGACCTTGATAATC | ATGACCTCGATAATC | 0,0 |
| OMS00095 | A | T | CTCCAATGGCTGTCAACAATTAAATATAAGAC | GTGTGCTGGTCTCTTCTTTTATTCTCA | AGGCAACTATATATTTTTTT | AGGCAACTATATATATTTTT | 1.5,0 |
| OMS00169 | A | G | AGCACTTGACTCAAACTCACATAAATCA | CTGAGACAGGAAGAACAATGTTAACAAAA | CAAAAAGCATTGATATCAAT | AAAAGCATTGACATCAAT | 0,0 |
| OMS00173 | T | C | TGGAAGTAGCTACTTAACAGGAAATGG | AACACGTGTGCTTGTTTTGTCAA | CATTAGCTTGTGTATGAACT | ATTAGCTTGTGTGTGAACT | 0,0 |
| OMS00176 | T | G | GTTGGAAGTTCCGGTGGTAGAG | CTGGGTCCTGAAGGAGCTT | TTCCAGCACTGCTGTC | CCAGCCCTGCTGTC | 0,0 |
| Omy_impa1-55 | C | T | CGCTGAGAGGATTGTCAA | TTTTCTTTGTTCAGTCTTCTGTCTCTG | CGAGATGATGCGTCTACA | CGAGATGATGCATCTACA | 0,0 |
| Omy_103705-558 | T | C | CTCCAATCGCAAATACCCAGACT | CGCAGGAGACGGATGCC | AGACTTACCCAGAGTGAGAG | ACTTACCCAGGGTGAGAG | 0,0 |
| Omy_105075-162 | T | G | GGAGAAGGACAAGGACATTGGTAAT | AAAGCAGACCACACCATACTTCTC | CTTTCTCTCCTACTTTCC | CTTTCTCTCCTCCTTTCC | 0,0 |
| Omy_107031-704 | C | T | GGCTTTCGGATACTGAGCAACAA | TGAACTCACTGTTGGTATGGACTAGA | TGGACATGATTGCATAGAC | CTGGACATGATTACATAGAC | 0,0 |
| Omy_107285-69 | C | G | GCCCTTGTGACAATGCACTGTTATA | AGGTCTAGACAGTGTGCCATTTG | ATACGTTACTTTTGACCTTGT | ACGTTACTTTTCACCTTGT | 0,0 |
| Omy_110201-359 | T | G | GGTAAGGCCTGTCTGACTATTTTGA | AGAGGTCAATGGATGCCAGTTT | TTTGGCTATTGAAATTATACATT | TTGGCTATTGAAATTCTACATT | 0,0 |
| Omy_CRBF1-1 | C | T | AGTTCCGTACGGTAGCCTATTCTA | CGCCCGGGTGAGAGTAATTG | CAGAGTCGCCAAAAT | CCAGAGTCACCAAAAT | 0,0 |
| OMS00114 | T | G | GGATGATGCTGTGAGTCGAGAAG | ACCTTCGCCACCCATGTTTTATT | AAACGTTTCACATGCACC | AAACGTTTCACCTGCACC | 0,0 |
| OMS00143 | T | C | GGAGGCACGCCCCAAA | TTTGTTAAAATAGAGCCCTTAGTGGGTTT | CCTGATCCAGAATCTAGA | CCTGATCCAGAGTCTAGA | 0,0 |
| OMS00174 | A | C | TGACTAACTATGCAGCCTGAAAGG | GGGATACTCTTGTAATAAACTGTTGGTTAGTA | CAAGAACAGG[AC]TAAATGT | CAAGAACAGG[AC]GAAATGT | 0,0 |
| Omy_97077-73 | T | A | GTGTAAACAAAATGACTCTGGGATTCAG | AGAAGTGGCAATGGTGTGAAGTAT | TGGTGCAATAGAAATA | CATGGTGCAATAGTAATA | 0,0 |
| Omy_97865-196 | A | G | TCCAGACTTCTGGTTTGTTCCATT | CCAGCCCCTATATTCACAATTAAGTGT | ATTAATTAACAAGCTC | ATTAATTGACAAGCT | 0,0 |
| Omy_97954-618 | C | T | GCTCTGCTTCCTCGGCAAATA | CACAATTGGTTTTTGCACAAAAGTAAAGTATT | CAACGCTTACCGGTGTGT | CAACGCTTACCAGTGTGT | 0,0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Omy_128996-481 | T | G | CTCATCCACACTGTACAGTACAAGT | CATGCCTTCGTCTCATCAATAACAC | CAAACCTCAACCAC | CAAACCGCAACCAC | 0,0 |
| Omy_aromat-280 | T | C | CTCCATTGATTCATGCCGAACATT | GGAGAGGTCAAACATAGCCTGGTA | TCTTGCAAACTCC | TCTTGCGAACTCC | 0,0 |
| Omy_aspAT-123 | T | C | GCCCATTTCACTGATGCTGTGA | AGGAGACCACTCCAAAGAGAACT | CCTTCCTAGGCAGTCAG | TTCCTGGGCAGTCAG | 0,0 |
| Omy_b9-164 | T | - | GCACAGAACACAGCCAATATTAACA | GCCTTGACTCTCCCTTCATGAC | CCTACAACTTGATCTAACGTG | CCTACAACTTGATCTACGTG | 0,0 |
| Omy_BAC-F5.284 | C | T | CCTCATTTACTGTAGGACCATGCA | ACAACGCCAACAACTTTCTCTTG | CAGTAGGGCGGCAAG | ACAGTAGGACGGCAAG | 0,0 |
| Omy_BAMBI2.312 | G | T | CGAGCTCATGTCCGAAACTCAT | TTTGACAGCCTCAACTTCTAGGG | CCGAAAGTTCAACTTT | CCGAAAGTTAAACTTT | 1.7,0 |
| Omy_carban1-264 | G | A | GCAAAGCCTCATCTTCAATCATTTGT | GCAAAACACAAGTCAGGAATCACTTA | CATTAATATTGCTAATAACACCAAG | ATTAATATTGCTAATAACACTAAG | 0,0 |
| Omy_cd59b-112 | C | T | TTTGGATAAGATTGTCTTATATGACTAAAATGTCATGT | GCCAACGTCCTAGATATGGTGTAAT | CTAAAAGCCTATAGCAAACT | CTAAAAGCCTATAACAAACT | 0,0 |
| Omy_cin-172 | C | T | CGCATGGGACAGGTGTGT | GAGAAAGCCTGTAGAACCATGTCT | CGCTCACCGTGGTTAC | CGCTCACCATGGTTAC | 0,0 |
| Omy_cox2-335 | T | G | AGCTGGGCTGTATTTGTCAATACTT | CAGCCCGCCACTGTCT | CTTTAAAGACAAAGACTTTAT | TTTAAAGACAAAGCCTTTAT | 0,0 |
| Omy_e1-147 | G | T | GCACTGACTGTTACCAGGAAAGAG | GTACTGCAGTGTTGAGGCTATATCA | CCATCCTGAATCTGATTAA | CCATCCTGAATATGATTAA | 0,0 |
| Omy_g1-103 | T | C | CTCAGCAAAAAAGAAACGTCCCTTT | AGTCGTGACAATGAGAAACAGTGTT | CCTTTTACAATGAAGATC | CTTTTACAGTGAAGATC | 0,0 |
| Omy_G3PD_2-371 | C | A | GCAGGTAAGGTACACCATAGAGACA | CTCCCCCTGCCTTACCAAAC | AGACATGTGGATTGGCA | CAGACATGTGTATTGGCA | 0,0 |
| Omy_gadd45-332 | T | C | AGAGAAGACTCACTGCTGTTTGC | AAATCAGTTCCCACGCTATGCT | TTGCTCCAAAATGG | TTGCTCCGAAATGG | 0,0 |
| Omy_gdh-271 | C | T | AGGTCAGTCTACTTACAGTATAAAGCAGT | GTCATGTCAACAGAGTAACATAATAAATCTGC | TCACCCTGAAGTGTAGAC | TCACCCTGAAATGTAGAC | 0,0 |
| Omy_gh-475 | C | T | AAGTTACCAGAATTTTGCAAACTCAACT | CCATATTTTGAGGTGTAGCTTTACCCT | CTGAAACTCATGGTATACA | CTGAAACTCATGATATACA | 0,0 |
| Omy_GHSR-121 | T | C | CTGTGTATAAGTTTATACAGTCAGCACAGT | TTCAGAGAGAGAAATGGCAGAAAGG | CCTAATAACCATGATAACAGC | AATAACCATGGTAACAGC | 0,0 |
| Omy_hsp47-86 | T | A | CACATTAAGCACTCCCAGGGA | TTGCAAAGGCCAAACAGCATT | CAGGAGTGTAAATGTTT | ACAGGAGTGTATATGTTT | 0,0 |
| Omy_hsp70aPro-329 | A | G | TGCGTATTATTGTTTTTCAAGGACTTTCAAA | TGAATATTTTCAAATACATGCCAATTCTTTCCAA | ACATTCCAATATTCAACTAT | CATTCCAATATCCAACTAT | 0,0 |
| Omy_IL1b-163 | T | G | GGAACAACAGGATTAAGCCTACTCT | CCTAAAGGCCTAGGAAACTAAACTTCA | CTGAGGTCATAAAAATA | CTGAGGTCATACAAATA | 0,0 |
| Omy_inos-97 | C | A | GATGGACAGGGTCCTCTTCAC | CCTGTAGATAAAACATGGTACCAGGTC | CCTTTCTTGATGGTATCC | TCCTTTCTTGATTGTATCC | 0,0 |
| Omy_LDHB-1_i2 | C | T | ACGCACACTTATCCTTGACAATGTT | ACTGTGACAACAAATTCGGTGACA | ATGGGCAGTCATTCA | TGGGCAATCATTCA | 0,0 |
| Omy_LDHB-2_e5 | T | C | TGCTAGGTGAGTCAGAGGTACATATT | GACTGGAAGGCCACCCATAAG | TTTACCTGTCAACCACTTC | CCTGTCGACCACTTC | 0,0 |
| Omy_LDHB-2_i6 | G | T | TCCTCGCCAATACCATACATGTC | AGAGTGAAGCTAACACACACATTTCT | CTGTGTTTTGCTTCCCCA | CTGTGTTTTGATTCCCCA | 0,0 |
| Omy_lpl-220 | C | G | TGACAATCACTGAGCAACTGAACTC | GTCCAGTCTTGCTTCAACTCATTCT | AGTTACTCAGTGACAGTCA | AGTTACTCAGTCACAGTCA | 0,0 |
| Omy_mapK3-103 | A | T | GAAGTCATTACTGGTCAGTGGTCAA | GCACAAAACATGAGGAAAGTTGAGA | AATTATTAAGCCTATTTTTTT | ATTATTAAGCCTAATTTTTT | 0,0 |
| Omy_mcsf-268 | T | C | CCAGCATTCGTTCCCATTTCC | CTTTTAATGTAGATTATATTCTTCTGTAGCCACTATGG | AAATAATAGATAAA[CT]CCT | AAATAACAGATAAA[CT]CCT | 0,0 |
| Omy_metB-138 | T | A | TCTGTCCCTGACGCTATAAAACG | GAAGTATTTCAGCTTAATTTCACTGTTGAGTT | TTCGCCAAAGAGAAAT | TTCGCCAAAGTGAAAT | 0,0 |
| Omy_myoD-178 | A | C | TGGCAAAGCTGTCATTCCTTCTAAT | GGTCAAATATTTCATTTACGATTACACTTAGGC | TTTTATGAGATATAATTTCC | TTTTATGAGATATCATTTCC | 0,0 |
| Omy_nach-200 | A | T | CTCATGAAAAACGGGAGAGCAAAG | CAGCGGCTCTTCAGTAGTCT | AACTGACAGAGTCACAAC | CTGACAGAGACACAAC | 0,0 |
| Omy_nxt2-273 | C | T | CTTTAGAAAAGCCAAGGTATATTTTAACATACTTCT | CTGCTGCCCTCTAATGGTAAGATAG | AAGGCACAGTAAATGT[CT]GAT | AAGGCATAGTAAATGT[CT]GAT | 0,0 |
| Omy_OmyP9-180 | C | G | CTGGATGTGTAGTATCGGTGGAAAA | CACTGGGCACCTCTGATCTC | CTGTAGTAGTCCCCATTGT | CTGTAGTAGTCCGCATTGT | 0,0 |
| Omy_pad-196 | C | T | CAAACAACCACAGTAGTCCTCCAAT | GCTTTTCACCCTTTTGTAAATTAAGCCAAA | AAGACAAAGGTGTAATACC | AAGACAAAGGTATAATACC | 0,0 |
| Omy_ppie-232 | C | T | CTGTTTTAGATTAGAATGTTTTTGGTCAGGT | CTGAACATAGGCTTTCATTTCAGACAT | AAATAGCGGAGAAAAT | AAAATAGCAGAGAAAAT | 0,0 |
| Omy_ca050-64 | T | G | GTCATACAGAACTGTTTTGTTGTGTCAA | ACCTTGAATTGGTTCCTAATGCTATTGT | CAGTTTGAAGAATATACTC | CAGTTTGAAGACTATACTC | 0,0 |
| Omy_sast-264 | G | A | GAAGTAGGGTTTGTTGACCATGTGA | TGGATTCCATTTTAGGCTGTAATACATCTT | CTAGCCAATGCGTCTAA | ATCTAGCCAATGTGTCTAA | 0,0 |
| Omy_SECC22b-88 | T | C | GGATCCCTCCTTTTAACACAAGACT | CTACAGGATGACTACCTAATTGCTAATAAAACA | CTGTCTGTCCATATATC | CTGTCTGTCCGTATATC | 0,0 |
| Omy_sSOD-1 | T | G | GCCGGACCCCACTTCAA | CAGACTAACCGAACAGCATCAGTGG | CCACAACAAGACCC | CCACAACCAGACCC | 0,0 |
| Omy_star-206 | A | G | CGTGTGCCAGCCCTTCT | GACCACTGAGATCATTGCTGTGA | TCTTTGGCACTATATCT | TTTGGCACCATATCT | 0,0 |
| Omy_sys1-188 | C | A | CTTAAATGGTGCTGGTTGCTGTATT | AGTGATATCTTAGTGGGTCGAGGAAA | AAACATGTACGACCTGTC | TGTAAACATGTACTACCTGTC | 0,0 |
| Omy_tlr3-377 | C | T | GTCGCTCCGGGTGCTT | GGCCCAAACACTTCCTTCCT | CGTGATTAGGTTCTTC | CGTGATTAGATTCTTC | 0,0 |
| Omy_tlr5-205 | T | A | GAGCGTATCTGGTATGGTAACAACA | CTCCAGCAGCTTTAGAGAGTTTACA | CAGTAATATTTCAGTGCCCG | CAGTAATATTTCTGTGCCCG | 0,0 |
| Omy_hsf1b-241 | A | - | AGCCCGAACTATCCTAAAGCATTTT | AAATCAATAGCTCAGAGAATAATGAACACCA | CAGTGTTTTGTTTTTTGTCATT | AGTGTTTTGTTTTTGTCATT | 0,0 |
| Omy_u07-79-166 | G | T | CCCGCTATATTATTTGATCACCCTTGA | ATTTAAATCCATTTCTAAAAATAAGCAAACCTAACCA | ACTTGGGAATACCCAGCC | CTTGGGAATAACCCAGCC | 0,0 |
| Omy_u09-52.284 | T | G | TTTGTGTGTATTGTTGTGACTTG | TGATGTTATTGCAGGTCTAGCGAAA | ACTGCATTGTTGTAGCTAG | CTGCATTGTTGTCGCTAG | 0,0 |
| Omy_hus1-52 | G | A | CTTGCCGGAGGGTAGCT | CCACAACTTCTCAAATGAATGGAATGT | CCCATCCCTCCTCCTGG | CCCATCCCTTCTCCTGG | 0,1 |
| Omy_u09-56.119 | T | C | CCAAGGTGGACCCACCAG | GCTGAGTTTATAGGTCAGTCATTATACATATTGA | AGTGAGCTGAAACAGAGCA | TGAGCTGAAGCAGAGCA | 0,0 |
| Omy_nips-299 | T | - | GACAGGATAGGAACGGTTTCT | ATCAGAAGTTTAATTCAATAT | CTGGATTTCACATGTA | CTGGATTTCACGTAAT | 0,0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | CAAT | GTACACGATCCT | ATAC | AC | |
| Omy_UT16_2-173 | C | T | GACTCATTATCACCTTAGTTGTAGCTTCA | AGCTACTTGCTGTATCACATGTTTGT | ACAGTCAACAAGGGACTTAA | ACAGTCAATAAGGGACTTAA | 0,0 |
| Omy_vamp5-303 | A | - | CTGCTTCCCAATTCAGTATCGTCTT | AGGCTGAAGCATTTCTGAGTATGAA | TGGCCGTAGTAGTTGGTCA | TGGCCGTAGTTGGTCA | 0,0 |
| Omy_zg57-91 | C | A | CACTCATACACTCACTCACAAAGGA | AGCAGATAAGCCTTGTGAGTGAATCTT | CACAGACTGCACAGCC | CCACAGACTTCACAGCC | 0,0 |
| Omy_ndk-152 | A | G | AAGAATTGAGGGATAAAAACAAAATAATATATAAACATGA | CAAACCTACATTCATTAAAGTCCAGTTTTGT | CACCCACTTTCAAAAC | ACCCACTCTCAAAAC | 0,0 |
| M09AAD.076 | T | C | ACTGTTACCACTCTCTCATCAACCT | GGGTCCAGGAGGTTTTTAAACAACAT | CACCAACCACTGGTGAA | CCAACCGCTGGTGAA | 0,0 |
| M09AAJ.163 | G | A | TCCCATGGCCCTTACTCTATCAA | TTGAGGTGTATGTTGAAAAGTAAACTT | AACAAAGTGAAAGTGTCCTTA | CAAAGTGAAAGTGTCTTTA | 0,0 |
| M09AAE.082 | T | G | CTATGTGCAGTGCCCTTCTCA | GGCTTACAAGTATGCATGACTAGCT | AGGTTGTTTTACAAATTTAA | AGGTTGTTTTACACATTTAA | 0,0 |
| OMS00002 | A | C | TTTGATTTGATTTGTATCTGCTTCTT | CCAACATGCCTCACACAAAA | TGTTTTGCAGCGCTC | TGTTTGGCAGCGCT | 0,0 |
| OMS00006 | T | C | TCCACGTAGGACATAGTTGAGCTA | TGTGGTGTCATGTTTGCCCTAC | CACTTACAAATACAAAATT | CTTACAAATGCAAAATT | 0,0 |
| OMS00024 | T | G | CACATACAACCATCACCCTTCCTAA | AGCATTGAGCGAAATTACCAAGAGT | AA[AC]CCCAAATTTTAC | AA[CA]CCCAATTTTAC | 0,0 |
| OMS00039 | A | G | GTCAGTACTGTGTGTGTCTGTGT | CCATCTACATTGTCAGCAGTGTGA | GTACGTGTCTCTGACC | GTGCGTGTCTCTGACC | 0,0 |
| OMS00053 | T | C | GGAGCCAGGTCAAGGTGATC | GGATGTCTGGTGTGGCTGTAAA | ATTTATATGTATCAATCA | ATTTATACGTATCAATCA | 0,0 |
| OMS00057 | T | G | GAGAAAGGGAGCATGAGACAGAG | GTTGGGCTCCGGTACGAT | CTCCACAGAACCTTG | CTCCACAGCACCTTG | 0,0 |
| OMS00058 | A | G | GTGACATTTGGAGCCACTGC | GCTAGGAGACAGAGGGTGAAAG | CAACACTTTGTACCCCTC | CACTTTGCACCCCTC | 0,0 |
| OMS00062 | T | C | ACCCTGGGAAGGCTACTGTAC | TGAACAGAGATCTGGAGAGTTGGAT | TTGACCAGCAGATGGTGTA | ACCAGCAGGTGGTGTA | 0,0 |
| OMS00064 | T | G | GTGGATATGTAGTTCGATGGAACAGT | TTTACAACAATCTTCTTTTAATAAAAATATAGCCACTTAT | CAGGCAACATTTTATATAACTA | CAGGCAACATTTTATCTAACTA | 0,0 |
| OMS00068 | A | G | GCACTAACTGGACAACATTTTTAAGAATGA | GGCAGTTGAGCATTTGGGATATT | AATATGCCTCCTTCGTCTC | TATGCCTCCTCCGTCTC | 0,0 |
| OMS00070 | T | C | CGTTCCTGCGGGACAGT | GTTTCTCTCACGTCCACAGATCT | CAAAATACGGAAATGCAG | AAATACGGGAATGCAG | 0,0 |
| OMS00071 | A | G | CCGGAGTGACCTCACATTTGG | GCATCGTACAGTTCACCTACCT | CTTGTTTGAGCTTTTTCT | TTGTTTGAGCCTTTTCT | 0,0 |
| OMS00072 | A | G | GTGGGAGAGCTCGTCTATGG | ACAACAGGTCATTGGATGTGATCAG | TAGAAGGTCCATGTATCTC | AAGGTCCATGCATCTC | 0,0 |
| OMS00074 | T | G | CCTGTTTATTCATCTAAACCAGTTCTTTAAAAT | AACTTAATTTAGCAAACAAATGTCTGAACAGAA | TGAAACAAAACAAATGTTCC | AAACAAAACACATGTTCC | 0,0 |
| OMS00077 | C | G | AATACCATCTTGAGCTCATTAGTAATTATTCAA | CCAGACTTTACACACTCTTGACTGA | TTCCGGTGGTGAAGTT | CCGGTGCTGAAGTT | 0,0 |
| OMS00078 | T | C | GAGGGAAGCAGCCATAAACAGAATA | GTCTCACTATGGTCCATATCTGTGTAGA | TTCACATGCATAAGAGTG | TCACATGCATGAGAGTG | 0,0 |
| OMS00079 | T | C | GTAACATTATGAATCTATCAGTTTCCCTAGCT | ACCTGCAACGTTAGAGCTGTTTATT | CTACTTTTCACAGTAACACAG | CTACTTTTCACAGTGACACAG | 0,0 |
| OMS00111 | T | C | CATGCGGACCTGCATAGCT | GCTTAGCCATTGACAGAGCATATCA | CAACCAGACTACCATTC | AACCAGACTGCCATTC | 0,0 |
| OMS00089 | A | G | GCACCATTTGAATAAAAAATCTGCTTTGT | GCAACCCAATTCAATATTAAGCACATGAT | ATGAATCCCAAATAAGAAC | AATCCCAAACAAGAAC | 0,0 |
| OMS00090 | T | C | AGGGCACAACACCACTCTAAATT | TCGAAAAGCAACATCTGTCTCAGT | ACAACCACACAAGATT | AACCACGCAAGATT | 0,0 |
| OMS00101 | A | G | GCGTGTCGTGGGTCAGTTAAATA | GTGCAATCCAACCTATTAGTAGATATGCT | CTCTAGTAGCCTTATAGAAAG | CTAGTAGCCTTACAGAAAG | 0,0 |
| OMS00105 | T | G | ACATTTGAAGTCAGTATGGGTGTTGAG | GAACCTCACCACAGTACTAAATGCA | CTGCTATTCAAATTGCT | CTGCTATTCACATTGCT | 0,0 |
| OMS00106 | T | G | CGTGTAGCATTCTTGAGGAAGCTT | TTTCCAACAGATGCCAGAATCCT | TCTGATGGAAACTTTC | TGATGGCAACTTTC | 0,0 |
| OMS00154 | A | T | GATGTTGGCTGGAGGTGTAGT | TGGGAACACTTTGCCTACCC | ACAGGGCTTCTGATTGA | AGGGCTTCAGATTGA | 0,0 |
| OMS00112 | A | T | TGGCAGCAAAAGGGATGCA | TCCTGAGCAACCAGTCAACATT | CCGGTTTCAAGTTTACTTGT | CGGTTTCAAGTATACTTGT | 0,0 |
| OMS00118 | T | G | GCTTATTTAGAGTGCATGCCAGATG | TGGAACCAATGGGACAGTCCTA | GCGGGGTGTGC[AG]CATT | GCGGGGGGTGC[AG]CATT | 0,0 |
| OMS00120 | A | G | GGCAGAAGAGGAGAGAGATATGATTG | CCTCAAATACCTCTGACATTGAAGGTT | C[GA]CCCACTAAAAC | C[GA]CCCACCAAAAC | 0,0 |
| OMS00121 | T | C | GGAAGGAGGTCCAGTGTGAGT | AAAATATGCAACACCACTAAAACTGGAAAA | ACAGCGTGATAAATT | CAGCGTGGTAAATT | 0,0 |
| OMS00132 | A | T | GTTTATGACTCCATTGCCGAAATGATT | ACGCGACCTGCAATTCATCAATA | CAGCAGTCCTCTGTGTGG | AGCAGTCCTCAGTGTGG | 0,0 |
| OMS00175 | T | C | TTGCGATATGGGACTGTATACATTTATTCC | ACTACCTCCAGTTAAAATAGTGTGGGAAA | ATCACTAGTTCAAATACAA | ATCACTAGTTCAGATACAA | 0,0 |
| OMS00179 | A | C | GTCATAACAAAATCAGGGCTTTCCAA | TGGGAGATTTGGGCTGCTTTAAA | TGCCTCTTCTCTTTTCTCAT | CCTCTTCTCTTGTCTCAT | 0,0 |
| OMS00180 | T | G | GCGCCGAATGGCATTAGG | CACATTGCTGTCGTTTAGTTTGACT | CTAAAAGTGCATTAAGCC | CTAAAAGTGCCTTAAGCC | 0,0 |
| Omy_101832-195 | A | C | TGGCTCTGGACCTGTTGAGA | CGTCACAGCTATTTTAGGCGTAGT | TGTAGTCTTTCAGAGTAGTATG | TAGTCTTTCAGAGGAGTATG | 0,0 |
| Omy_101993-189 | A | T | ACAAAACACAGTGGAATTACAATTAACGTT | GGAAGTTAAATTTCGCTTCGTCAGAA | CTTGATTTGCAGCTTGTCAA | TGATTTGCAGCATGTCAA | 0,0 |
| Omy_102505-102 | A | G | CTGCAAACTGACATGGTAGCAAAA | TGCTTGCTTTTTAAAAACAATCTCCCA | AACAGGATGTTTTTGC | CAGGATGCTTTTGC | 0,0 |
| Omy_104519-624 | T | C | CGTGTGAGTTTGCGGTAAAGAC | TGACGAGTCCGTCTTATCATCCT | CAGCAGGATACATCCGACT | AGCAGGATACGTCCGACT | 0,0 |
| Omy_105105-448 | C | T | CAATTTGCAAGCAGGGAAAGGTTAT | GTGATGGGCTGCAATTGCTT | AAGGAGAATGCATAATC | TGAAAGGAGAATACATAATC | 0,0 |
| Omy_105385-406 | T | C | ACCTACCCTCACCTGAACTTCA | CGCTCTTCTGGGCGTATCG | CTTGGAACCATTGCTAC | TTGGAACCGTTGCTAC | 0,0 |
| Omy_105714-265 | C | T | CCACTCAGTGCAAGCATGGA | GCTTTCAATCCTTGGCTCCAATATC | CTGTTGTTTGAGGTTCAG | TGTTGTTTGAGATTCAG | 0,0 |
| Omy_107806-34 | C | T | TCTTTGTCCATGCACATTGAT | AGCACATTTAGTTAGCAGTGA | ATTGGATGTCAGTGTC | ATTGGATGTCAATGTC | 0,0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | ATT | TGGA | ATT | ATT | |
| Omy_108007-193 | A | G | GTGAATACCACCCAGGCTTGT | GTCCCTTCCCCAGTTTCACTTAATT | ATGTTTTCTCCCTACTTAAC | TTTTCTCCCCACTTAAC | 0,0 |
| Omy_109243-222 | A | C | ATGTGCACCTCTTAAATTGTAAGTAAAATGT | ACCCTATATTCAGTGGCAAGATTGC | TGTTCATTAAATTGACTTTTT | TTCATTAAATGGACTTTTT | 0,0 |
| Omy_109894-185 | T | C | GGGAGGAATTGGAATGACAGATTAAC | CGGTGTCATTATGGTTGTCATTGTG | CTCCCTGATCCCCC | CTCCCTGGTCCCCC | 0,0 |
| Omy_110064-419 | T | G | GTGCAAGGGACCTAGCTAATCC | TCTGAACTGACACTGAAGAACAAAGAA | ACGTTAGCTTTTAATTTC | AACGTTAGCTTTTCATTTC | 0,0 |
| Omy_111383-51 | C | T | CACGCGCAATCTCTCGTTTTAC | TCTTTAGGCAACAAGCGTGTCA | AGCAAGCGCACT[AG]GGT | AGCAAGTGCACT[AG]GGT | 0,0 |
| Omy_113490-159 | C | T | CATAGTACATTTACAGATAATGTTTTAAAGTGCATGT | CGAGATACCAAAATGCCACAGTTACAT | CATCTGTTTTGGTTTAGC | CATCTGTTTTAGTTTAGC | 0,0 |
| Omy_114315-438 | T | G | CCTCACCGATCTAGTCAACTTCATC | AGGAGGCTGAGGGAGATTCTAG | TTATGGGCTTAAGGGTC | TTATGGGCTTACGGGTC | 0,0 |
| Omy_114587-480 | T | G | CAGATTACGTTATTACGTTTGGGAAATTTTTAAGT | GTGAAAGAGTGGGAAATATAATTATAAGGTCAGA | CCTGTCCAAAATTGT | CCTGTCCACAATTGT | 0,0 |
| Omy_129870-756 | C | T | TCGTTATTTTGCCTCGCGGTA | TCCCATGAAGATGTATACATGTTTTGTGA | ACAGGTATTTCGTGAAATG | CAGGTATTTCATGAAATG | 0,0 |
| Omy_116733-349 | C | T | GAAATGGACATGCCTACAAATTGCT | GATGTGATCAGTTTAGGCAAGGC | AGAGAATCTGATAGTATTTC | AGAGAATCTGATAATATTTC | 0,0 |
| Omy_128923-433 | T | C | ACGTTTCTTTGGGCTGAGACTTATT | CTATGTCCTTGGCAGAAGTCTACA | CTTCATTTTCATTCACTGTTTT | CATTTTCATTCGCTGTTTT | 0,0 |
| Omy_130524-160 | C | G | CGAAGGTAGCGATTGGTCGTT | TGTCTGTTCTGCTGTGTGCTT | ATGGCTTGATCCTCA | ATGGCTTCATCCTCA | 0,0 |
| Omy_97660-230 | C | G | TCAGTTATGTGTAATCTCATTACCTCTCCAA | AACAGAAAAGGTCTCAATGTATTTTTTGCA | ACGTAACTTGTAGCGTTTT | ACGTAACTTGTACCGTTTT | 0,0 |
| Omy_99300-202 | T | A | CAGTTTGACCCGATGGTGTGA | GATTATGGCGTGGCCTTTTGG | TCAGGCATGAGAGAAA | ATCAGGCATGTGAGAAA | 0,0 |
| Omy_aldB-165 | C | G | GGGTTAGGTGGATTTGAAGGAGTAA | AGGAAGGTGATGCCTGAGAGA | CTAAAATGAACTC[CT]CCACCA | CTAAAATGAACTCGCCACCA | 0,0 |
| Omy_anp-17 | C | A | GGTAATGCCACATGCGGTAAATT | GGCGAAATCTGAAAATGTGCTGTTA | CTCTCATTGGTATAGTAACC | CTCATTGGTATATTAACC | 0,0 |
| Omy_arp-630 | G | A | CTGCACAACTTGTTTCCTGCTATT | ACCAAGTGTCCCTGTAAGCC | CCGCTCCGTCTGCT | CCGCTCTGTCTGCT | 0,0 |
| Omy_b1-266 | G | T | TCATGTGAACTTTAATTGACTAGGAAGTCG | GATATGAAAATATCTGAAGAGTTATATTTGGGAAATTGAC | TCTATAAACAACATTTTTC | TCTATAAACAAAATTTTTC | 0,0 |
| Omy_BAC-B4-324 | G | T | CGTACTTTTCTTTTACAAAATTAAGTGGAGGAT | GCCTAATATTGGCCTAATGTCCTTCA | CATTGCCAAATACG | TACATTGACAAATACG | 0,0 |
| Omy_ada10-71 | C | T | TCTTTGAGCGACAAAGTCCTTGT | ACCCACACATGAACGCAAAAG | CTTCCTGCGTCCAA | CTTCCTGCATCCAA | 0,0 |
| Omy_redd1-410 | C | T | GTACTCCCACTAACATACAGTAGACTCA | GGCACCATTGTGTTTTAGGATGTAG | AAAATATCCTGCAAGGAAT | AATATCCTGCAAGAAAT | 0,0 |
| Omy_cd59-206 | C | T | CGATTGGCCCAGATGTTTCCAT | GCTCCGTTGCATAGGTGACT | CAACAATCGAAGGTAAAT | CAACAATCAAAGGTAAAT | 0,0 |
| Omy_colla1-525 | C | T | CCTCGGCGTGACAACCT | CCCAGAGAATGGTGCGATTAGG | CTGTTGGGAGAAGAG | TGTTGGGAAAAGAG | 0,0 |
| Omy_cox1-221 | T | A | CACTGAACTGTAAGCCATTGTGATT | GCAACATGGGAATGATTCATAAATGCA | CGGTAAGACCATTAAAA | CGGTAAGACCATTTAAA | 0,0 |
| Omy_crb-106 | G | T | GCTCAAAAAGATTCTGCCAAATTCACA | ATTACAATGAAAGTACTTGAGTGTTTATGCAAA | TTGCAATGCGTCTTT | TTGCAATGAGTCTTT | 0,0 |
| Omy_g12-82 | T | C | GATCAATTCGATCGCTCATGAAACTT | CTTCTCTCGTTCTCATTGTGTCTCA | CAAACTCTCAGGATTAG | AAACTCTCGGGATTAG | 0,0 |
| Omy_gluR-79 | C | T | GACTGTCTATAGCTATTCTTCTCAAACTGT | AGAAACTACCATTGTGATTAACAGATAGAAAATACAT | CAAGTATTTTGCGTAGGAAT | CAAGTATTTTGCATAGGAAT | 0,0 |
| Omy_hsc715-80 | C | A | CCGGTCTACCCTATAGCTGTTG | AGTCAGTCAATTAGTGGTTTGAAATACTATCA | AACTGTATTTGGGAAAAT | ATAAACTGTATTTGTGAAAAT | 0,0 |
| Omy_hsf2-146 | A | - | GGAGCAGAAAAAGGATTGGACCTT | CCAACAATTGCAGCCTCATCTTAAT | ATAATCTACTA | ATAATCTAACA | 0,0 |
| Omy_IL17-185 | G | A | CCACCACACTCTGCAGCTT | TTGACGGGAATCCGAGACTTC | AAGAATCTCACCTGCCCAT | AAGAATCTCACTTGCCCAT | 0,0 |
| Omy_Il-1b_.028 | T | C | ACTGTCTGGCTAGAGCACATTG | ATCTTCTACCACCGCACTGTTTTAA | CTGAGGCAACTTTTGT | TGAGGCAGCTTTTGT | 0,0 |
| Omy_Il1b-198 | A | T | TTTAATCTCGGTGCTGAGCTAGTG | CAAGCAAAATTGACTCCAGCCATTA | GGGAATGAAGCAACAACTA | GGGAATGAAGCTACAACTA | 0,0 |
| Omy_IL6-320 | C | T | CTTGTTCCTCGTTGTCTTCCTTCTA | CGACTGATCTCCTGCAGACATG | CTATAGGAGAGAGGACAACA | ATAGGAGAGAAGACAACA | 0,0 |
| Omy_metA-161 | T | G | CGCATGCACCAGTTGTAAGAAAG | AGTGCCACCAGCGATAAGAAAA | CAAGTAAGTGGTTATATTCT | CAAGTAAGTGGTTCTATTCT | 0,0 |
| Omy_NaKATPa3-50 | A | C | GTTGAGCGTGTTATGGGAAAAGAG | TTGCATCGGCTTTCTGAAAACC | CACTCTGTTTCCTTTCTTT | TCTGTTTCCGTTCTTT | 0,0 |
| Omy_txnip-343 | T | C | CCTTCAAACTAACGCATCATAGACATG | GGTCACTTGGCTAATCCCCTTAT | CCAACTGAAGAGATCTG | CAACTGAAGGGATCTG | 0,0 |
| Omy_nkef-241 | C | A | AGTGTCATTGATGTCGGCCTATTTT | AAACGAATGTCCACCTCAGATGTT | CTTCTGTATCATTTTTG | TCTTCTGTATAATTTTTG | 0,0 |
| Omy_ntl-27 | G | A | GGTGTGTTACTGTAGTTGTGTCCTT | TGTGTAGCTAGTGATCCTGATTGTCT | CAGACAAGAGTACCCCAAGAC | CAGACAAGAGTACTCCAAGAC | 0,0 |
| Omy_Ogo4-212 | T | C | TCCTCTCTCCCATTCAATCACTAATGA | AGACAGTAACAAAGCCTCAAACTTGA | CATTTGATGAGACATCTT | ATTTGATGAGGCATCTT | 0,0 |
| Omy_bcAKala-380rd | G | A | TTGCTCTCTTCTGGTTGCCTTA | CTTCAGGAGAAAGCGCTACTGT | CATACCCATCCTATGTCAG | CATACTCATCCTATGTCAG | 0,0 |
| Omy_Ots249-227 | C | T | CCCCTAGATTAAACCTGTCCAGTCT | CTATCTATCTATCTATCTATCTATCTATCTATCTATCTACTTACTGAGA | CCCTCTGAGAACTAC | CCTCTGAAAACTAC | 0,0 |
| Omy_oxct-85 | A | T | CGTCACTGAAACATTACTGTAACATCCA | CATCATCACGCTGTTGGTTTCTTAA | CATCGCTTATTTATGC | CATCGCTAATTTATGC | 0,0 |
| Omy_p53-262 | T | A | CCCCAACATCCAGTATACAGTTTCA | CCCAAATTGGCAATTTTAATAGGATTCAGA | CAAGTAGTATGGAGCTCTAT | AAGTAGTATGGTGCTCTAT | 0,0 |
| Omy_rapd-167 | G | T | CCCAACATGCTCTATTGCAGCTA | AGTTGCATAAGATGAATCAATAAATTAAAAACACAGAT | AAACAATCCCCCCCAAA | AAACAATCCCACCCAAA | 0,0 |
| Omy_rbm4b-203 | - | T | CTGAAATTTGATGAATGGAAGCTGCA | CGTATTCAAGTCGATATACAGTCACGAT | CACGTTATTATGAAAAGGATGT | ACGTTATTATGAAAAAGGATGT | 0,0 |
| Omy_srp09-37 | C | T | TAGTTGTATTAACTCTTCTTTGAGTCTAGA | TCATTCCAGCTCCGTTCTCTTC | TTGTGCTATTGACGCCACAG | TTGTGCTATTGACACCACAG | 0,0 |

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|---|---|---|---|---|---|---|---|
| Omy_stat3-273 | G | - | CAGACCTCCTCTATCTCCCTATGAG | ACCTCCTTTAAATTGTGCCCAAGAA | TTTTCCAGACTCCAGTTTG | TTTTCCAGACTCAGTTTG | 0,0 |
| Omy_u09-53.469 | T | C | ACAGCCTGAGCGTTTGCA | GGAAACTGGGAGAGATCAAAGGA | TTGCAGCCCTTATTGTG | TTGCAGCCCTTGTTGTG | 0,0 |
| Omy_u09-54-311 | C | T | GTGGCTCCCCAGGAACAAG | AAGTTTCATGTCACATTCCAGTTACCT | TGGTAATTATTCAACAGATCAGT | TGGTAATTATTCAACAAATCAGT | 0,0 |
| Omy_U11_2b-154 | T | C | GGGAAGCAGAAAAACTGGAAGTT | CCCTCTGTGGGCTTGATATTCA | AATGATACTTTTCAGATTGTAAC | TGATACTTTTCAGGTTGTAAC | 0,0 |
| Omy_vatf-406 | T | C | TTGCTTCATTTTGTCATAACCTTGGG | TGCATGCTCTGACAAATGTTACACT | TTGCAGATGACTATCCACA | TGCAGATGACTGTCCACA | 0,0 |
| OMY1011SNP | C | A | AGGCTGGTTTGGGATTCACTG | CGCCAAACACTAACTCTCTGTCT | CTTTACCTCGAAGACAAT | ACTTTACCTCTAAGACAAT | 0,0 |
| OmyY1_2SEXY | X | Y | GCGCATTTGTATGGTGAAAA | GCCTGGCATATGAGTGTTGA | | ATGTGTTCATATGCCAG | NA |
| OMS00041 | G | C | GATTCTGTTCCATCCTCTTTCTGTCA | AAACATAAAAAAGGGCATGAAGGTGTC | CCACTCTATGCCTGCCCT | CACTCTATGCGTGCCCT | 0,0 |
| OMS00103 | A | T | GAGATCACTGTAGGATTGGCTGTTT | CCTCAGAGCAGCTCACAATGGCATC | CTCCACAGTAATTTTTTTTT | CCACAGTAATTATTTTTT | 0,0 |
| OMS00116 | T | A | GCCTTTCTCCCATATCACATTCGA | AAACGCATCTTACACTGTGTTGTG | CTTTTACATTTTCAATATTCTG | TTTACATTTTCAATTTTCTG | 0,0 |
| OMS00127 | T | G | CACCTTTCTCTCTCTCTCCATCTCA | AGTGTGCTACACAACCTTAAAAAATATATATCTATT | CACACACCCAAATGTA | ACACACCCCAATGTA | 0,0 |
| OMS00128 | T | G | ATGAAAGAACTCCCAGACACGTATTTT | ACATTTTAACACAGTAACACTAATACACACCA | ACTCTCAGAATTAATTATG | CACTCTCAGAATTCATTATG | 0,0 |
| OMS00134 | A | G | GAAACTGAAATGATCCCATCGTGTT | GCTAGCATAACAGCATTGCCATAT | TCTATAGCTGCAGTATATTA | TAGCTGCAGCATATTA | 0,0 |
| OMS00153 | T | G | ACTTTGCACCATAGGCTTGACAT | TGATAAGGATGATCAAAAAGCTGAAGTATGTA | ACAAAATGTAATTTTCC | CAAAATGTCATTTTCC | 0,0 |
| OMS00156 | A | T | GAGCAGAACACATAGAGGAAAGACT | GTAATCACCCTCTTAGCCTGTATGG | TGTGTGTCCTGCTGTAACA | TGTGTCCTGCAGTAACA | 0,0 |
| OMS00164 | T | G | CAGAGGAGAGGAGAGCAAAATACTT | ACAACCTACTCATTGAAACTCATTGGA | CCAGATTCAATTAAATTTA | CAGATTCAATTCAATTTA | 0,0 |
| Omy_1004 | A | T | GAGAATCGGAGCTAATCTTAGTTATTGTGA | CACTTTATTGAGCTACATGGCAAATCTG | CATGTGATGTTTTTTTGC | ATGTGATGATTTTTGC | 0,0 |
| Omy_101554-306 | T | C | GCCTGTATTTCTCCTGTATGTGCAT | TCAACTTTTGCAAACTTTTTTATTCTTTGTCATTT | TGCTTCTCACATTTTTA | TGCTTCTCACGTTTTTA | 0,0 |
| Omy_102867-443 | T | G | CATTTGTTTAATTTGATTTGGCACAACTTCA | CCCTAGTTCTGTAACACAAGACGTAA | TTTGGGTACATAATTTTT | TGGGTACATCATTTTT | 0,0 |
| Omy_104569-114 | A | C | CCGAGGCCGACGTGATC | GCGCCTCGCTCATCATCA | CGCCACTCCGACGCC | CCACGCCGACGCC | 0,0 |
| Omy_107336-170 | C | G | GCCCTCTCACTCATGACATCAAC | GCTCCAGCCACTCGCA | CACTCCTGGGTGCAGAA | ACTCCTGCGTGCAGAA | 0,0 |
| Omy_109525-403 | A | G | CCTCATTCTCATTGGTGAGTTGTCT | TGTAAGATCTGACCACATGAGTATAACCA | CCTACACCTCTTTTTTCCACA | CCTACACCTCTTTTCTCCACA | 0,0 |
| Omy_110362-585 | G | A | GCAGCCAAGATGAACGAAAACTTC | CCGGCCTGGGTCTCAATG | CACCGCCCTGCCCGT | CACCGCCTTGCCCGT | 0,0 |
| Omy_110689-148 | A | C | GTGTGTGGCAGAGAACTAACTGAT | GGTTAAGACATTAACATAACACTGGACTCT | CAAATGAACACATTATTTATC | ATGAACACATGATTTATC | 0,0 |
| Omy_111084-526 | A | C | CACCACACCAAGCAACTATTTCATT | ACCCAACTACTGTCCCATTTTTCAT | CCAGTGAAATTTATTTTT | CAGTGAAATGTATTTTT | 0,0 |
| Omy_111666-301 | T | A | GGGTGAAAAGAGTGGGACATTTACA | GTCAATTTCAAGGCACCAGACAAT | AGTATAACACAGTAAGACAAT | AGTATAACACAGTTAGACAAT | 0,0 |
| Omy_112301-202 | T | G | GTAAACCCTGCCCACATAATTAGGT | CTGAGACACTGCTCCAAGGT | AATGCGAAGACAAACT | AATGCGAAGCCAAACT | 0,0 |
| Omy_112820-82 | G | A | CCTTTCCTTTTGCATTTCCTCTACTTATTTATTT | AAATGAACTCACGTTGACCTCTGA | CGCCGCCAAGTTA | CGCCGCTAAGTTA | 0,0 |
| Omy_114976-223 | T | G | GACAAACAGCACTTCATTGCAGTAA | GTTGCTCCAGCACCAGGT | ACCGATGGAACAATC | CCGATGGCACAATC | 0,0 |
| Omy_116938-264 | A | G | GTTCATTCATGTTGAAGTGCGACAT | CTCTGCATGCTCCCATCCT | CCTTGTCTCAATTTTTCCTCT | CTTGTCTCAATTTCTCCTCT | 0,0 |
| Omy_117286-374 | A | T | TGATGTGTTGTTCCTCATGGCTTA | CTGTGCATTTATTCTTGTGATGCTAGG | CTTTCCTCATCATACTCTATGG | TCCTCATCATACACTATGG | 0,0 |
| Omy_117370-400 | A | G | TGCAAACACAGAGGAAAGGGATTT | GGCTTATTTGTTCCGTACTTGCATT | CAACTCCAATGAATTAA | AACTCCAACGAATTAA | 0,0 |
| Omy_117540-259 | T | G | GGCAGGTTAACACAGTCATCTACTATAAA | CAGCATGTTGCTTTAATCCTTCACA | TGTCACTTCAAAGTTTG | TGTCACTTCAACGTTTG | 0,0 |
| Omy_117815-81 | C | T | CTGCTTTATGCACACCACATTGT | GCTCTTTCTGGAGAACAAGGTACTG | CTATACGGAGACCAGC | CTATACGGAAACCAGC | 0,0 |
| Omy_118175-396 | T | A | AGGCTTCACACACACATGCA | GACGCGCAACCTCTAGATTATACTT | CTCTTGCAGACATACCCGTA | CTCTTGCAGACATTCCCGTA | 0,0 |
| Omy_118205-116 | A | G | CTGCGGTGGGCTACACA | CGCAGCTGCGGATGAG | CTACTGAGGCTGAGTGCT | TACTGAGGCCGAGTGCT | 0,0 |
| Omy_118654-91 | A | G | CAGCGTAGACCGTTTCCTCATTAT | GCGCCGATGAGCAGCTT | TCAGCTTGTCTTGCCGC | CAGCTTGTCCTGCCGC | 0,0 |
| Omy_120255-332 | A | T | GGCTACAGGGACTTTACAATGGG | GCTAGCTAACATTGAAGGGTGGAAT | ACTATGCCATGAAGTTA | ACTATGCCAAGAAGTTA | 0,0 |
| Omy_121713-115 | T | A | TGTGACAGAGCCAAGGAAAACC | TGGGCTAGTGAGGGAGTGA | TCAGGTTGAGTATTGC | TCAGGTTGTGTATTGC | 0,0 |
| Omy_128693-455 | T | C | GCCTGCAGGAGAAGGTAGAGTTA | GAAATGGAATGGACCCCAATCCT | CACTCAACTGATACCC | CTCAGCTGATACCC | 0,1.8 |
| Omy_131460-646 | C | T | GTGAAAAGGAATGGAGGAGTACAGT | TGCTAGGACAGGAAGATCATTTGTG | AATAAAGCAGAATTTGTTACTG | AAAGCAGAATTTATTACTG | 0,0 |
| Omy_187760-385 | A | T | CGGCTATTCTCGCGTAAAAGCT | AAATGCAACCAGAAACGGAATGTC | TCCTTATCCAAAATTATTGTGC | CTTATCCAAAATAATTGTGC | 0,0 |
| Omy_96222-125 | T | C | GTAAGGAACTAATTGGCGCAACATT | CAGTTTGTCTAACACCCAGGCATAT | AACTACAACTGTAGCTAATT | CAACTGTGGCTAATT | 0,0 |
| Omy_98683-165 | A | C | GCCATTGCCAGAGAATTTGGTTAA | AACACACGCACCATCTTAAAGC | AGCCAGATACATATTTGT | CCAGATACAGATTTGT | 0,0 |
| Omy_BAMBI4.238 | T | C | CATGATGAGGAGGACCAAGATGAG | AGGTGTGGTTCAGGGCAG | CACCGCAATCACCG | ACCGCGATCACCG | 0,0 |
| Omy_cyp17-153 | C | T | GCCCTCCAAGTTCCAAGTGAAAA | CAGGTCATTGATGAAACGTCAGAAC | ATACCTGAGTGTCATCG | ATACCTGAGTATCATCG | 0,0 |
| Omy_ftzf1-217 | A | T | ACAGGGATGGGCAACTTTGTT | GGATGACCCACGTGACACT | TCATGACGAGTTCTGATTT | TGACGAGTTCAGATTT | 0,0 |
| Omy_G3PD_2.246 | C | T | TCATGTATCAATTAAGGCATT | GTTAGACACAGTGACCACCTC | AGTAAAGCCCATTGTT | AGTAAAGCCCATTATT | 0,0 |

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|---|---|---|---|---|---|---|---|
| | | | GTCTTGTCT | TTT | GAGT | GAGT | |
| Omy_GH1P1_2 | C | T | TGCATTTGATGGAAACAAACATATTTATAATGTGT | CAAAAACAAGGACAATTCTAAGTGACCTC | AAACTGTTGAACGGTAGTG | AAACTGTTGAACAGTAGTG | 0,0 |
| Omy_gsdf-291 | T | C | GCATGGAACCAGTTCTCTACAAAAG | ATGGAGTGGAAAATCACAGCACATAT | CATAACCCAGAATTATTA | CATAACCCAGGTTTATTA | 0,0 |
| Omy_hsp90BA-193 | C | T | GGAATCGATGACGACGAAGTGATC | TTCCTCCATGCGTGATGCA | CCTCCGCGCCTGC | CCTCCGCACCTGC | 0,0 |
| Omy_MYC_2 | T | C | CGGTTGCAGAACTCTCATGTTTG | CACGCCATGTCTTAACTTGCATTA | CATAGACTTTTTGACCTTAT | CATAGACTTTTTGGCCTTAT | 0,0 |
| Omy_u09-61.043 | A | T | TAGTCACATCCATAGTAATACTTCC | TGTTCAGAAGCAGAAAACCAATCTCT | CACTTGGTCCTTTTTCA | CTTGGTCCATTTTCA | 0,0 |
| Omy_UBA3b | A | T | GCCACTCAATGCATGTGTTTTCTAG | CAGCTAGCTTAAGTGGGATGCAA | TGGAGATAACGCTAACTATT | AGATAACGCAAACTATT | 0,0 |
| Omy_RAD17632-23 | C | T | AAGCTCCTGCAGGTCATCTC | TCTGTGAACTGTCTTCTGCAAGT | CATGTGAGACCTTTGCA | CATGTGAGATCTTTGCA | 0,0 |
| Omy_RAD23577-43 | T | C | AATAGGAACCAAGCCCCAGC | CAGAGCCTGAACCCATGGAG | TCTGGCTCTGTCGGTCT | TCTGGCTCCGTCGGTCT | 0,0 |
| Omy_RAD26080-69 | G | A | TGTGGGACAGCACATACTCC | CCAGGACACCAGTGGAGAAG | ATTAGTAGCATCATCGAG | ATTAGTAACATCATCGAG | 0,0 |
| Omy_RAD29700-18 | C | A | AATGGAATTGGCCCCAACCC | TCTCCATTGTGTGTAATCATGGT | ACAATTCAAATGATTTA | ACAATTAAAATGATTTA | 0,0 |
| Omy_RAD36848-7 | G | A | CGAGGACGTTCATAGGGAGC | TCGATAAGTCCACCAGCTGG | TGCAGGGACACCACCCT | TGCAGGAACACCACCCT | 0,0 |
| Omy_RAD38269-10 | C | A | AAGCCACACCGTTCAACTGA | TGGCTTATCGCGCTCTAGTG | TGCAGGCGCCCGGCCCGC | TGCAGGCGCACGGCCCGC | 0.5,0 |
| Omy_RAD43612-42 | T | C | GTGGAGAGGGATTTTGGGGG | TGACAGGACAAACACAAGCCA | AAATGTGTATTTGTGTA | AAATGTGCATTTGTGTA | 0,0 |
| Omy_RAD45104-18 | A | G | TGGTGCTTCAGTGCTGTCAA | AGAGTGAAAACTGTGTGCGG | CAAGACACCGCACACAG | CAAGACGCCGCACACAG | 0,0 |
| Omy_RAD47080-54 | A | G | TCAAAACCTGCAGGACTTGGA | TGGTTATATCTACAGTACAGTTCGT | TGCAAGACTTAAAACGA | TGCAAGGCTTAAAACGA | 0,0 |
| Omy_RAD47444-53 | C | T | GTCGTCTGGAGGAGCTGAAG | GGGTGACGTTTTCCTTCAGC | GGCGAGCTTGGCCCAAA | GGCGAGTTTGGCCCAAA | 0,0 |
| Omy_RAD48799-69 | A | G | GCTGAGCCACCTACACACAG | GTCTAACACTCGCAGCAGGT | CATCCTAGAATAGAAGT | CATCCTGGAATAGAAGT | 0,0 |
| Omy_RAD5026-64 | G | A | TCAGCGTTATACCTGCAGGA | CCCTCCTAACCTGTGGTGTT | TGTAACGCAACACCACA | TGTAACACAACACCACA | 0,0 |
| Omy_RAD52458-17 | C | A | ACGTGTCCCTGAGGATGGTA | AGCTCTAGGTCTGGGTCCTG | ATGGCCCC[CT]AAGAACCC | ATGGCCCA[CT]AAGAACCC | 0,0 |
| Omy_RAD52812-28 | C | G | AGGAGTCCTGTCCCATGTCA | GCTTAAGGCTGTGGTATGTGG | CAACCTC[TC]ATTCCACAT | CAACCTG[TC]ATTCCACAT | 0,0 |
| Omy_RAD58213-70 | A | T | CCTGATGGGTGCTCTTCTCTC | AAACAGCATCATTATCCATAGTGTT | TTTTTT[TA]AAAATATACT | TTTTTT[AT]TAAATATACT | 0,0 |
| Omy_RAD58835-15 | G | T | GTCTGCTAAGGTCCTGCAGG | GCCGACCATGAGAGACCTG | ATAGCTGCTGGGACCCA | ATAGCTTCTGGGACCCA | 0,0 |
| Omy_RAD62596-38 | A | T | GCAGGACACTGGTTCCCAAA | CCTGAGATTTGAGATCACTGGCT | TTAAAAAATATATATTA | TTAAAATATATATATTA | 0.5,0 |
| Omy_RAD66834-17 | C | T | CTCCTGCAGGTCATCTCTGG | CTGTCTTGTGCTCAATGCCTG | TCTGGCTGACACCTTTA | TCTGGTTGACACCTTTA | 0,0 |
| Omy_RAD69583-33 | C | T | GACTCTAGACTGCTCCCTGC | GGCCTCAGTCTCCTTCCAGA | CCGGAGACATT[CT]CGCGT | CCGGAGATATT[CT]CGCGT | 0,1 |
| Omy_RAD7210-8 | C | A | GCGCCTTGGTCTCCTTCATA | ACACCACACTCCACAAAGCA | TGCAGGACTTGCTTTGT | TGCAGGAATTGCTTTGT | 0,0 |
| Omy_RAD74691-49 | A | G | CATCTCAGATCAGCCACCCG | AGCACAAATTCTTCTGTTGTGCA | ACTGTGGATTTGCACAA | ACTGTGGGTTTGCACAA | 0,0 |
| Omy_RAD77789-54 | T | C | AGACAAAACCTGCAGGGGAC | AGCACGTTAAAACCAAACTGTCA | TAAATTATATTTGACAG | TAAATTACATTTGACAG | 0,0 |
| Omy_RAD88122-32 | G | A | TCAGTGGATGGAGTGTCCCT | GGTCTTTGGCCTTGTTGCTG | GCTGTGGAGATCAT[CT]CG | GCTGTGGAAATCAT[CT]CG | 0,0 |

***O. tshawytscha* GT-seq panel (298 loci plus sex determination marker)**

| Assay: | A1: | A2: | FWD: | REV: | A1-Probe: | A2-Probe: | Allele Corrections: |
|---|---|---|---|---|---|---|---|
| Ots_110495-380 | G | C | GCCTAGGTATGTACGAAACTTCACA | AGGCTTTTTCAGATGGTCGTATGA | CATAGAC[AG]GGGGCCAT | CATACAC[AG]GGGGCCAT | 1.7,0 |
| Ots_ARNT | G | T | CCACTGGCTGTGGAGCTT | GGGTTCAGTGATAGTTGGGCAAAT | TACAGATGTCATTTTAC | CTACAGATGTAATTTTAC | 2.2,0 |
| Ots_crRAD18289-33 | T | C | GCAGGGAAAACTGGTCAGGA | AGGTGAACCTCCGTCCCA | GAATGGTGTTAAAT | GAATGGCGTTAAAT | 0,0 |
| Ots_crRAD48459-74 | T | C | GGTCACGATCGTGGGGTC | ACCGTTCATCCTCCAGATCT | GGCTGATGACCGG | GGCTGACGACCGG | 0,1 |
| Ots_crRAD55400-59 | C | T | CGCAATGAGCCAACCCCT | CTGGTTTGTTCCCGGGCT | CTAACCCGGA[CA][GA]AC | CTAACCTGGA[CA][GA]AC | 0,0 |
| Ots_crRAD57376-68 | T | C | TGCAGGCATCATGCTTAATAACT | ACGTGACACAGGTCTGGG | ATAAAGTGTGTTAT | ATAAAGCGTGTTAT | 0,0 |
| Ots_100884-287 | T | C | CGGAAGACCAGATTCTCCAAGAGTA | CGACCAAGTAGCGGCACTT | ATAGAACTACAATTCACATATAT | AACTACAATTCGCATATAT | 0,0 |
| Ots_101119-381 | T | C | TTTTCTAGGACAGGTTGCTTGCA | CCAGGTTTCTTTAGCCTACTTATTCTTTACA | TGCCACATGATAATTGA | CCACATGGTAATTGA | 0,0 |
| Ots_101554-407 | C | G | TGAAAGATATCAATTGTAGTAGTGGTGGTG | ACACGCCAGTCCACAAGT | ATGGAGGATTGTGGTTGT | ATGGAGGATTCTGGTTGT | 0,0 |
| Ots_101704-143 | T | G | ACTTCTTGAGCCAATCGGATGATG | CCAGAGATAAACTAGTGGAGGAGATCA | CTTAGACGTCAGAGGTC | CTTAGACGTCCGAGGTC | 0,0 |
| Ots_101770-82 | G | T | GCGACTTGACAACGAGGAGAA | CCCTCTTCATAACGTTACCAAACAC | ACTTCCCGGAGCTGC | ACTTCCCTGAGCTGC | 0,0 |
| Ots_102213-210 | A | G | CATTCCATGACAATGATTGAAATCTAAAAACAC | GAGTATCTCAATTGCAACACTATGGTATGT | CTGTATACAGTAAGAGTATTAAT | ACAGTAAGAGCATTAAT | 0,0 |
| Ots_102414-395 | A | G | GCCTACTGATAAATGTATGACAGTAATGGA | CAATAACAAACAAGCTAGGAACAAAAGTGT | CACATAGTGTAGCTTTACTAC | CACATAGTGTAGCTCTACTAC | 0,0 |
| Ots_102457-132 | A | G | CCAGCAGAGACTGGGTTCAC | TTCCCTACCGGCGAAACC | TGGGGCAACGCACAATTGGCT | TGGGGCGACGCACAATTGGCT | 0,0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ots_102801-308 | C | A | TGGGACAGAGGTGGGAATTGA | CCCAAAGATGCTTAACTGAAGATGTG | AGGGACAGTTTCGCAGACG | AAGGGACAGTTTCTCAGACG | 0,0 |
| Ots_102867-609 | A | G | CTCTGCCATTCATTTGGGCTTTG | GTCTAAAGTGGTCCCCTTGGAT | ACAGAGAGAAGTCCCAGGTG | AGAGAGAAGCCCCAGGTG | 0,0 |
| Ots_103041-52 | A | G | ACCACCCACCTCCTCAGA | AGACAGAGAAAGTCGGGACACT | CATCCTGCTGGACCC | CATCCTGTTGGACCC | 0,0 |
| Ots_103122-180 | T | C | CAAACGCGCACTCACACACA | TCACAATGGTACGATTTTACGACTCAA | CATCAACACAATCTGC | CATCAACACGATCTGC | 0,0 |
| Ots_104048-194 | C | T | CAGCTGCTGCAGTCAATGAG | GCTCCTTACCAGTGTTGTCAGT | C[TC]GCCACCACCACCAC | C[TC]GCCACCGCCACCAC | 0,0 |
| Ots_104063-132 | C | T | GCGTTACTGGTGTTATAAACGTTAGC | GTTTATTTAATTATGAAGGACGATGTTGAAGTCA | CTTTCGTCCTTAGCACATAG | CTTTCGTCCTTAACACATAG | 0,0 |
| Ots_104415-88 | C | T | CCTGAGCATCCCAGTTGAACT | TGTTTTCAATACACTGCAATTTAGTTTTGGT | TCCTGAAAAACGACATCC | CTGAAAAACAACATCC | 0,0 |
| Ots_105105-613 | C | G | AGTACAAGTGCAGAGAATGACATCATG | GGTGTTTTATTTTCCCATATATCTTTTAACTTTAAGCT | CCGAGCTTGAGTTAGGA | CCGAGCTTGACTTAGGA | 0,0 |
| Ots_105132-200 | G | T | CGATGTACTGAGGGCAGTGT | GAGTGGAGTTCCTTAATAATCATTGACCTT | CAAGAGTGGCATAAAA | CAAGAGTGGAATAAAA | 0,0 |
| Ots_105385-421 | A | G | GACTGTCTTGGAACCGTTGCTA | TCCCGGAACACACCAATGTC | CCTCCTGGGTATATCG | CTCCTGGGCATATCG | 0,0 |
| Ots_105401-325 | G | T | GAACTGAGCGGCTGCTG | CGCCTCCTGGTGTCTATCCT | CCCGGACAAGATGAGACAG | CCCGGACAAGATGAGACCG | 0,0 |
| Ots_105407-117 | T | A | TGTGTACATCCGCGTAAATATTGAAGATAA | CTGTGAGCTGCTGCAAACC | CAGGTTAGGAATGGTTG | CAGGTTAGGATTGGTTG | 0,0.5 |
| Ots_105897-124 | C | T | CCTCAGTGTTATTTGTATATGATCATTTTGAAACATTT | AGCCCAATGCATCTACTGAATTCAT | AACCAATAATATGAAACTGTG | CCAATAATATGGAACTGTG | 0,0 |
| Ots_106313-729 | A | G | TTGTTCAATGGGCATTAATGCATGTT | TGCTTATGTGCAGATACTTGAGACAAA | AAGAGTCCAGCGTTACTT | AAGAGTCCAGTGTTACTT | 0,0 |
| Ots_106419b-618 | G | T | CAAGGGCACATTGGCAGATTTT | ACCGGACCAAAGCACACA | CAATGATTAATGATTAATCCTTC | TGATTAATGATTCATCCTTC | 0,0 |
| Ots_106499-70 | C | G | ACTCTATCATCGGCAGGACCAT | ACCGTAAGTGTGGTTGTGTTCATTA | CATTTTTCAGAATTGTATTC | CATTTTTCAGAATTCTATTC | 0,0 |
| Ots_106747-239 | C | A | ATCGAGGATGCCTCAAAGACATC | GTTAGACCCACCACCAGTCATC | CCCGCGGTGAGTAT | CCCGCTGTGAGTAT | 0,0 |
| Ots_107074-284 | A | T | CCCACTTCCAGAGCCTGAA | TTTTCCATGGCTGTGTGTACTGT | ACCGTAGCTGCACCTG | CGTAGCAGCACCTG | 0,0 |
| Ots_107285-93 | T | A | GCCCTTGTGACAATGCACTGTTATA | AACATACACCAATACTTAGGTCTAGACAGT | AAGTAACGTATCAAATGGC | AAAGTAACGTATCATATGGC | 0,0 |
| Ots_107607-315 | A | C | GTGATGAGAGGTTTCCGGAAAATCT | GTGTTCTGGATTCCATTGTGCAAA | ATGGGAGACAGATAACT | ATGGGAGACATATAACT | 0,0 |
| Ots_107806-821 | T | A | CTCCCTTGCTTTTGGTCATTGG | TGCAGTGCTGAATTAGAGATTAATTTTTGTG | CAAAGAAAATCAAAATTT | CAAAGAAAATCTAAATTT | 0,0 |
| Ots_108007-208 | A | T | CAGGCTTGTGTTAAGTAGGGAGAAA | CATTGGACAAGACCGGGTAGTC | CAGTTTCACTTAATTTTAAAATG | TTTCACTTAATTTAAAAATG | 0,0 |
| Ots_108390-329 | G | C | GAGGTTTGTTACTGTCACCCATAGA | CCTGCTGTAGCAAACTGTCTCAAA | CTACTTATGTAGCATTTTAA | CTACTTATGTAGGATTTTAA | 0,0 |
| Ots_108735-302 | C | T | CCTTTTTCTTATTAGTTTTACTTCCCCAGAGA | CAATTCCATTCTTGATTCTGTTTAACGGT | AAACAAACAACGCCTCATG | AACAAACAACACCTCATG | 0,0 |
| Ots_108820-336 | G | A | TGAAATAAATTGTTCTGTTGATATGTGAATTTTGGA | CAACGACACACCAACAACGT | ATTGCCCATCTCAGAATA | AATTGCCCATCTTAGAATA | 0,0 |
| Ots_109525-816 | C | T | GCCAGATAGTAGCGTACATCATGAG | CTCCCCATGTCCCTGAGTCT | CATGAGGCGTTCGGC | ATGAGGCATTCGGC | 0,0 |
| Ots_109693-392 | T | G | TCTCCCTCATTCCCATGTCATATCA | GGGAACGTATCAGGTGAGTGT | TCCGTTAGTTCATCCTGG | TCCGTTAGTTCCTCCTGG | 0,0 |
| Ots_110064-383 | C | T | AACAAAGAATGTTAAACACCAAACAGGAA | GTGCAAGGGACCTAGCTAATCC | CTACGTAATGAACGTTAGCT | ACGTAATGAACATTAGCT | 0,0 |
| Ots_110201-363 | A | T | GTTTGGCTATTGAAATTATACATTAAAACATGTAGCT | CCATGGCATCCTGTAAAGAACAACA | TTTTAAAA+CTGGCATCCA | TTTTTAAACTGGCATCCA | 0,0 |
| Ots_110381-164 | A | G | CTCTTGTTTGCTATGGGAGATGTAGT | CCGTATCCTAAACCCTTCACTGTT | ATTTGCGTCTTCTCCC | TTGCGTCCTCTCCC | 0,0 |
| Ots_110551-64 | C | A | GAGTGGTCAAGGTTTCAGTTTCTG | GAAATGGACAGACACAAGGTCAAAC | ACGCTCGGAACATT | ACGCTCTGAACATT | 0,0 |
| Ots_110689-218 | T | G | GTATAAACTAGAGTCCAGTGTTATGTTAATGTCTT | CATGGCAGACAACAGTAGAGAATATGA | CACCAATCAATTAATTATT | ACCAATCAATTCATTATT | 0,0 |
| Ots_111084b-619 | G | T | TTGTGGAATTACACCTTCAGAGTTCAAT | GCCTGTTTGGCTTTCTTAAACTGAT | TCCATGG[AT]AACGGACAAT | TCCATGG[AT]AACTGACAAT | 0,0 |
| Ots_111312-435 | C | T | CCATGCGCCTTTGAGGAAATTAA | TTCATGGTCTTTATCCCCCCTACA | ACTCATACCTAGAGGTCACAT | CTCATACCTAGAGATCACAT | 0,0 |
| Ots_111681-657 | G | T | CTGAGCTTTTTCAACTTACTTGTTGGA | GGCGCAGCAGCAACTG | TAGCGCAAACCCCGAACC | CGCAAACACCGAACC | 0,0 |
| Ots_112208-722 | C | A | CTGCATGAACGTTAACTCAAATAAAAGGT | AATGAGTTCTACTGACATTGTATACTAGAATAAGTATCA | TGTGAGGGCGGTCTT | ATGTGAGGTCGGTCTT | 0,0 |
| Ots_112301-43 | T | C | GCATGGCTGCCCTAGAACA | TCAGAACATTTCCTTCAGCTTCGT | CGTCGCATTCAGC | CGTCGCGTTCAGC | 0,0 |
| Ots_112419-131 | A | T | GTGGGTAATCGATGCCAAAGAGAT | TGGCAGTGTTTTCAACTAGCTTTG | AAGCGACTTGATTATC | AGCGACATGATTATC | 0,0 |
| Ots_112820-284 | C | T | CATAGATGTTTATATGAAAAACCTCCCACTGT | GCATCCAAAAAGACGTGTGTGTTT | ACTCACACTCGAGTGACT | ACTCACACTCAAGTGACT | 0,0 |
| Ots_112876-371 | C | A | GCCTACAGCAAATTCAGCTACACAT | TGGACCTTCAATCATCACAGCTT | CATCACAACGATGTGTG | CACATCACAACTATGTGTG | 0,0 |
| Ots_113242-216 | C | T | GAGGCCTAATGTCTCTTGTGACT | GACATCTTCAACAAGTGTTCATTCACC | ATTACCAACGGAGAACC | TTACCAACAGAGAACC | 0,0 |
| Ots_113457-40R | C | T | CCCAAGTGGTGAGTGTCAGT | ACTACAACAGGTGTTGATAATAGAATCATTCTC | CCCT[AG]TTCTCCAATCCATAT | CCCT[AG]TTCTCTAATCCATATG | 0,0 |
| Ots_115987-325 | T | G | GGAGGTGTAGTGAAATGGGAAGAT | GCATTCAGTGAACCAGTAGTGCTAT | ATGCATAAAAGGTAATTGTG | ATGCATAAAAGGTCATTGTG | 0,0 |
| Ots_117242-136 | A | G | GTGACAGGAGACAGAAAGAGACATT | TGGTCCTCCCTGTCTCTATCTACTA | CAGCACATAACTTGACCTC | AGCACATAACCTGACCTC | 0,0 |
| Ots_117259-271 | T | G | ACACCCACTTCAACCTCCATAAC | GCCTCAGAGCTTAGCTTGGA | CTCTCCTGATCACTCTGT | CTCTCCTGATCCCTCTGT | 0,0 |
| Ots_117370-471 | G | T | TGCAAACACAGAGGAAAGGGATTT | GTTGGCTCCTTCAATTCAATTTGGA | ACGGAACAAATAAGACATTT | CGGAACAAATAAGCCATTT | 0,0 |
| Ots_117432-409 | A | G | TCATCAAAACATGCCTCTTCTGTGT | TGTTGAACCTGTCACTCTGTCTTC | TTTAGACTTTGCTCTATAACAG | ACTTTGCTCCATAACAG | 0,0 |

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|---|---|---|---|---|---|---|---|
| Ots_118175-479 | C | T | TGCGCGTCTCATTCAACCAT | ACCTTACGTCCTAGGTAGGAAACA | AGAATGAAGTGAAAAGAA | AGAATGAAGTAAAAAGAA | 0,0 |
| Ots_118205-61 | T | C | CCATACAGCCAGTCCAGGTG | ACTGGACAGGGCTGGGT | TAGTAGCCCCTACACCTC | TAGCCCCTGCACCTC | 0,0.4 |
| Ots_118938-325 | C | T | ATTTTCAAACAGGCATTTATCATTGGTGAA | GGTCTGTCCCTCATTCTTTGCA | AGAGATGCAAAGTGGAGTT | AGAGATGCAAAATGGAGTT | 0,0 |
| Ots_120950-417 | A | T | CAGACAGGTCACCATCACACT | TGGTGAAGCTGTAGGAGAAGGA | CTGGACCAGAACTCTGA | CTGGACCAGATCTCTGA | 0,0 |
| Ots_122414-56 | C | T | GCACCGTATCAACGAGCTCAT | TGCATGGATTTCCTTTGTGTTGTTG | TGTATGACCTCTGACCTGT | TGTATGACCTCTAACCTGT | 0,0 |
| Ots_123048-521 | A | C | CTCAACAGTGCACCTCCCTTAATT | CCAAACACACCCTTCCATAATCTCT | TCACATCCAACTCAGTACT | CATCCAACGCAGTACT | 0,0 |
| Ots_123921-111 | A | G | TCGCTAGGCAGAAATATAGGGTTCT | GAGCATGGCGCTTGCA | TGCTAAATGGCATATATTAT | CTAAATGGCACATATTAT | 0,0 |
| Ots_124774-477 | T | C | AGTTGTTCTTTTTATATTGTGTTTTTATTCCATTCCA | GCCAAATAAAAACAAAGCATGAACACA | CCACCGCCATCTGATA | CACCGCCGTCTGATA | 0,0 |
| Ots_126619-400 | C | T | GGATGGTTGTCATTTCTCTGCAAA | CCGGGATACAATAATAATATTTGGTTAAGAGTTTTTT | AGAAAGTTCTAGAAATAATT | AAAGTTCTAGGAATAATT | 2,0 |
| Ots_127236-62 | T | A | TGGAGAACTTGCACTGAATGTGAAA | GCTGTTGGACCTTGACTTTAACAAATT | TCTCTTATCTGAGTTCTGC | CTCTTATCTGTGTTCTGC | 0,0 |
| Ots_127760-569 | C | T | CTGCTGGCGCAGACATG | CGTTATAGAGGATAGTTTGGAGGAAGGA | CCGGTTTACCGATTTG | CGGTTTACCAATTTG | 0,0 |
| Ots_128302-57 | C | T | GGTTGCAGGGCAGAACTGT | ACCCATCCAATAACCCATTTTCCTT | CCTGCAATACGACCAAC | CTGCAATACAACCAAC | 0,0 |
| Ots_128693-461 | C | T | TCAATGTTCATCAATGCACTTCCTGTA | GCCTGCAGGAGAAGGTAGAGTTA | CACTCAGCTGGTACCCA | ACTCAGCTGATACCCA | 0,0 |
| Ots_128757-61R | A | - | CGTGTCCGGCTTCTTTTATTTCATT | GATGGGTATGTTAATCATATTACCAGCGTAA | TTGTGCATTTTCCCC | TGTGCATTTCCCCC | 0,0 |
| Ots_129144-472 | C | A | CTGTTAGTGCAGAAGACGTAGCT | GCAGAGCTATTGAGCCAAGTTACAA | TGGGTCTCGAGCCTGTA | TGGGTCTCGATCCTGTA | 0,0 |
| Ots_129170-683 | A | C | AACCCTATGGGAACTCGTAGAACT | GCTAGGAGTTCTCAAAAGGGTTCT | ATTAGAACTCGTAGAACTAT | ATATTAGAACTCGTATAACTAT | 0,0 |
| Ots_129458-451 | T | C | TGGGACCCACATAAAGCAACTG | GACATAAGACCCATTTAGCCCCTTTT | CATCTGGCAATGCCTT | CATCTGGCAGTGCCTT | 0,0 |
| Ots_129870-55 | A | T | GCATGTAACACATTATTTGGCATATGTACT | CAGTACACTGGAGATTTGCAATGTT | ATGCATTCACCTGTATTAT | TGCATTCACCAGTATTAT | 0,0 |
| Ots_130720-99 | A | G | CGGTCATTGTAAATGTCAACGGTTT | TGCTTGCATGTTCTTGGTGTAGTAA | CCTGTCTCATTCCC | CTGTCCCATTCCC | 0,0 |
| Ots_131460-584 | T | C | CCTATTTTTGATAGGTCATAGTGAATGGGATAG | CTGTACTCCTCCATTCCTTTTCACT | CTATCAAAGCAATACATTG | CTATCAAAGCAGTACATTG | 0,0 |
| Ots_131802-393 | C | T | TGATTGTCTCATGGCCAATTGTCA | TGTAAATTCCACTTGGCAATCTTTGG | TGTTCGAGAATGAAGATGAGTAA | TCGAGAATGAAGGTGAGTAA | 0,0 |
| Ots_131906-141 | A | T | GGCTCGAACCACCCAGTTTA | TGCCCAACTGGTTTGCAATC | CACGGTTTACACTCCTATTA | ACGGTTTACACTCCAATTA | 0,0 |
| Ots_94857-232R | T | C | GGCACTCTCCCTGGCTAGA | CCCCATCACTTCTCTGGCTTTAAAT | CAGGATAATAACAAACAAG | CAGGATAATAACGAACAAG | 0,0 |
| Ots_94903-99R | G | T | CCGTCTGAGTAGGAGGATCAATACA | TTTGGATCCAGCTCTCCGTATAGA | CAAACCAGCAAACAT | ACAAACCAGAAAACAT | 0,0 |
| Ots_95442b-204 | A | T | GTCTCTCTCTCTTTGCATCATTACACT | GGACTCTTGAGCTGTCTGGCTATAT | TGGTTCCCCAAATTT | TGATGGTTCCCCTAATTT | 0,0 |
| Ots_96222-525 | C | T | GCTCTTGCCCATCTGTAGGAT | GGCGCAACATATGTATTAAGCAACT | TGTAGCTAATTTTAAGTTCTC | AGCTAATTTTAAATTCTC | 0,0 |
| Ots_96500-180 | G | T | GATCATGTCAGATAGGATGCTGAAAGT | CAGGTCTGGTCTACATCGAACAC | AAAACAAATCATTTTTCG | AAAAACAAATAATTTTTCG | 0,0 |
| Ots_96899-357R | T | A | TCTCCTGAACTAATTTAGACCTCTGAATGT | CCTCATATTGCTTTCATCTGAAGAGAGA | CTGAATGTTTTTTTAATCTTT | CTGAATGTTTTTTTTTATCTTT | 0,0 |
| Ots_97077-179R | G | T | CCTGAACAAATACTTAACGCTCCAGTT | GTAATAATACTTCACACCATTGCCACTTC | TCACAAATGTATCCTAAAGC | CACAAATGTATACTAAAGC | 0,0 |
| Ots_97660-56 | A | T | TTCCCTAATCTGACGTACTACCAACT | CGCCACTGACGTTCATTCCA | ACGAGACAGATATTC | ACGAGACTGATATTC | 0,0 |
| Ots_98409-850 | C | T | CTGCGTTTCTGGAATGTTTTCAGT | CAAACCTGTTACTGGCCAAATGAAA | TTGTTCACGAACCTTG | TTGTTCACAAACCTTG | 0,0 |
| Ots_98683-796 | A | T | GCAATGGCATGACAATGGAAGTC | CACTGGCACTGGTGGAGATTA | CTCAGCCCCTATATTACAA | CTCAGCCCCTATTTTACAA | 0,0 |
| Ots_99550-204 | C | T | TGACAGATTTCACCTTTAACTAGCTAAGC | GCAACCTCTTTCACACTTCAGTAAC | AAGGCTTTGGTTGTTTG | AAGGCTTTGATTGTTTG | 0,0 |
| Ots_afmid-196 | G | C | CGTGGAGTAGGTGGTTACAGTTTAT | CTCGTAACAAGCTACTGTAGTGTACT | CAAAGTCAAAGATCCTATTAAA | AAGTCAAAGATCGTATTAAA | 2,0 |
| Ots_AldB1-122 | C | T | GCCATGGAGGACTGGATGA | GCCACCACTACTTGCTGAGAAAATA | TGTTGGCGAAGTG[GT]GT | TGTTGGTGAAGTG[GT]GT | 0,0 |
| Ots_aldb-177M | T | A | GCGATCAGGTGACGCTAAAATGA | AGGAAGGTGATGCCTGAGAGA | CCAAATTGCTTAACCC | CCAAATTGCTTTATCC | 0,0 |
| Ots_AldoB4-183 | T | A | TTTGTGCGTAAAGTCAGGTAGTGT | GTGCATGCCATGAGAACTTTGTTT | CTGTGTGTCTAAGACAAT | CTGTGTGTCTATGACAAT | 0,0 |
| Ots_arp-436 | A | T | GCCCTGGAGAAGTACGTTTTAAACTAA | GCAACCATGTCAACATTGCACATAA | CTAGGTGAAACTTTTTTTAAA | CTAGGTGAAACTTTTTAAAAA | 0,0 |
| Ots_AsnRS-60 | T | C | CCGACGCCTCACTGAGT | TGGTTTTTCAGGTCATGGTTTCCA | TGAGTCCCTGACCAGC | AGTCCCCGACCAGC | 0,0 |
| Ots_aspat-196 | G | C | CCTGAACAGGTACACACAAACGA | TCCAACTGATGAATATGACCAACATGAAT | CACTCTTTATATCCACACC[GA] | CAGTCTTTATATCCACACC[GA] | 0,0 |
| Ots_BMP2-SNP1 | C | T | ACTGCCACAGACACGAACTC | GCCACTATCCACTCGTTCCA | CCCACTTCGCTGAAGT | CCCACTTCACTGAAGT | 0,0 |
| Ots_brp16-64 | T | C | ACTCTGGGTCCAGGAGGTTTT | CTGACGAGACCATGCACCAA | AAGTCAGCATCTTTCA | AGTCAGCGTCTTTCA | 0,0 |
| Ots_Cath_D141 | T | C | CACTTGTTCTGCACACTACTTGTC | CACACATGGATTTTGCCTGTCTAAA | TGGGAAGCAATCAA | AATTGGGAAGCAGTCAA | 0,2 |
| Ots_CCR7 | C | T | CTGCTCACCTGCATCAGTGT | CCATGGTGGTCTGGACGAT | CCACGTAGCGATCG | ACCACATAGCGATCG | 0,0 |
| Ots_CD59-2 | G | A | TGTTTATCTCTGAGTGAAAAAGGTGTGT | CATGTTACCCAGCTAAAAGTCTATAGCA | CTAAAATGTCATGTAAATAT | ACTAAAATGTCATATAAATAT | 0,0 |
| Ots_CD63 | A | C | TGCATGTTTTCTAACTGTGTTTTTGTGT | TGAATGCCCCCCATCAACA | AGATCATGGGAATCATAT | ATCATGGGCATCATAT | 0,0 |
| Ots_cgo24-22 | T | C | AGGTCCTCTGTCGCACCTA | GGAGGCGAGGTCTGGTG | CCAGATGAACAACTTCAC | CCAGATGAGCAACTTCAC | 0,0 |
| Ots_Chin30up-211 | C | T | GGACAATCGAAGACGAAAATATGCA | CCTGCCCTGCAGACTTAGG | CAGGGTGGGAGAAT | CAGGGTGAGAGAAT | 0,0 |

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| Ots_CirpA | C | T | GCTGTGATTGTGCTCTAAAGACATG | CTCCCACTTAGCATTCCTACCTT | CAGTTCTGTAATGCATT | CAGTTTTGTAATGCATT | 0,0 |
| Ots_cox1-241 | C | T | CACTGAACTGTAAGCCATTGTGATT | GTAAATGTAGTATACAGTATAGGCATCGTAGGT | CACTACGGTAAGACCAT | CACTACAGTAAGACCAT | 0,0 |
| Ots_CRB211 | A | C | CAACGCGGGAATGGCTTTTAA | GCCAGAGTCGCCAAAATAGTAGAAT | CTACCGTACTGAACTC | CCGTACGGAACTC | 0,0 |
| Ots_crRAD10447-25 | C | T | CCGTTGCAGGACTCATCAGT | GCGTGGTTCAACAGCAGTG | AGCTAGCGCTCCTC | AGCTAGTGCTCCTC | 0,0 |
| Ots_crRAD11620-55 | C | T | TGGGATAGAACAGGAGCTTAAACA | TGTCTTGGTCGCGCAGTT | AGAAGCCCAGCTCC | AGAAGCTCAGCTCC | 0,0 |
| Ots_crRAD12037-39 | A | G | TGCAGGAACTTGCTATGCT | TGTGGAAAAAGTCAAGGGGTCT | CATTCAAAAAGTAT | CATTCAGAAAGTAT | 0,0.5 |
| Ots_crRAD12711-37 | C | T | GCTGTTATAGCGCGGACTCA | CCTCCTCAGACCAATTGGCA | CAGTTTCCCAAGAC | CAGTTTTCCAAGAC | 0,0 |
| Ots_crRAD13725-51 | C | A | TGCAGGAGGAGGAAGGCA | AGAGCTGCCAGGTGGAGT | GAGGCCCCAGATTC | GAGGCCACAGATTC | 0,0 |
| Ots_crRAD16540-50 | C | T | TGTGTATTCGTCGACCGGA | TCACCTGACCAAAGCACTGG | ATTAAACGT[CA]TGGA | ATTAAATGT[CA]TGGA | 0,0 |
| Ots_crRAD17527-58 | C | T | TGCCGCTGGATTTATTGACA | GCGTCAGATCAGCTGGTCT | TAGCTCCGAGCTAA | TAGCTCTGAGCTAA | 0,0 |
| Ots_crRAD18492-65 | C | T | GCAGGGCGCAAAGTTCTT | CAGTGAGCGACTGTAATCTGA | TTATGGCTATTATT | TTATGGTTATTATT | 0,0 |
| Ots_crRAD18937-60 | G | A | GGCACAGCGACAGGAGTT | TGAGCTGGTGCGTCTGAG | CTCCTCAGGTGGGC | CTCCTCAAGTGGGC | 0,0 |
| Ots_crRAD20262-46 | A | G | CCTCTGCTGAGTTTGAGGGG | TGAGCAGAGCCTATGAGGACT | GGTTACA[TC]CCCAAA | GGTTACG[TC]CCCAAA | 0,0 |
| Ots_crRAD20376-66 | G | A | GGGAGGCAGGCAAAAGGT | GGTTCACCACCAGCCTTCT | GGGA[TA]GGAGTATTT | GGGA[TA]GAAGTATTT | 0,0 |
| Ots_crRAD20887-70 | G | A | CTGCTTGTAGCCGTTCAGC | AGAACACATCTGGCCAGGT | GAACTCGTCGTTGG | GAACTCATCGTTGG | 0,0 |
| Ots_crRAD21115-24 | C | T | TGCAGGTGGGACTTAAACACA | ACCTGTGGCAACGGTTGA | CACACACATGCACG | CACACATATGCACG | 0,0 |
| Ots_crRAD22960-32 | C | T | ATCAGGTCTGGGGCGACA | TTCACCTCTGCCATCGCC | CGACACCACTTACA | CGACACTACTTACA | 0,0 |
| Ots_crRAD23631-48 | G | A | GCCATATCCCGGGGCTTG | TGCCTCTGAGCACTGACTG | GGGCTTGGGGGCAT | GGGCTTAGGGGCAT | 0,0 |
| Ots_crRAD24807-74 | A | T | TGCAGGAGAGCAGGGTAGA | CGTGCCTAACATCATGTGCA | ATGATAATTTGCA | ATGATATTTTGCA | 0.5,0 |
| Ots_crRAD25367-50 | T | G | ACTGCAGGCGTCATGCTT | TGGACAAAAGACCACAGGCT | GTATATTTAGAATG | GTATATGTAGAATG | 0,0 |
| Ots_crRAD255-59 | T | C | TGCAGGAGCTGTGATGGG | GTACGGAGCGTCACTGCT | AACTGTTCAAACCC | AACTGTCCAAACCC | 0,0 |
| Ots_crRAD26081-28 | T | G | GGGAGAGGGAGACGTGGA | TCACCAGCTCCTCCTCCTC | TGGAGGTGGAGGAG | TGGAGGGGGAGGAG | 0,0 |
| Ots_crRAD26165-69 | C | T | GGGCCACGGGGTTGTAAA | TCCCAGGATGCAATGGGA | CTCT[GA]CCCCTGGAC | CTCT[GA]CTCCTGGAC | 0,0 |
| Ots_crRAD26541-47 | G | A | TGCAGGAGAAGCTGACTGAC | GCAGCTTTGGAGGGTCGT | CTGCTCGACAGAGA | CTGCTCAACAGAGA | 0,1.7 |
| Ots_crRAD27164-55 | A | T | GGAGGCTCTACGTAGGCCT | ACAATATCTGACACTGACTTGGTCA | AATTTGAATGACCA | AATTTGTATGACCA | 0,0 |
| Ots_crRAD27515-69 | T | A | CAGATGGTGCAGGCCGAA | ACTCGTTGTGATTCCAGCCA | GCATTTTAAAAATC | GCATTTAAAAAATC | 0,0 |
| Ots_crRAD2806-42 | C | A | GCAGGGGCAGACTGAAGG | ACTTCATGCCAATCTCACTAAACA | GTTTGGCATAAAGT | GTTTGGAATAAAGT | 0,0 |
| Ots_crRAD28677-65 | C | T | CTTGCGCGGCAGTTGAAC | TGTGTCCTCCGAAACATGACC | CTTCCGGGTTAAGAGGA | CTTCTGGGTTAAGAGGA | 0,0 |
| Ots_crRAD292-21 | C | T | TGCAGGGTGGAAGAATTCATC | TCACAGTCTGACCTGTCGA | ATTCATCATTTATG | ATTCATTATTTATG | 0,0 |
| Ots_crRAD30341-48 | T | A | TGCAGGCTGACTTGGGTA | TAACCCGGAAGCCAGCTG | G[AG]CACATTGGTGCA | G[AG]CACAATGGTGCA | 1.8,0 |
| Ots_crRAD33054-62 | A | T | CGACCATGGCCCCCAATTCAT | GTGAGGCTGACCGTGACC | CACGGGAATGGACA | CACGGGTATGGACA | 0,0 |
| Ots_crRAD33491-71 | C | T | CAGTTCGCTTCTCCAGGGA | TGTGGGTAGCAGACTGACG | GAGAGCCGAGCTTT | GAGAGCTGAGCTTT | 0,0 |
| Ots_crRAD34397-33 | C | G | TGCCTAAACACTCCCAAGGT | GTTCCGTTTTTGTTCCGCGA | AA[GA]GTGCCTTCCCC | AA[GA]GTGGCTTCCCC | 1,0 |
| Ots_crRAD35313-66 | A | G | TGCAGGAAGAGTTCAGAGAAATCT | GCTCGTTGCAGGTAGAAATGT | TTTAAGATGTAGTT | TTTAAGGTGTAGTT | 0,0 |
| Ots_crRAD36072-29 | T | C | TGCAGGACCAACTTTCTCAT | GGCTGACTGGTGAAGGGG | AACCTGTGTGATTT | AACCTGCGTGATTT | 0,0 |
| Ots_crRAD36152-44 | C | T | CAAAGTGCAGGTGCTGGC | CCAGCCAGGTGTTGAGCA | CTGCCACCCTTTGA | CTGCCATCCTTTGA | 0,0 |
| Ots_crRAD3758-51 | T | C | GGCGACACACACAGGGTT | TCACAGTAAAGCAGTGAGATTTCA | TCT[GA]GTTTACAATT | TCT[GA]GTTCACAATT | 1.8,0 |
| Ots_crRAD38095-29 | A | T | GTGCCGCAACAGAGTGGA | CTGCCTTTCCAGGGTGCA | GAGTGGAGTCTGAC | GAGTGGTGTCTGAC | 0,0 |
| Ots_crRAD38746-36 | T | A | TGACCCTCCAGCGTGACT | ACTCTTCGCTGGCCATGG | CGTGACTATGCCAC | CGTGACAATGCCAC | 0,0 |
| Ots_crRAD42058-48 | A | T | AAGCTATGCAGGCGACGG | GTGCACAATTGGCCCAGC | GAGCCAAGTAAAGC | GAGCCATGTAAAGC | 0,0 |
| Ots_crRAD44588-67 | C | T | CGCAAGTCAGCAGGGTGA | TGGGGTTTTAGGCTGGGT | GTGA[AG]CCAATCAAT | GTGA[AG]CTAATCAAT | 0,0 |
| Ots_crRAD46081-56 | C | T | GCAGGGTCTGTGTGGGTT | ATGAGGACACTCCGCCCA | GCACCACTGGACCC | GCACCATTGGACCC | 0,0 |
| Ots_crRAD46751-42 | C | T | CAGGAACCTGCTTTAATGCTCT | GCTTCTGCAGGGGGACAA | TTTCTACTTAGTAA | TTTCTATTTAGTAA | 0,0 |
| Ots_crRAD47297-55 | T | C | CTCCCTGTTCGCTAGCCG | GGACGACCAAAGGTAGAACCC | TAGCCGTCACCGAT | TAGCCGCCACCGAT | 0,0 |
| Ots_crRAD5061-27 | T | C | AGATGCAGGAGGCTCTGGA | AGGACTGGAGTGTGATAGCAC | ATTAGGTAT[CT]TTAA | ATTAGGCAT[CT]TTAA | 0,0 |
| Ots_crRAD55475-26 | T | G | TGCAGGGTTGGGGACAATT | AGTCTATTTCCCGATTTGACTGGA | CCATTTTAATTCCA | CCATTTGAATTCCA | 0,0 |
| Ots_crRAD57520-66 | T | G | ACAGAGCTGTGTCTACCAGA | ACCCTCTCTTGGCCTTGC | TTTTTGTTCAAAAG | TTTTTGGTCAAAAG | 0,0 |
| Ots_crRAD57537-24 | A | C | TGCAGGGGGACAAGAGAGA | CGCTCATAGCTTGTTCTCCA | GAGCCC+ATGAGAAA | GAGCCC+CTGAGAAA | 0,0 |

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|---|---|---|---|---|---|---|---|
| Ots_crRAD57687-34 | T | G | TGCAGGGACGGGGCT | TGCTGTTGTCTTGGGTCTCTC | ACAAATTAATTAAA | ACAAATGAATTAAA | 0,0 |
| Ots_crRAD60614-46 | G | T | TGCCGTGAGAAACTGGTCA | TTTCCTCCTCTCTGCCTCA | AAGATGGTATGTAT | AAGATGTTATGTAT | 0,0 |
| Ots_crRAD60620-51 | A | G | CAGGCAGTCACTGAGTCCG | TTTGAGCACCGTTTCCGA | GTACGGAAAAAACA | GTACGGGAAAAACA | 0,0 |
| Ots_crRAD61523-71 | A | G | GCCAAGTGATCAAGTGCTTGT | CCAGCAGTTCAGTTGCGG | CAGAGCATGTGCTG | CAGAGCGTGTGCTG | 0,0 |
| Ots_crRAD66330-60 | G | T | ACTCTCCCAGAAGGATTCAGAGA | TCCCAAAGCATCCTGCCA | AGAGAGGGGTCAAA | AGAGAGTGGTCAAA | 0,0 |
| Ots_crRAD69327-53 | G | T | GCCATTTGACCAACGGAGC | ACTCATACAGTATTTCCGCCTGT | ATAGGAGAATTGGA | ATAGGATAATTGGA | 0,0 |
| Ots_crRAD73823-60 | T | A | GCAGGAAGCAAAGTTCGGTG | AGCAACTCATCGCGTGGT | GCACGATG[CT]AGAAC | GCACGAAG[CT]AGAAC | 0,0 |
| Ots_crRAD74766-28 | G | A | GCTGACCACCGACCACAG | AGCTCTGCAGTAACAATGGGA | AGACTGGTAAAAG[AT] | AGACTGATAAAAG[AT] | 0,0 |
| Ots_crRAD75581-70 | A | G | ACACATGGCTCGTCTGCA | GGAGCTCAGGGTGCAGGA | GAACTTAAAACACT | GAACTTGAAACACT | 0,0 |
| Ots_crRAD76512-28 | A | T | GCAGGGACAGGGCCCT | TGGTGCTGGGTGCTGTAC | TAAAAAAATATAAA | TAAAAATATATAAA | 0,0 |
| Ots_crRAD78968-46 | C | T | CCTGCTCTGTGTCTGGGC | GTGAAGACGACCCCGGTG | AG[CA]AATC[CA]CACAGC | AG[CA]AATT[CA]CACAGC | 0,0 |
| Ots_crRAD92420-25 | G | T | AGTGCAGGTCTCCAGATTTACA | ACCGAAGTGTATGTAAACTTCCGA | CAATCGGAAGTCGG | CAATCGTAAGTCGG | 0,0 |
| Ots_crRAD9615-69 | T | C | GAATGCAGGGCCAGGGAG | ACTCCCAGACCATCCAGCT | TATTGGTCAGGGAA | TATTGGCCAGGGAA | 0,0 |
| Ots_DDX5-171 | C | T | ATGACCAATTGAAGAGTTCTTCCGT | CAAAGCCAAACGTCACATTTACACT | TTCATAATTGAACGATTTCA | CATAATTGAACAATTTCA | 0,0 |
| Ots_E2-275 | A | G | GGTGCCACTTTAGTATAGCTGCTTA | CCCTACCCCCTGTGTTCCA | CCCCCATATTGCTG | CCCCACATTGCTG | 0,0 |
| Ots_EndoRB1-486 | G | A | CCTTTGGGTCTGCTTGAGGTT | GGAGCCAAATCCTAATGCTGAAGTA | TCCTTCTCACGCTTCT | CTCCTTCTCATGCTTCT | 0,0 |
| Ots_EP-529 | A | G | GCCCTGCCTGCAACTTC | GAAACCAACGTCTTGATGTAGACCTA | CAGTGTCATTTTCGGC | ATCAGTGTCATCTTCGGC | 0,0 |
| Ots_Est1363 | A | T | GGTGATTTTGCCACAGAGTAGAGAT | AGTGTTAAATGTAACTTGCATATACAGGCAAT | CCATCCTGTCTTGTCTG | CATCCTGTCATGTCTG | 0,0 |
| Ots_Est740 | T | C | GGACTCGTGCTTGAGGAAGATG | TGCATGGCTCCAACTCCTT | TCTGGATGGAACCGTTAG | CTGGATGGAGCCGTTAG | 0,0 |
| Ots_ETIF1A | A | C | TCTGAACTCACCAAAGGAACACTTG | GAGAGAAAAGGAGAAATGATTGCCATT | CAACTGAAGAAAATAATATG | CTGAAGAAAAGAATATG | 0,0 |
| Ots_FARSLA-220 | G | A | GTTCGTGGGATTGTTCAATGTTCAT | CTTGGACAGGCTCACATTACCATA | CCTTGGATGGGATGTG | CCTTGGATAGGATGTG | 0,0 |
| Ots_FGF6A | G | T | TCAAAAATGTCTATCCAACAAATACTCTGAAAAATATTG | CTTGTGCGCACCTTGCA | CACGATTAGCAATGAACAA | CACGATTAGCAATTAACAA | 0,0 |
| Ots_FGF6B_1 | A | C | GAGACAAAGGTTTGCAGGTTCATG | GGGAGCCATGCACTAATATATTGGA | CCTGTTATCAGACCCAAAT | CTGTTATCAGCCCCAAAT | 0,0 |
| Ots_GCSH | C | T | GTTCTTTTTAATGATGACTACAGGTCTTTCAC | GCTACTTTACATAATACCATTTGAGCTGAGA | TATCTGGGCGGGCTG | CTATCTGGACGGGCTG | 0,0 |
| Ots_GDH-81x | C | - | CTTTTCTGAATTAGTGCTGTGCTTGT | CCAACTTCTTCAACTCTGTCAGTGA | TGTTACGGGACATACT | TCTGTTACGGACATACT | 0,0 |
| Ots_GH2 | A | T | GCGTACTGAGCCTGGATGACA | CCCCCAGGTTCTGGTAGTAGTTC | TGACTCTCAGCA[TA]CTG | TGACTCTCTGCA[TA]CTG | 1.8,0 |
| Ots_GnRH-271 | C | T | CAGATGAAAAATAAATAATTGGGCCATTAGGAA | CAGAGAGACTGAGACCATATGATGTAGT | CAATGAATACAATATCTAACCTAAT | AATGAATACAATATCTAATCTAAT | 0,0 |
| Ots_GPDH-338 | G | A | CACTAAATATTCCTTATCATTTCATACTAAGTCTGAAGAA | AGCTGATACACAATCAAAACACAAAACAT | CCACTACTTAACGTGCTTT | CCACTACTTAACATGCTTT | 1.7,0 |
| Ots_GPH-318 | C | T | GGTGATAACAGGTGTTGCACCAA | TCAGGTGGTGGTGGACAAC | ATCAAGCTGACGAACCA | CAAGCTGACAAACCA | 0,0 |
| Ots_GST-207 | G | A | GGAGAACATGCATCACCATTCAAG | TCAGCAAACGAAGGCTATGTAGAAT | ATGAGAGAGTCTTTCTCTGTT | ATGAGAGAGTCTTTTTCTGTT | 0,0 |
| Ots_GST-375 | C | T | CAGCCCGTCCCAAAATCAAG | CAGGAATATCACTGTTTGCCATTGC | TTTCTTGTAGGCGTCAGAG | TCTTGTAGGCATCAGAG | 0,0 |
| Ots_GTH2B-550 | C | G | CACAGGAAGGACGTGTTTTGATG | CACAGGAAGGACGTGTTTTGATG | ATAACATCTGCAGCATTAA | ATAACATGTGCAGCATTAA | 0,0 |
| Ots_HFABP-34 | C | T | CAAGAACACCGAGATCTCCTTCA | TCGGCGGTGGTCTCG | TCGAACTCCGCTCCTAG | TCGAACTCCACTCCTAG | 0,0 |
| Ots_HMGB1-73 | G | T | TGCTTCAGTGAAAATAAGCGTGAGA | GTCGAGCGGTATGAATACTTTCTGA | ACTGTATATGTTACGTTTTC | ACTGTATATGTTAAGTTTTC | 0,0 |
| Ots_hnRNPL-533 | A | T | TCTTTGATATTGAGCTCATAAAAGCAAGGT | TCCTTGTTCATCCATCAGGCATAAAA | CATTTACCAGTTCTCACACAC | TTTACCAGTTCACACACAC | 0,0 |
| Ots_hsc71-3'-488 | C | T | TGCATCCATTCATACCTGACCAATT | TTTGGTTAGGCACACGATAATTTGC | TTTCCAATGGTATAGATATGA | TTTCCAATGATATAGATATGA | 0,0 |
| Ots_hsc71-5'-453 | C | T | TTGAGAACATGTGGTAATTAACTACAATGACTAA | GTACGAAGTTGCGCCTTGTC | GCCTGAGGTGGCAAA | GCCTGAGGTGACAAA | 0,0 |
| Ots_hsp27b-150 | G | A | TAGGAGTTGGAAAGACTGCACA | CCCATTGGTTCTTTGGTGTT | [CT]GATCTGGACCAGGCT | [CT]GATTTGGACCAGGCT | 0,0 |
| Ots_Hsp90a | G | C | ACAGTATACCGGCTGCCTATTCATA | GTCGTTTTTCATAGAAAATAGCTCACAGTT | ATTTGACTTGTCTTTTT | ATTTGACTTGTGTTTTT | 0,0 |
| Ots_HSP90B-100 | C | T | CACCTTAGTTCCACGCAACATG | CTGCGTGTATTGTAGTGGTGACA | TCTATGGTGTGATTCATT | TTCTATGGTGTAATTCATT | 0,0 |
| Ots_IGF-I.1-76 | A | T | GGTAGGCCGTCAGTGTAAAATAAGT | GATGGAGGCCACTGTGTTCTTA | CTGCCTAGTTAAATAAAATA | CTGCCTAGTTAAATTAAATA | 0,0 |
| Ots_Ikaros-250 | G | A | GAGGCTGACTTGGACTTTGC | GGCCTGTCAGCCAAGGA | ACAGAAGATTTTCGGCTGC | ACAGAAGATTTTCGACTGC | 0,0 |
| Ots_IL11 | T | C | CCTCCAGATGAGACCCACTCT | CAAAATGGTGCTCAAACGACTTCA | AGCTCCATGCGGACT | AGCTCCACGCGGACT | 0,0 |
| Ots_IL8R_C8 | C | T | CGTGGTGTTCGCCTTCCT | TGTCGGCCATCACTGTCATG | CTGGACGCCGTTACA | TGGACGCCATTACA | 0.7,0 |
| Ots_IsoT | T | C | GACTCAGGTAAGGAAACATCAATGTCA | GAAAGCAAAGCATTTTATCCACCACTA | AACCAGTAGAATAACC | CAGTGGAATAACC | 0,0 |
| Ots_LEI-292 | G | A | CACCTGAACCTCCACTGTGT | GCTGCTGACCTATGAGAAAATTGTG | CATCATGTCAGGCCTG | ATCATGTCAAGCCTG | 0,0 |
| Ots_LWSop-638 | T | C | CAATTACTCTTTCTCAGCCCTGTGT | GCGGTAAGATGCAGTTTTACATGGA | TTTAACAAGAAAATTATACATTTC | CAAGAAAGTTATACATTTC | 0,0 |
| Ots_mapK-3'-309 | T | G | CGTGACCCTTGTAACTGAAAA | GGCCACTGTCATAGAATTAGG | ATGCTATTAAATGAAT | ATGCTATTAAATGACT | 0,0 |

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|---|---|---|---|---|---|---|---|
| | | | GC | CATT | ATTC | ATTC | |
| Ots_mapKpr-151 | A | T | TGTTGTCTCGGACTGCATGAC | GAAGGCACAGAGATGAAGGACAT | CGTATGTGCAATGCATG | CGTATGTGCATTGCATG | 0,0 |
| Ots_MetA | T | A | GATCATTTATCAAGACTATAGGCTATGGATACG | AGTTGAGTTAAGTAATTGGTAATTAGCCTGTT | CCTTAAGCATATTTCT | CCTTAAGCGTATTTCT | 1.8,0 |
| Ots_MHC1 | G | A | GTCCACATTCTCCAGTACATGTATGG | CAAACCCCTCTGTCTGTTCAGT | CATCATCCCGTGAGCAG | TCATCATCCCATGAGCAG | 0,1.8 |
| Ots_MHC2 | T | G | GTCCTCAGCTGGGTCAAGAG | GTAGTGGAGAGCAGCGTTAGG | CTGGAGCGTTTCTGTA | CTGGAGCGTGTCTGTA | 0.5,0 |
| Ots_mybp-85 | C | T | CAAGGGATGTGACAAATTAATCAAACACATAA | AAGAGGTCTAATAAATCTCCAATGTAAAAACGT | AGAGCATGTAGTTTTG | AGCATGTAATTTTG | 0,0 |
| Ots_Myc-366 | T | C | CCTTAGCTGCTCTTTGAAGTTGACT | GGCTATAGAGTGTATTTACAGCATGCA | TCTCTGCTCATCTGTC | CTCTGCTCGTCTGTC | 0,0 |
| Ots_myo1a-384 | A | C | CTCCCCCCTGGACTTTGG | GCTCTATTGCACCGTGTTCTG | ACAGATCCATCCACCACT | AGATCCAGCCACCACT | 0,0 |
| Ots_myoD-364 | T | G | GTGTGTGTGTGTGTGTGTCATCGT | TTTACACATATACAAAAATGGTCCTCTATTGTCAT | TCATCTTTTGTTATTTCCTTG | ATCTTTTGTTCTTTCCTTG | 0.7,0 |
| Ots_NAML12-SNP1 | A | G | TGCCACCTCAGTTTTAGTGTTATATCC | AGCGCCAACCTGTCACT | AAACCATTTTCATTCTTTTG | CCATTTTCACTCTTTTG | 0,0 |
| Ots_nelfd-163 | A | G | CTCACTGCAAATCCAACTTCATCAT | CCACTACATCCTCATCCAAGGTT | ACCCACCAGTGTCATT | CCACCAGCGTCATT | 0,0 |
| Ots_NFYB-147 | C | T | CCGTCCACAGCACAAGACTATAATA | CAGATGATAGCTTCAGTAAGTGGTTCA | TGTTCCAATGTAAAATGTATGC | TTCCAATGTAAAATATATGC | 0,0 |
| Ots_nkef-192 | C | T | CATTTAGCAGACACTCTTATCTTAGTGTCA | CGAATGTCCACCTCAGATGTTACAA | AATAGGCCGACATCAA | AAATAGGCCAACATCAA | 0,0 |
| Ots_NOD1 | C | G | GTGCTGCAGGAACCATGTG | CTGTGTGGACTGCTGTCTAAGG | CCAACGGCGACTTG | CCAACGCCGACTTG | 0,0 |
| Ots_nramp-321 | G | A | GGCCATCTTTCAGGACGTACAG | GCATGCTCTGCAATACGTTGAG | AAC[GT]GGCATGAACGACTT | AAC[GT]GGCATGAATGACTT | 0,0 |
| Ots_ntl-255 | T | A | TGCAGTTACAAGCCTAAGACAATCT | CAACTAAAGTAACACACCAGCAACTG | ATTCTTCCTC[TC]ACAATTG | ATACTTCCTC[TC]ACAATTG | 0,0 |
| Ots_Ostm1 | C | G | CCAGCCCCGTAACACACAT | GAGAGGAAGCAGAAAGGTCGTTTAA | CCGTGGTATTGTTTCAA | CCGTGGTATTCTTTCAA | 0,0 |
| Ots_OTALDBINT1-SNP1 | T | C | CGCTGGGCATGGATGAGT | GGCCAACACTGCTACTTCCT | CTACTGTTGTATTTTCTC | CTGTTGTGTTTTCTC | 0,0 |
| Ots_OTDESMIN19-SNP1 | C | A | GGTCTGTCTGTCTGTCTATCTGTCAATG | TGTGTGTCTTTGTTCATTCCTACCA | CCAGTCATGGGTCATT | TCCAGTCATTGGTCATT | 0,0 |
| Ots_Ots311-101x | A | - | AAATGAGGCCGTCCTTTACACT | GCAATACAAGCCCTTGATAATGAAGT | CTGAGATCACTTTGAGCAC | ACTGAGATCACTGAGCAC | 0,0 |
| Ots_OTSMTA-SNP1 | C | T | GCCGAAAAATAAGCGATTAGTGATGA | GCCCCATGGTAAACCTAATTAACCT | AATTGCCTCATTGGGTG | AATTGCCTCATTAGGTG | 0,0 |
| Ots_OTSTF1-SNP1 | G | T | CGGACAAAGAGCTACAGAAATGC | CGTCCCTCTTCACGCATGA | CCGCCACCTTGGCT | CGCCACATTGGCT | 0,0 |
| Ots_P450-288 | A | G | ATGTCAATATATTTCACTATAATGATTGGAAGCCA | CACTGAACTCGAAGCTGTTAGGA | CTATAAAGTTGGACAGTTGG | AAAGTTGGGCAGTTGG | 0,0 |
| Ots_P450 | T | A | TGAGCGAGATTTATCAAACTGTCAAAGA | CCCAAGCGGGAGAACTTACAG | CCCCGAAGTACTTTT | CCCGAAGAACTTTT | 0,0 |
| Ots_P53 | G | A | GGAACTTCCTCTCCCGTTCTG | GCACACACACGCACCTCAA | CTGGGTCGGCGCT | TGGGTCGACGCTC | 0,0 |
| Ots_parp3-286 | A | G | AGTCAGTGTTGGTGTAGTGAAGAGA | CATTTGTGGAGTGTTTATTGAACAGTAACA | AGTTACAAGTGGTGTTTCA | ACAAGTGGCGTTTCA | 0,0 |
| Ots_PEMT | C | T | AGAGCATTCAATTTAAAAGCTGAAAACGA | CTTTGATCCCTGCTTGCAGTATTTT | TGC[AT]TTGCTAAGACTTG | TGC[AT]TTGTTAAGACTTG | 0,0 |
| Ots_PGK-54 | T | A | CTCATACTTTGTACCTGTGTGTTCCA | CGACCCAAGTGGCTCATCAG | CCACCATCAAGCACTG | CCACCATCATGCACTG | 0,0 |
| Ots_pigh-105 | A | - | GCATTACTAAAAACTGGTGTGTGGAA | GCATTACTAAAAACTGGTGTGTGGAA | TGACCTGAAAATA[TC]ATATTTTT | ACCTGAAAATA[TC]ATTTTTTT | 0,0 |
| Ots_pop5-96 | T | C | CTCTTGCTACTTGCAGTGTATCTCA | AGTTTGAGGGCTCTATTCTGTCATG | TTCTGTTACTGGACTGATG | CTGTTACTGGGCTGATG | 0,0 |
| Ots_ppie-245 | C | A | TGTTTTTGGTCATGTATTTTCTCTGCTATTTTT | GGACTGGAGCTGCTGAACATA | ATGTCTGAAATGAAAGCC | AATGTCTGAAATTAAAGCC | 0,0 |
| Ots_Prl2 | A | G | CCTGGTCTGTTTGTGATCAAGATG | GGTTAACTCAAATAGAACATACTCTGACACA | ATGTATTGTTCATTTAATG | TGTATTGTTCGTTTAATG | 0,0 |
| Ots_RAD4543-52 | T | C | TCTTTGGACTGTGTATACCAGGTGTA | GCCAGATGCTGTGTGTGTTT | TACATATGACTAATGAAA | TACATACGACTAATGAAA | 0,0 |
| Ots_RAG3 | C | T | CATTTCCACGAAAAGCCAGATGAC | ACAGAATAAAGTATCTTCCTCTTACATCACTACTAAT | CTCTACAGTATGAACTATG | CTCTACAATATGAACTATG | 0,0 |
| Ots_RAS1 | C | T | TCATAAACATGGTGTCTTTCAGTCAGTT | CTGACATGTGAAACTACTAAAGCATTTAATCAC | CAATCTATCATCGACCAGC | CAATCTATCATCAACCAGC | 0,0 |
| Ots_redd1-187 | A | G | TTCTGGGTTGCCATACTCTTTCAAT | AGTTGAGACCTTCAGTTCTTAGGGTAT | ATTCTGACAGCTGTTTTG | CTGACAGCCGTTTTG | 0,0 |
| Ots_RFC2-558 | A | - | AAGGTCTACTCCGGTTGTATTCGGT | CAATACGACAGTACCGGTGTTAAACT | TGCATGTAACAAATAACAT | TGCATGTAACATAACAT | 0,0 |
| Ots_S7-1 | T | C | TGCCATCATAAACAACCTAACAAGTAACT | CCTGGTTTAAAAACGGCCAACTG | TACAGGAGATAAGGTCGCA | CAGGAGATAGGGTCGCA | 0,0 |
| Ots_SClkF2R2-135 | A | T | CCAAATACAGACCAGCTACTTGTGT | CTTCAAGTCCCTGAATAATGGTACGT | ATTCAAAGTCAAATTTT | ATTCAAAGTCTAATTTT | 0,0 |
| Ots_sept9-78 | G | A | GTCGATTACCGTTAGCTTCATCCT | ATTTCTCCTGTGTCTCTCTCTGTCT | CTCTTCGATGTCTAGACA | CTCTTCAATGTCTAGACA | 0,0 |
| Ots_SERPC1-209 | A | T | CTAAGTTCTTCCTGCCTAATGTGGAT | CCAAGATTGAGACTTACTATACATTTACAAGTACA | CATTCAGCTTTTTTTC | ATTCAGCATTTTTTC | 0,0 |
| Ots_SL | A | G | AATATTGGCTTTCTGAGAATGCATTTGG | CCAAGATACTTCCTTTAACTTCTCTGTCA | TCAAAGATATGATTCAATTAA | AAGATATGGTTCAATTAA | 0,0 |
| Ots_slc7a2-71 | G | T | CCATTCCCATCGGCATCGT | GCAGCAGACACACCGAAGTA | GTCTCTGACGGTGTGCTTTC | GTCTCTGACTGTGTGCTTTC | 0,0 |
| Ots_stk6-516 | C | A | TGTGTTTAGGATTGAACTGACCATGTT | GTAAACTCCACCTGCAAGAAGGA | AACATAACGGACTCCC | TAGAACATAACTGACTCCC | 0,0 |
| Ots_SWS1op-182 | T | A | TCAAAGACATCGAACACAAGAACGA | GCAGGTAAATTCAAACGTCATCATAAGAA | ATGTACTTTAACGATTCATTT | ATGTACTTTAACGTTTCATTT | 0,0 |
| Ots_TAPBP | C | T | TTTCTCATCCTTCTCTCTTCCAGTCT | GGACAAACCAGCACTCCAGAA | CAGCTGTCCAGTTCTG | CAGTTGTCCAGTTCTG | 0,0 |
| Ots_TCTA-58 | C | T | ACCAGTACCTAAACGTTAGAAAGCAA | CGTTAGTTAGCTATGTCTGAAAGGCA | CTGCCATGAAGTGCTAG | TGCCATGAAATGCTAG | 0,0 |
| Ots_TGFB | C | T | GCCTCACATTTTACTGATGTCACTTC | GAGCAGATCTCTTCAGTAGTGGTTT | AGCCTAGCTCTCGGAAG | AGCCTAGTTCTCGGAAG | 0,0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ots_Thio | T | C | TTTTAAAAATGGAGATAAACTCCTGACCTGAA | AATACCAAACCATGCCACTAATACCT | CAGTGTATTAGTCATTCTTA | CAGTGTATTAGTCGTTCTTA | 0,0 |
| Ots_TLR3 | C | T | TGCACCTGCGAGAGCAT | CTGGCGTTTGTTCCGTTCAG | CTGTGGTTTGTGGCGTG | CTGTGGTTTGTAGCGTG | 0,0 |
| Ots_TNF | C | T | CCAAATCCTCATCCCACACACT | CCGTTGCACTTGACCCTAAAC | CTGGCTGTAAACGAAGA | TGGCTGTAAACAAAGA | 2,0 |
| Ots_Tnsf | A | G | GCCAATACGGGTTCTGAACTGT | CGGAATAGTCATAGTAGGGCTCGTT | TGCTCCAGATCTC | TGCTCCAGGTCTC | 0,0 |
| Ots_tpx2-125 | C | T | TGTTGTAATCTTTCTGAATATTTGCTTGCTT | TCTTCCAAATTGAGCACAAAAGCAT | CAGGCGGTTCTCC | CAGGCAGTTCTCC | 0,0 |
| Ots_trnau1ap-86 | G | T | GGACAAGTTGAAACAGATCAGGAAGT | GCCACTGGATACCATCACTTCAAA | AATCCCTCCTTTTTCC | TCCCTCATTTTTCC | 0,0 |
| Ots_txnip-321 | T | C | CCTTCAAACTAACACATCATAGACATGCTT | TTATCAAACTGAAGGCGGATTTACTGA | TCTGGCGGATTTACA | CTGGCGGGTTTACA | 0,0 |
| Ots_u07-07.161 | C | T | GTCAACAAATGCAGGTAACATAAATGGT | GATGCAAACACCTGTGAAATTGTGA | ATCAGTGACATAAGTTGTCCA | TCAGTGACATAAATTGTCCA | 0,0 |
| Ots_u07-17.135 | A | G | CTCGCCTCTGTCATTGTATTACCTT | TGACACACGAGCCATTTTGATGAT | AAAATGTACCACATACTTGT | AAATGTACCACATACTCGT | 0,0 |
| Ots_u07-17.373 | A | - | TTGCCCATTCACCATCGGAAT | TTGCCCATTCACCATCGGAAT | ACACATACACATTTGAATG | CACATACACATTGAATG | 0,0 |
| Ots_u07-18.378 | A | T | GGAAACCAGCTAGGATTCAGGAA | CGTTATATGGTTTGCTTGTTTGCGATA | ATATGGTATGTAGAGGCTAGTTA | TATGTAGAGGCAAGTTA | 0,0 |
| Ots_u07-19.260 | C | T | GGATGTAGAGTGAAATCACCTTCGA | GCAGACTGACTGGTTTAGTTTAACG | CTTTAGACTGGTGGACTC | CTTTAGACTAGTGGACTC | 0,0 |
| Ots_u07-20.332 | A | C | CGCGAGTTAGCTCGAATATTATGATTTC | TCAAGCTAGCATAGCAACTTCATCAA | ACCATTTGATATAACTGCGTTAG | CATTTGATATAACGGCGTTAG | 0,0 |
| Ots_u07-25.325 | T | C | AGACAATCATGGTGTTTTGAGTCTTTCT | GCCTAGGCTTGATGGAGTCA | CCGCTTGAAAGTTTGA | CGCTTGAAGGTTTGA | 0,0 |
| Ots_u07-49.290 | G | A | GCTGAGGAAGGATTCTGTATTTGCT | TCGGACAGAGCGCATCC | CTTTCCCCGTGTTGGT | ACTTTCCCTGTGTTGGT | 0,0 |
| Ots_u07-53.133 | C | T | AGCTAGGCTGTAAATGCAAGGAT | CAGTGCTTTCAATTCATGCTGTCAA | TAACACATGTTGGAGGTC | AACACATGTTAGAGGTC | 0,0 |
| Ots_u07-57.120 | A | T | GGTTTGAGCCAATCAGTTGTGTT | CGGTCTAATGTCCATTGCTCATGTT | GTGACAAGGTAGGGGTTG | GTGACATGGTAGGGGTTG | 0,0 |
| Ots_u07-64.221 | G | C | GAGGATGACACTGTCCGTTTGT | CACAGTCCTTCGTATTCACCTTGAT | ATCGACCCTGTCATTAG | CGACCCTGTGATTAG | 0,0 |
| Ots_u1002-75 | T | C | CCGCCTTTCCCACCTTCTC | TCAAACGAGAACACACTAAGGTTGT | ATGGCCCTTACACTATC | TGGCCCTTACGCTATC | 0,0 |
| Ots_u1004-117 | C | T | GGGACCACATAGAAAACATCTGTCT | GGTGACAGTGACTGTTTCATTGG | AGCCATGGTGGATTT | CAGCCATAGTGGATTT | 0,0 |
| Ots_u1006-171 | C | T | GGCAGGTAAGTGGAACGTTTTAGAT | CTCGCAAATATTTTTTTTGTTCTTGGTTCA | CAGGAATATACTAATGATATAAA | TCAGGAATATACTAATAATATAAA | 0,0 |
| Ots_u1007-124 | A | G | CGAAATAAGGGCCTGGTGTTTAAAA | TGTACCAGGTGGAAGCTTTGG | TGTCCTGTCCTCAGATCA | TCCTGTCCCCAGATCA | 0,0 |
| Ots_u1008-108 | T | A | GGATGACTCCTACTAATAGACGGATGT | AGGACAGGAAAGAAGCAGCAAATA | TTGGTAAACCTGTTTATTGGTA | TGGTAAACCTGTTTTTTGGTA | 0,0 |
| Ots_u202-161 | T | A | CACTTTTGACTTTACATGGAACTTAACTCAT | GGGACTTCACTTTCTACAAACATGTCA | AGCTAGTGCTTAGCAGCTA[AC] | AGCTAGTGCATAGCAGCTA[AC] | 1.5,0 |
| Ots_u211-85 | C | T | TGGTGAGAGCAGCTTTAAATGTCTT | ACCCATTCTTCTGTCTGGTTTAAGC | TCCCAAAGTCGAGTGTG | CCCAAAGTCAAGTGTG | 0,0 |
| Ots_U212-158 | G | A | CCCCATATGAGACGCTACAGTAATG | CAAATGCCCTCTAAGCAGACCTT | CTGGAAGAAGGCCTC | CTGGAAAAAGGCCTC | 1.5,0 |
| Ots_U2305-63 | T | - | CCAGGTCGTCTTTATTGCAGATTATCA | TGTCATCTCTATTGCAATCTCAGTAGATTTCTAT | AATGTCATATAGAAATCTAC | AATGTCATAGAAATCTACTG | 2,0 |
| Ots_U2362-227 | A | T | TCGTGGATTGTGGCTTACGT | GGGTGTTTAACAAGTAGTCCCTTCA | AAGAAGCATTTTTT[GT][GT] | AAGAAGCATTTATTTT | 0,0 |
| Ots_U2362-330 | A | G | AATGGGTAACAAAGAAATAGCTAGCTACTT | GACAGACCACAGTGAAGGTGAAA | ACTGGGAAGATTGTTTG | CTGGGAAGACTGTTTG | 0,0 |
| Ots_U2446-123 | C | A | CTGGTCTGTGACGTCAAAATGATG | AGCTAGACCAGGCCATTTGAG | CTGCAACTCGACGCAAG | ACTGCAACTCTACGCAAG | 0,0 |
| Ots_U2567-104 | G | A | CATAGTATAGTGATTCGAGTCTGGAGTCT | CGGGCTTTCTTAGGATATTTTCCTGA | GAGACTGTTGAGAC | GAGACTATTGAGAC | 0,0 |
| Ots_u4-92 | T | C | ATCCAAGGAGCCCCATTAAAGATTT | CGTACCAGAGTTGTAGAAGCATCT | CTGTGTTGAATTTAACATAAT | TCTGTGTTGAATTTAACGTAAT | 0,0 |
| Ots_U5049-250 | G | T | CAATGTCTAAAGTAATGGTGGTATTCTTGC | TCTTTGACACACCATCTGCCAATT | TGGAATGGGTAAGGTGTA | TGGAATGTGTAAGGTGTA | 0,0 |
| Ots_U5121-34 | A | G | CCAGAGGTTAGATGGCCCTTT | CTGAGCCAGAACCACAAATTGAATT | AGGGTCTCATGCTCCCT | AGGGTCTCGTGCTCCCT | 0,0 |
| Ots_u6-75 | C | T | GAAAAAGTAAAGTAAAAGTAAAGTATTATACCACTAAAGACAAT | GATCCACACTGTTGGTCTACTACAA | TTAGTCAACTGTTGTTTTT | TTAGTCAACTGTTATTTTT | 0,0 |
| Ots_unk1104-38 | C | T | TAACCATGACTTCTATCAATCACCCC | CCTCCATACATCGTCAAAGCTGTA | CCACTAAGGATTACGTTACG | CACTAAGGATTACATTACG | 0,0 |
| Ots_unk1832-39 | C | T | GAAACGTCTATGCTGTCCCCTTTAA | CTGCAGTATTAGCTCTAGTTGAATCCA | CACCACTAGAACTCTC | CACCACTAAAACTCTC | 0,0 |
| Ots_unk3513-49 | C | T | TTTGAGTGAGTCACTGCACCAA | CAGCTCCACAGTGTCACCAT | AGTGCGAAGAACC | AGTGCAAAGAACC | 0,0 |
| Ots_unk526 | A | G | TCAAGACTGTGCTGTAGTTGTCTAC | CCTCCCCCTTTTCCACATCAG | CAACATTCCAGTCTGAAAC | CATTCCAGCCTGAAAC | 0,0 |
| Ots_unk7936-50 | C | G | ATGGGTTGGGATTATGGTTCATTGT | CAAAATGGTTACTTGCATAGTCTTTTGT | AGACATGTAGCTATGTAGGTAA | AGACATGTAGCTATCTAGGTAA | 0,0 |
| Ots_unk9480-51 | G | C | CAAATCAGAACAAAACCTCCCACAA | GGAAGTCTGTCTGAATGGTTGTCTT | CTCCCACAAACCC | TCCCAGAAACCC | 0,0 |
| Ots_USMG5-67 | C | T | GGGCAATGGTGGCTATGCT | CGTATGTTGTTCTGTCCACAGTGT | TCTTGCTCACGTATGCA | CTTGCTCACATATGCA | 0,0 |
| Ots_vatf-251 | G | - | CTTTTCGGGTTATTCATGCTGTTGT | GCAAGCATTTGAAAAACAGACTGGAT | AGACCACAAGATACAGTACC | AGACCACAAGATAGTACC | 0,0 |
| Ots_zn593-346 | A | T | CTACGCGAGAAATAACACTTTTCAAAACT | GGCGAGTTTATTACGGTGTTATGAC | TCTTGCAATCATTTTTAAC | CTTGCAATCATATTTAAC | 0,0 |
| Ots_zP3b-215 | G | T | TGCTGAGGACCATCTGCAATTC | AGGTCCATGAATAACTGAAAATGTACAAGT | CCAAATATCCTACCCGTGATG | CAAATATCCTACCAGTGATG | 0,0 |
| Ots_ZR-575 | G | A | GCCTACCAGAAAGTACCAATTGTGA | ACTTTTCACTGTCCTATTACAATTAGTATTTGTGATAT | CC[GA]ACACAATTTTGT | CC[GA]ACATAATTTTGT | 0,0 |
| Ots_SEXY3-1 | X | Y | GGTCTTGCAGTCAGGAGAGG | CCAGGTGGTGAAGGTAGGAA | NA | TCAGCGAAGTGGAGAT | NA |

***O. kisutch* GT-seq panel (258 loci)**

| Assay: | A1: | A2: | FWD: | REV: | A1-Probe: | A2-Probe: | Allele Corrections: |
|---|---|---|---|---|---|---|---|
| Oki_100771-83 | C | T | ACAAAAGGTTTAAAGCCGTGTTCA | TTCGGAATGAATACACCCCTG | ACCAGAGCCAGGGG | ACCAGAGTCAGGGG | 0,0 |
| Oki_100884-210 | C | A | CGGCCAACACGCAATCTTAT | TGGAGAATCTGGTCTTCCGC | GC.TGTCCCGATGT | GC.TGTCACGATGT | 0,0 |
| Oki_100974-293 | T | G | TGGTGGTTATGTGAACGGGG | TTACCCGCCTCCACAAAGTC | GAAAAATTTGACTT | GAAAAATGTGACTT | 0,0 |
| Oki_101419-103 | C | A | CCCAATTGGAGACCAGGGTT | TCATTCAGACAGTTGGGAGACA | CTACTTGCCTGTCT | CTACTTGACTGTCT | 0,0 |
| Oki_101770-525 | C | A | GCACTCCTCTGCACTCTGTT | ACAGGGCCCTCTTCCTTAGT | ATTAAGTCATGTGT | ATTAAGTAATGTGT | 0,0 |
| Oki_102195-92 | A | G | ACACTTGATTACCACTGCGT | TGCACTGTTGACAATGTGCA | AAACATGAGGAAAA | AAACATGGGGAAAA | 0,0 |
| Oki_102213-604 | C | T | CTGTGTCGTAACAGGTAAGGA | ACACAGCAGGTAAGGAGAAGT | AGGAAAGCATTTTC | AGGAAAGTATTTTC | 0,0 |
| Oki_102267-166 | A | T | GACAGCCACGCAACAAGTTT | AAGTAACTTGTGCTAGCGGC | ATGTGGAAGCCGCT | ATGTGGATGCCGCT | 0,0 |
| Oki_102457-67 | C | A | TTCAAAGTGGCCAATGCTTG | GGAGGCCCTACCAAGACATT | AAAGGTTCAAGTAA | AAAGGTTAAAGTAA | 0,0 |
| Oki_102801-511 | C | T | GCTCCTGGGGCTTTTCGTTA | TCGCTGTCAGGGTACTCTGT | GACGCCCCTGGGTG | GACGCCCTTGGGTG | 0,0 |
| Oki_103271-161 | A | G | AGACAACTAAGCAACCTCTGAGA | TCATCCAGCGCTTGCAAATG | AGTTATGACAGATT | AGTTATGGCAGATT | 0,0 |
| Oki_103577-70 | A | T | AGCGAGAGGGCCTACAGTTA | CACATGAAGAATTTCCCTCCACA | ATGTGAAATGTGGA | ATGTGAATTGTGGA | 0,0 |
| Oki_103713-182 | A | G | CACCAAGGCAGAGAGCTCTC | TTGTGGCACCAATCTACTGT | TGAAATGAAGATAC | TGAAATGGAGATAC | 0,0 |
| Oki_104515-99 | T | G | TCCAGCCAGTCCATTCAGAC | AGCTGAAAGTGAACGAATTACGC | CAGACTTTGGGCTG | CAGACTTGGGGCTG | 0,0 |
| Oki_104519-45 | C | T | TGAGAAAGAGGTGTGAGCGA | CCCAAATAGGAGGGGCTGTG | TTGATGACGCCGCT | TTGATGATGCCGCT | 0,0 |
| Oki_105105-245 | T | G | GCGTATCAAGCATCAACGCC | TCTTTCAGCAAGGTTGGGCA | ATGTAACTCTCAAA | ATGTAACGCTCAAA | 0,0 |
| Oki_105115-49 | T | G | TCGGGTAACACTTTCGTAGCT | GCGTTGAGGTGACATGTAGC | CTTTAAGTTATTTC | CTTTAAGGTATTTC | 0,0 |
| Oki_105132-169 | C | T | TGCCCTGAACCACATGTCAA | TGGAATAAAAACCTGCAGACACTG | CACGATGCACTGAG | CACGATGTACTGAG | 0,0 |
| Oki_105407-161 | C | T | GCAGCAGCTCACAGCCTT | TGTCCTGACAGCCTATAGGAT | CAGCCTTCGTTTGT | CAGCCTTTGTTTGT | 0,2 |
| Oki_106172-60 | C | T | ACTACTTGGCGTGTGTGTGG | TCCACTGAGAGGATGAGGCA | AACCCTCCATCGTG | AACCCTCTATCGTG | 0,0 |
| Oki_106313-353 | A | G | TCCCCATTACAATATGTCCCTGAC | TGAGTTTTCCAAACCCTGTGTG | ACTTACCAACTGTT | ACTTACCGACTGTT | 0,0 |
| Oki_106419-292 | T | G | TGCATCTGTAAGTAGCTCTGGA | AGTCTACCATTCTACAAGTTCCTT | CTAAAACTGAAAGG | CTAAAACGGAAAGG | 0,0 |
| Oki_106479-278 | A | G | CCCTCTAGGTCTTTAGCAAACACT | TCAGTCATTTGTTTACGTGCTGT | ACTACACAGATGCA | ACTACACGGATGCA | 0,0 |
| Oki_106747-503 | C | A | GTTAACATGGGAGGGCGACA | GCCTGCAAGACGATCCATCA | GACAGCACCAAA.G | GACAGCAACAAA.G | 0,0 |
| Oki_107031-314 | A | T | AAAAACAGCCAGCGAAGGGA | TGTCCTCAGCTACACACGAG | TTTTTGTATTTACT | TTTTTGTTTTTACT | 0,1.8 |
| Oki_107607-213 | A | G | TGCGTTGCACCTGATCTAGA | AGGTAAACCGCGTTCCATGT | CTACATCACTGGAG | CTACATCGCTGGAG | 0,0 |
| Oki_107974-46 | A | G | AACTGGCAGACCTCGAACTG | TCATTGACATCTACGGCGCG | CTGCGCCACTGGTG | CTGCGCCGCTGGTG | 0,0 |
| Oki_109525-359 | A | G | CTTCCAGACATCACGCCTCA | TGAGCAGCAAGTCCTACACC | CATTGGTAAGTTGT | CATTGGTGAGTTGT | 0,0 |
| Oki_109651-152 | A | T | GGCTGTTGTCATATCATCCCG | GTCTACACACAGCCCAGGTT | TTTTTTTAAAGCTA | TTTTTTTTAAGCTA | 0,0 |
| Oki_109894-418 | C | A | GGAGGTACCAGGTGAGCTCA | GACCAGACCATAGACATTGCCT | CTGGTTGCTTGAAC | CTGGTTGATTGAAC | 0,0 |
| Oki_110064-418 | A | G | ACGTAGCCTTTTAGGGATTAGCT | TGGTTTGCTTTGCACTCTTAACA | TTAGCTAAGTCCCT | TTAGCTAGGTCCCT | 0,0 |
| Oki_110078-191 | T | G | ACACACACACTCGCTCTAGC | ACAGTGTTCTGAAAGGGCCA | TACACTCTAATGTC | TACACTCGAATGTC | 0,0 |
| Oki_110381-77 | A | G | TGAAACGTCCCCAACTTCCC | ACCTCATGGACGATGCCATC | GGGTTTAAGATACG | GGGTTTAGGATACG | 0,2 |
| Oki_111312-141 | C | A | GGGAGGGCTAAAAATACAGACCA | CTGGGGTCCTATTGCTACTGT | AAAAAATCATAAAA | AAAAAATAATAAAA | 0,0 |
| Oki_111681-407 | A | T | TTCATCCCATTGGAAGCCCC | ACAGCCTATATCTGTGCGCT | ACTGCAAAAGCGCA | ACTGCAATAGCGCA | 0,0 |
| Oki_113457-324 | A | G | TTACTGAGGTGGTCCAGGCT | ACCAGCAACTCTTTCCTCCC | CTCTGTGACTCGTT | CTCTGTGGCTCGTT | 0,0 |
| Oki_113979-170 | C | T | AAGCTTCCAACCTTCAGACAA | TTGGCCATCGATGTGGGATT | CAGACAACGGAAAA | CAGACAATGGAAAA | 0,0 |
| Oki_114250-187 | T | G | GGCGATTCAGAGCAGGTCAT | TGGGAAATGTGTTGAATGTCCT | CGA.TAGTTCTTTT | CGA.TAGGTCTTTT | 0,0 |
| Oki_114448-101 | C | T | ATGTTCGATCAACCACTGCA | CCTCCTGCTGGACTAGGCTA | CACTGCACCCGTCA | CACTGCATCCGTCA | 0,0 |
| Oki_114587-309 | T | G | GTCACAAATGATCTGCAAAACACA | ACCAGGTGAGGGGTTAACCA | TTACTATTCATTTT | TTACTATGCATTTT | 0,0 |
| Oki_115987-366 | C | T | GACTGGTCGTTATGTGGGCT | CTGCTGGCCGTAGTACAGTG | GGTTCACCGAATGC | GGTTCACTGAATGC | 0,0 |
| Oki_116362-411 | A | T | GGATGCAGGTGAGGGTTGAA | AATTCCCACCTTGCCTGCTA | TTACACAAAACATT | TTACACATAACATT | 0,0 |
| Oki_117043-374 | C | T | TTCCTCTTAACCACCGCAGC | ACCAAGACTATGCAAGGCCC | AGGACACCGATAAC | AGGACACTGATAAC | 0,0 |
| Oki_117144-64 | C | T | CACATGCTCCACAGACACCT | GCCAATTGGTTGAAGGAGGG | CCTCCACCACTGAG | CCTCCACTACTGAG | 0,0 |
| Oki_117742-259 | C | T | GAGACTTCTGGTGGCGTCTG | TGCAGAACTCCACTGAGACG | GTCTGCACGTGGAC | GTCTGCATGTGGAC | 0.7,0 |
| Oki_117815-369 | C | A | GGTACAGCAAGCCTCACAGA | TGCTCTGTCTCCCACTCTGA | CAACAAACAAAGCC | CAACAAAAAAAGCC | 0,0 |
| Oki_118152-314 | A | G | ACGGTACAAACAGGCTCACA | CTCCAGAACCTGTTGTTGGGA | TTTAGCTATCTACT | TTTAGCTGTCTACT | 0,0 |
| Oki_118654-330 | C | T | TCCTTAACACTGTCCGACGC | TTGCTGACCTGGTTGAGGAC | ACACCTCCGACCAG | ACACCTCTGACCAG | 0,0 |
| Oki_120024-226 | T | G | ACCATAATTTCACAAACGAGGCC | AGCAGAGGTCGAATGAACGG | TTGATTATAGTTTC | TTGATTAGAGTTTC | 0,0 |
| Oki_120255-113 | A | G | GGGGGTAGGCTAAAACTAAATTACT | TGACTATGCCATGAAGCTACCC | AGTTACTAGGGTAG | AGTTACTGGGGTAG | 0,0 |
| Oki_121006-412 | C | A | AGGCAGAGGACAGTGACTCT | TGCAGTACTCCAAGGGTTGA | CAAAAACCTCAACC | CAAAAACATCAACC | 0,0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Oki_122138-111 | T | G | ACATGACTAGTTCTGTTCAAGCCA | TCTAGGGCCTCCTGTGTCAT | AATTACATCCATAG | AATTACAGCCATAG | 0,0 |
| Oki_122593-430 | A | G | TCTGGGTAAAGTGTGCCTTTT | TCGATTCCAGGGTCTCAAAAGA | TCTCACCAGTCTTT | TCTCACCGGTCTTT | 0,0 |
| Oki_123044-68 | C | A | ACTGCCATATCAGTATTGGGGG | TGCTATGTTAACTAAACCGGAATCA | TT.AAAACGTTTTT | TT.AAAAAGTTTTT | 0,0 |
| Oki_123921-90 | A | G | GGCGACGGAGATGAAGGTAT | CCAAGCCCTGAACCTTAGGG | ATTGTAAATTATCT | ATTGTAAGTTATCT | 0,0 |
| Oki_124162-62 | A | T | GAACTGCCAGGTGTCAGGTG | ACCTTTTTGTGCACTTTACATGT | AGCAAAAATATAAA | AGCAAAATTATAAA | 0,0 |
| Oki_125998-340 | T | G | CGCAGGTCTTCTTCTAAGCAG | TCACTTTTATTCGTACAGGCCCT | AACATACTGAGGGC | AACATACGGAGGGC | 0,0 |
| Oki_126160-142 | CT | TG | TGCTCACCAACACCTGTTTG | TCCGGTCACTCCCTTGTACA | TTTGATCCTAAAT | TTTGATCTGAAAT | 0,0 |
| Oki_126619-265 | T | G | TGCGTAGTTAATTTTCACCTCGG | TACGCAGCACTGAAGACTGG | CGGATTGTGCACAC | CGGATTGGGCACAC | 0,2 |
| Oki_127645-235 | C | A | TTGGTTGGATCTGGTGCCTC | GCTACTTGTATGAACTTTGATCGCT | GTGGCCTAAAAA | GTGGCATAAAAA | 0,0 |
| Oki_128302-547 | A | G | AGCTGGAGGGGATTCACTGA | GGGATAAGAGGGTTTACAGTAAAGT | AACAAATAGGGATG | AACAAATGGGGATG | 0,0 |
| Oki_128693-70 | C | A | AGAGGTCAGGGGTCAAGAGG | CATGTCCCCACCAAACTGGA | AGAATTACATTTTC | AGAATTAAATTTTC | 0,0 |
| Oki_128757-232 | A | T | TCAAAACGTTATTGTACGATGACCT | GACCGGGTGCAACACAAAAA | TTTGGGAAAGCTTT | TTTGGGATAGCTTT | 0,0 |
| Oki_128851-185 | A | G | CTCCAGTCTCCCAGTTTACACA | GGCCCTCTCCTGGAGAAAAC | TAACCAGACTCCCT | TAACCAGGCTCCCT | 0,0 |
| Oki_129870-552 | A | G | AGGGAGACAGGCTGACATCA | AGGAACAGAAATGTTGCGTCA | TGCTATTATGTTTT | TGCTATTGTGTTTT | 0,0 |
| Oki_130113-304 | T | G | GGGAGAGTGTTGGAATCCCC | CTTGTTCAGGGGCAGAACGA | TACAAATTTATCGT | TACAAATGTATCGT | 0,0 |
| Oki_130295-48 | A | G | TGAGCACAAATATAAATGTGGCTGT | AGAAAAATATTCTGTGGTCCCCT | AAGCAATAAACAGT | AAGCAATGAACAGT | 0,0 |
| Oki_130524-184 | C | T | CGATTGGTCGTTGGCATGAC | TGCTCTGCTGTGTGCTTACA | CAGGAAGCTGACTC | CAGGAAGTTGACTC | 0,0 |
| Oki_131147-353 | T | G | GGCCTTTGTCAAAAGTAGTGCA | CCAGTCTCTTTGCGTCCCAA | AAAA.ATTTTTGGG | AAAA.ATGTTTGGG | 0,0 |
| Oki_131460-243 | C | A | GGAACAATCGAGCAAGGAGC | GCTTGGCCATGATAACCTCA | TTTCCTTCTACATC | TTTCCTTATACATC | 0,0 |
| Oki_131906-261 | C | A | TGTGGTGCTTCTGTGCTGTT | CCAAAGAACTGCAGCAGCTG | TTTGTTCCAAAGGG | TTTGTTCAAAAGGG | 0,0 |
| Oki_94903-192 | A | T | TCCAAACCGCATCGTAAAAGT | CCGACATATGTGAATGCGAGA | AATTTAAAGTCAAT | AATTTAATGTCAAT | 0,0 |
| Oki_95318-100 | C | T | CGCCTGCACTAAATATGTAGACA | GGGTGAAGTGCCCCTTTAAC | TTGAAGGCTGTTAA | TTGAAGGTTGTTAA | 0,0 |
| Oki_96158-278 | A | G | CCACCTCGATCTCCTTTCGG | ACTGTCCAGTTTGTGACGGG | CTATTGTAGGGTCG | CTATTGTGGGGTCG | 0,0 |
| Oki_96376-63 | A | T | CTGCTACGTGTTTGACAGTGA | TGTGGAACATGAACTCAAAACGT | GAGAGTTAAAAAAA | GAGAGTTTAAAAAA | 0,0 |
| Oki_97660-149 | T | G | CACTGGTCCGGTCCAAATGA | CTGTTACTCCCCAACCCTGT | GGTTACATACAGGG | GGTTACAGACAGGG | 0,0 |
| Oki_98188-150 | C | T | CGACGAGGAGGCCTTTGAG | CCTTGTGGGTGACAGGACAG | CCCAGCCCCC.ACC | CCCAGCCTCC.ACC | 0,0 |
| Oki_99550-284 | T | G | AGAGGTTGCAATTGTAAGTCTTGT | CTCACAGTGAGGGATCTCTTCT | TGTTTCTTTT.TTT | TGTTTCTGTT.TTT | 0,0 |
| Oki_RAD100310-36 | T | C | TGCAGGACTTGTTTGGTTTACTG | TGGGAGAGAAAGGTATGTCTGT | TAAAAATGCCGAGC | TAAAAACGCCGAGC | 0,0 |
| Oki_RAD100331-48 | G | A | CGCCACCCAAATAACCCAGA | TTCCCAGGCAGTTCTGAGAC | CAGACCGCGTCTCA | CAGACCACGTCTCA | 0,0 |
| Oki_RAD100388-66 | A | G | CGATTTGTTGAGGGGCCCTA | AATATTCCCTCCAGGCACGC | AAACAGATAGTACC | AAACAGGTAGTACC | 0,0 |
| Oki_RAD100479-50 | G | A | GGTCTTTTCCACACTGCTGC | TCCAGAGAAAGGGCTCATCC | ATGGACGTGTTTTT | ATGGACATGTTTTT | 0,0 |
| Oki_RAD100507-58 | T | G | TGCAGGCGTGTATAGTGGAG | CAGCTGGTCCACTGTCTATCA | TTCTCTTACAAGCT | TTCTCTGACAAGCT | 0,0 |
| Oki_RAD101032-66 | C | T | TTGCACCATCTGGAGACTGG | CCCCACTACACCAATCGAAGA | TATGCGCTGATTTA | TATGCGTTGATTTA | 0,0 |
| Oki_RAD101136-60 | A | G | TGCAGGCCTCAATGCTCAAA | TGGTCACTTGTAACTTGTAGCTGT | ACTGACAGTCTAAA | ACTGACGGTCTAAA | 0,0 |
| Oki_RAD101478-57 | C | T | AGAGCATATGGCCACGTCTG | GCTCTCTCTCGCCCACAAC | AACCACCATTAACC | AACCACTATTAACC | 0,0 |
| Oki_RAD101607-49 | C | T | CCGGGGCTTTCAGAGAGATG | TGTTTTCCCCCTTTTGCCCT | GAGATGCGTCCGTG | GAGATGTGTCCGTG | 0,0 |
| Oki_RAD104180-61 | G | T | ATATAGGCTGGGAGGGGAGG | ACAGCTGTGACTTGAACCACA | AAAATGGCAGGATG | AAAATGTCAGGATG | 1.7,0 |
| Oki_RAD104335-44 | T | C | GTAGTGCAAAGCTGAACGCC | TCACTTTGTCCGGTTCCTGG | CCGCTGTGAGGGGA | CCGCTGCGAGGGGA | 0,0 |
| Oki_RAD104946-41 | C | T | CATGTGGCTGTAGTGGAGGG | GCCCCTGAATGACAGCTCAG | GAGGGGCGCCCTGG | GAGGGGTGCCCTGG | 0,0 |
| Oki_RAD106191-62 | T | C | TGAGATCGAGCTTGCTGTGG | CCCTCCCGAGCCTCAAAATA | GAGAAGTGATCACC | GAGAAGCGATCACC | 0,0 |
| Oki_RAD106666-44 | T | C | ACGCCAGTCTGATTGGAGTC | CGGTTTTGATTTACCTGGCCG | CGGCTATACACAGG | CGGCTACACACAGG | 0,0 |
| Oki_RAD109528-59 | T | A | GGCCTCAAAGAGAAAGAGCA | GGAACTCTGGAGAAGGTAAAGAA | ATTATGTTATTTTC | ATTATGATATTTTC | 0,0 |
| Oki_RAD111744-32 | A | T | CTTTGACAGACAGGGTGGGG | CCATGCTCCAGAGTCTCGAC | GGGTCGAAGGTCCG | GGGTCGTAGGTCCG | 0,0 |
| Oki_RAD115799-69 | C | G | CTGCATCGGTAGTGGTCGAT | CCAGGAGTTTGCCCTGGAAT | ATCCTGCTCCGGCA | ATCCTGGTCCGGCA | 0,0 |
| Oki_RAD11844-57 | T | G | TGCAGGTATTTCCGCTACACT | TCGCAGAAGGCCATTTTATGT | AAACACTGACATAA | AAACACGGACATAA | 0,0 |
| Oki_RAD12124-45 | A | C | TGCAGGAACTTGATGATCTGA | CCAGGATTTGGTTCATTGCTT | TCGAAAACTGTAAT | TCGAAACCTGTAAT | 0,0 |
| Oki_RAD16167-62 | C | T | GGAGTCGGCTGTCTTTGACT | GCAAACAGCATTTCGTTCGA | GCGTGTCCAACAAA | GCGTGTTCAACAAA | 0,0 |
| Oki_RAD17541-50 | G | T | CGTGCAAAGAACGTTCCCAA | GGAAAGAGAATTGTTTGGAGCGT | TCTTAAGAACGTAA | TCTTAATAACGTAA | 0,0 |
| Oki_RAD23788-32 | C | A | AGGGGGCTTAAACACAGCAT | TCTTTGAAATTGTTGCATGTTGC | TATTATCCTAAACA | TATTATACTAAACA | 0,0 |
| Oki_RAD25212-35 | G | C | TGTCTAGTTCCCAGCTTGTTCT | TGGAGAACCATCGAGCAACG | TTCTGGGACATCCC | TTCTGGCACATCCC | 0,0 |

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|---|---|---|---|---|---|---|---|
| Oki_RAD27801-45 | T | A | GCAGGTAGCGATGTGGAAGT | CCTCTTTGGTATTCTGTGCGG | CACAGCTAACCGCA | CACAGCAAACCGCA | 0,0 |
| Oki_RAD29028-42 | A | T | GTCACTCTGAAGTAGCTGCACT | AGCCACAGGAATAGAAAGCAA | ACTTCCAGGAATTA | ACTTCCTGGAATTA | 0,0 |
| Oki_RAD29136-50 | T | G | CCTTCACAAAGACAACATGACTGT | AGCAACGGAAATAGGCAAGGA | GTAAGGTTTCCTCA | GTAAGGGTTCCTCA | 0,0 |
| Oki_RAD34432-38 | T | G | TGCAGGATTTTGTGGAGAGGA | TCATCGGTCTACCTGACGGT | TGTGAATAGATGGC | TGTGAAGAGATGGC | 0,0 |
| Oki_RAD345-59 | G | A | GACACTTCTCACTAGCGGCC | TGACTCACTACCGCTGAGGA | CAGAGGGGCTTCCT | CAGAGGAGCTTCCT | 0,0 |
| Oki_RAD35219-62 | T | C | ACCGAACGGAGGTGAGGATA | TCAGCCACAGTCTTGGTGTG | AGGATATGGCTCAT | AGGATACGGCTCAT | 0,0 |
| Oki_RAD35990-63 | A | C | TCAAGACATACAACAAAAAGTGGT | CACAGTTAAAGACCCATTGCGG | CTCAAGAGGGGTAA | CTCAAGCGGGGTAA | 0,0 |
| Oki_RAD36669-48 | A | G | GGTCCTCCTGTCCTCTTCCT | AGAGGGCAAGCAGTCAGTTC | CTTCCTATCAGTGT | CTTCCTGTCAGTGT | 0,0 |
| Oki_RAD37278-54 | T | C | AGCGTGGTGTAACTTCAGAGG | CTCAAGTTAGGATTCAGCCCCA | TTTTGGTGATTTGG | TTTTGGCGATTTGG | 0,0 |
| Oki_RAD37493-51 | G | A | ACGCATCACAGTGAGACCAG | AAAGTAACCGCCTCACCGAG | CCAGCCGGGAACAC | CCAGCCAGGAACAC | 0,0 |
| Oki_RAD37537-45 | T | C | AGTCCACTTGTAACACCATGT | TCCACCCATTACCACGAACC | ATGTACTCACAGTA | ATGTACCCACAGTA | 0,0 |
| Oki_RAD37698-60 | T | G | TGCTGAGGTCTTTTCTGTTGC | TCTCTCTTGGATAAGGTGAGTTTT | A[GA]TTTTTGGGAGTA | A[GA]TTTTGGGGAGTA | 0,0 |
| Oki_RAD37979-59 | G | T | GGGGTCTCTGTCATTCAAAGGA | TCACTGTGTTTTCCCAAGGAA | TATGAAGACATTCC | TATGAATACATTCC | 0,0.7 |
| Oki_RAD38077-34 | A | T | TGCAGGTCATCTATGAATGTTTGA | ATGTTAGTGGCACTGAATGAATTT | ACATTTAAAAAAGC | ACATTTTAAAAAGC | 0,0 |
| Oki_RAD40179-68 | T | C | AATGCCACCCATCTACAGCA | AGAGCAGCACATAGGGTTTGT | CTGAAGTTGACTAC | CTGAAGCTGACTAC | 0,0 |
| Oki_RAD41030-31 | T | C | GCTGAGCCTGGTCTGGG | TGGATACCCCAACTCCTCCA | GGGGCCTAGGGGCT | GGGGCCCAGGGGCT | 0,0 |
| Oki_RAD41603-39 | T | C | GCAGGATGCACAGATAACACAG | CGACCATTCCGATTAATTGGGC | GCACACTAGAGGTT | GCACACCAGAGGTT | 0,0 |
| Oki_RAD42204-39 | C | T | TGCAGGGAGAGGAGAAGGAA | AGGTTGTGCGTAAGGTACAGT | ATTCAGCACATTA[GA] | ATTCAGTACATTA[GA] | 0,0 |
| Oki_RAD43051-33 | G | A | AGGACGTTGGTAAAGCCCTG | ACCAGTTTCGGCTACATGCT | CAGCCGGCTGAGCA | CAGCCGACTGAGCA | 1.4,0 |
| Oki_RAD43627-30 | T | A | GCAGGCAGCATGTGGTTAAA | AGGACACACAGATAAGAGACAGA | CATTTTTAAAATTA | CATTTTAAAAATTA | 0,0 |
| Oki_RAD44268-51 | T | C | ACAGACAATGACCTACACTGAGT | AGTGCCTTTGAACAGGGTGT | TGAGTTTACAAAAC | TGAGTTCACAAAAC | 0,0 |
| Oki_RAD44444-52 | G | A | TGCCAGTAGGTAGCTCAGGT | AGGCCTCAAAGTGTAGCACA | TTACATGTAGGTCA | TTACATATAGGTCA | 0,0 |
| Oki_RAD45691-45 | T | G | GGGCCCGCGTTATCTGATTA | CTGATTCGGTCTGGCCTGAA | GAGTACTGCATG[TA]C | GAGTACGGCATG[TA]C | 0,0 |
| Oki_RAD45878-53 | G | T | AGGACAGATCGAGTTTCGCC | TTTCTCTCTCGCCCTCTCGA | ACAGGGGTTCGAGA | ACAGGGTTTCGAGA | 0,0 |
| Oki_RAD46160-48 | C | G | TGCAGGTGTCTGTAGCTTGG | ATTCTTGTTAGCTCGCGCAC | GTGCTACTGAATGA | GTGCTAGTGAATGA | 0,0 |
| Oki_RAD46744-47 | T | C | GCAGGCCCGATGGTATTGTT | GTTTCATGCCTTCCTGCCAG | TCGCTCTTCATACA | TCGCTCCTCATACA | 0,0 |
| Oki_RAD46974-68 | T | G | TGGAACGGTTCACCCATTTT | CACATGAATTAACCCAGGGAATCG | CATTTTTAATGTTA | CATTTTGAATGTTA | 0,0.4 |
| Oki_RAD47313-50 | G | A | TGCAGGACTCTGAGGTTACAG | ACCCAAGACAAGAGATAAACTTACC | GGCACCGTGGTAAG | GGCACCATGGTAAG | 0,0 |
| Oki_RAD49111-64 | C | A | TTACTGAACAGCCACCTCCG | TATGCATGCACAGCTGGTTG | GGGATGCTCTGGGA | GGGATGATCTGGGA | 0,0 |
| Oki_RAD49348-51 | G | A | AGCCCTCTCTACGTGTCTCA | AACAAACGCACAACATCGCT | CAAAGCGGAGCGAT | CAAAGCAGAGCGAT | 0,0 |
| Oki_RAD51428-47 | A | G | CTGCAGCCAGGGAGGTTATA | CCAGAGGAAACCCAGCAGAG | GTTATAACAGCAGT | GTTATAGCAGCAGT | 0,0 |
| Oki_RAD51585-47 | G | T | ACTTTCTAGTAGGCGTGTGGC | CAAAACCCTGGCGTTGCAAG | TCACTTGGTAGAGC | TCACTTTGTAGAGC | 0,0 |
| Oki_RAD52040-63 | G | T | CGCCCAACCAAACACTAACC | AGTGGCCTAACTTTAATTTGACACA | AAAAA[CT]GATTGTAA | AAAAA[CT]TATTGTAA | 0,0 |
| Oki_RAD52785-52 | C | A | CTAAAACACAAGCCCTGGCA | TTTAATTATCTACCTGTTCAGTGGC | GCAAC[AT]CGGCCACT | GCAAC[AT]AGGCCACT | 0,0 |
| Oki_RAD53121-66 | C | T | CTCTAAATACCCGGGTGCCC | CACATTCTTGAGACAAGCAAGGG | CATTCCCTCATTCC | CATTCCTTCATTCC | 0,0 |
| Oki_RAD53655-42 | T | C | GGTGAAGGTTTCAGAGGGGG | GCGCTCTCCGTGATCTCATT | GGGGATTTGAGAAA | GGGGATCTGAGAAA | 0,0 |
| Oki_RAD53703-50 | C | T | TGCAGGAGGACACAAACACA | CACAGCCTTAGACCACTGCA | GCCTCACGAGTGGT | GCCTCATGAGTGGT | 0,0 |
| Oki_RAD53750-45 | A | G | CAGAGGAGGGGCCGTGA | CCCTGTATCAACACGGTGCT | CGTGACAGTAGAAA | CGTGACGGTAGAAA | 0,0 |
| Oki_RAD54417-49 | G | A | GAGGACAGGGTGGGACAAAG | CTGTGACCCTATGCCAGTCC | AAATGGGGTTTCTA | AAATGGAGTTTCTA | 0,0 |
| Oki_RAD54918-40 | T | C | CAGGCCCAGCTGTGAGTAAA | ATAGGGTGCCATCTTGGACG | TCATCCTGAGGCCA | TCATCCCGAGGCCA | 0,0 |
| Oki_RAD55090-49 | C | A | ATCGCAGCACGGCTCTATG | CTCCATCTCCTTTGGGCTGG | GAGAGCCGGACGGG | GAGAGCAGGACGGG | 0,0 |
| Oki_RAD55690-46 | A | C | CCACAAGGGCACAATGAGTC | GACCAGTAGTCGCATAGGGC | GTAAAGACCCCTAA | GTAAAGCCCCCTAA | 0,0 |
| Oki_RAD56094-43 | G | T | AAGAGGTATGCCACGATCCC | AAACGAACCTCCAACCTCCA | CGCACCGTTCCTTC | CGCACCTTTCCTTC | 0,0 |
| Oki_RAD57307-33 | A | G | TGCAGGGCTTGAGTTGAGAA | ACGGGCATTGATCCAGTCAG | CTCAAGATTTTAAA | CTCAAGGTTTTAAA | 0,0 |
| Oki_RAD57826-44 | T | C | TGCAGGTGACGCTTTAGAGT | GTGCAACACCAGAGTTCGAA | TTGGCATCAGATTG | TTGGCACCAGATTG | 0,0 |
| Oki_RAD57956-47 | C | G | AGGTCATGGATGAGGCATGC | CCTTTTAGCATGGCGCATCC | CCTACTCTTTGTCA | CCTACTGTTTGTCA | 0,0 |
| Oki_RAD58310-55 | A | G | CGGCCCTCTGTTGAGTATGG | GGATATGGATTAGGGGATAGGGGA | ATCACTACTATCCC | ATCACTGCTATCCC | 0,0 |
| Oki_RAD59054-54 | A | T | TGATTGAATACCTAGTCTCCCTATG | CGCCACTCAGAAGCCCAATA | TTTTGTAAAAAAAA | TTTTGTTAAAAAAA | 0,0 |
| Oki_RAD59556-32 | T | C | GGCCATAGCAGCTGCCTG | ACCATGTCTCATAGTAGACATGCA | CATTAGTGTAATAA | CATTAGCGTAATAA | 0,0 |
| Oki_RAD59920-68 | G | A | GGCTGAATCCCCCTAGAACAC | GCCATGGTTAAAGGTTTCAAGC | ACACAGGACAT[TA]AG | ACACAGAACAT[TA]AG | 0,0 |
| Oki_RAD59945-45 | T | C | CAGGTGGATGAGAGGCTTGG | CCAAGACCAGCCCTGAGC | GCTCTCTTTGTTCC | GCTCTCCTTGTTCC | 0,0 |
| Oki_RAD60246-68 | A | C | GCAGCCCCTACCTACCATTC | GAACATCGCCAGGCATTGAA | ATTCTCACGAAGTG | ATTCTCCCGAAGTG | 0,0 |
| Oki_RAD61746-62 | C | T | TTGGGGAGAACTGTGTGTGG | CGCCCATTGCACTGTTGATC | GCTATTCGGAAAGA | GCTATTTGGAAAGA | 0,0 |
| Oki_RAD61821-61 | A | T | TGCAGGCTAAAACCAGTACTT | TGACCAGAAGACCCCTCTGT | TAAAATAAACTCAA | TAAAATTAACTCAA | 0,0 |

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|---|---|---|---|---|---|---|---|
| Oki_RAD64084-65 | C | A | AGGCAATTTTTACATAGATGGCAA | TCGCAAGATCATTATCCAGTGGT | AATATACGTTTTAG | AATATAAGTTTTAG | 0,0 |
| Oki_RAD64627-67 | T | A | GGTCCTCCTTGGTGATTGGT | GGTTACATCCTCAATGGGTCCA | AATAAATAGGCTCC | AATAAAAAGGCTCC | 0,0 |
| Oki_RAD65234-35 | T | G | TGCAGGAAGAGGTTAGAAAATAGA | ATGTATGGACTTGACAACAACAAA | CCAGATTTTTTGTT | CCAGATGTTTTGTT | 0,0 |
| Oki_RAD65388-37 | C | A | GTGGTGGTGGTCAGAGACAG | AAGCTGATTTCCTTGGCAAAAT | AAAAAACCATGTGG | AAAAAAACATGTGG | 0,0 |
| Oki_RAD65610-58 | A | T | TGCAGGCCAGTTCAGTGTTT | GGCAGTTAATCACGTGCACA | GTTATTACCTGTGC | GTTATTTCCTGTGC | 0,0 |
| Oki_RAD65902-30 | C | T | CCTTGTTCACCAGGCTTTGC | ACCGTTGACTCTGAGCTGTG | CTTTGCCGGAAAAA | CTTTGCTGGAAAAA | 0,0 |
| Oki_RAD66265-54 | C | T | TGTTGTGATTGAGTTTGGGGGA | TTTCCACCACCAAGACACCC | AGGTTCCGTCAGAT | AGGTTCTGTCAGAT | 0,0 |
| Oki_RAD66663-68 | G | A | GCCCACTGCTAAGGCCTATA | CGCCATTAGTCCAGTTTGCA | ACCACCGTAACAAT | ACCACCATAACAAT | 0,0 |
| Oki_RAD66994-58 | G | A | AAAAAGTGGGAGCAGCATCG | AAGCCTCCTCCTCACAGCTA | GGACTAGTCTGCTC | GGACTAATCTGCTC | 0,0 |
| Oki_RAD67081-48 | G | A | GGCTGTCGGTGTTTCACAAT | AGCAATTTCGATGACCATAGCT | TGATGCGGTGACAT | TGATGCAGTGACAT | 0,0 |
| Oki_RAD67114-64 | T | A | AGTCAGGTGAGACTCAAATCCT | GACAGGAGTCTACCGTGGTT | ATGATATGTACAGA | ATGATAAGTACAGA | 0,0 |
| Oki_RAD67674-60 | C | T | TGCAGGAGTAAACAACACCA | AGCACCGACTGTTGCTCAAT | ATCTTCCATTTAGG | ATCTTCTATTTAGG | 0,0 |
| Oki_RAD68033-63 | A | G | CCTGAACAAAACACATTAGGAATCA | TCTCTCCAATTCATACTGACCACT | TATCACAATGTAGG | TATCACGATGTAGG | 0,0 |
| Oki_RAD68190-55 | G | A | TGAGGGGGTTGGGAGGG | CCCCCATTAAGTCTCCCACG | GCTAGGGACGTGGG | GCTAGGAACGTGGG | 0,0 |
| Oki_RAD69161-64 | G | T | CCAGTATGAATGCATCGGTTGT | AGGAGAAGATGAAGCATCGTCA | TTGTGAGAATGATG | TTGTGATAATGATG | 0,0 |
| Oki_RAD69355-42 | G | A | GCCCTTCAGCAACATGGTTG | GGAGAAAGGTGCTGGCATCT | CACCCTGGACTCAG | CACCCTAGACTCAG | 0,0 |
| Oki_RAD70262-64 | C | A | GCAGGATAAGGCACCCTACG | CAGCACTGAATCATGCGCAG | CTTAACCCTTATCC | CTTAACACTTATCC | 0,0 |
| Oki_RAD70338-46 | G | A | GAGAAACTTTGTAGCGGGGC | TCCTTGCCCGTCCAACATTT | GGAGAAGCATTTGG | GGAGAAACATTTGG | 0,0 |
| Oki_RAD70600-60 | G | A | CTGCACCTACCACCAACAGT | ACGATAAAGTCTTGCACTCCGA | AAAAAGGGACATCG | AAAAAGAGACATCG | 0,0 |
| Oki_RAD70812-52 | A | T | TGCAGGGGTTGTTGATGTTA | AGACGACCCAGAGATTCTCA | AGTATGATAAACTA | AGTATGTTAAACTA | 0,0 |
| Oki_RAD70820-47 | A | T | TACCGACAACCTTGCCTCTC | CAGACCCCATCCCCAATCAC | ATACGGAGGTGATT | ATACGGTGGTGATT | 0,0 |
| Oki_RAD70963-47 | A | G | GGTCAGACCTGCCTTTATCTGA | CAGATCAGATGAGGCCGACA | GCAACAACTGGTTA | GCAACAGCTGGTTA | 0,0 |
| Oki_RAD71346-63 | T | C | ATGGGACTGGATTTGTCGCT | CGACTCATTTGCAACCTTGGT | AGAGGATGTTGGGC | AGAGGACGTTGGGC | 0,0 |
| Oki_RAD71442-69 | G | A | AGGGTGTGCTTCAGTATGACA | AGACAGTGCACCAACGTTGT | TGAATGGAAGTTTA | TGAATGAAAGTTTA | 0,0 |
| Oki_RAD71948-56 | A | G | AGGACCAGCTTAGCCTCTCC | CATCAGGTCGCAGGTAGGAG | TTATTGAAATCTAC | TTATTGGAATCTAC | 0,0 |
| Oki_RAD72095-45 | A | C | GGACACACAAATCACAGGGGA | GCAGCATTGCCCCTGAAGTA | AAAATAAATGGAGC | AAAATACATGGAGC | 0,0 |
| Oki_RAD72101-67 | A | G | TGCAGGTGCGAGAAACAAGA | GCAGGAGTGGTTGGAATTGC | GCTTGCACAGAGCA | GCTTGCGCAGAGCA | 0,0 |
| Oki_RAD72759-48 | A | G | CCAGGTTCAATGGTAGCTAGCT | AGGGGGTGAATACTTTCGCA | CATGAGACTGTAAC | CATGAGGCTGTAAC | 0,0 |
| Oki_RAD72979-40 | G | A | TGCAGGCTGTGTAAGGACTC | TCGGGTGATTCTGGAGGCTA | GAGAATGATGAAGT | GAGAATAATGAAGT | 0,0 |
| Oki_RAD73094-68 | A | G | AGCGCCACCAGAACTAAACA | TGCATGTACGTATGTGTGCG | AAACACATACGCAC | AAACACGTACGCAC | 0,0 |
| Oki_RAD73130-59 | T | C | TCAGCCTGGTGAGCAAACAA | TAGCAACAACCAGGAGGCAG | AATACCTCCTAACG | AATACCCCCTAACG | 0,0 |
| Oki_RAD73234-42 | T | C | TTGGGCCCAGTTATCCCTCT | TAACAGGGCTGCAACCACAA | TCTCGCTTCGCATT | TCTCGCCTCGCATT | 0,0 |
| Oki_RAD75909-38 | T | C | CCAGTCTACTTCCAGCTGGTG | AGTCCTGCTCTGAGGGGAAG | GGTGGATGTTCTGC | GGTGGACGTTCTGC | 0,0 |
| Oki_RAD75911-69 | G | T | ACTAATCAGCGGCTCACCAC | TACCCTGTTGTAGCACCCCT | GACCTTGAAGGCAA | GACCTTTAAGGCAA | 0,0 |
| Oki_RAD76218-42 | T | G | CCACAACCAGATCAGCACCA | AGCCTGTTGGAGTTGAGGTG | ACCATTTCCCCAGG | ACCATTGCCCCAGG | 0,0 |
| Oki_RAD77207-61 | A | G | GACGGTTCTGACTGTGAGGG | CCTGGGGCTTGGCATTAGAT | GGAACCATTTAGGA | GGAACCGTTTAGGA | 0,0 |
| Oki_RAD77210-64 | A | T | TGAACAGCCCTGCTCAAGAA | TGTTTTGCCATTGTGTTTCCCT | GTGCAAAGA[TC]ATTA | GTGCAATGA[TC]ATTA | 0,0 |
| Oki_RAD77803-60 | G | A | TGAATGTGTCTGCTAAGTGTCA | TCTTCTGTAGCGTCCGTTGG | TCATATGTTGTTAT | TCATATATTGTTAT | 0,0 |
| Oki_RAD77883-62 | C | G | CACCAGCGCCTCAAAATTGT | TGCATCGGCTGTGAGATTAA | TGGGGGCTCGTACA | TGGGGGGTCGTACA | 0,0 |
| Oki_RAD78112-64 | T | G | ACCCGCATCATACTTATGCA | CTGTGTCCAGGCATGTGGTA | AATAAATGCACGAG | AATAAAGGCACGAG | 0,0 |
| Oki_RAD78543-33 | A | G | CAGGGCACATCCTCTGGC | CTTTGGGAAGGAGCTGAGCA | CTCATCAGCATTCA | CTCATCGGCATTCA | 2,0 |
| Oki_RAD79761-66 | A | G | TGTGTTGGCTTTATGTAGGCT | GTCTCTCAAAATCATTGTCTGTGGT | TATTAGATTTGTAT | TATTAGGTTTGTAT | 0,0 |
| Oki_RAD80460-54 | C | T | GCAGGGTAAGCTCTACTGTCA | TTTAGCAGCCCTAGTGCCAG | AACACTCTGGCTTC | AACACTTTGGCTTC | 0,0 |
| Oki_RAD80645-70 | G | C | TGCAGGGAGGATAGACAACC | TGCTGTTATTCACCCCTCGT | GCACAGGTGACGAG | GCACAGCTGACGAG | 0,0 |
| Oki_RAD80982-68 | T | C | CAGCCTAGTGGACACCTGC | GTCCCCACCGTCTCCATAAC | GCCGGGTATCGTCG | GCCGGGCATCGTCG | 0,0 |
| Oki_RAD81387-37 | G | A | GCAGGAGTCCATGTCTACTCAG | AGTCCAATGGCTCCTGCAAT | CTATCTGACTAGTT | CTATCTAACTAGTT | 0,0 |
| Oki_RAD82856-48 | C | T | TGCACATGACCAGTACTCGC | GATCCACTGCATGCTCCAGT | CGCCTACCAGTCGA | CGCCTATCAGTCGA | 0,0 |
| Oki_RAD83766-63 | T | A | AGCAACATGACCACGTCACT | TTGTTTTGTCCGGCTCCTGT | AAAGACTGAGGAAA | AAAGACAGAGGAAA | 0,0 |
| Oki_RAD83875-36 | G | A | AGCTTGGCAAGGAAGTCTGT | GAAGTGGGCTAAACGCTCCT | TGTGATGTAGCTGC | TGTGATATAGCTGC | 0,0 |
| Oki_RAD84577-58 | T | G | CAGAGAGAAGCACAGCACCT | TGCTCTGCTTCCCTGTGTTT | ACCTACTTCTGCCA | ACCTACGTCTGCCA | 0,0 |
| Oki_RAD85448-48 | A | T | AGGCAAAGCAATGGAGTGGA | GGAGGCATCTCTTGAAATGCTG | ATGGAGATATCTAC | ATGGAGTTATCTAC | 1,0 |
| Oki_RAD85949-47 | G | A | TCAGTTAGTGGGTCTCCTCTCT | TCGTCAACAGTGCAGTAGGC | TAACACGCGTTCTA | TAACACACGTTCTA | 0,0 |
| Oki_RAD86627-60 | A | T | TCCTCCAAACACCTGCTTCG | CTTGGGTAGCAAATCAGCCA | AGCATTATCACTTT | AGCATTTTCACTTT | 0,0 |
| Oki_RAD87141-55 | T | C | ACCACCCAGTAAGGCTCCTA | TCTGTCCTCCAGACTCCTGT | AGCTCATTTCTTTT | AGCTCACTTCTTTT | 0,0 |
| Oki_RAD87310-41 | T | C | GCCCTTTTGTGTGCCATGTG | CTCCTTGGGCTCAGTGGAAG | CTCCCCTCTGCAAC | CTCCCCCCTGCAAC | 1.2,0 |

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|---|---|---|---|---|---|---|---|
| Oki_RAD87446-62 | G | A | TGTGTGAGAGAGTGTGCGTG | GGGGAGCCCTGCATTAAGG | GTGTATGCAATCCC | GTGTATACAATCCC | 0,0 |
| Oki_RAD87621-67 | T | G | TGCCCAAGGAATGACTCACC | CAGCCCTGGTTGCATCCTTA | C[CT]GCATTGCTGCTA | C[CT]GCATGGCTGCTA | 0,0 |
| Oki_RAD87777-48 | A | T | TCGTAAATAAAGCGCGCCAA | AGGCTCTAGTCTATCTTGGGT | GCCAACAAAGACTT | GCCAACTAAGACTT | 0,0 |
| Oki_RAD88551-51 | A | G | GGCTAAGGGCTACGCTAACC | TGGCTCCCGAGATTCTGAGA | GAAAGCATTTGCAT | GAAAGCGTTTGCAT | 0,0 |
| Oki_RAD89259-51 | T | G | GCAGGGTATCTGAGGCACAT | GGCAAAGAACAGCTATTATGACCA | TATTACTGAACAAT | TATTACGGAACAAT | 0,0 |
| Oki_RAD89374-40 | T | G | TGCAGGCAAGGGAAGTTTAAC | CTGGTACTTAAGCCAGCAGGT | GTACTTTCCAAGAT | GTACTTGCCAAGAT | 0,0 |
| Oki_RAD91362-68 | C | A | GCAGCAGAAGAGGCACAAGA | ACTGTAGAATTGCTAAAATCCCACA | ATGGCACATATTTT | ATGGCAAATATTTT | 0,0 |
| Oki_RAD91430-44 | A | G | TGCGAGGCCCTTCAATGTTA | AGTCTCACAACCCCCTCTCT | GCTGCTACAAATGG | GCTGCTGCAAATGG | 0,0 |
| Oki_RAD91470-66 | C | A | GGACCTGAACAAGTGGAGCT | TGCAATGCATGGAACTCCTCA | AGGTCACTGCTGAG | AGGTCAATGCTGAG | 0,0 |
| Oki_RAD91478-52 | T | C | TGTAGCAGTCTAATGACCGGC | GCCTAGTTGCCTGACAATGC | CGGCTATAGCTGTG | CGGCTACAGCTGTG | 0,0 |
| Oki_RAD91907-38 | T | G | ACAGAGGAGCACATACTGGT | GGGCAGAAGGTAAGATATCAGACT | ACTGGTTGTGAGAC | ACTGGTGGTGAGAC | 0,0 |
| Oki_RAD92875-31 | C | T | CCAAGAGGGTGTCCATCGAC | TCGCCAACCCATCTCAACAT | ACACCACGCCGCTC | ACACCATGCCGCTC | 0,0 |
| Oki_RAD93028-59 | A | G | GGTGTGTAACCTGTCTGGACA | GCCAAGCCAATTAGCTGTGC | GCTCACAGAACTCA | GCTCACGGAACTCA | 0,0 |
| Oki_RAD94215-66 | A | G | AAGGAGACACGATGGGGAGA | CTGCAGCTCCAGATGATCGA | GAGGATAAGGCGGA | GAGGATGAGGCGGA | 0,0 |
| Oki_RAD94241-30 | C | G | TGCAGGTGGGCAACAAGATT | CTGTATCTCTGGACCATGCAGT | CAGTAGCCTCTTAT | CAGTAGGCTCTTAT | 0,0 |
| Oki_RAD96072-42 | A | G | AGGGCACAGGAGGAGTCATT | GCAGTGGGAGTTTGTTGTGC | TGAAGGATAAGCAC | TGAAGGGTAAGCAC | 0,0 |
| Oki_RAD96498-69 | C | A | CCACAAGGAGTTGCAAGAGC | CATAGGGCGCCGCATAATTG | GCCAAACGCATCCT | GCCAAAAGCATCCT | 0,0 |
| Oki_RAD97325-35 | T | A | TGCAGGGAGCTACAATGGTA | GCTCACCTCTCTAGCCCTCT | TCTTGGTCAGCTCC | TCTTGGACAGCTCC | 0,0 |
| Oki_RAD97993-40 | C | T | GCTGCCCTGAGAACAGAGTT | CCTGTCTGTGTGATGAGGTGG | TGGTTCCGTAATAC | TGGTTCTGTAATAC | 0,0 |
| Oki_RAD98280-45 | G | C | GGTCACGAGTCCTCTTGAGC | GGTGTGATGTGGCTGAAACC | TTTACAGTTGGTTT | TTTACACTTGGTTT | 0,0 |
| Oki_RAD98485-66 | A | G | GGGACCTTGACTGTTTAAATTCAA | AGCACATGTGAAAGCCGAGA | TATTCTAATTGGCA | TATTCTGATTGGCA | 0,0 |
| Oki_RAD99931-47 | T | C | GCTCCAGAGGCTCCCTTTTC | CGCTCACTCCCTCCATCAAT | TTACCATCAATATG | TTACCACCAATATG | 0,0 |
| Oki_SECC22-67 | T | G | ACTGTTGAAGACTTGTTTTTCCCA | ACCACTACAGGATGACTACCT | TCCCAACTGTCTGT | TCCCAACGGTCTGT | 0,0 |
| Oki_afp4-10 | T | C | ACCTTATCACCTCGGACCGA | TGAAAGCTTGTCGGGCTCTT | ACAGCTCTATGGGC | ACAGCTCCATGGGC | 0,0 |
| Oki_arp-105 | C | T | TGGCCATTGACAAAGCAGGT | TTGCAGGGGAAACAAGAGCA | GCTTGTGCAGTACT | GCTTGTGTAGTACT | 0,0 |
| Oki_aspAT-273 | C | T | ATGCTGGGAGAAACAGTGGG | CTCCTCTGTAAGGGGTGGGT | AGTGGGGCACGGTG | AGTGGGGTACGGTG | 0,0 |
| Oki_bcAKal-274 | T | A | ACGGACACCACAAGTTCCC | GCAATCAAACTAAGGCCACACA | AGTTCCCTTACTAC | AGTTCCCATACTAC | 0,0 |
| Oki_ca050-17 | A | C | AGCTCAGTAAATCTGGTCCCA | TGGGCAGTTTGAAGACCATACT | TTTAGTCATACAGA | TTTAGTCCTACAGA | 0,0 |
| Oki_gdh-189 | T | A | CCTGTGTTGAAGTGGAGTAGGT | GCTTTATACTGTAAGTGGACTGACC | .ATTTTTTTCTGTA | .ATTTTTATCTGTA | 0,0 |
| Oki_gh-183 | A | G | ATGTGGTACTGGCTCAAAACT | TGCAGTAGAGCATGCTTGGT | CATCAATACAATTT | CATCAATGCAATTT | 0,0 |
| Oki_gshpx-152 | A | C | TGTAGTTTTGTCGCAGTTGTTG | GTTTCAATGATGAGTCCCAAAAGT | TTGCAACATTGTAG | TTGCAACCTTGTAG | 0,0 |
| Oki_hsc713-56 | C | T | TGTGTTCTACCCTCTTGTGTCTG | TCAAATTTCACTCCTTGACAAGTCA | TGAGTCTCGTGACT | TGAGTCTTGTGACT | 0,0 |
| Oki_hsc71p-313 | T | G | TGAACTGTGCCATGTAGTAGGT | GGGGCAGGCATAAAAGTAGA | TGGTTATTAACTAC | TGGTTATGAACTAC | 0,0 |
| Oki_hsf1b-85 | C | G | GACCAGGACCCTGAAGAGGA | TAGTTCGGGCTTGTCTGGTG | AGAGGACCCTACCA | AGAGGACGCTACCA | 0,0 |
| Oki_hsp90B-83 | A | T | GAGGGGGCGAATGAAGGTC | TCATCGATTCCTGGAGGGGA | GAAATGTATGCTGA | GAAATGTTTGCTGA | 0,0 |
| Oki_itpa-85 | G | T | ACCACACTCCGTCCTCCATA | AGCGACTTGACTCTGAACAGA | TAAATAAGTTGTTT | TAAATAATTTGTTT | 0,0 |
| Oki_nips-159 | G | T | TCTTTCCTGTGTCGGCATCA | TCCAAGTCTGGTTAGAGCCCT | TCAAAATGACATGC | TCAAAATTACATGC | 0,0 |
| Oki_parp3-19 | - | T | AGCTTTGCCTCTAGACTTGTGT | ACCTTGAAGATCCATCCTGGC | CCAATTTAAAGCC | CCAATTTTAAAGCC | 0,0 |
| Oki_pigh-33 | T | A | ACCGCATACCAAGTCATGCA | TCATCAGTTTTTCTTTCCATTGGGA | GTTAACATTTCCCA | GTTAACAATTCCCA | 0,0 |
| Oki_pop5-265 | G | T | AGAAAACCATGAGGCTCCGG | CAGCTGCATTGAAGCACCAG | TACTCCTGGAATAG | TACTCCTTGAATAG | 0,0 |
| Oki_rbm4b-129 | GAT | - | ACGTCCTTGATATACTGTAACGTGT | TAACGTGCTGCAGCTTCCAT | GTGTCATGATACAA | GTGTCATACAA | 0,0 |
| Oki_sast-230 | A | G | ACAGTAGTATCTATGCCTTTGAGCA | CGCATTGGCTAGATTCACATGG | AAGTAGTATTTGTT | AAGTAGTGTTTGTT | 0,0 |
| Oki_srp09-107 | A | G | AACGGAAGAGAACGGAGCTG | GCAGCGAAGGTTATGCTCTC | TGAGAGGAGAAATC | TGAGAGGGGAAATC | 0,0 |
| Oki_sys1-141 | T | G | TGGAACATTGCACACCTCTCA | GCAACCAGCACCATTTCAGT | TGGAAATTAACTGA | TGGAAATGAACTGA | 0,0 |
| Oki_taf12-40 | - | T | GTGTGTGATTTGTCAGCTCCAC | GAGTGTGTGATTTTGGCCAGT | CCTTTTTAATGCT | CCTTTTTTAATGCT | 0,0 |
| Oki_thyK-100 | T | G | CCACCCTGCAACTCTGATCA | CCAATCCAAGTCAACTTCCCC | ATTACCATTAGACT | ATTACCAGTAGACT | 2.2,0 |
| Oki_txnip-35 | C | G | GGCAGGACCAAGGTCTTCC | GATGGTCTTTCCCTGCCAGG | AGCTCTCCTCTGTG | AGCTCTCGTCTGTG | 1,0 |

***O. nerka* GT-seq panel (93 loci)**

| Assay: | A1: | A2: | FWD: | REV: | A1-Probe: | A2-Probe: | Allele Corrections: |
|---|---|---|---|---|---|---|---|
| One_ACBP-79 | G | A | GAGGTGTGGGCTGACCA | TCGACCGCTGGCAGTG | CAGAGGTCATGGTTCTA | CAGAGGTCATAGTTCTA | 0,0 |
| One_agt-132 | A | C | GACCCAGATCAACAACTTCATCCA | TGGTTGAGCTAAGGTCCTTGAAC | ACAGGAAAATCACGAGCCT | CAGGAAAATCCCGAGCCT | 0,0 |
| One_aldB-152 | A | G | CGATCAGGTGACGCTAAAATTAACTC | GTGGCTTCCTCTTCACTCTGA | CTCAGGCATTACCTTC | CAGGCATCACCTTC | 0,0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| One_apoe-83 | C | T | CGCCATGGACAAGGTCAAG | GGCACAGTGCTTCCAAACC | TTTAGACGGCGGTCTC | ATTTAGACAGCGGTCTC | 0,0 |
| One_c3-98 | C | T | GAGTGTGGAACTGGTTCTTGTTG | GCCGGCAGGGCATCA | GTTGATGGACCACCTGGTGG | TTGATGGACCACTTGGTGG | 0,1.65 |
| One_CD9-269 | C | T | ACGCTCTGAGGTGATATGAAACAC | CATCCGACGTCAACATCCAAAC | TGGAATGGAGAAATC | ATGGAATGAAGAAATC | 0,0 |
| One_cetn1-167 | A | C | CAGAAATCCTGACTGTTAAAACAATGCA | CTGCTCGTTGATCTCTCCATCTC | TTGACGAAGCAGACCGA | TTGACGAAGCCGACCGA | 0,0 |
| One_CFP1 | C | T | CGCAGGTCAAAGTAGTACTTAGCAT | GAGCGTCACTTCCTGGAACTT | TGCAGTTCAACATCAA | CTGCAGTTCAATATCAA | 0,0 |
| One_cin-177 | C | T | CCTCAGACTAGTGACCGTACCTA | CGCTCACCGTGGTTACGT | TCACGCACGGGACAG | CACGCACGGAACAG | 0,0 |
| One_Cytb_17 | A | G | CCTGGGAGATCCAGACAATTTTA | CGTAAGCGAAAAGGAAGTATCACTCT | CAACCCGCTAGTTAC | AACCCGCTGGTTAC | 0,0 |
| One_dds-529 | A | G | CATAATGCTCCCCATCTTGAATTGG | CACTCAGCCCTTTAGGGAAGA | AGCAATCCCATCTCTC | AGCAACCCCATCTCTC | 0,0 |
| One_DDX5-86 | C | T | CTCCCACATTGATCTGGACGTA | TGCCACTTGGCCCAAAGAG | AGGACTTCCTGAAGGAC | AGGACTTCCTAAAGGAC | 0,0 |
| One_E2-65 | C | T | GTGGCACCCCCTTTCTCT | TGCAAACCTCAGTGGAGAACC | CATTGTCCCTAGGAAAG | ATTGTCCCTAGAAAAG | 0,0 |
| One_gdh-212 | C | A | CCTGTGTTGAAGTGGAGTAGGTTAA | GCTTTATACTGTAAGTGGACTGACCTT | ATCTGTTACCAGAATGTTT | ATCTGTTACCATAATGTTT | 0,0 |
| One_GHII-2165 | T | A | GGCATCAACCTGCTCATCGA | TGCACAAAGTGCGGCAC | CACAAATGGAAATTGA | CACAAATGGTAATTGA | 0,0 |
| One_ghsR-66 | A | T | TGTAACAATACAAGGATAATGCAAATAATGTAGGT | GGTTATTAGGTTACTGTGCTGACTGT | AGGTTAAGCTGTGTATAAGT | TTAAGCTGTGAATAAGT | 0,0 |
| One_GPDH-201 | T | C | GAAGCTGATCCTAGACCTGTACCTA | TGGTATGATGGTGCTACTGGAAGT | CTTCACCCCTGGAGCC | CACCCCCGGAGCC | 0,0 |
| One_GTHa | A | G | CAAGAAGAATCAAGAGAAAGAGAGATGGT | CCTAGTGTCATGCACATAACGTGTA | CAAGAACTAGAATGAAACAGA | AAGAACTAGAATGGAACAGA | 0,0 |
| One_HGFA-49 | A | T | ACTTGCTACTTCAGGGTTTTTGTGA | TGGCAGAACAATTCCTCAATGCATA | CTAAAGCACCATGTTGC | ACTAAAGCACCTTGTTGC | 0,0 |
| One_HpaI-99 | C | T | CCTGAGTTGTGTTCAATGGGCATAA | TGGGTCATGTTCATTAGAGCACAAA | AACGGAAGAAACCCCTCAA | AACGGAAGAAACTCCTCAA | 0,0 |
| One_hsc71-220 | C | A | ACAGCGAAACTATTGATTTAAGGCTCAT | CGCAGGTAAATCACTGATCATGTTT | ATTGGCCACAGCGC | ATTGGCAACAGCGC | 2,0 |
| One_Hsp47 | A | G | CGTTCAAATAAATGCTGTTTGGCCTTT | GTGGTGTTCGGATTTTTCCTGAAA | TTATTGACTATGGCACATTG | TTGACTATGGCGCATTG | 0,0 |
| One_IL8r-362 | C | T | TTGCTAGAAGCGTTGGTTATGATGA | CAGCAAAATTGAGAAGTCACTAGGAAAA | CAGCCAAAGAAGAGTC | AGCCAAAAAAGAGTC | 0,0 |
| One_ins-107 | C | T | TTGAAATGAATGTGAAGGCA | GAACCCTGCAAGAGGAGAA | TACAGTAGTCCATACAACATA | ATACAGTAGTTCATACAACATAT | 0,0 |
| One_KCT1-453 | G | T | GGGAAAGTATGCTGTGGGATCAG | GGTTCCTCAGTGAGTGTTCTCTATG | TGGTCAGGGTATCGCCATA | TGGTCAGGGTATCTCCATA | 0,0 |
| One_KPNA-422 | A | G | TGGGCCCTGGGAAACATC | CCATAGCCACTTTCGATACAGGTAA | CTGGTATGAGAAGGCACA | TGGTATGAGGAGGCACA | 1.3,0 |
| One_LEI-87 | A | G | ACAGCGCATCCCCATAATGG | GCCTTTGTGGAGGTCAACGA | ACTCGCCACCTCTGT | TCGCCGCCTCTGT | 0,0 |
| One_lpp1-44 | C | T | GGTCCAATAGGGAGCTCAGACA | GGGAATGAACCAGACATGTGAATG | TTGTGCTTTCCTGACCTAT | TTGTGCTTTCCTAACCTAT | 0,0 |
| One_MARCKS-241 | T | A | CCTATCACAGCTTGGTTGAGTTCAA | TCCACCCGCTCATTTTTGTAAGAT | TTGCTTAAAAGGTCTTCC | TTGCTTAAAAGGTCATCC | 0,0 |
| One_metA-253 | C | G | TTCTTATCGCTGGTGGCACTTT | GACCAAAGACTATTTAGTTGCCACCTA | AGGCAATTGAGGTTAAT | AGGCAATTGACGTTAAT | 0,0 |
| One_Mkpro-129 | A | G | TGACGTATGTGCAATGCATGTCTAT | AGATGAAGGACATGGCTGAAAACAT | ATGCATATACATGTAATATAT | TGCATATACATGTAACATAT | 0,0 |
| One_ODC1-196 | C | T | CCGAGGTGGGATTCAACATGAC | TCAGATGGTTCATTATGACAGCAACA | CCACCTCCGATGTCC | CACCTCCAATGTCC | 0,0 |
| One_Ots208-234 | - | A | CAGCCGACATGCATCAGTTA | TGACCCCATGTTTCATGCT | CACACGTTACATCAGATAACT | CACACAATGTTACATCAGATAAC | 0,0 |
| One_Ots213-181 | T | A | CCATAGTGTATCACACAATACTCATGTCT | TCTATCATCTGCAAATCTGTGTACTAGACT | CTTTGAATTAAAAACATTTTT | CTTTGAATTAAAAACTTTTTT | 0,0 |
| One_p53-534 | C | A | GACAATCTTAAAGCGGTGGTCTTG | AACCTTTATCAGCCATCATCCAACT | ATGTCCAAAGATCTGG | AATGTCCAAATATCTGG | 0,0 |
| One_pax7-248 | C | A | AGTAAAGGTAGTGATGCAATGATGCA | AACCGCATAGGACGTAAAGCA | AATTCAAAACGAAATGTG | TGAATTCAAAACTAAATGTG | 0,0 |
| One_PIP_3 | C | T | ACAGAGTCAGGACTTGATATGTACAGA | CCTGACGAGGGTCTACTACACT | AACACACATTTCTCAACACA | ACACACATTTTTCAACACA | 0,0 |
| One_Prl2 | G | T | ACCTCTCTCTCTCTCAGGACTCTCA | GAGGAGGTGTGACACATAGATGGA | ACCAATGGGACGAGTG | CCACCAATTGGACGAG | 0,0 |
| One_psme2-354 | A | G | TGGTCCTTCAGGTACTTTTCAGAGA | CAAATGCCAATTCTCACCACATGA | TGATGCAGTAGCTAAAG | ATGCAGTGGCTAAAG | 0,1.8 |
| One_rab1a-76 | G | T | TCGCCATATTCTCTCTCCCTATCC | ATCCACTCAGACCCATATCTACCAA | TGTGGAGCAAGGTAACT | TGTGGAGCAATGTAACT | 0,0 |
| One_RAG3-93 | C | T | AGATAAAGATGGTTTCAAAGTCACCCA | GGGCTGCCATCTAAAAAATATTGCT | CATTTTGGACTTCGGGACC | CATTTTGGACTTTGGGACC | 0,0 |
| One_redd1-414rd | A | G | GTTGGCTACATCCTAAAACACAATGG | CAGCCCTGGAGTACTGAATCAG | CCTAAGTCAGTCACTGTAG | CCCAAGTCAGTCACTGTA | 0,0 |
| One_RFC2-102 | A | G | TCCAGGAGCTGCATTTTGAGTTAAA | AAGGTGGATGACAATGTGTTAGTGT | ATCACGTTGTATTTCTTT | CACGTTGTGTTTCTTT | 0,0 |
| One_RFC2-285 | A | T | GGATGAGGCTGACAGGTAAGTC | ACAGTCGTTATAGGTACAGGTACACT | CACGACATCTAAGCTGAA | CACGACATCTATGCTGAA | 0,0 |
| One_RH2op-395 | G | T | GCTGCTAGGTCAAACTCGAAGAG | CAGCCTTGTTCAACCCCATTATCTA | TGGGAACATCATTTTTTAA | TTGGGAACATAATTTTTAA | 0,0 |
| One_rpo2j-261 | G | T | GATTCTGAGATCATACAGTGGATTGGT | GCTTGTCATCTTTCAGCACATACCTA | CACATGTTTTACTCATTTGA | CACATGTTTTACTAATTTGA | 0,0 |
| One_sast-211 | G | T | TGTACTTAGTCCAATAAGCATTTCAACAGT | TGGCTAGATTCACATGGTCAACAAA | CATCATTTGCATTATTG | CATCATTTGAATTATTG | 0,0 |
| One_spf30-207 | G | T | AGCATTTCAGTTTTGTACATTTACAGTAAAACA | ACCTACTCGTAATTTCAGGGCAAAA | AGGGACATCTTACCTCAAAA | AGGGACATCTTACCTAAAAA | 0,0 |
| One_srp09-127 | T | A | CGGAGCTGGAATGACGACAT | AGGTTCAGCAAATCCCTCTTTAGAG | CAGCGAAGGATATGCT | CAGCGAAGGTTATGCT | 0,0 |
| One_ssrd-135 | - | T | TGGAAACTCCTAGTGTACTTCATTCTCA | CGTTCCACGCTCCCTAGAATAGA | CTGCGGCTTTGTCTTG | TGCGGCTTTTGTCTTG | 0,0 |
| One_STC-410 | T | C | CAACACAACATCAACATCATTAATAAACATTCTG | AACATCCCCGTTTTGACCACTTAT | CCGATGGGTATATTATTATA | CCGATGGGTATATTGTTATA | 0,0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| One_STR07 | G | C | CACACCTGAGGCACAAGCT | GTATGTCTACCAGAGAGGTCAAGGA | ACGCACACTGTCCTT | ACGCACACTCTCCTT | 0,2 |
| One_SUMO1-6 | C | A | GCACAAGCCAAAAAGTTTTCTCCAT | GGACATAGTTGGAGGCAGACAAAA | CAAGAT[AT]GAAATTGGTTTGC | CAAGATTGAAATTTGTTTGC | 0,0 |
| One_sys1-230 | T | G | CTACCTGTCTAACAGTGAATGCTAACTT | TGAAACCATTAAGCTCTTTGTAGGACAA | CAAAGCAAGTGATATATTAGTG | AAAGCAAGTGATATCTTAGTG | 0,0 |
| One_taf12-248 | G | T | ACCTTCAATATGGTGGTGGTTACC | ACTAAACGCACAACAGCAAACG | CCAGACAAAATCAAATTA | CCAGACAAAATAAAATTA | 0,0 |
| One_Tf_ex11-750 | G | A | AGCAGGTGTAAGCATGTGTACTT | CCTGCTCTGCCTCAACAATGTTAA | CAGGGTCGCTGCAC | CCAGGGTCACTGCAC | 0,0 |
| One_Tf_in3-182 | A | G | GCCCTTAGCACTTCAGTTGCA | CAGACAGAAACCATTTGATCCGATTC | AACAGAAAGTCTACACTTT | ACAGAAAGTCTGCACTTT | 0,0 |
| One_txnip-401 | C | T | GCCAGATCCCTTCAGTTGGA | GGCCATTTCAAAAGGCTGCAT | TGACTGCACTAGTTTAGAC | TGACTGCACTAATTTAGAC | 0,0 |
| One_U1003-75 | C | T | TCACGAGCCCCAGTCAGA | CGGGTTTCGGTGGTTTAGTATTCTA | AGAGACTACTTCCTTTTTG | AGAGACTACTTCTTTTTTG | 0,0 |
| One_U1004-183 | A | G | GGTGTGACTGCTGTGTTTAATTGC | ACCATCATTACACAGCAATTCTGAGT | AAGTTCCCTGTATTTCTT | TCCCTGCATTTCTT | 0,0 |
| One_U1009-91 | A | G | CTCTGTCCTTGAACTGTTGTCTGTT | GCCGCTGCTACTCTTCCT | CATGTTCTGTATGGACCC | TGTTCTGTGTGGACCC | 0,0 |
| One_U1010-81 | A | G | CAGCCCCTCGAGGTAACTG | GTTGAGACAACAAAACGTCTACTGT | CACACCAACGTTATGTAGAG | CACCAACGTTGTGTAGAG | 0,0 |
| One_U1012-68 | C | T | TCTATTACCATACAGGCCCAGTACA | CCTTTTGTGTCTTCCAGTCATGTGA | TGACGGGTGTTCCTGATAA | TGACGGGTGTTCTTGATAA | 0,0 |
| One_U1013-108 | G | T | TCTGTGCTCTCCTCCAGGAT | CGAAACTGAGGAGTGCTCTGA | ACGGAATTCCTGTTGCCCT | ACGGAATTCCTTTTGCCCT | 0,0 |
| One_U1014-74 | C | T | TCCCCTGCAGCAACTGTTTT | GGCAGAGACGGCATCCT | TTGACCTGCGCCAGTAT | TTTTGACCTGCACCAGTAT | 0,0 |
| One_U1024-197 | G | T | CTGAACTGATCTACCGCTCTGT | GGAACAGATACTCCAGGAGAGATGA | ACCTGACCCAACAAA | ACCTGACACAACAAA | 0,1.4 |
| One_U1101 | C | A | CTATGACATGTTTATTTTAATTAGCCACCAACT | AGTATAGCTAGGGAACCTTTCGATCTT | TGGACGTATGTCATATTT | TGGACGTATGTAATATTT | 0,0 |
| One_U1105 | T | A | GCCTTAATAGTGTCTTCTGATCCCTTT | CCCTCTGTTGTCCAGACTCTTAG | CCTGTTTTTTTTAAAAGAC | TCCTGTTTTTTTTTAAAGAC | 0,0 |
| One_U1201-492 | A | G | GCTTATGACGGAGAAGAGATGCA | AGGATACTGAAGCCCAGAGACA | AAGACTTCCTCCAGGCTC | ACTTCCCCCAGGCTC | 0,0 |
| One_U1202-1052 | T | C | CGATTTGAGTCTCCAATGGTCTCT | ATTCCTATGGTTAACATCAATTCTATAAAGTCAT | CAAACTTTTTCATCTACATTTA | ACTTTTTCATCCACATTTA | 0,0 |
| One_U1203-175 | G | A | CCCGGAGACATACTTGATGCA | GGAGGACCTGCAGGATCAC | CCATAGTTGCTGGGCTT | CTCCATAGTTACTGGGCTT | 0,0 |
| One_U1204-53 | C | T | GTAAAACCCTTCATGTTGGCCATT | CTCCATGTCTGAATGTCCCATCA | ATGCATACACGCTGATGC | ATGCATACACACTGATGC | 0,0 |
| One_U1205-57 | A | G | AGTAAATGGTTATTCACGTAACGGATAAG | CAGGACAGTTCCACATTCTAACAGA | AGTTATCATGGTCATCTCT | AGTTATCATGGTCGTCTCT | 0,0.8 |
| One_U1206-108 | G | T | CTGAGATGGTGCTTTCTGAGGATA | TGGATGAAAGGGAAATTCTGTCAACA | AACATTGAGCTTCCC | ATAACATTGATCTTCCC | 0,0 |
| One_U1207-231 | C | T | GGCCAAACTGACAGGGATCTATTAA | GGGTCCAGTCTGTACACCATCTAT | ACATTCCTTGGCATTGC | CATTCCTTGACATTGC | 0,0 |
| One_U1208-67 | A | C | ACTTGAATGTCTGTTTCGTAGGTGAT | ACACAGTTGACAGTGGAGCAA | CCCAATGTGATTGTCAC | CCAATGTGCTTGTCAC | 0,0 |
| One_U1209-111 | C | T | GTCACGTAATCACGAGAAAGATACTAAATGT | TCTGCGTCTCCAGAGAGGTT | CTCACATCGAGATGATC | TCACATCGAAATGATC | 0,0 |
| One_U1212-106 | A | G | CGTAATGACCTACCACCATATCAGT | TGGCATGACTTTAACAATTCCCAAAAAA | TTTTGACATACAAAAAATA | TTTGACATACAGAAAATA | 0,0 |
| One_U1214-107 | A | C | CCAAATGTACTCCATGTTGGTTAGC | TGCCTGAGTATTAAGCTATATCATTGAAGTTTT | TAGTGACCTATTAAATTGC | TGACCTATTCAATTGC | 0,0 |
| One_U1215-82 | A | C | GTTGCTTGGTTTCGTTTGGAGTAG | CTCCAGAAGAGGAATACCACAGTTC | AATGAGACAAAGTATTTGGT | AATGAGACAAAGTCTTTGGT | 0,1.9 |
| One_U1216-230 | A | T | TGGGATCGGACGTCAATAGATTTC | GTAATACAGAGTGAGCGTGATACATTGT | CCTGGCTACTAAGTAAC | CTGGCTACAAAGTAAC | 0,0 |
| One_U301-92 | T | G | AGCCAGTAGCCGATAATGTTTGTC | CCCCTCCCAAATTGCTAGCT | CCATGGATTAAAATATTT | CCATGGATTAAACTATTT | 0,0 |
| One_U401-224 | C | A | GGGTGGAGACGAACGGATTC | GTACGATTTTTTTGTAGCCCCAAGT | CACCTGGAAAGGACTGA | ACACCTGGAAATGACTGA | 0,0 |
| One_U502-167 | A | G | GCTTTTGTGCAATAGCTATGTTGCTTA | GCAAAGGTAGGCAGCAGATTG | CTTCTTGATCAATAACG | CTTCTTGATCGATAACG | 0,0 |
| One_U503-170 | T | G | GATTCAGAATTGCCACGACAAAGAA | GTGATTGGTACATGTCTGTCGAGTT | AAGTACTAAAATC[AT]GTTTTACATTG | TACTAAAATCAGTTGTACATTG | 0,0 |
| One_U504-141 | C | A | GCTATAGCTCACAGAGGATCCCA | TATTGGCGGGTGAGGGATG | TCAAGGACACAAACAA | TCAAGGACAAAAACAA | 0,0 |
| One_U508-533 | C | T | AGGCACAACCTCACATTTGGAA | CTCAAAGGGTCTGAATACTTATGTAAATAAGGT | ACACTACAGCCTTATTC | ACACTACAGCTTTATTC | 0,0 |
| One_UCA-24 | C | T | AACTCTGCGTCTGTCTGCTT | TGTCCTCAGACCCAGGGAAA | CGAACAGGGCTGGATG | CGAACAGGACTGGATG | 0,0 |
| One_vamp5-255 | C | T | GGTTGACTTTTCTTAACTTTTTAATCTGTGATATTGT | GCTGAGCTAGTGATGGTACCATTT | TAGGCTCCGTGCTCAGT | TAGGCTCCGTACTCAGT | 0,0 |
| One_vatf-214 | C | A | TCATTCCTTTGCCTGGAGCATT | GGCATACAGCAAAACAATTCAACCA | TGGTATTACTGTGCATTGAC | ATG[CG]TATTA[AC]TGTTCATTGAC | 0,0 |
| One_VIM-569 | G | A | TTCTGGGTGGACTCATTGATCAC | ATGCGTTATACCTGTAATCTGCAAGT | AAGTGTTTCCATACTCACTATA | AAGTGTTTCCATATTCACTATA | 0,0 |
| One_ZNF-61 | C | A | CCATTCATGTTCTATTCAGATATATTTTGTGCA | CCTAGCTAGAGCTCAACAATATGCA | CTATGGACATGATCTTT | TTCTATGGACATTATCTTT | 0,0 |
| One_Zp3b-49 | C | A | TCCTCGTGGTTATAGTTATAAAGATGTCAGT | TTGGCTCTGCACTCGGTTTA | AGGCCCAATCCTT | AGGCCAAATCCTT | 0,0 |

***E. tridentata* GT-seq panel (308 SNP loci)**

| Assay: | A1: | A2: | FWD: | REV: | A1-Probe: | A2-Probe: | Allele Corrections: |
|---|---|---|---|---|---|---|---|
| Etr_1004 | A | T | CGCCCAGCGTGTTCAC | CGACCGCTTTCTCTCTGCAAA | TGCGATTAACGGTTCC | TGCGATTATCGGTTCC | 0,0 |
| Etr_1007 | C | T | ACACGAACACCCAAAAGTGATGT | ATGACTACTGACGATTCCCATTGAC | CACTCATCAGCGAGCCT | CACTCATCAACGAGCCT | 0,0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Etr_1022 | C | T | GCACGAAAGCACTGAAGCT | TCAGGAAGGTTTTGCATTGATACCA | TTTGGTCTGGTGATCTG | ATTTTTGGTCTAGTGATCTG | 0,0 |
| Etr_1034 | T | G | CAGCAGCAGAACCGAATCCT | ACCTTTGATGGTCCATGGGG | CCGAATCCTTGAGCTG | CCGAATCCTGGAGCTG | 0,0 |
| Etr_1060 | A | G | TCGCACGCACTCACGTTA | GTGAAGTCCGTCGTCTTACCTTTT | ACTCGCCACATTGC | CTCGCCGCATTGC | 0,0 |
| Etr_1068 | G | A | GGGCCCTGGAGGGTCAC | GCACACGCAATACAAAGATTCCT | CCTCAACAGACTCTTGG | CCTCAACAGATTCTTGG | 0,0 |
| Etr_1104 | A | G | AGCAGAGGGGGAAGAGGAAA | CCACTTGAGCTGCAATGTTGA | GGGAATGACAACACAA | GGGAATGACGACACAA | 0,0 |
| Etr_1106 | T | C | TCCCTAGTTCTGAGAAACCCAG | AAGGTCGCATCGTCAGTGTT | GAAACCCAGTAGAATTA | GAAACCCAGCAGAATTA | 0,0 |
| Etr_1131 | C | T | TTAACGGCGTGCATGCATG | AAACTGGTGGAAAAATGTGGG | GAGCTATCTCTGCAGA | GAGCTATCTTTGCAGA | 0,0 |
| Etr_1163 | A | T | TGCAGGAACGCGTAAAC | TCTGACGCTTGTATGGAATCTGTTC | TGCAACCGTGTTTATAGAG | CAACCGTGTTTTTAGAG | 0,0 |
| Etr_1181 | G | A | AGTCGACCACCTTGCTGAAGC | GGGCAGCTGTCCCGTTT | CACTCCACAGAAACGGG | CACTCCACAAAAACGGG | 0,0 |
| Etr_1184 | A | G | CTTGCAGACCCAGGCGAC | GCTGTCTTTGTTTTTCGGGGT | CCAGGCGACATGAGCTC | CCAGGCGACGTGAGCTC | 0,0 |
| Etr_1187 | C | G | ACAAAAGCTGTCTGGCCTGA | CAAAGGACCGGGCTCTGTC | GCTGCAAATCT | GCTGCAAATGT | 0,0 |
| Etr_1188 | C | T | AGTCTTCCGTTGCCACCTTTAAAA | CCAGGGACGCCATCCAT | CACACAACCGCTTTTA | CACACAACCACTTTTA | 0,0 |
| Etr_1193 | T | G | AGCTACACTACTTTGGTGCGT | CTCCATCCAGCAGTGGGATT | GCGTTTTATTGACTG | GCGTTTTATGGACTG | 0,0 |
| Etr_1210 | G | A | GAAGGAGCTCGAGTCGAGAG | GACACCGTAGAACTACCATGCA | AGGCCGGCTCCTG | AGGCCAGCTCCTG | 0,0 |
| Etr_1238 | A | G | GATCTGGCAGAAGGCAAACAG | AGATCTGGACGCTTGCAAGAC | CATAACGGTGAAGCGAC | CATAACGGTGGAGCGAC | 0,0 |
| Etr_1257 | C | T | GGCAAACGACCGCATCAAC | CACGAGCGGGTCCCT | TGCGAAGTGATGCTGATAT | TTGCGAAGTGATACTGATAT | 0,0 |
| Etr_1321 | G | A | GTGGCGGACGCATTCAAG | GCGTCGTGCGAGGATGA | AGCCTGCGCAGACC | AGCCTGCACAGACC | 0,0 |
| Etr_1341 | C | T | TGCAGGAATAACATTCGAATTTCTACTC | GACATGACAGTCGCTAGATTCCT | CCAACCGGCGATATG | TCCAACCGGTGATATG | 0,0 |
| Etr_1349 | G | C | CGGTGAGCAGCCTCTGG | GGTGAAACCCCTTCATTGTGTGA | CCTGGGTTCAACCC | CCTGGCTTCAACCC | 0,0 |
| Etr_1359 | T | A | CTGTATTGGTTGCTGTCGCA | GTCACTTTCAATGCCCGCTT | TCGCAGACTTGCG | TCGCAGACTAGCG | 0,0 |
| Etr_1376 | C | A | GCAACTCAGGTGGGAAACG | GCGGTCCAGATGAGATTCCA | CTGCATGTTCTGACACTG | CCTGCATGTTCTTACACTG | 0,0 |
| Etr_1378 | G | C | ACACAAAGACTGGAGCAAATGG | CTCCCATAGGCTTGCTCGAG | TCGAGATGTGGAAAGCC | TCGAGATGTCGAAAGCC | 0,0 |
| Etr_1383 | G | A | GGAGAGGACAGGTCCAAGGT | CGTAGAGCCTGCGAAAGTGTT | TCAAGCCGAACGTTG | TCAAGCCAAACGTTG | 0,0 |
| Etr_140 | A | C | TGCGGTGGTATCTATACGACGAT | ACACACACCAAGTACCACT | AACACAGTTGTCACTGCT | ACAGTTGGCACTGCT | 0,0 |
| Etr_1428 | T | C | CAGCAGGGATATCATCACCTTCTT | ATGGCACGGGCAGAGAA | TTGCGGTCATGATGC | TTGCGGTCGTGATGC | 0,0 |
| Etr_1507 | C | T | AAGGGACAATCTGAGAGCGC | CAAACCCGGACAGTGGCAA | ACGGCAGCGCGCGGGGC | ACGGCAGCGTGCGGGGC | 0,0 |
| Etr_1509 | A | C | CCACGGGTGGGTATGCATAT | CCGAGGCCTAATTCACACCA | TATATGTATATCTCCAC | TATATGTATCTCTCCAC | 0,0 |
| Etr_1522 | T | C | TTTGCCGTGCTCATGTATCTACA | GACCCTGCGGTGATCACA | CGCGATCCTCACCGC | CGCGATCCCCACCGC | 0,0 |
| Etr_1548 | T | C | GCCCTAGCTATTAATGCCGGT | CTGGCACACAACGGCCTA | ATATTGCACTGACT | ATATTGCACCGACT | 0,0 |
| Etr_1551 | C | G | GCGTAGAACAACAGGCCCTA | ACCCGGCTGTACCTGAGATA | CTACAAACCCCCGGCAA | CTACAAACCGCCGGCAA | 0,0 |
| Etr_1556 | A | G | AGCGCACATGGCTGGAG | GGTGCTCTGGATCAGGAACC | TGGCTGGAGACGCTGCC | TGGCTGGAGGCGCTGCC | 0,0 |
| Etr_1561 | A | G | GTCGAAGAAGACGCCAAAGTC | TCGCCTTTTCTTAATGCGCG | GCCAAAGTCACGCTGTT | GCCAAAGTCGCGCTGTT | 0,0 |
| Etr_1567 | T | A | TTGCACCACCTCCTTGCT | GTAATGGTGGGACAATGCAAAGG | ACAGTTCGAAAGCCAG | ACAGTTCGTAAGCCAG | 0,0 |
| Etr_1569 | A | T | CGGGGTTGAAGCAGTTTCCA | AAGTCACAACTCTCCTGGGT | TTGTTGCTGATTTTATT | TTGTTGCTGTTTTTATT | 0,0 |
| Etr_1589 | G | A | TGTGACCGCGTGAGCAGCA | CTTTGACTCCGTGCGTCTCT | AACCGCAGGACACACA | AACCGCAGAACACACA | 0,0 |
| Etr_1613 | C | G | CGCTTACGACCCAGTGCATA | TTTACTGGTAGCACGCTCGT | CCCCTGCCACCGTCC | CCCCTGCCAGCGTCC | 0,0 |
| Etr_1625 | T | C | GGTTCACGGTCTCCTCCATC | AGGATGTTCACCTGCCACG | TCCTCCATCTCAATCGA | TCCTCCATCCCAATCGA | 0,0 |
| Etr_162 | T | C | CGAGGCCTTCGCTGAGAA | CTGCGGTGACATGAAGTTGAAT | CTGACCCCAACGACC | TCTGACCCCGACGACC | 0,0 |
| Etr_1667 | A | C | CGACACGGCACATCATTATAAGG | AGGTCAGCAAGGTATTGTGGT | GTTATTGCCACAAATT | GTTATTGCCCCAAATT | 0,0 |
| Etr_1684 | T | C | GAGGAACCTGCGGGAGAAG | TGTGTTTGCGTGGAGGAGATG | TGAGAGCCTTTCCATCGC | AGAGCCTTCCCATCGC | 0,0 |
| Etr_1696 | G | A | CCGTGTAGAGGTGGACATAGG | TGGCCATCTGCATGTTGGT | CCCGCGGCCGCC | CCCGCAGCCGCC | 0,0 |
| Etr_172 | T | C | CTCACGCTGCCCCCAGG | TACACGAGCAGCTCCTCCTT | TGTCCCCTATAAGGAGG | TGTCCCCTACAAGGAGG | 0,0 |
| Etr_1762 | A | C | TGTCACCAGAACCCCCTCTC | CACCCTCCCTGAGAAATGCC | CCCCCTCTCATCTGGGG | CCCCCTCTCCTCTGGGG | 0,0 |
| Etr_1765 | C | T | CGCACCGATAACTAGAGCGA | ACCAAAAAGAGGGGGCTCAA | TTGGAGTCCCAAGCACG | TTGGAGTCCTAAGCACG | 0,0 |
| Etr_1773 | A | G | GGTCTGGCTGAACGACAATT | CAAACACATGGTGCCACACA | TTCACTGAAAACGTGGT | TTCACTGAAGACGTGGT | 0,0 |
| Etr_1795 | C | T | CAGCGGGTGAACGTAGCTAC | ATTCAACACCTCGCCACCAT | GCGAGATCCCAAATGGG | GCGAGATCCTAAATGGG | 0,0 |
| Etr_1806 | A | G | GTAATGGCGCTGTCCGTTTG | CGAGTACTACTCTGGCCATGTAG | AACACTGACAATATCTAAAG | CACTGACAATGTCTAAAG | 0,0 |
| Etr_181 | C | A | GAGCGGATGGGCGACTT | GCGCGCAGCACACA | TCTCATCTCTCGCCTGCT | CTCTCATCTCTCTCCTGCT | 0,0 |
| Etr_1834 | G | A | AGCAGTTGATACGCGACGATGC | GGATGTTGCCTGCTCGTGA | CGGCGAAACGTTCGCTC | CGGCGAAACATTCGCTC | 0,0 |
| Etr_1843 | C | G | TTACGGCAGCAAAAACAGCC | GCCCTGCTGAGTTTCAATGC | GTGCGACCCCAACGAAA | GTGCGACCCGAACGAAA | 0,0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Etr_1848 | G | A | ACCGAATAAAGTGTGTCTAGCA | TACACTGCACACCCACACTC | TCTACATATGCATGTGG | TCTACATATACATGTGG | 0,0 |
| Etr_1857 | G | T | CTGCTGTTCGCCGTGTGT | GGAGATGATCTGCATGCAGC | GGTCTCCGTGGCTGTGT | GGTCTCCGTTGCTGTGT | 0,0 |
| Etr_1875 | C | A | CGACTTCCACATTAGCACCG | GTGCATTATTCCAGCATTGCCT | CACCGAAGCCCAATATC | CACCGAAGCACAATATC | 0,0 |
| Etr_1882 | G | T | TGCTCTGCTTTCCACAGACG | GGGTTTGGCCACGTAATGATG | GGCGCGTTAGGATCTAC | GGCGCGTTATGATCTAC | 0,0 |
| Etr_1894 | C | T | ACAGATTCTGATTCTGAACATGGGA | TTACTTGGTGGGCAGCAGAG | ATTTTCTGCGATGTCC | ATTTTCTGTGATGTCC | 0,0 |
| Etr_190 | A | G | GCAGGAGACCCTTGCTTGTC | AGGTGGCACACGAAAGTATCAAAT | CTGACATTACAATGTTTTAT | TGACATTACAGTGTTTTAT | 0,0 |
| Etr_1944 | C | T | TGAAGTAGGTCTCCCAAAGGC | CCCACAGGTACGCAAAGGTA | AAGGCTATCCGTGC | AAGGCTATCTGTGC | 0,0 |
| Etr_1975 | C | A | TGTTAGATGTGTAAAGGCGCAG | AGAGGTCACAAACAGCCCTC | GCAGCCCTGCAACTGCT | GCAGCCCTGAAACTGCT | 0,0 |
| Etr_2013 | C | T | CGTGGCGTCGCTTTCC | CCGACGCTCCGAGTGAAA | TCAAGAATCACAGGCAGAG | TCAAGAATCACAAGCAGAG | 0,0 |
| Etr_2015 | C | T | GGGCTTCGGCTGCGTTATAA | AGCTCCTTCTTCTGCTGCG | GCTCGATGACGAGACCG | GCTCGATGATGAGACCG | 0,0 |
| Etr_2016 | T | A | TTTCATTATTTTCTTGACGCTTGTG | GGATAGACGCCTCTGCTGAG | ACGCTTGTGTCAGGTGT | ACGCTTGTGACAGGTGT | 0,0 |
| Etr_2050 | T | C | CCCATGCTAAACGACCAGCT | GCACCTCACACATCTGCTCT | GCTGTGCAGTGGAGGAG | GCTGTGCAGCGGAGGAG | 0,0 |
| Etr_2066 | G | A | GAACCTGTCGCCCTCACTCC | GCGCAGGATGAAATTGCAGA | CGCCTGCTCGCGCTCCT | CGCCTGCTCACGCTCCT | 0,0 |
| Etr_2068 | C | T | CAGCACTGCATCGACGTG | CAGCTCTACTCGTACCTGGC | GTGCGCACGCGGAATGT | GTGCGCACGTGGAATGT | 0,0 |
| Etr_2071 | A | C | CACAGGTTCACTCTGGGTGG | AGAGCTGCTCATTGGTTTTCA | GGCACAGGCACGACACA | GGCACAGGCCCGACACA | 0,0 |
| Etr_2097 | C | T | GGGCGTGCGGACATACT | GCGAACATGGTCAACGAATGC | CAGGTCTGGGAGCCGA | CAGGTCTGAGAGCCGA | 0,0 |
| Etr_2099 | G | A | AAGACCCACGGCGATTCATC | CCCTCAACAGCCTTGCCATA | ACCCGCGCGGACACGTG | ACCCGCGCGAACACGTG | 0,0 |
| Etr_2107 | C | T | TGACCACACGGCGTCTTCG | AAGCACGAGAGCGCGTT | CGAACGGCGCGAGAAGC | CGAACGGCGTGAGAAGC | 0,0 |
| Etr_211B | T | G | GGGTGGAGGAGCGTAACCT | GTGCACGTAGTTGCGGTTG | GCGTAACCTTGAGCACT | GCGTAACCTGGAGCACT | 0,0 |
| Etr_211 | T | G | GCGCGGGTGGAGGAG | AGGCAGTGCGGGTTGAG | CCAGTGCTCAAGGTTA | CCAGTGCTCCAGGTTA | 0,0 |
| Etr_2126 | A | G | GAGACCGTGGGCGACT | GACGCGGCGATGTAGGT | CCGTCCCAATTCGCGCA | CGTCCCAACTCGCGCA | 0,0 |
| Etr_212 | A | G | TCTTTCCCCGTGTGCTTCTC | GCGACACGAGGGTATTCGAT | TGCTTCTCTACTTTTGC | TGCTTCTCTGCTTTTGC | 0,0 |
| Etr_2151 | T | C | TCTTTACTGTTTCCTACCGCAAAG | TCGTTGGTAATCGCGACAGG | GGTACCCGATACACGAA | GGTACCCGACACACGAA | 0,0 |
| Etr_2193 | C | G | GGTTCATCTGGGAGCTTTTGC | AAGCCCACAGAGAAGTGACATC | TGCGGCTGGAGACG | TGCGGCTGCAGACG | 0,0 |
| Etr_2226 | T | C | GCAAAACGCCGTACACCTTT | TAGTTGCGTTGAAAGCGAGC | TTTGCGTTCTCGACGCT | TTTGCGTTCCCGACGCT | 0,0 |
| Etr_223 | A | G | GTAAGGCGTGGGCTATTGGT | AGTTACTGAGATGACCGAGGA | CTATTGGTTATGAGGTT | CTATTGGTTGTGAGGTT | 0,0 |
| Etr_225 | C | G | TGGTTGAATCCAGTGCGGATAAA | GTGCAAACCCGGTCTCTAATG | CACTGGCATTGTCG | CACTGCCATTGTCG | 0,0 |
| Etr_2272 | A | C | AAGGGGCAGGGAGAGAAGG | ACAACAAGAACTGCAGCAGTG | GAGAGAAGGAAT | GAGAGAAGGCAT | 0,0 |
| Etr_2287 | T | G | TTCATGTGACACCTGCTGCT | GAGGCGGGTGTCATACAGAG | CTGCTTGTATCTCCCCT | CTGCTTGTAGCTCCCCT | 0,0 |
| Etr_2304 | G | A | ATCGGCACATTTCTTCCCGT | GCTAAAGAAGCGCGATGGAC | CGTGCTGTAGAGAGA | CGTGCTGTAAAGAGA | 0,0 |
| Etr_231 | G | A | CCAGGAATAAGGACACGGTTTGG | CGTCCCCTCCCTCCTTGT | ACGATGCCGTCCGCC | CGATGCCATCCGCC | 0,0 |
| Etr_2334 | C | T | CCAGCCACCACGTTCAAGT | GTGCGGTTGGCAGAGATG | TTCGCTCAGCTCCCCG | TCGCTCAACTCCCCG | 0,0 |
| Etr_234 | T | C | CTCCTCCACGGCGATGTT | TGCACTACGAGAACAACTCTCC | CCCCAGTGTGACACC | CCCAGTGCGACACC | 0,0 |
| Etr_2409 | G | T | CCAGGTGCTGAAGGGCCG | GCTCTCGGCCTGGACAAC | CCGCACGGGGAGGTCCA | CCGCACGGGTAGGTCCA | 0,0 |
| Etr_2414 | A | G | AGACCATTCCTCTGCCAAGC | CCCCAGGGTGCTCTTAAACA | GCCAAGCGGACCCCTCT | GCCAAGCGGGCCCCTCT | 0,0 |
| Etr_2416 | C | T | TCATTACACGAAGCCTCGTTCAG | CGGAGCCCTCCCTGTGT | TGGTGCGGTGCACGC | TGGTGCGGTACACGC | 0,0 |
| Etr_2418 | C | T | TCGGCCTATTAACTCCGTGC | TGGGTACTGGCAGGAGAGAA | TAATCTTACCAAGTTTC | TAATCTTACTAAGTTTC | 0,0 |
| Etr_2451 | C | A | GTGAGGGAGAGAGGGAAGAGT | CGAGAACACATACTGGGGGC | TATACCTGTCGCCCCCA | TATACCTGTAGCCCCCA | 0,0 |
| Etr_2460 | T | C | CATGCAGCCGACAAACTGG | CAACCTGCCCGAGGAGTTC | CTGGCGGCTTCGCACGG | CTGGCGGCTCCGCACGG | 0,0 |
| Etr_2499 | G | A | CCCGAGGGAGTCATCAGAGA | CCGTGCCGTTGGGTGAA | CAGAGAGACGGTGCTCT | CAGAGAGACAGTGCTCT | 0,0 |
| Etr_2512 | A | G | AGCACGAGGAGCGAGAGA | TGCACTTTGAACATGGGTTACAAC | TTTCCCGTGGACTCAC | CCGCGGACTCAC | 0,0 |
| Etr_2517 | G | A | GGCAGGCTGTGTTAACCACT | ACGGAATGAGCGATCGATGT | AACCACTGCGCACCGC | AACCACTGCAACACCGC | 0,0 |
| Etr_2603 | A | G | GCTTTGTGCACCCTAACAACA | AACCCAAGTGGCAAAACCTG | GTGCACATTATGGACAG | GTGCACATTGTGGACAG | 0,0 |
| Etr_2642 | T | C | AGAGATCCCTGTGGCTCCAA | TCGTCGTCATCGTCGTCATC | GCTCCAAACTGGCAT | GCTCCAAACCGGCAT | 0,0 |
| Etr_2675 | G | A | GCTGGATAATTGGCATCTCACACA | CTCAATCGTCTGTTCGCCAAAC | AAGACGACGATTCCCT | AAGACGACAATTCCCT | 0,0 |
| Etr_2730 | G | A | CAGCCACCTCGAGAGCTG | ATGGGAGGGCATTTGAGGTG | GTTGAACCCGTAGCGCG | GTTGAACCCATAGCGCG | 0,0 |
| Etr_2765 | C | T | ATCTGCACAAGCTTCAGGTT | ACGTGTTAAACCGAGCCACT | TTAATCATGCCAATGCC | TTAATCATGTCAATGCC | 0,0 |
| Etr_2776 | A | C | GTACCTGGACGTCAAGCACA | CGACAGCTGCATTGACATCG | GGAGCACCCAAAC | GGAGCACCCCAAC | 0,0 |
| Etr_2791 | A | G | AGGTGGTACTGCAATGGACC | GCTCCGTCCATACCATCATATGT | CCCAGAGAAACAGCAGA | CCCAGAGAAGCAGCAGA | 0,0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Etr_2823 | C | T | ATGTGCGCCATGCCGAT | CACACGGGGGATCTTTGTCT | CGCACGCGCCGAGCAGT | CGCACGCGCTGAGCAGT | 0,0 |
| Etr_2841 | G | A | ACAGGTAGTACTGCAACGCA | GCTGGATGCTTGGAGACCAT | CGCATCTTTGTCCCTGC | CGCATCTTTATCCCTGC | 0,0 |
| Etr_2858 | T | G | GGCAGAGATCCTTGAGAGCA | CTCCACTATTCCGCATCGTGA | GAAAAGAAATGGTTTGA | GAAAAGAAAGGGTTTGA | 0,0 |
| Etr_2878 | C | T | AGCTTGCATCCGTGACTTCA | GGTTGTCAAGGTTCTCGTGGA | CTTGTCAATCTCCACGA | CTTGTCAATTTCCACGA | 0,0 |
| Etr_2915 | C | G | GCCCTTCAAGTTCCAGTTCAC | GTTCACAGTAGATCTTGACCCTTCA | ACAGCCTCCCTTCCAC | AGCCTCCGTTCCAC | 0,0 |
| Etr_292 | A | G | ACATGCAGAATAGGGACAGAACA | CGTGTGCCTCACAGTGAGAA | CAAATAAACACCACACA | CAAATAAACGCCACACA | 0,0 |
| Etr_2937 | T | C | CTTCGTGCTGGTGATCGGTC | CACCACCTCCACGTAGCAG | GGCCACGTTTTTCCGCG | GGCCACGTTCTTCCGCG | 0,0 |
| Etr_2971 | T | A | AAGCTTTACGTGCAGGCTCA | CAGCACCACCTTTTTCCGTG | CATTGAGGGTGCA | CATTGAGGGAGCA | 0,0 |
| Etr_2974 | G | A | TGAGACCAGCGCACCTG | TGAGTGTGCATGGTGAGTGT | CGCCTGCCCGCACACCT | CGCCTGCCCACACACCT | 0,0 |
| Etr_2990 | A | G | GAGCCTCTGGGTGATCTCCT | GGAGAACCCGTTTGCGTTTC | CTCAGAGACATCCTCGG | CTCAGAGACGTCCTCGG | 0,0 |
| Etr_3007 | G | A | CGGTGTGAAAATCAGACGGG | CCGGTTGGCCTCACATAACT | GGTTGTAAGGGTTGGGA | GGTTGTAAGAGTTGGGA | 0,0 |
| Etr_3037 | G | A | CACCTTCAGGAAGCACACGA | GGGTACGCACAACTCTTGGG | CACGATCTCGTTGTCTG | CACGATCTCATTGTCTG | 0,0 |
| Etr_3038 | G | A | AGTCGACCCCTCAACCACAATT | ACGTAGTGCAACAGTAGAGC | TTTCTACTCGGCTCTAC | TTTCTACTCAGCTCTAC | 0,0 |
| Etr_3069 | C | T | GGCAATCACATCTGTTTCATGCA | CCAGACGCAGCCATGTATACTG | TTAAGGCGCAACACAC | TTTAAGGCACAACACAC | 0,0 |
| Etr_3081 | T | G | TCCCTCCCTGTTTCAAAGCC | CTCGGCTTGTCTTCCAGGAG | TCACAATCATCTCCTGG | TCACAATCAGCTCCTGG | 0,0 |
| Etr_3107 | C | T | GGCAAATCCTTTCTAATTACCATCC | GCATCTCTGGCTGGCTAACA | AAAGGACACCACAGATT | AAAGGACACTACAGATT | 0,0 |
| Etr_3128 | C | A | GGGACACTTGGAAGGACACC | AGGATTCCGACCACTTCACA | ACCAGTCACCAATGACT | ACCAGTCACAAATGACT | 0,0 |
| Etr_3145 | C | T | TGGTGATGACGATCGTGGTGCC | TTCATCATCTTCCGCACGGT | GGTGCCCATCGGAGGA | GGTGCCCATTGGAGGA | 0,0 |
| Etr_3169 | C | T | ATAATGGTTCGCGACAGGCA | ATAACACCGCAGCATCTCGG | AAGCCGGTGCCACCGAG | AAGCCGGTGTCACCGAG | 0,0 |
| Etr_3189 | C | T | CAGGTGCAGTACGCACTCA | GCGCCAACCGCTACAC | CACGCGCGCACGC | CACGCGCACACGC | 0,0 |
| Etr_3234 | T | C | CCAAGTGCTAAGTACTCACTCTGT | TGTTCATGAAGGGCACTGAGA | TGATTTCTTTAGCTCCT | TGATTTCTTCAGCTCCT | 0,0 |
| Etr_3240 | T | C | ACCTGCGTCAGCTGAAAAAC | AAAACCATTTCGTTGAGGGCC | AAACCTGGGTGTGGGCC | AAACCTGGGCGTGGGCC | 0,0 |
| Etr_3253 | A | G | CAGGAGCAAGAGCAGTCTCA | CCACTTGAGCTTAAGTTCGCG | CGAGTTCACACGCGAA | CGAGTTCACGCGCGAA | 0,0 |
| Etr_3255 | C | T | CAGCCACTCCACCACCATG | TTCGAGTGCCAGATGACGC | GTGGGGGTCCCCGATGG | GTGGGGGTCTCCGATGG | 0,0 |
| Etr_3262 | C | A | AGGTGCCTCCTTCCAAAAGT | ACTGTACCAGCTTAAGTGGAAA | CCAAGAATGCT | CCAAGAATGAT | 0,0 |
| Etr_3292 | G | A | GCAGGTGAACTGATTTCATGTATCCA | GAGCGGCAGCCTAGGAA | TGCTCTCAAACGTGTTCCA | TGCTCTCAAACATGTTCCA | 0,0 |
| Etr_3330 | G | A | ACTGGGGAAATGTGAACTTGA | ACAACCCCTTGTGTCGTCAA | GAACTTGATGGTTTGGG | GAACTTGATAGTTTGGG | 0,0 |
| Etr_3350 | G | T | GGCAGGCAATAGATCCTCATTCAG | TGATTTTGGGCGAAGATTAACGT | AGCAGGCCGTCTGTC | AGCAGGCCTTCTGTC | 0,0 |
| Etr_3356 | T | G | GTCATTGCTCCACACACGTG | CGGTGCTCGCAAAAAGAGAG | GCATACACGTACAACAG | GCATACACGGACAACAG | 0,0 |
| Etr_337 | T | C | ATCGTCAGGAGGAGCCCAG | CTGGGTGGCAGGTTTCACAA | AGGTGAGTCTTTGT | AGGTGAGTCCTTGT | 0,0 |
| Etr_3383 | T | G | GGTCGTCTCGAGGTGTTTGG | GCACGCACGCGTCAA | CACCCGTTATAGAAAC | CACCCGTTCTAGAAAC | 0,0 |
| Etr_3403 | T | C | GCAAACCCAAATACGCATCGT | TTCCAGACAGCAAGGGCAG | CGTATCCTTTCATGGGG | CGTATCCTTCCATGGGG | 0,0 |
| Etr_3411 | G | C | ATGTCGCACCTCCACATGAG | CGGGATAACTCACGGGCTG | GCCGACCCCGCAGCCCG | GCCGACCCCCCAGCCCG | 0,0 |
| Etr_3466 | G | T | TGCCCCGAACATTGTAATGGA | ACGTAGCCATTCGACCACTT | AATGGACACGATTCCAC | AATGGACACTATTCCAC | 0,0 |
| Etr_346 | G | A | TGGCGTGATCGGTAGAAACT | TGCAGCAATATAGACCTTACCTGT | TGAATTTTCGGCCATAC | TGAATTTTCAGCCATAC | 0,0 |
| Etr_3502 | A | T | TACAGCGCTACACATGCACAA | GTCTTTAACGTGAAAGAACCTCCA | AACCCAAAAAAATGCTT | AACCCAAAATAATGCTT | 0,0 |
| Etr_3549 | A | G | CAACCGCCATGCTTGCA | CTGCCGCTCGGGTCT | CCCGTACATGGTCACC | CCGTACACGGTCACC | 0,0 |
| Etr_3555 | C | T | GCCCATCGCTCGTTTCAC | GCAGTGCGCCAACCATAA | CACCAACCGTGGCAAT | CACCAACCATGGCAAT | 0,0 |
| Etr_3601 | T | A | TGGCTCTCCACTATCCCAAA | GCCTTTGTTTTGATTACAAGAGCA | CCCAAATAATAAACTTT | CCCAAATAAAAAACTTT | 0,0 |
| Etr_360 | G | T | TGCTTTCCATGAGTGGTGGT | AAGTGTGCGCATTTCATCCG | TGGTGCGTTGGTGGTGC | TGGTGCGTTTGTGGTGC | 0,0 |
| Etr_3638 | C | T | TGTGCACGTTCTTAGGTCAGA | ATTAGTTGTGCACGCAGCTC | ATTGTAGACCGAGCTGC | ATTGTAGACTGAGCTGC | 0,0 |
| Etr_3725 | T | C | ACACTGCTCCAGTAGGTATCC | AGATAGGGCCCAGACAGCA | TAGGTATCCTAGCTCCA | TAGGTATCCCAGCTCCA | 0,0 |
| Etr_378 | G | T | CTGAGAGGCTGTCTGCAGAG | GCCCTACATTTGGGGAGTCA | AGTCAAAATGTATTTTA | AGTCAAAATTTATTTTA | 0,0 |
| Etr_3837 | C | T | TGCCCTAAAGTTGACATCCGT | CCAGAAAGAATAAGCGCGGG | GACAATTGTCACGTGCC | GACAATTGTTACGTGCC | 0,0 |
| Etr_384 | G | T | GCCACCCATTCTGGAATTCCT | ACGCATGTCCCATGATGCT | CCAAGATTTGTAATCTC | CCAAGATTTTTAATCTC | 0,0 |
| Etr_3885 | T | A | GCACTTTGCTCGTACTGAACA | GCCAGTGATCCTGAGGTTTCT | AACATTATTTACAGTTA | AACATTATTAACAGTTA | 0,0 |
| Etr_3939 | C | A | TGAGTGTTCCTCGGGGAGAC | TTCGCTGAGGGAAGGAGAGT | GGAGACCAACATATATC | GGAGACCAAAATATATC | 0,0 |
| Etr_3960 | T | C | TGCAGGGATTACTGGTGTCAAAAT | CCCCTGGCCGCTTAGAAA | CATCGCCATTGATCG | ATCGCCATCGATCG | 0,0 |
| Etr_3963 | C | A | CCCAGAAGGATGTTTGTTGTGT | GCATTGCGGTTAGAGCACTG | TGTTGTGTGCGATGA | TGTTGTGTGAGATGA | 0,0 |

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|---|---|---|---|---|---|---|---|
| Etr_4000 | T | C | CAGCGCTCTGGATTGCAC | TAGGCCCAGGAGGAAGCC | TTGCACGTCTAAC | TTGCACGTCCAAC | 0,0 |
| Etr_4015 | G | A | ACTGTCGTATTTCCCTTCTCGT | CGGTAAATCGTGCATTGGGC | TCTCGTCTCGGGGACTG | TCTCGTCTCAGGGACTG | 0,0 |
| Etr_4028 | T | C | TGCCTTGGAAATCCGACACC | TGTTGTTCCGTGGGCGAC | ATAAATCAATGTCGCCC | ATAAATCAACGTCGCCC | 0,0 |
| Etr_4037 | G | T | TCCTGGTCTCTTTATTTCTCACAA | GCTTTCTCACAGCACTTGCC | TCACAAAATGAACTTGA | TCACAAAATTAACTTGA | 0,0 |
| Etr_4079 | G | A | TCTATGGGTGATTGCCATGTT | TGCACCAATCTTACCACGGA | CTACATTCAGTTTAATG | CTACATTCAATTTAATG | 0,0 |
| Etr_4093 | G | A | CTCTGGAACGTGGCCCAG | GCATAAACACGCTGCCCATG | AACGCACGCGCGGGCAC | AACGCACGCACGGGCAC | 0,0 |
| Etr_412 | G | A | GGTAGCTTCTCCCCCTAATGCT | TGGTGAGAAAGAAGTTCAACATGCA | CCTCGAAGCAGCTTT | CCTCGAAACAGCTTT | 0,0 |
| Etr_4130 | A | G | CAGGCCGTTCCTGCG | GCTCCCCTCGGAAGCC | ACGATGGCAACGACG | ACGATGGCGACGACG | 0,0 |
| Etr_4142 | T | C | CATCCTGTGGTCTGCACCTG | GAGACGATGTTGCTGAAGGC | TGTGCAAGCTGCCTTCA | TGTGCAAGCCGCCTTCA | 0,0 |
| Etr_4156 | A | G | GTAGCGGTTGGTGTCTAGCA | GACGTCATCCTCAACGGCC | TAGCAGCTCAGGGTGCA | TAGCAGCTCGGGGTGCA | 0,0 |
| Etr_4165 | C | A | ACTTTCCTCTATCTTGCGCCA | GGAGACCGAACAGAGAATGGG | GCCAATATTCTC | GCCAATATTATC | 0,0 |
| Etr_4173 | A | G | GCACAACAATGTTATAACGGCACAA | GACGCCATGTCAGAGAGACT | CCAATGCATAAGTAATC | CAATGCATGAGTAATC | 0,0 |
| Etr_4194 | A | C | ACTTTCCAATGTGCCATGCG | ACTCCATCGTAACTGCAGTGA | TGCGAATCAAACTTCAA | TGCGAATCACACTTCAA | 0,0 |
| Etr_4214 | C | T | TGGGTTCCTCGCACTGTTAG | TTCACGTTCCTAATGCTGTCTGA | TGCGTTCACGTTCATAG | TGCGTTCACATTCATAG | 0,1 |
| Etr_4215 | A | G | TCCTCGTGGATGATGTAGCG | GGGCTGCACCAATACCTCTT | GATGTAGCGATACGTGA | GATGTAGCGGTACGTGA | 0,0 |
| Etr_4254 | G | A | ATTCCTGCTTGTGCACGCTT | CGAGAGCCTTCACGCCTAAT | CTTTCCCATGTGTGCCT | CTTTCCCATATGTGCCT | 0,0 |
| Etr_4281 | A | T | TGCAGGAGGACTACACCAACT | GCACGGTTAGTCATTGGGTCAA | ACGTGGCAGTCTATG | ACGTGGCTGTCTATG | 0,0 |
| Etr_4288 | A | T | AGCCACATTGCTCCTCATGT | TGGTGATCGACTGAACCAGC | AAGGATGATAG | AAGGATGATTG | 0,0 |
| Etr_4390 | T | C | ACGTAATAGTTGGCGGTGGT | GGGCCTCACCTGGTTTTCAA | CGGTGGTCATGGGTCAT | CGGTGGTCACGGGTCAT | 0,0 |
| Etr_4414 | G | C | CTCCGCATTAACCCCTTTGTC | GCGCGTGTTGTCCAAAATTG | AGGAGGCCGCCCGAG | AGGAGCCCGCCCGAG | 0,0 |
| Etr_4455 | T | C | TCGTTCCGGGGGTCTGAG | GCCGTAGCTATTTGAGTCACG | GTCTGAGCTTGCGGGGG | GTCTGAGCTCGCGGGGG | 0,0 |
| Etr_4479 | C | T | AATGATGTCGGCGCTGTACT | CTTGCGTGGGAGTACCGC | CATGATGCCCTTCTTGC | CATGATGCCTTTCTTGC | 0,0 |
| Etr_4498 | T | C | TGGCAAGTGGCGGTAATTCT | AATGAATCGTGGCCCCTCTC | GCAAGGGGTTGGT | GCAAGGGGTCGGT | 0,0 |
| Etr_4504 | C | T | TCAGACACTCCTGAGATCCCA | TTCATGGGTGGGAGTGGGAT | CTGATTGTCCACACCAA | CTGATTGTCTACACCAA | 0,0 |
| Etr_4521 | C | A | GTAGCACAGCGGGATCTCCG | CCTCGTCTCGCTGGACTTT | GGTTGCACGCAAAGTCC | GGTTGCACGAAAAGTCC | 0,0 |
| Etr_4531 | G | A | GTTTGAGTTTGCGAAAGGTACGA | GTACGTAGCGAGCGTGTGT | CCGCACGCGCTCG | CCGCACACGCTCG | 0,0 |
| Etr_4544 | G | C | GGCACACTGGTTCCATCTCT | GAATTCGGGGTGTGGAGGTT | TGTGATTCAGCAACCCT | TGTGATTCACCAACCCT | 0,0 |
| Etr_4574 | G | T | CGGCGCACATCTTCCAAAG | GAGTGGAAGACGACGTCTCG | CTTCCAAAGGCCCTGGT | CTTCCAAAGTCCCTGGT | 0,0 |
| Etr_4596B | G | C | GTGTGGGTGAGATGAACCGT | TTCCACATTAAGGCCTCCGG | TTCTGGTAGGCCGGAGG | TTCTGGTAGCCCGGAGG | 0,0.7 |
| Etr_4596 | G | C | TGAACAGTGTGGGTGAGATGAAC | CATCGTCTCCTCCTTCCACATTAAG | CCTCCGGCCTACCAG | CCTCCGGGCTACCAG | 0,0.7 |
| Etr_4633 | G | A | GAAGGGACGAGGAGGAGAGGT | CATGTCCAAGTCGCTGCTTT | CTGGGCAACGAAAGCA | CTGGGCAACAAAAGCA | 0,0 |
| Etr_464 | C | A | TGCAGGGACCGCGTTAC | GTGCCCCACCGGTCT | TAGCGCTTCACCCCGTCCA | CGCTTCACACCGTCCA | 0,0 |
| Etr_4670 | G | A | AGGATCCGAGCCCATAATGAGA | GTTTGGTCGACATCGGAAAAGG | CCGTAACACTGTCCCCGG | CGTAACACTGTTCCCGG | 0,0 |
| Etr_4686 | T | C | CTAGGATAGCAGCACCGACGC | CCAAGGCCCCTATGCGTAAA | GGTCTGCTATTCGGTG | GGTCTGCTACTCGGTG | 0,0 |
| Etr_4694 | A | C | GCACCATGACGCCTTCATTC | TCTGTTGAGTGGTGTGATATGCA | ATCACATACATAAA | ATCACATACCTAAA | 0,0 |
| Etr_4716 | G | A | GCCGACACGAGCATCAGAA | CCTGACTGTCTTGCCACGTA | CATCAGAACGATAGCCC | CATCAGAACAATAGCCC | 0,0 |
| Etr_4750 | T | G | CAAGGTAAGCGGCAGTCAGA | ACTGCAATATACACCTGTCCTT | AGCTCGTTTTC | AGCTCGTTTGC | 0,0 |
| Etr_477 | C | T | AAGTGGGTGCTGGACTGGC | TCGCTGGTCCAGTAGATGGT | AGCTGCAGATCACCA | AGCTGCAAATCACCA | 0,0 |
| Etr_4800 | G | A | GCGCTTGGGTTTCTTGTTGA | CTGCTGCTGCTGATTGAGTG | ACCTGGTGCGAGAACGG | ACCTGGTGCAAGAACGG | 0,0 |
| Etr_480 | C | T | CGCACGTGCCTTGTTTATGT | TCCGACAATTCGCAAGTCGA | CAGGGACTCCTCTACTT | CAGGGACTCTTCTACTT | 0,0 |
| Etr_4845 | G | T | AGGAATCCGATGAGCTACGA | CGTACGTCGGACACCACTG | AGATGTCCAGTCGGGGC | AGATGTCCATTCGGGGC | 0,0 |
| Etr_4853 | C | T | CCTCGCACGGGGGTCTATA | GTGCAGGTTCACTCTCCCC | CGTCGAAGGCCTCCAGC | CGTCGAAGGTCTCCAGC | 2.4,0 |
| Etr_4859 | C | G | CCCTGACCACCCACTCACAG | AGCTTATATTAACGCAAGCGGC | CACAGGGATCGATGGCA | CACAGGGATGGATGGCA | 0,0 |
| Etr_485 | A | G | CAGCCACCGTCGACACA | AACTGCTGAAGTTACTGATGTTCACA | CACCAATTAAGCATTGTATTT | CCAATTAAGCGTTGTATTT | 0,0 |
| Etr_4889 | T | C | TGTTGGGAACAGGGCACAAA | CTTTGTTCGCGCCTTCGTTC | AGGTTATGTTATGAAGG | AGGTTATGTCATGAAGG | 0,0 |
| Etr_4965 | T | C | GCGCCAGGTGAGGAGA | CTCCTCTTCCTCGTTGCAACTT | CCACCGAGTTGGCTAC | CACCGAGTCGGCTAC | 0,0 |
| Etr_49 | A | T | TGGGTGAGCGAGGATGGT | CGTCCACACTGCGTTCAAC | TTGTGATGCAACTTCGT | TTGTGATGCATCTTCGT | 0,0 |
| Etr_5020 | A | C | CCCCCACGTGACGCA | GCTGCAATGTGGGAGACCTTT | TGCAACGAAATAATTTAC | TGCAACGAAATCATTTAC | 0,0 |
| Etr_5043 | A | C | TGCAGGGTTTATATTTGCCAAATCA | GGCGAATGGCGGTTGTTATT | AACAACTTTAATTCGGC | AACAACTTTCATTCGGC | 0,0 |

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|---|---|---|---|---|---|---|---|
| Etr_5112 | C | T | AGAACAGCTTGCATTGGGGG | GGCGTCTCGGAGCAAGTTAT | TTGGGGGTGCCCTTAGA | TTGGGGGTGTCCTTAGA | 0,0 |
| Etr_518 | C | G | CCGGGATTCGAATTCTGGGT | CCTGAGCAGCCCGATGG | TCAGCGGTGCCAGGTCG | TCAGCGGTGGCAGGTCG | 0,0 |
| Etr_5193 | T | G | ATTGGCCGCCCTCATGAA | ATACACTGTGAAGCAGATGGAACTT | TGGTTAATTCACCAGAAGTA | TGGTTAATTCACCCGAAGTA | 0,0 |
| Etr_5197 | C | T | GCAGGTGATTTGTCCATAAGAGGTT | GTGGTGGGTTTAACGACACATTT | ATATATTTACGCGATCTAAC | ATATTTACGCAATCTAAC | 0,0 |
| Etr_5267 | G | T | GGAAAGAGGCTCCGGCTG | AGTTGTCCATCATGCGCTCA | GAGACGCGCGGGCATGC | GAGACGCGCTGGCATGC | 0,0 |
| Etr_5272 | C | T | CACCGTGTCCGAGTCGTG | GAGGACAGAGCGTGAAGGAG | GCGCGCAAACGATGCTC | GCGCGCAAATGATGCTC | 0,0 |
| Etr_527 | A | C | GGTTACTCGGTTGGTATCACACA | GGCAATGCTGCTGCTTCTG | CAGCAGAAAAAGCA | AGCAGCAAAAGCA | 0,0 |
| Etr_5317 | A | C | CGGATTTTCACCTTTTCTGCGTTTC | CAGTTCACGAGCCAGACTACAG | CACGAAATTTTGAACTTTT | ACGAAATTTTGCACTTTT | 0,0 |
| Etr_5346 | T | C | TGTGTGGGAAATGACAACATCCAT | GACATACGGTGCTGGTACTACAAT | AAGGCTCAATAATGC | AAGGCTCAGTAATGC | 0,0 |
| Etr_534 | T | C | CTCCACGGTCTGCGTGAACCG | CGGGTTAGCCTTCAAGGGAG | CCGTGCTCGTACAA | CCGTGCTCGCACAA | 0,0 |
| Etr_5352 | A | G | ACAGGATCTATGGTCTGCAGAG | ACCCGTGAGACTCGTGAAAA | AGAATCTGGACAATGGC | AGAATCTGGGCAATGGC | 0,0 |
| Etr_5465 | A | G | CGACTGCCCTTCGATGCA | TTGACCTTGACGGATTGGATCTC | CCGCGTGTTCCAGC | CGCGTGCTCCAGC | 0,0 |
| Etr_5510 | A | G | TGCAGGAAGTAACTGTGTAATTAAACG | GCGACGTAAATATGTCTGCAAGTTT | TCGTGTTGACCTCTTCAGTA | CGTGTTGACCTCCTCAGTA | 0,0 |
| Etr_5540 | A | G | AGGCTGGAGTGGCGAATTTA | TGGAGGGAATGCCTTGTCAG | CTTTATGCCAACTGACA | CTTTATGCCGACTGACA | 0,0 |
| Etr_5581 | G | A | CCCCACCTACCTGCTGATGA | TGATAGGCGCGAAACCCATT | ACCTAATCCGTCT | ACCTAATCCATCT | 0,0 |
| Etr_5600 | G | T | CAGGAGACGTAGCCCCTCTA | GAGTAGACAAGAGAAGACGAATTCACA | CCAATGTCACTTGCACCGA | ACCAATGTCACTTTCACCGA | 0,0 |
| Etr_5603 | G | A | CGCTCCACATTGTTGAGAGC | GTTGTTGTGAGCTGTGCTGC | GATACTCCAGCTCCTTG | GATACTCCAACTCCTTG | 0,0 |
| Etr_5626 | T | C | ACGTTTTTGATAAAGGTCCCGC | GTCTGAATTTTCCTTGTGCCCA | TGTGTGATGTATTGGGC | TGTGTGATGCATTGGGC | 0,0 |
| Etr_5654 | T | G | AGGAGATCGAGAGGCTCACA | TGAGACAAGGGTTCACGTGG | TGAGGAATGTAAAACTG | TGAGGAATGGAAAACTG | 0,0 |
| Etr_5711 | C | G | CTCAGGCTGGATCGATGTCG | TTAACGCACGGACATCACCA | CTCCTCTGCCGCGCGCA | CTCCTCTGCGGCGCGCA | 0,0 |
| Etr_5754 | T | C | AGGCCCCCTTTGTGTTTAACT | GAAAATGGATGCCCACTCGC | TGCGGAGAATGCTGCGA | TGCGGAGAACGCTGCGA | 1.2,0 |
| Etr_5757 | A | G | TAACCAGCATCGCTTCGGAC | ATGTCCACATCGTCCTGCAG | GGTGCCAGGAAAGG | GGTGCCAGGGAAGG | 0,0 |
| Etr_5762 | C | G | GGTAAACGTGGAAAGAGCGC | AAAGTCCCCGTCTCTTCGTC | GCGCGACACCAACGACG | GCGCGACACGAACGACG | 0,0 |
| Etr_5780 | T | G | AGCTGGGTGGTTGAGTTGAG | ACAATGCGTGTGTTCAACCG | TTGTGATCTTCAGTATT | TTGTGATCTGCAGTATT | 0,0 |
| Etr_57 | A | G | GCGCCAATTGTGTTTTGTTGA | CCCCTCGGAGGTTTATTGCA | ATTAGCACAACGTGCCG | ATTAGCACAGCGTGCCG | 0,0 |
| Etr_5831 | A | G | GCGCTCTCGATCCCTTGTTA | ATAAACTTCGGGTGGCCCAG | GCAATGCGCATGCGCGC | GCAATGCGCGTGCGCGC | 0,0 |
| Etr_5960 | C | A | TGAAGCCAAACACTCGTCCA | ACATGGAGGGCATGCAAATG | ACTCGTCCACCAAACAT | ACTCGTCCAACAAACAT | 0,0 |
| Etr_5993 | T | A | GACACGTCCACCACAGGG | TGTCAGTGTTTTCGCAACGAC | TGGAGTCGATTGGAAAC | TGGAGTCGAATGGAAAC | 0,0 |
| Etr_6026 | C | T | TCGGGAGGCACGTTCTTC | GCATAAAATCGGCAGAAATGAGAGA | TCCACCCAGCCCTACC | TCCACCCAGTCCTACC | 0,0 |
| Etr_6037 | G | A | CCAGGACCAGCCTCAATGTT | TACGCTTGCGAAATGTGGAC | AACGGCGACGAAG | AACGGCGACAAAG | 0,0 |
| Etr_603 | G | A | CAGGAGGAGAAGCCGTGG | GGGCAGGGAAGAAGTGAGT | AGGTGTTCCAAGTTTGTT | AGGTGTTCCAAATTTGTT | 0,0 |
| Etr_6076 | T | C | GCTGAGCATTTCTCCGAGGT | TCAGCCAGCCACTTATAGGC | AGGAGAAATTCCTCAGC | AGGAGAAATCCCTCAGC | 0,0 |
| Etr_615 | A | G | GCGGCTTGGGATGTTATCTTCAATA | GCCTGGGCGGCCTATC | CACGGCACGGTCG | ACGGCGCGGTCG | 1,0 |
| Etr_6179 | T | C | ATGCCAGGACACAAGTTCGT | CTGCTCATGCTCCACAGGTC | AGCTCGCAGTGAC | AGCTCGCAGCGAC | 0,0 |
| Etr_6229 | A | G | CCCCCAAACATTGCTTTGGT | ATGCTGGTTGGGCTCTTACC | TTTGGTGCAAACTTACC | TTTGGTGCAGACTTACC | 0,0 |
| Etr_6318 | G | A | GACTTGTTCCGGCACTACCC | GCCGTGAAAGAGAGCGTGAG | TACCCCGCCGTGTTTGT | TACCCCGCCATGTTTGT | 0,0 |
| Etr_6363 | A | G | CACGATGCCACAAACATGTCA | GCGTTTCATTTTTCATTGGATCCC | CTAAAGTATAATTAAAG | CTAAAGTATGATTAAAG | 0,0 |
| Etr_6369 | C | T | GAGCAGGACAAAGGCAGGAG | CTTCCGCTCCAGCTGATTCA | GCTGGTGCACAAGCAGA | GCTGGTGCATAAGCAGA | 0,0 |
| Etr_6389 | G | A | ACATTACCTGTAGGTGGTTGTTAAAGG | CCACGATTATAATCGGCAAGATCAC | AATGGTAAACAGAGCATTG | ATGGTAAACAAAGCATTG | 0,0 |
| Etr_640 | G | A | AGGTAGCACAGCAAGTAGGA | AATGCCCCAAAAAATCCGTGG | AAGTAGGATGGTGGCCT | AAGTAGGATAGTGGCCT | 0,0 |
| Etr_642 | G | T | GACGCTCACTGCATGCAAG | ACCATTTTCATGCCACCCCA | TGCAAGGTTGGAA | TGCAAGGTTTGAA | 0,0 |
| Etr_6436 | G | A | CAGGGAGCACTCGTCAACAA | GATGTGGCCAGTGACAGACT | GTCAACAATGTGCGACA | GTCAACAATATGCGACA | 0,0 |
| Etr_6440 | G | A | AGTCAGTACATTGAGTTCCAACT | ATCCCTCATCCCCATGGTCA | ACAGCGGTTGTCCTCAG | ACAGCGGTTATCCTCAG | 0,0 |
| Etr_64 | A | C | GGAGGCGCTGTAGCTTCAT | AGGACTTTCTTTTTAGGTTTGTAGCCAAT | CCTGTACTGAAAGTAACTC | CTGTACTGAACGTAACTC | 0,0 |
| Etr_668 | A | G | GTCCCGTGGACAAGAGTCA | GCTGCCAGGCACTTGTG | CGCAACCAATGCCGC | CGCAACCAGTGCCGC | 0,0 |
| Etr_673 | C | T | GCCGACAGCTGCTTCTCT | CCACGTTGCTGTTGTTTTGTCA | CGGCCGCTTCTCT | CGGCCACTTCTCT | 0,0.5 |
| Etr_678 | G | T | AAACTGGGCTTGGTAGGTCA | ATTCTTGACCGTCGGCTGTC | GGTAGGTCAGGTCCGCT | GGTAGGTCATGTCCGCT | 0,0 |
| Etr_681 | C | T | CGCGTCGCCATAGGTGTT | CAAGCACATGCTCAGCAACAG | AGCACGAGACGAGCGG | CACGAGACAAGCGG | 0,0 |
| Etr_687 | C | T | AAGAAGCTCCATCGCCACTT | CGTGGTTTCAGTTGCGAAGG | TCGCCACTTCATTCACC | TCGCCACTTTATTCACC | 0,0 |

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|---|---|---|---|---|---|---|---|
| Etr_705 | G | A | AGCAGAGACACGCAACGTAAATA | GGTTGTGCTGGACATTGTTATTTGA | CCGCTATCTCCGGCTGG | CCGCTATCTCCAGCTGG | 0,0 |
| Etr_7081 | T | C | GGAAGAAAGAGGGAGGCCTG | AGCACAATTCGTCGTAAAGGG | ACATTGTTCTATTCTCA | ACATTGTTCCATTCTCA | 0,0 |
| Etr_7142 | G | A | ACCGGTGTTCTCTTAGGGGT | GGCATAGTCAGGGTCGAACC | GGTCTTGGCGCCACGGT | GGTCTTGGCACCACGGT | 0,0 |
| Etr_7166 | C | T | CAAGCAGCAGTGAGAGGACA | TGCCAGTTTAAAGCTAAGCGA | AGGACAATTCCCATCTT | AGGACAATTTCCATCTT | 0,0 |
| Etr_717 | T | G | CCCCAAAGAGTACGAACGGTTA | CGATCGCTCGTCAGATTCTCA | CAAGACAAAGATCCACACGTG | CAAGACAAAGATCCCCACGTG | 0,0 |
| Etr_7262 | G | A | TGACAAGACAGCACAACCGT | GGCAGGTCCAGGGTCAAATT | CGGTTGTAGGCACTGTC | CGGTTGTAGACACTGTC | 0,0 |
| Etr_7292 | T | G | CAGAAGTGATTTGGAATCGGCA | GGCCTTCTCTGCATATATACCAGT | TGGTAAAATTTACT | TGGTAAAATGTACT | 0,0 |
| Etr_7358 | T | C | GAAACACAACCGCAGCCG | TGGCGTTCACGTGTTTTGTC | GCCAGTGAATGTGAACG | GCCAGTGAACGTGAACG | 0,0 |
| Etr_7382 | C | G | AGGTGGTAGGGTTAAGGCGA | TCCTCAAACACCCCGATTGC | CAGTGGAGGCAGTTAGA | CAGTGGAGGGAGTTAGA | 0,0 |
| Etr_7387 | G | T | CGGTGGTCGAGGCGAATG | CGTCTCCGCGGAAGGT | AAGGAGTGGCGGTGTAA | TGAAGGAGTGGCTGTGTAA | 0,0 |
| Etr_73 | T | C | TGGCAGGTGTGGAAAGCA | CTCGCGCTGTTAAACCTCTTG | CGCTGTCATGTTCC | CGCTGTCGTGTTCC | 0,0 |
| Etr_7416 | T | C | GTGTCGGCAAGGGTGAGATAT | AGGAGCTTGACAAAACAAAAACAGATTTATTATC | CTCCTGTGACATCCAG | TCCTGTGGCATCCAG | 0,0 |
| Etr_7443 | T | G | GCCTCGATCAGGTCCTAGGT | CCTCTTCACCCTCCCCTCTT | TCCTAGGTTTG | TCCTAGGTTGG | 0,0 |
| Etr_752 | A | G | TGGGTGGGTGAGTTTGTGAG | GCTGTTAGCGAGCACAACAC | GTGCGTGATAAA | GTGCGTGATGAA | 0,0 |
| Etr_754 | T | C | CAATTATAGCCGAGGAGCCCATCT | AAGATCGGTGAGGCAGAGAGA | CTCGTTTCCGTTCTGCCT | TCGTTTCCGCTCTGCCT | 0,0 |
| Etr_7649 | G | A | CCTTCCCAGACAGAGGTTGGA | GGCAAACACGCACCTGTAG | ACGAGTGGGAGCCTG | CGAGTGAGAGCCTG | 0,0 |
| Etr_766 | T | C | GGAAGCTGACAGCCAACATTG | GGCCTGCGAGACATTGAGT | ACGATCTGTTCTCTTAGTAGC | CGATCTGTTCTCCTAGTAGC | 0,0 |
| Etr_773 | C | T | CCGCTGCTATGGCGTTAGT | CACGTACCACGACTAGTGCTA | CGCGGGTTAGGACAT | CGCGGGTTAGGATAT | 0,0 |
| Etr_7781 | T | C | CTCCCTGCAACCACCTGAC | CACGTACTCAGCTCACAGCC | GGGGGAGTGTGGCTGTC | GGGGGAGTGCGGCTGTC | 0,0 |
| Etr_781 | C | A | GCCACTCTTGTCGTTAACCTTGA | CGGGCTTGGGTAGGATATGTC | CTGGAAGAAATGATTCTC | ACTGGAAGAAATTATTCTC | 0,0 |
| Etr_785 | C | T | GGACGCGTGCCAATTGAG | GCCCGATTGGCCACCAT | TTGGTGCAGGAAGTGA | TTGGTGCAGAAAGTGA | 0,0 |
| Etr_786 | A | T | TCCTCTTTCTGTTGCTTCCCC | AACGAGCTCGGGAAAAGAGG | TGCTTCCCCAGCAATTT | TGCTTCCCCTGCAATTT | 0,0 |
| Etr_7872 | T | C | GCACAATGCAAACAAGGCTG | GCACTGGAAGCCCTTACACT | GGAATTCTATGGAGGCT | GGAATTCTACGGAGGCT | 0,0 |
| Etr_7918 | T | C | TACGGACCCAAAGCAGGTTG | AGCTCCACTCCTCACTCCTC | CCGACGGGATATCCGAG | CCGACGGGACATCCGAG | 0,0 |
| Etr_7974 | G | A | CTTCAGCGCCACGTTCTCAG | AATTCAGCAGGAGAGGCCTC | CTCAGCCACGAGCTTCG | CTCAGCCACAAGCTTCG | 0,0 |
| Etr_8064 | A | G | GTGTGATGCTTCTGATCTGTCC | GCGCAAAGTGTGAAAATCTGG | GATCTGTCCACCATTGG | GATCTGTCCGCCATTGG | 0,0 |
| Etr_810 | A | G | CAGGTAGTTGATGGTGACCCA | GCAGCGCTCGCATCCT | CCAAAGGCACCCTCC | CAAAGGCGCCCTCC | 0,0 |
| Etr_814 | C | T | GGTCCACGGTCCGATGTG | ATGAGATGACTTAACAAACAAAGATTGCA | TTTCTGCCCCAACACC | TTTTCTGTCCCAACACC | 0,0 |
| Etr_8196 | A | C | GCTTGTTCGCTCACGACACT | ACCTCGAACTCGCTTGCT | AGAAGGACCTCAAATAGAT | AAGGACCTCCAATAGAT | 0,0 |
| Etr_824 | C | G | TGCAGATGTTCGTCACCGAT | CGACCCAGCCTCAAATGAGT | ACCGATGTTCGTGGCCG | ACCGATGTTGGTGGCCG | 0,0 |
| Etr_8281 | G | A | GGAGAGTATTCCTCGTGCCG | ACAGACTGGTGAGGCAAGTG | CCTTCTGCAGCCTTCGC | CCTTCTGCAACCTTCGC | 0,0 |
| Etr_8298 | G | A | TCTGCTGAAGTGAAATCCGGT | AGCAATTAAGCAGGACCCCT | GAACGAGCAGAGCTGGT | GAACGAGCAAAGCTGGT | 0,0 |
| Etr_832 | C | T | GCAGGTCAAAGTAGACAGTCTTGTG | GCACCTACGAGATCTGCTTCAG | ACGAGTTCTCGACGTTCA | ACGAGTTCTCAACGTTCA | 0,0 |
| Etr_833 | G | T | CTTCGGGAGGCAGCATGT | AGCTGTTTCGTGGGCCATTA | GCAGCATGTGGGGGCAG | GCAGCATGTTGGGGCAG | 0,0 |
| Etr_836 | A | G | ACGCAGCTGCTCTCTGATTG | GTGCCGCTCAACAGCAT | ACGTGATCACTGCCGTC | CGTGATCACCGCCGTC | 0,0 |
| Etr_84 | A | G | TGCAGGTAAATAGAGGTGTGATCCA | CCCTGTGCTGATGTGTGTAGAA | CTGAAGTCTCGTAGTTACG | AAGTCTCGTGGTTACG | 0,0 |
| Etr_8649 | G | A | TCTCAGGAGGCTGGGTAAGG | GCCAAGGCAAGTAAACAGTGT | AAGGCACCGGGAGCAAC | AAGGCACCGAGAGCAAC | 0,0 |
| Etr_8681 | T | C | CTTACACGGACCCACGCTGGAC | CGACCGTGTGATTTGCATCG | GACGCAGGCTGGTTGGC | GACGCAGGCCGGTTGGC | 0,1.4 |
| Etr_874 | C | T | AGGGAGAGCCTCAAGAGCAT | TGAGAGTGATGGTTCTCAGGA | GAGTGGCGTCGACGCAT | GAGTGGCGTTGACGCAT | 0,0 |
| Etr_875 | C | T | TGCAGGCAACGGTTGTAGAG | CCCAACGGGACGAGGTTTT | AGCGCGCCTCGTC | CAGCGCACCTCGTC | 0,0 |
| Etr_8780 | T | C | TCGTTGTTGAAACATTGGCAT | ACATCTCGGCGTAAGTGATTTG | GCATAAAACTTCAAATC | GCATAAAACCTCAAATC | 0,0 |
| Etr_8909 | G | A | TCCGAATTCTCCACGTTGAGA | AGACCAACTGCCGCTAACTC | TTGAGATGCGACAGGCC | TTGAGATGCAACAGGCC | 0,0 |
| Etr_8960 | G | A | TTCAAAACGCCTCGCCAATG | AGTGGCAGTGTTCCGGAAAA | CAATGCCCCGAATGGTG | CAATGCCCCAAATGGTG | 0,0 |
| Etr_899 | A | G | ACGGTGACATAGTCTCCTGGTA | GGCACTGGATTCACACCATGA | CATTCGCCACTTGCT | ATTCGCCGCTTGCT | 0,0 |
| Etr_905 | C | T | GCTTCTGCAGGGAGTCTTGT | TGAAGTTCCTGCGGTACCAC | GTGCGTGTTCTCCCGCA | GTGCGTGTTTTCCCGCA | 0,0 |
| Etr_906 | G | A | AGCCAGAGTTTGCTTCACCA | GCATGCGAAGGCCAAGAAAT | CACCGTCTTGATGCT | CACCGTCTTAATGCT | 0,0 |
| Etr_9113 | C | A | CTGCAACACGGCTCGAAATA | ATCACTTTGCATGCCCCGAA | ATATGCGTCCGATAGTT | ATATGCGTCAGATAGTT | 0,0 |
| Etr_917 | G | A | CAGGTGGCACCGTTGGAT | CCACAAATATTGAACACAACTAAGACACAT | TGAGGAAATCTGGACACTC | TGAGGAAATCTAGACACTC | 0,0.3 |
| Etr_9189 | G | A | GACACGTGTCACCCTGTCTG | TGTAAAATGTTTTCACGCAAGATGT | AGGACACACGTAACATC | AGGACACACATAACATC | 0,0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Etr_930 | G | C | GAAGCATCAGGGAGGGTGAC | TGCACACGTCTGATTGATCAC | GGATGAGCAGGTGATCA | GGATGAGCACGTGATCA | 0,0 |
| Etr_951 | G | A | TCCCTCAAAACGAATGTTCAATT | GCGTGTCACTGCTGAAACAT | TCATTTGCTGGTTGG | TCATTTGCTAGTTGG | 0,0 |
| Etr_963 | T | G | GCTCCCACCACTGATGGAT | CGGATTGACCATATCTGGTGAAGAT | TGCGTCTATGTGTTATTAT | CGTCTATGTGGTATTAT | 0,0 |
| Etr_965 | C | T | GGTGTCTCTGCACTATGAGGT | TCCTCTCTGGTCATCGTGGG | TGTAGGCAACGGAGCCC | TGTAGGCAATGGAGCCC | 0,0 |
| Etr_972 | C | T | TCGCACTGAATCACGTGACA | AGTGGCATTGGCTGGAGAAA | ACGTGACACCTGAGTGC | ACGTGACACTTGAGTGC | 0,0 |
| Etr_97 | T | G | GGTAGCGCTCCGGTCAG | GACCTCCATGGCTCTTTGCT | AGTCGCATGCCCC | AGTCGCCTGCCCC | 0,0 |
| Etr_98 | T | C | CCGTTTTTAAGCCACGTGATG | CTCAAGCAGCCAGTGGACC | TTCACACTGTAGGTC | TTCACACTGCAGGTC | 0,0 |
| LampSD_1589 | G | T | CGACGTTGGGCAAATCGTT | TCACTGTTTCCATCGCAGTACTTATTAAA | AGGGAGCCGATATTG | CAGGGAGCCTATATTG | 0,0 |
| LampSD_327 | A | G | GCCTAAACCACTCGGATGCA | ATGTCAACAAACACAATCCACACAATT | AAGTAGGTGTCTCAGTAAAA | AGGTGTCTCGGTAAAA | 0,0 |
| LampSD_478 | G | A | CAGGAGTAGGCCGCAGTAG | CGCTGTGCCTGTGTCAGAT | CCCAGGGCGTGCCG | CCCAGGGTGTGCCG | 0,0 |
| LampSD_700 | G | T | TGCGATCGCTGATGCTGTAG | GACCCATACCGGTTTCACCAT | ACGACGCAAAGCG | CGACGAAAAGCG | 0,0 |

## Section 2: Genetic Baseline Expansion

### Introduction

Distinct population aggregates of Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), and the species *Oncorhynchus nerka* (including sockeye salmon), have evolved through the cumulative effects of selection and genetic drift (Waples 1991; Nielsen et al. 2009). Homing to spawn in natal rearing sites (philopatry) is a distinctive behavior of Pacific salmon species that has been well documented. This life history attribute can significantly restrict gene flow and thus shape productivity limitations among naturally reproducing populations (Hasler and Scholz 1983; McIssac and Quinn 1988; Quinn *et al.* 1991). Population distinctions may be more readily resolved on a large geographic scale where gene flow and reproductive restrictions are often well defined by migration distance and adjacency in stream networks, yet the distribution of suitable spawning habitat and local adaptations may produce fine scale genetic structure between stream sections or watersheds in close proximity (Beacham *et al.* 2006; Matala et al. 2012). Homing miscues (straying) are thought to be necessary to buffer loss of genetic diversity in salmon (Milner and Bailey 1989), particularly in small populations. However, the rate of straying among wild fish is generally low (Quinn 1993; Heard *et al.* 1995) and despite the resulting moderate gene flow, genetic structure between populations may persist (Neville *et al.* 2007). There is some evidence that the incidence of straying is higher among hatchery origin fish. This may be an artifact of changes in fish passage protocols, transport through the hydro system, or artificial rearing practices. An elevated rate of immigration between populations may erode local adaptations, and lead to changes in spatial and temporal variability within and/or among populations (Hess and Matala 2013).

In the Columbia River Basin, salmon have been studied in great detail (Chinook salmon; Narum et al. 2004; Waples et al. 2004; Beacham et al. 2006; Narum et al. 2008b; Matala et al. 2011), and steelhead to a similar degree (Winans et al. 2004; Currens et al. 2009; Blankenship et al. 2012; Narum et al. 2011). Genetic evaluations of *O. nerka* (both sockeye salmon and kokanee) have been comparitively limited in scope (Gustafson et al. 1997; Iwamoto et al. 2012). Conservation units such as distinct population segments (DPS) evolutionarily significant units (ESU) major population groups (MPG), and viable salmonid populations (VSP) have been established based on a core set of criteria including population ecology and viability, ancestry and descent, reproductive isolation, and inferred local adaptations (Fraser and Bernatchez 2001; Fraser et al. 2011). However, since the majority of studies to date have been based on neutral genetic variation, conservation has not been commonly informed by direct evaluations selection and adaptive divergence. Landscape genetics is an approach aimed at describing population differentiation relative to features in an organism's environment (Segelbacher 2010; Sepulveda-villet & Stepian 2012), including natural or human erected barriers and local climate. However, landscape genetics has been described primarily on the basis of neutral divergence (Dionne et al. 2008; Narum et al. 2008), where restricted gene flow is explained in the context of heterogeneous habitats (Latch et al. 2011). And, although local adaptation may be inferred from neutral genetic structure coincident with habitat (Olsen et al. 2011; Blankenship et al. 2012), inferences based exclusively on neutral differentiation risk incorrectly identifying the underlying processes affecting population distinctions (Funk et al. 2012; Landguth & Balkenhol 2012).

*Project objectives and higher level harvest management questions*

Objective two of project #2008-907-00 (Genetic Assessment of Columbia River Stocks) describes efforts to evaluate genetic diversity among populations that will inform managers in the areas of harvest monitoring, and conservation monitoring. Our approach involves the collection, analysis, interpretation and distribution of single nucleotide polymorphism (SNP) genotypic data. These data serve as species-specific baselines to characterize Chinook salmon, steelhead, and *O. nerka* population structure throughout the Columbia River Basin. SNPs are highly prolific in the genome, with substantial coverage for linkage analyses (Moen et al. 2008). Large numbers of highly informative SNP loci can be discovered via next generation sequencing technologies such as Restriction-site Associated DNA (RAD) sequencing (Miller et al. 2007; Baird et al. 2008; Hecht et al. 2013). SNPs are amenable to superior high throughput capabilities and are relatively easily amplified and scored, even with poor quality tissue (DNA) sources (Campbell and Narum 2008). Because SNPs are commonly found within or adjacent to coding and regulatory regions of a genome, corresponding allelic diversity and allele frequency variation observed among populations may be indicative of non-neutral influences (i.e. selection and local adaptation). Techniques such as outlier detection methods, and genome wide association studies (GWAS) provide evidence of non-neutral population structure and allow a more resolved understanding of landscape differentiation beyond what can be concluded from neutral loci alone (Narum et al. 2010b; Matala et al. 2011; Ackerman et al. 2012a, Bourret et al. 2013). Putative non-neutral population differentiation can then be interpreted in the context of contemporary risks and vulnerabilities (e.g., climate change) for salmonid populations in the Columbia River Basin, revealing highly correlative relationships (see Limborg et al 2011) between genetic variation and the physical environment. This additional information may ultimately influence conservation criteria for delineating populations across diverse landscapes. Currently our SNP baselines are being used to characterize populations in archival studies, in efforts to reintroduce fish into extirpated regions within historic ranges, hatchery-wild interactions and domestication studies, genetic identification of stock proportions caught in tribal and sport harvest fisheries, and evaluation of migration timing through the hydro system.

*Time line for completion of objectives*

Objectives will be ongoing and our most recent results will be reported each year. As new genetic techniques are developed they will be applied to our objectives and data will be routinely uploaded to the FishGen.net database (http://www.fishgen.net/home.aspx) as a repository for data sharing and collaboration.

Figure 1. Map displaying sampled steelhead (*O. mykiss*) populations. Each numbered population represents a genotyped RAD library identified by number in Table 1.

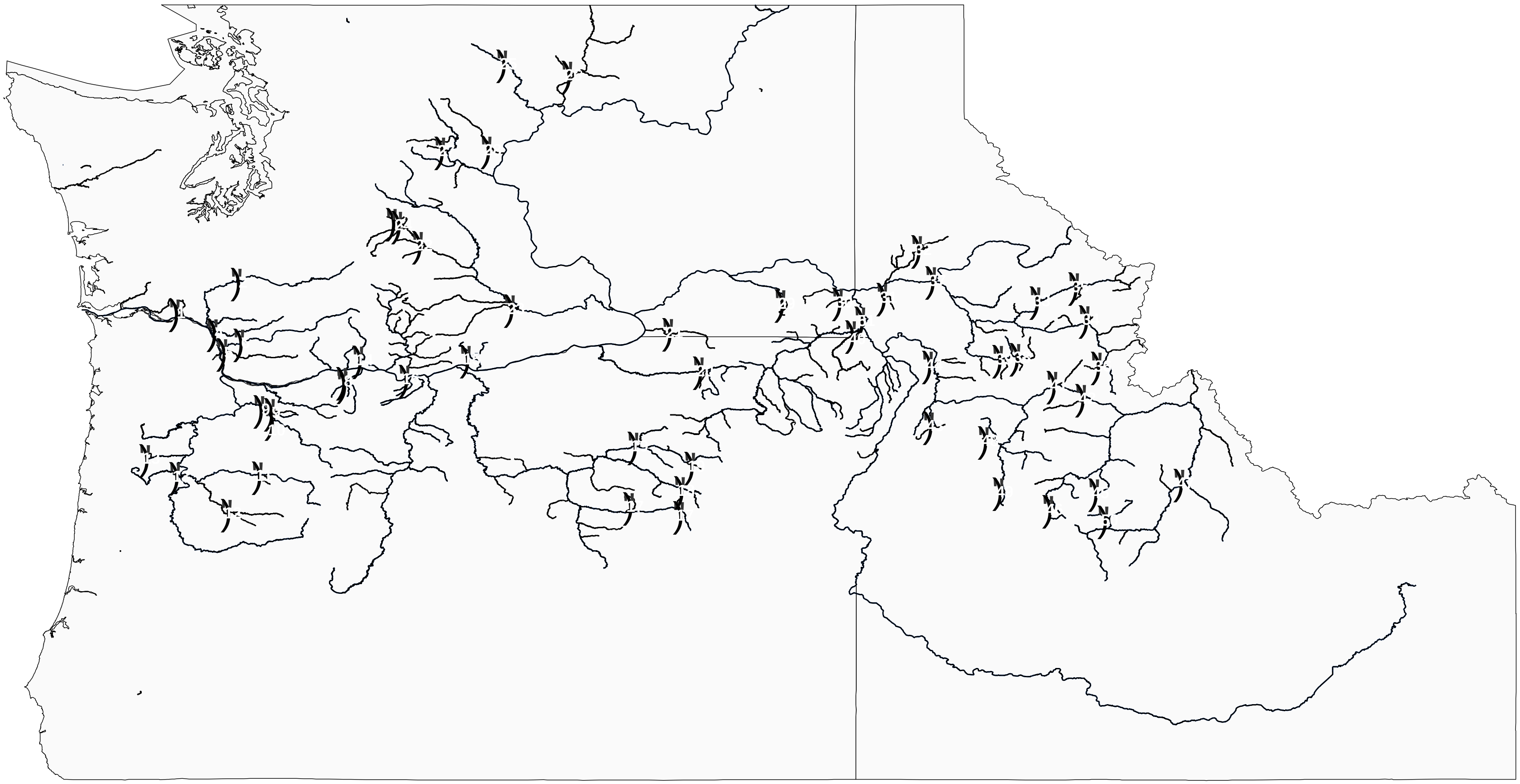

Table 1. Geographic distribution and locations of steelhead RAD populations.

| RAD library | | RAD population | | | | | |
|---|---|---|---|---|---|---|---|
| # | ID | location name | tributary/ region | DPS | BPA subbasin | lat | Long |
| 1 | L-0154 | Abernathy Cr. | Abernathy | Lower Columbia | Elochoman | 46.2256 | -123.1481 |
| 2 | L-0219 | Cowlitz R. | Cowlitz | Lower Columbia | Cowlitz | 46.5026 | -122.5881 |
| 3 | L-0147 | Kalama R. | Kalama | Lower Columbia | Kalama | 46.0449 | -122.8039 |
| 4 | L-0146 | Kalama R. | Kalama | Lower Columbia | Kalama | 46.0449 | -122.8039 |
| 5 | L-0220 | E. F. Lewis R. | Lewis | Lower Columbia | Lewis | 45.8655 | -122.7184 |
| 6 | L-0218 | N. F. Lewis R. | Lewis | Lower Columbia | Lewis | 45.9516 | -122.5654 |
| 7 | L-0155 | East Fork Hood R. | Hood | Lower Columbia | Hood | 45.5745 | -121.6271 |
| 8 | L-0195 | West Fork Hood R. | Hood | Lower Columbia | Hood | 45.6047 | -121.6335 |
| 9 | L-0157 | N. F. Eagle Cr. | Clackamas | Lower Columbia | Willamette | 45.3254 | -122.2885 |
| 9 | L-0157 | Eagle Cr. | Clackamas | Lower Columbia | Willamette | 45.3514 | -122.3840 |
| 10 | L-0148 | Skamania Stock | Clackamas | Lower Columbia | Willamette | 45.2417 | -122.2817 |
| 11 | L-0221 | Little Rock/Mad Cr. | Willamette | Upper Willamette | Willamette | 44.7508 | -122.3967 |
| 12 | L-0217 | S. F. Santiam/ Wiley Cr. | Willamette | Upper Willamette | Willamette | 44.4136 | -122.6772 |
| 13 | L-0150 | Canyon Cr. | Willamette/ West Side | Upper Willamette | Willamette | 44.9077 | -123.4194 |
| 13 | L-0150 | Luckiamute Cr. | Willamette/ West Side | Upper Willamette | Willamette | 44.7474 | -123.1477 |
| 14 | L-0149 | Big White Salmon R. | Big White Salmon | Middle Columbia | Big White Salmon | 45.7993 | -121.4846 |
| 15 | L-0212 | Rock Cr. | Rock | Middle Columbia | Columbia Lower Middle | 45.8066 | -120.5104 |
| 16 | L-0164 | Fifteen Cr. | Fifteenmile | Middle Columbia | Fifteenmile | 45.6251 | -121.0656 |
| 17 | L-0228 | Beech Cr. | John Day | Middle Columbia | John Day | 44.4733 | -119.0332 |
| 17 | L-0228 | Upper Mainstem J. D. | John Day | Middle Columbia | John Day | 44.3945 | -118.5764 |
| 18 | L-0187 | Upper M. F. J. D. | M. F. John Day | Middle Columbia | John Day | 44.6195 | -118.5679 |
| 19 | L-0186 | Granite Cr. | N. F. John Day | Middle Columbia | John Day | 44.8383 | -118.4770 |
| 19 | L-0186 | Middle N. F. J. D. | N. F. John Day | Middle Columbia | John Day | 45.0213 | -118.9905 |
| 20 | L-0172 | Iskuulpa Cr. | Umatilla | Middle Columbia | Umatilla | 45.6997 | -118.3971 |
| 21 | L-0216 | Touchet R. | Walla Walla | Middle Columbia | Walla Walla | 46.0470 | -118.6770 |
| 22 | L-0173 | Nile/ Naches R. | Yakima | Middle Columbia | Yakima | 46.8338 | -120.9451 |
| 23 | L-0165 | Satus Cr. | Yakima | Middle Columbia | Yakima | 46.2621 | -120.1124 |
| 24 | L-0226 | Pileup/ Naches R. | Yakima | Middle Columbia | Yakima | 47.0448 | -121.1829 |
| 24 | L-0226 | Quartz/ Naches R. | Yakima | Middle Columbia | Yakima | 47.0178 | -121.1338 |
| 25 | L-0185 | Methow R. | Methow | Upper Columbia | Methow | 48.4756 | -120.1819 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 26 | L-0168 | Salmon Cr. | Okanogan | Upper Columbia | Okanogan | 48.3747 | -119.5911 |
| 27 | L-0169 | Chiwaukum R. | Wenatchee | Upper Columbia | Wenatchee | 47.6881 | -120.7407 |
| 28 | L-0213 | Entiat R. | Entiat | Upper Columbia | Entiat | 47.6964 | -120.3227 |
| 29 | L-0244 | Tucannon R. | lower Snake | Snake | Tucannon | 46.3097 | -117.6572 |
| 30 | L-0191 | Mission Cr. | Lapwai/ Clearwater | Snake | Clearwater | 46.3228 | -117.1368 |
| 31 | L-0196 | E. F. Potlatch R. | Lower Clearwater | Snake | Clearwater | 46.3672 | -116.7360 |
| 32 | L-0170 | Fish/ Lochsa R. | M. F. Clearwater | Snake | Clearwater | 46.7984 | -116.4194 |
| 33 | L-0239 | E. F. Moose/ Selway R. | M. F. Clearwater | Snake | Clearwater | 46.3336 | -115.3471 |
| 34 | L-0192 | Lake/ Lochsa R. | M. F. Clearwater | Snake | Clearwater | 46.1634 | -114.9006 |
| 35 | L-0241 | Little Clearwater/ Selway R. | M. F. Clearwater | Snake | Clearwater | 46.4632 | -114.9965 |
| 36 | L-0184 | Dworshak Hatchery | N. F. Clearwater | Snake | Clearwater | 45.7441 | -114.7895 |
| 37 | L-0238 | Crooked R. | S. F. Clearwater | Snake | Clearwater | 46.5160 | -116.2920 |
| 38 | L-0243 | Tenmile Cr. | S. F. Clearwater | Snake | Clearwater | 45.8211 | -115.5272 |
| 39 | L-0236 | Asotin Cr. | lower Snake | Snake | Asotin | 45.8057 | -115.6833 |
| 40 | L-0189 | Captain John Cr. | lower Snake | Snake | Snake Hells Canyon | 46.0278 | -117.0177 |
| 41 | L-0240 | Joseph Cr. | Grande Ronde | Snake | Grande Ronde | 45.5716 | -115.1919 |
| 42 | L-0237 | Bargamin Cr. | Bargamin | Snake | Salmon | 45.4523 | -114.9310 |
| 43 | L-0190 | Chamberlain Cr. | Chamberlain | Snake | Salmon | 45.2019 | -116.3114 |
| 44 | L-0194 | Boulder Cr. | Little Salmon | Snake | Salmon | 45.7523 | -116.3198 |
| 45 | L-0166 | Whitebird Cr. | Lower Salmon | Snake | Salmon | 44.5976 | -114.8123 |
| 46 | L-0167 | Loon Cr. | M. F. Salmon | Snake | Salmon | 44.4493 | -115.2301 |
| 47 | L-0193 | Marsh Cr. | M. F. Salmon | Snake | Salmon | 44.6844 | -114.0403 |
| 48 | L-0245 | Pahsimeroi Hatchery | Pahsimeroi | Snake | Salmon | 45.0692 | -115.8140 |
| 49 | L-0171 | Lick Cr. | S. F. Salmon | Snake | Salmon | 44.6070 | -115.6810 |
| 50 | L-0242 | Stolle Meadows | S. F. Salmon | Snake | Salmon | 44.3514 | -114.7297 |
| 51 | L-0156 | W. F. Yankee Fork R. | Upper Salmon | Snake | Salmon | 46.1515 | -116.9340 |

Figure 2. Map displaying sampled Chinook salmon (*O. tshawytscha*) populations. Each numbered population represents a RAD library in preparation (Table 2). Red circles identify additional collections with available genotypic data from a companion project: Range wide analysis of Chinook salmon (Hecht et al. 2015).

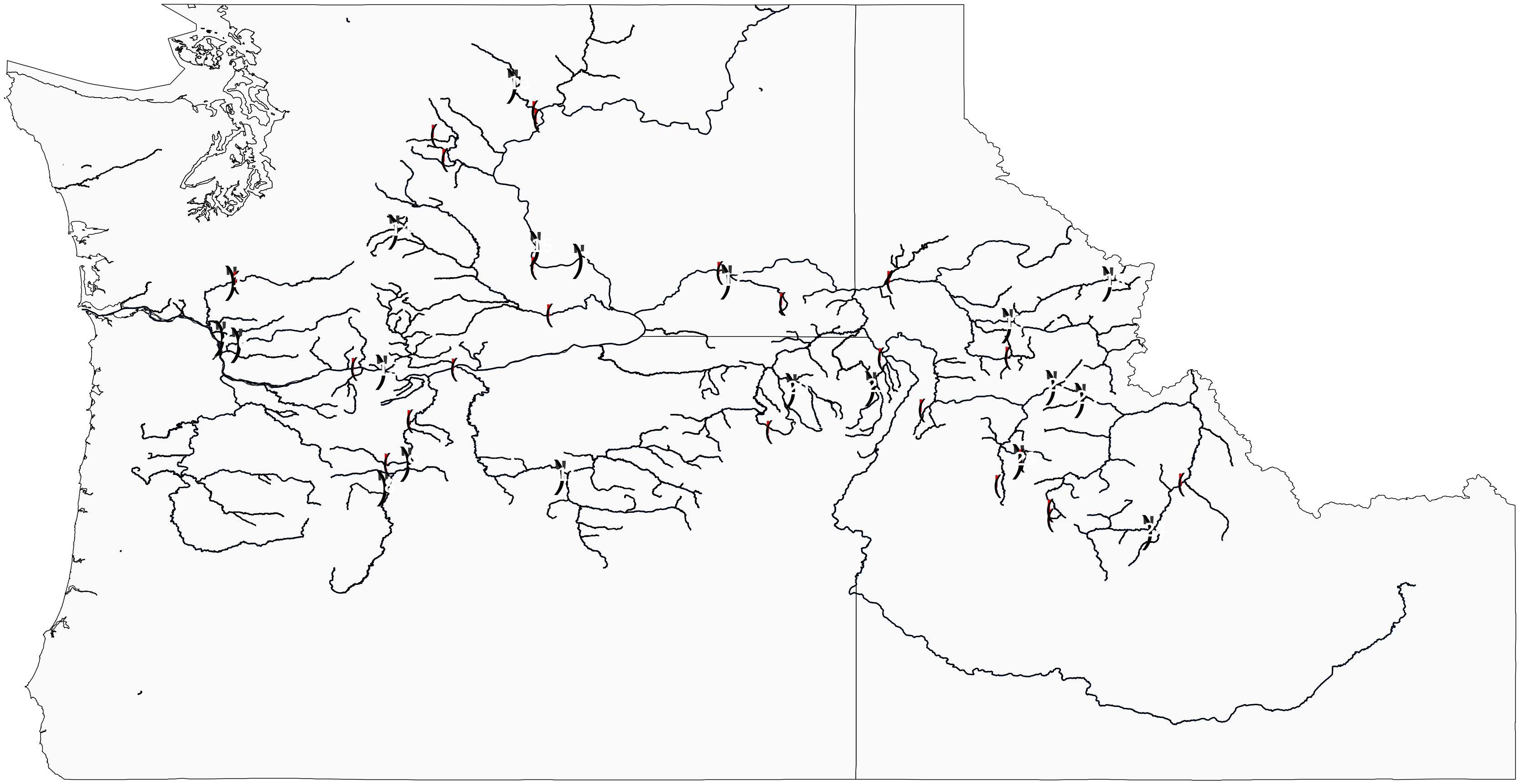

Table 2. Geographic distribution and locations of Chinook salmon RAD populations.

| population | | | | | | | | | | sample size (n) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ID# | name | BPA Subbasin | region | Lat | Long | Lineage | Run-type | Origin | Objective | prep | target |
| 1 | Cowlitz R. | Cowlitz | LC | 46.5130 | -122.6350 | LC | Fall | NOR | 1,2,3 | 60 | 48 |
| 2 | Kalama R. | Kalama | LC | 46.0170 | -122.7330 | LC | SP | NOR | 1,2 | 60 | 48 |
| 3 | Lewis R. | Lewis | LC | 45.9530 | -122.5844 | LC | early Fall | NOR | 1,2,3 | 48 | 40 |
| 4 | Lewis R. | Lewis | LC | 45.9530 | -122.5844 | LC | Late Fall | NOR | 1,2,3 | 48 | 40 |
| 5 | Lewis R. | Lewis | LC | 45.9530 | -122.5844 | LC | SP | NOR | 1,2,3 | 60 | 48 |
| 6 | Lewis R. | Lewis | LC | 45.9530 | -122.5844 | LC | SP | HAT | 1,2,3 | 60 | 48 |
| 7 | Hanford Reach | Col. lower Mid. | MC | 46.7125 | -119.4811 | OT | Fall | NOR | 1,2 | 60 | 48 |
| 8 | Deschutes R.; (1970) | Deschutes | MC | 44.6572 | -121.2576 | OT | Fall | NOR | 1,4 | 60 | 48 |
| 9 | Upper Deschutes R. | Deschutes | MC | 44.8777 | -121.0478 | ST | SP | NOR | 1,2 | 60 | 48 |
| 10 | M.F. John Day R. | John Day | MC | 44.7600 | -119.6500 | ST | SP | NOR | 1 | 60 | 48 |
| 11 | upper John Day R. | John Day | MC | 44.7600 | -119.6500 | ST | SP | NOR | 1 | 60 | 48 |
| 12 | Klickitat R. | Klickitat | MC | 45.7100 | -121.2700 | ST | SP | HAT | 1,2,3 | 60 | 48 |
| 13 | Klickitat R. | Klickitat | MC | 45.7100 | -121.2700 | ST | SP | NOR | 1,2,3 | 60 | 48 |
| 14 | American R. | Yakima | MC | 46.9760 | -121.1580 | ST | SP | NOR | 1 | 60 | 48 |
| 15 | Lower Crab Cr. | Crab | UC | 46.8281 | -119.8742 | OT | Fall? | NOR | 1,4 | 60 | 48 |
| 16 | Methow R. | Methow | UC | 48.2960 | -120.0840 | ST | SP | NOR/HAT | 1,2 | 60 | 48 |
| 17 | Tucannon R. | Tucannon | Snake | 46.5260 | -118.1420 | ST | SP | HAT | 1,2 | 60 | 48 |
| 18 | Lochsa R. (Powell) | Clearwater | Snake | 46.5080 | -114.6810 | ST | SP | NOR | 1,2 | 60 | 48 |
| 19 | Selway R. | Clearwater | Snake | 46.1308 | -115.5929 | ST | SP | NOR | 1,2 | 60 | 48 |
| 20 | Lostine R. | Grande Ronde | Snake | 45.5420 | -117.5550 | ST | SP | HAT | 1 | 60 | 48 |
| 21 | Imnaha R. | Imnaha | Snake | 45.5610 | -116.8340 | ST | SPSU | NOR | 1,2 | 60 | 48 |
| 22 | Bargamin Cr. | Salmon | Snake | 45.5679 | -115.1930 | ST | SP | NOR | 1 | 60 | 48 |
| 23 | Chamberlain Cr. | Salmon | Snake | 45.4540 | -114.9330 | ST | SP | NOR | 1 | 60 | 48 |
| 24 | East Fork Salmon R. | Salmon | Snake | 44.2590 | -114.3170 | ST | SPSU | NOR | 1 | 60 | 48 |
| 25 | Johnson Cr. | Salmon | Snake | 44.8990 | -115.4920 | ST | SPSU | NOR | 1,2,3 | 60 | 96 |
| 26 | Johnson Cr. | Salmon | Snake | 44.8990 | -115.4920 | ST | SPSU | HAT | 1,2,3 | 60 | 48 |

Figure 3. Map displaying sampled sockeye salmon and Kokanee (*O. nerka*) populations. Each numbered population represents a collection that has been genotyped to characterize Columbia River stocks in a reference baseline (Table 3). Red circles identify collections added in calendar year 2014.

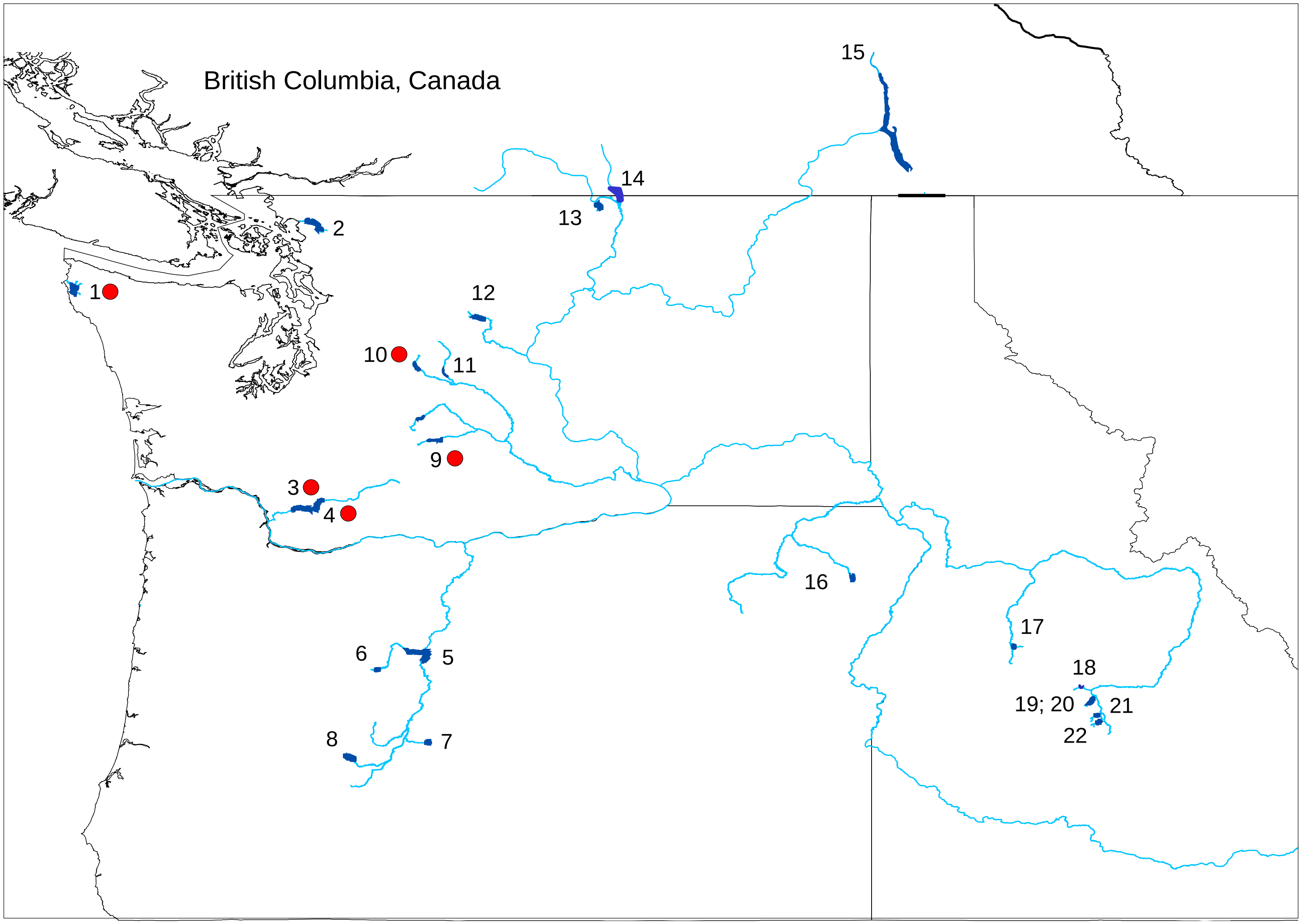

Table 3. Geographic distribution and locations of *O. nerka* reference baseline populations.

| reference population ID# | name | BPA Subbasin | region | Lat | Long | life history | Origin | (n) |
|---|---|---|---|---|---|---|---|---|
| 1 | Lake Ozette | na | WA coast | 48.1249 | -124.6283 | Sockeye | native | 205 |
| 2 | Lake Whatcom | na | Puget Sound | 48.6730 | -122.2780 | Kokanee | native | 46 |
| 3 | Speelyai Reservoir | Lewis | LC | 45.9877 | -122.4088 | Kokanee | stocked | 96 |
| 4 | Cougar Creek (Yale Reservoir) | Lewis | LC | 46.0613 | -122.2928 | Kokanee | stocked | 29 |
| 5 | Lake Billy Chinook; Metolius River | Deschutes | MC | 44.6180 | -121.4677 | ? | stocked | 589 |
| 6 | Suttle Lake/ Link Creek | Deschutes | MC | 44.4184 | -121.7553 | Kokanee | stocked | 687 |
| 7 | Paulina Lake | Deschutes | MC | 43.7130 | -121.2770 | Kokanee | stocked | 199 |
| 8 | Odell Lake | Deschutes | MC | 43.5851 | -122.0434 | Kokanee | stocked | 59 |
| 9 | Tieton River (Rimrock Lake) | Yakima | MC | 46.6601 | -121.1266 | Kokanee | stocked | 47 |
| 10 | Gold Creek (Keetchelus Lake) | Yakima | MC | 47.3928 | -121.3809 | Kokanee | stocked | 92 |
| 11 | Cle Elum Lake | Yakima | MC | 47.2455 | -121.0743 | Sockeye | reintroduced | 100+ |
| 12 | Wenatchee Lake (Tumwater Dam) | Wenatchee | UC | 47.6170 | -120.7230 | Sockeye | native | 344 |
| 13 | Palmer Lake | Okanogan | UC | 48.9113 | -119.6471 | Kokanee | stocked | 62 |
| 14 | Osoyoos Lake | na | B. C. Canada | 48.9423 | -119.4296 | Sockeye | native | 212 |
| 15 | Meadow Creek (Kootenay Lake) | na | B. C. Canada | 50.2170 | -116.9830 | Kokanee | hatchery | 46 |
| 16 | Wallowa Lake | Grande Ronde | Snake | 45.2810 | -117.2090 | Kokanee | stocked | 66 |
| 17 | Warm Lake (S. F. Salmon River) | Salmon | Snake | 44.6480 | -115.6710 | Kokanee | ? | 68 |
| 18 | Stanley Lake | Salmon | Snake | 44.2090 | -115.0840 | Kokanee | ? | 53 |
| 19 | Redfish Lake | Salmon | Snake | 44.1442 | -114.9133 | Sockeye | native | 86 |
| 20 | Fishhook Creek | Salmon | Snake | 44.1476 | -114.9243 | Kokanee | native | 96 |
| 21 | Pettit Lake | Salmon | Snake | 43.9780 | -114.8820 | Kokanee | stocked | 70 |
| 22 | Alturas Lake | Salmon | Snake | 43.9090 | -114.8650 | Kokanee | stocked | 59 |

Figure 4. *O. nerka* baseline NJ tree topology. Bootstrap support values appear in red font. A primary node with 71% bootstrap support (blue star) separates sockeye salmon populations and Snake River kokanee populations from all remaining kokanee populations (black circles represent sockeye salmon).

## Methods

*Baseline sampling and expansion*

Collections of *O. tshawytscha*, *O. mykiss*, and *O. nerka* have been chosen for baseline expansion based on availability, novelty, and in accordance with our goal of reaching complete coverage of extant stocks within the Columbia River Basin. Priority collections for all three species have been identified as those important to basin-wide harvest and hatchery management, particularly in tribal fisheries. This includes major supplementation stocks for all three species, lower Columbia, ocean-type, and stream-type lineages of Chinook salmon, inland and coastal lineages and summer-run and winter-run ecotypes of steelhead, and the anadromous (sockeye salmon) and land-locked (kokanee) forms of *O. nerka*. Species-specific baselines may include life history variants such as potentially distinct populations of resident *O. mykiss* (Narum et al. 2008a; Narum et al. 2011). Existing baselines comprised of putatively neutral SNPs (e.g. 180 loci for *O. myiss*) have been well characterized and are currently used extensively for genetic stock identification (GSI). The GSI application continues to inform managers on several fronts, including: harvest management, abundance estimates, life history distinctions and conservation needs. Our most recent efforts focus on expanding genetic characterizations throughout the basin that will provide information about adaptive potentials, influential natural selective forces and the responses of fish to those forces. Advanced technologies in genotyping were initiated by CRITFC in 2014. We have begun employing a genotyped by RAD-tag sequencing approach as described in detail in section 1 of this report. Screening of thousands or tens of thousands of SNP loci is likely to result in an unprecedented level of resolution in GSI evaluations, while revealing many potential loci under selection.

In Calendar year 2014, there were 51 *O. mykiss* populations designated for RAD genotyping (Table 1; Figure 1). Sequence genotypes were collected and are currently in the quality filtering phase of analysis. No genetic analysis of these populations has been completed. In Calendar year 2014, there were 26 *O. tshawytscha* populations designated for RAD genotyping (Table 2; Figure 2). Sequence genotypes are currently being collected but no genetic analysis of these populations has been completed to date. The *O. nerka* baseline was expanded by five collections (Table 3; Figure 3), and genotyped at 96 SNP loci described in Hess et al. (2012). Our two primary goals for these three species are: 1) annual genetic stock identification (GSI) analyses that will be used for monitoring of fishery returns through the migratory corridor, including harvest GSI in the lower Columbia River, and fish passage GSI at Bonneville and Lower Granite dams (see sections 3 & 4 of this report), 2) maintenance of a ten year SNP baseline expansion (including RAD-tag sequencing) for application in various analyses including population structure analyses, investigation of landscape genetics, and adaptive differentiation among populations.

*Laboratory Protocol*

Methods for DNA extraction, DNA amplification, microfluidics, and genotyping of SNP assays are available at (https://www.monitoringmethods.org/Protocol/Details/230). The Monitoring Methods template for section 2 of this report is ID#230, owner: Matthew Campbell. Additional species or population specific details are available in Hess et al. (2012). For methods using genotyping by sequencing, or RAD-tag sequencing see Monitoring Methods #4144, owner: Nathan Campbell. SNP discovery using the RAD-tag sequencing technique is described in section #1 of this report.

## Results

*O. nerka*

The mean pairwise genetic distances among all Snake River populations and among all Deschutes River populations were $F_{ST}$=0.318 and $F_{ST}$ =0.052 respectively. For comparisons within life history types the mean among-group variation was $F_{ST}$ =0.227 for sockeye salmon populations, and $F_{ST}$ =0.167 for kokanee populations. The comparison between life history types (i.e. kokanee vs. sockeye) revealed an $F_{ST}$ of 0.264. Note that this is lower than the genetic distance between Snake River kokanee and Redfish Lake sockeye ($F_{ST}$=0.318). Genetic similarity among *O. nerka* populations within each region or major sub-basin was depicted through phylogenetic relationships in the topology of an unrooted NJ phylogram (Figure 4). The confidence or concordance (>50%) of the NJ topology is indicated with bootstrap values at the nodes. Results revealed defined clustering of the most genetically similar collections for *O. nerka*. Collections within each region exhibited greater similarity than comparisons between regions (i.e., Wenatchee River, Deschutes River, Osoyos Lakes, and Snake River). With the exception of Snake River kokanee populations, the sockeye salmon populations clustered distinctly from kokanee populations from across a broad geographic distribution.

## Discussion

Over the past several years we have compiled extensive data sets of SNP genotypes for Chinook salmon steelhead and *O. nerka* covering diverse regions in the Columbia River Basin (including the Snake River Basin). Our goal has been to construct SNP baselines that will be expanded annually to provide continued evaluation of these species that is both spatially and temporally stratified. This strategy assures the greatest likelihood of discerning reproductively distinct aggregations for each species through time (Waples 1991), while monitoring population viability related to demographic trends that occur locally and/or regionally. Philopatry (Quinn et al. 1991, Hendry et al. 2003) and hatchery supplementation activities (Ford et al. 2006; Hard & Heard 1999) will play a major role in how genetic divergence and differentiation is distributed geographically, and it will be important to evaluate such impacts for potential effects on the ability to differentiate populations both qualitatively (phenotypes; landscapes) and quantitatively (e.g., genetic stock identification). Our past results have been verified and substantiated through replication and comparisons of published data (Waples et al. 2004; Narum 2008b; Narum et al. 2010b). That work has led to the discovery of outlier loci for adaptive divergence. Our current efforts will expand our understanding of non-neutral genetic variation among populations for all three species. The RAD datasets under construction will demonstrate the utility of SNPs to characterize adaptive variation, as was observed in a recent range-wide analysis of Chinook salmon (Hecht et al. 2015). Environmental and climate related variables, likely to have significant influence on allele frequencies, have been identified (e.g., precipitation, temperature maximums and minimums, elevation, etc.) and those data have been recorded for the purposes of in-depth testing of landscape associations.

The expansion efforts reported here complement previously reported results. The continued expansion of SNP panels and updating of baseline collections will help us achieve a greater level of resolution (or statistical power to identify population distinctions), at least among the major tributaries and sub-basins throughout the CRB. Such results will be most beneficial to the larger application of the baselines, namely genetic stock ID. Annual implementations of each baseline

expansion have proven valuable for frequently increasing resolution on a regional scale (but also locally). In comparisons among species-specific SNP panels, the panel for *O. nerka* has been extremely powerful owing to the biological and life history complexity of this species and its distribution within the CRB. In the past, our ability to differentiate among regions and in some cases within regions has exceeded what we have been able to ascertain with Chinook salmon and steelhead. However, the application of next generation sequencing techniques (i.e. 21,619 Chinook loci) has proven powerful, and the datasets currently being compiled for Chinook salmon and steelhead should yield a comparable depth of information. Locus associations with environment may be highly informative for GSI and other applications, particularly with regard to run timing. Applications of this nature have already been shown to be useful for identifying population differences distributed across landscapes (e.g., Narum et al. 2010a; Matala et al. 2011). Our data will be implemented in current and ongoing application of PBT and GSI methods for each species. PBT can be used to validate assignment origins based on GSI. Future efforts include adding collections to the baseline to increase basin-wide coverage of all species, particularly those that account for stock transfer history of *O. nerka* throughout the basin. We also intend to continually strive to increase the numbers of markers (SNP loci) employed for genetic applications.

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**Section 3: Genetic Stock Identification of Chinook Salmon, Sockeye Salmon, and Steelhead Harvest Mixtures in the Mainstem Columbia River**

## Introduction

Genetic Stock Identification (GSI) methods have proven to be effective in determining the proportion of stock origin in mixed stock applications of salmonids (Shaklee et al. 1999, Winans et al. 2004, Beacham et al. 2006, and Beacham et al. 2011). These methods have been demonstrated to be useful even at relatively fine geographic scales within the Columbia River Basin (CRB) (Hess et al. 2011, Hess and Narum 2011, Hess et al. 2014). Within the CRB, Chinook salmon consist of three major genetic lineages and steelhead consist of two major genetic lineages, and lineages of both species can be further broken into populations that are genetically structured on a finer spatial scale (e.g., Waples et al. 2004; Narum et al. 2010; Blankenship et al. 2011). In this study we use separate groups of SNP markers to discriminate 19 reporting groups for Chinook salmon, 4 reporting groups for sockeye salmon, and 14 reporting groups for steelhead.

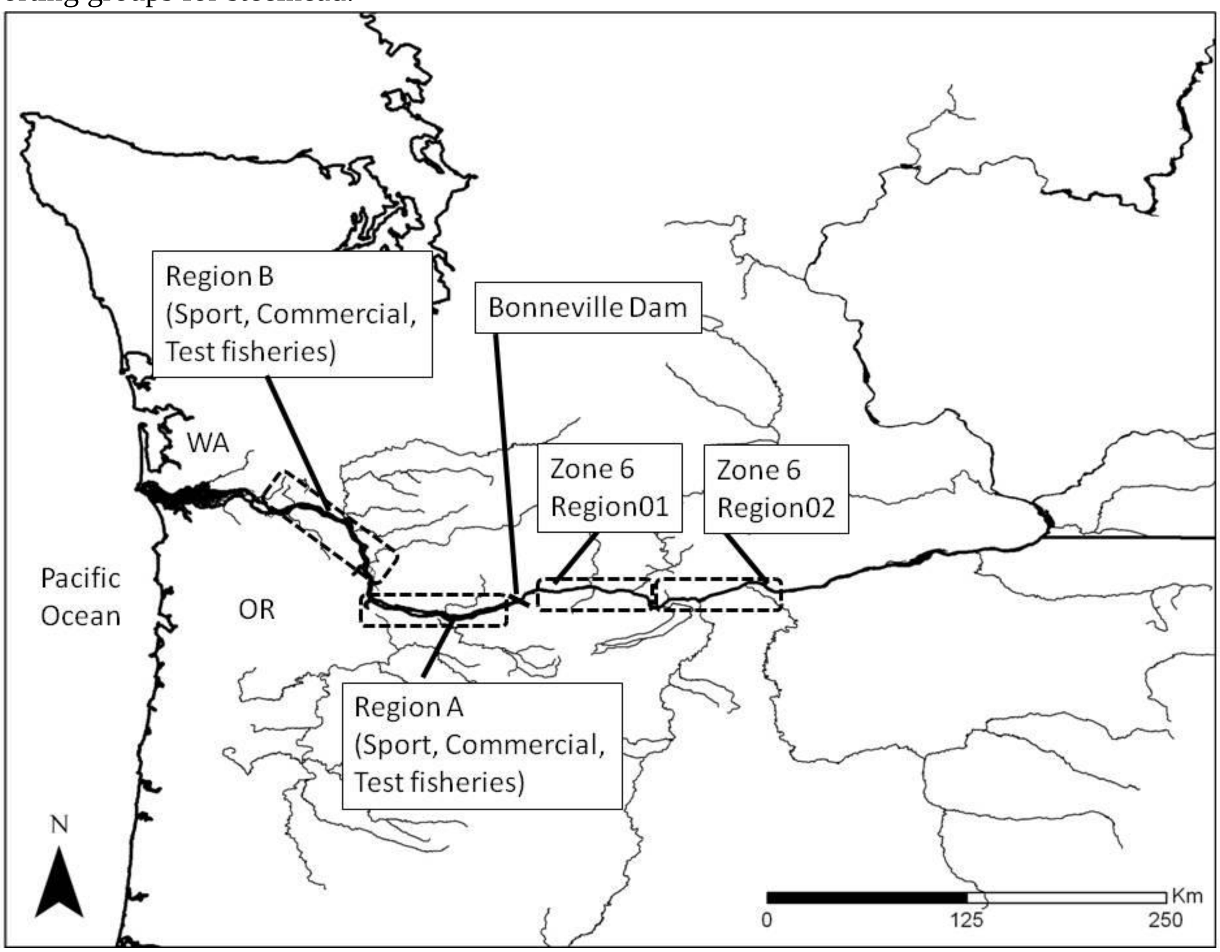


**Figure 1.** Project scope showing sources of Chinook salmon, sockeye salmon, and steelhead mixtures that were analyzed using GSI.

Despite continuous improvements of the power of our Chinook salmon and steelhead baselines in GSI applications (Hess et al. 2014), we have determined that further improvement in the detail of data and accuracy of stock assignments could be made by utilizing a recently developed genetic technology, parentage based tagging (PBT), in combination with GSI, in a tiered approach for stock identification. PBT is an efficient approach for mass tagging of fish. The method is carried out by first genotyping a set of potential parents which then provides the opportunity to assign a set of genotyped offspring to their true parent pair. PBT is currently being utilized on a broad scale in the Columbia River Basin to tag all Snake River Chinook salmon and steelhead hatchery broodstock (Steele et al. 2011). This application has effectively tagged all Snake River hatchery Chinook salmon and steelhead starting with the 2008 brood years. When parent pairs of a Snake River hatchery fish are identified with PBT, we can provide accurate information including age of the fish and the source hatchery in which its parents were spawned. We use PBT in this Chinook salmon and steelhead harvest study to identify all Snake River hatchery-origin fish, and then we use GSI to estimate stock-of-origin of all other hatchery fish that were not assigned with PBT (i.e. non-Snake River hatchery-origin) and all wild fish. PBT can assign the 3-, 4-, and 5-year old Snake River hatchery-origin spring Chinook salmon (i.e. brood years 2009 – 2011) from the 2014 spring Chinook salmon harvest and the 1-, 2-, and 3-ocean age Snake River hatchery-origin steelhead (i.e. brood years 2010 – 2012) from the 2014 steelhead harvest. Eventually the PBT baseline will be expanded beyond the Snake River, and this year we continue with our inclusion of the first middle Columbia River hatchery, Klickitat spring Chinook salmon hatchery.

An additional improvement to our genotyping technology has been the application of a genotyping-in-thousands by sequencing (GT-seq) approach that has been developed in our laboratory (Campbell et al. 2015). This approach has increased the cost-effectiveness for genotyping moderate numbers of SNP loci (100s) for relatively large numbers of individuals (1000s), which allows us to run all SNP loci regardless of whether we intend to use primarily PBT analyses or a combination of PBT and GSI. Therefore, we avoid the difficult decisions we have had to make in past years (Hess et al. 2015), in which we needed to consider the primary goal of the project before selecting which panels of SNP markers were required. Not only is the genotyping decision process simplified, but our projects now benefit from the additional data that comes from genotyping with all available markers.

Fisheries conducted in the mainstem of the lower and middle Columbia River provide an ideal and important application of genetic stock analyses because the fish harvested consist of mixtures of stocks from a large extent of the CRB. Further, Chinook salmon fisheries in this location represent a majority of the CRB harvest of this species taken by the commercial, sport, and tribal fishermen. In order to help support sustainable fisheries, PBT and GSI can be used to address two primary questions: 1) how are Chinook salmon and steelhead stocks temporally and spatially distributed in the mainstem Columbia River; and 2) how are these stocks temporally and spatially distributed in the harvests of fisheries.

*Project objectives and higher level harvest management questions*

Our study had four primary objectives: 1) utilize a combination of PBT and GSI analyses to estimate stock composition of Chinook salmon passing Bonneville Dam; 2) determine stock composition of Chinook salmon harvested in sport, commercial, and tribal fisheries in the mainstem Columbia River; 3) utilize a combination of PBT and GSI to estimate stock composition of unclipped steelhead harvested above Bonneville Dam in the zone 6 fishery; and

4) utilize GSI to estimate stock composition of sockeye salmon harvested above and below Bonneville Dam in commercial, sport, and tribal fisheries. Results from these objectives were used to address:

**Harvest RM&E: F&W Program Management Question: What are your in-river monitoring results and what are your estimates of stock composition and stock-specific abundance, escapement, catch, and age distribution?**

Increasingly, we are tailoring our analyses to address specific questions that fisheries managers have presented to us. For example, in 2012 managers proposed extending the geographic boundary of one of the mark selective spring-run Chinook salmon sport fisheries above Bonneville Dam that occurs at the mouth of the Wind River. This extension created a larger "bubble" boundary at the mouth of the Wind River and was intended to increase Columbia River mainstem fishing access while maintaining targeted focus on Wind River spring-run Chinook salmon. In 2012 and 2013, we examined the stock composition of the Wind River sport harvest and provided context by comparing stock proportions among the various samples from other fisheries and Bonneville Dam that were analyzed that same year. We repeated this analysis for fish harvested in 2014, and supplied similar information for the sport harvest in a nearby location, Drano Lake. For steelhead, we have sampled a group of fish that were non-adipose clipped and captured in the tribal fishery harvest above Bonneville Dam in Zone 6, as well as the harvest conducted specifically in Drano Lake. This steelhead project was in collaboration with Alan Byrne (Idaho Department of Fish and Game) and Stuart Ellis (Columbia River Inter-Tribal Fish Commission) and is currently being written into an IDFG Technical report. Finally, we include in this report the second year of analysis of sockeye salmon fisheries in the Columbia River mainstem. Differences in relative abundance of the three main stocks (Okanagan, Wenatchee, and Snake) provide challenges to managing lower river harvest because the desire to harvest the highly abundant Okanagan stock around the much less abundant Snake River stock and moderately abundant Wenatchee River stock. Stock composition estimates are expected to help determine how harvest is impacting these various stocks.

*Time line for completion of objectives*

Objectives will be ongoing and GSI results updated each year for harvest analyses of salmon and steelhead throughout the accords-funding. As new genetic techniques are developed they will be applied to this project and results will be compared between years to determine the extent of improvements.

Our study was not designed to address the following question:

**Harvest RM&E: F&W Program Management Question: Can selective fisheries targeting hatchery fish or healthy populations reduce impacts on ESA-listed populations?**

## Methods

Methods for estimating stock composition are available at (https://www.monitoringmethods.org/Protocol/Details/229). The Monitoring Methods Protocol is entitled Snake River steelhead and Chinook salmon stock composition estimates (2010-026-00) v1.0.

*Tissue collection of Chinook salmon, Sockeye salmon, and steelhead*

Tissues were sampled from Chinook salmon in 2014 from a total of ten different mixture sources: 1) Bonneville Dam (results discussed in section 4), and the spring-run seasons of the following fisheries: 2) lower river commercial, 3) lower river sport, 4) lower river test, 5) Wind R. sport, 6) Drano Lake sport, and 7) tribal spring, and the summer management period harvests of the following fisheries: 8) lower river commercial and 9) lower river sport, and the fall-run harvest from 10) the lower river mark-selective sport fishery of 2014. While fisheries generally harvest jack sized Chinook salmon at low rates and do not have specific harvest limits on jacks, jacks do comprise part of the harvest and may be sampled if encountered. Jacks are sampled at the Bonneville AFF trap in the proportion that they are encountered in the sampling. Sampling restrictions at the AFF can result in biases in the size of fish sampled compared to the run at large. In addition, we analyzed a test fishery from the lower river that was conducted during the spring-run fishing season. A portion of the spring season zone 6 tribal was sampled by Megan Begay as part of the Yakama Nation fishery program. Harvest tissues were collected in coordination with existing monitoring programs led by Washington Department of Fish and Wildlife (WDFW) and Oregon Department of Fish and Wildlife (ODFW) and Yakama Nation. The spring management period Chinook salmon fisheries were sampled below Bonneville Dam in the sport and commercial fishery and tribal bank fishery immediately downstream of Bonneville Dam (regions A and B), and sampled above Bonneville Dam in region 01 as part of the Wind River and Drano Lake sport fisheries and Yakama Nation zone 6 fishery (Fig. 1, Table 1). The summer management period fisheries were sampled below Bonneville Dam in the sport and commercial fisheries, and above Bonneville Dam in Zone 6 in the tribal commercial fishery. Due to limited funds, we analyzed a subset of samples (approximately 50 fish per weekly strata) obtained from the spring Chinook salmon sport and commercial fisheries below Bonneville Dam and the spring season zone 6 tribal fishery, and we analyzed subsets of up to 100 fish per weekly strata in the summer season sport and commercial fisheries below Bonneville Dam. All samples were analyzed from the spring season sport mark-selective fisheries from the Wind River and Drano Lake, and the fall season mark selective fishery below Bonneville Dam because there were relatively few numbers of fish collected for each of these fisheries. Fisheries in which we had to subsample the harvest, we selected fish randomly and with a balanced design across spatial regions.

One part of the fall management period Chinook fishery was sampled only below Bonneville Dam. Stock proportions were calculated for some groupings within each fishery source, such that stock proportions could be compared across geographic regions as well as adipose-clipped versus non-adipose-clipped categories for particular fisheries. We use the following four main geographic regions (Fig. 1): Region A corresponds to our grouping of pre-existing Oregon and Washington state sport fishing zones 1-4 (or commercial zones 4-5), Region B corresponds to our grouping of sport zones 5-10 (or commercial zones 1-3), and Region 01 and Region 02 in the Zone 6 fishery correspond to pre-existing Oregon and Washington state fishing Zone 61 and a grouping of Zones 62 and 63, respectively. These sets of groupings were established for this study in order to achieve balanced sampling for analysis of these fishery datasets, as well as to set an appropriate spatial scale of analysis to minimize variance of our estimates of stock proportions over temporal strata.

**Table 1.** Characteristics of Chinook salmon harvest samples by fishery source, fin clip category, geographic region, and weekly strata.

| | | | | Statistical week | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fishery | | | Spring | | | | | | | | | | | | | | Summer | | | | | | | Fall | | |
| Season | Source | Clip | Region | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 37 | 38 | Total |
| Spring | L River Commercial | Y | B | | | | 25 | | | | | 22 | | 25 | 25 | 25 | | | | | | | | | | | 122 |
| Spring | L River Commercial | Y | A | | | | 25 | | | | | 24 | | 25 | 24 | 24 | | | | | | | | | | | 122 |
| Spring | L River Test | N | B | 3 | 7 | 12 | 7 | 8 | 6 | 6 | 5 | 2 | 2 | | | | | | | | | | | | | | 58 |
| Spring | L River Test | Y | B | 11 | 26 | 36 | 40 | 38 | 41 | 28 | 17 | 5 | 8 | 2 | | | | | | | | | | | | | 252 |
| Spring | L River Sport | Y | B | | 18 | 25 | 25 | 24 | 25 | | | 23 | 25 | 11 | 4 | 13 | 20 | | | | | | | | | | 213 |
| Spring | L River Sport | Y | A | | 3 | 24 | 25 | 24 | 25 | | | 23 | 25 | 37 | 14 | 20 | 16 | | | | | | | | | | 236 |
| | Bonneville | N | | | | | | | 29 | 55 | 70 | 66 | 113 | 122 | 126 | 178 | 149 | 64 | 30 | 38 | 33 | | | | 27 | 39 | 1139 |
| | Bonneville | Y | | | | | | | 85 | 189 | 161 | 113 | 131 | 139 | 85 | 90 | 99 | 44 | 19 | 19 | 20 | | | | 22 | 9 | 1225 |
| Spring | Wind R. Sport | Y | 01 | | | | | | 9 | 26 | 72 | 42 | 13 | 2 | | | | | | | | | | | | | 164 |
| Spring | Drano Lake Sport | Y | 01 | | | | | | 2 | 13 | 54 | 42 | | | | | | | | | | | | | | | 111 |
| Spring | Tribal Zone 6 | N | 01 | | | | | | | 3 | | | | 13 | 4 | 12 | 17 | | | | | | | | | | 49 |
| Spring | Tribal Zone 6 | N | 02 | | | | | | | 7 | 12 | 0 | 0 | 20 | 21 | 12 | 16 | | | | | | | | | | 88 |
| Spring | Tribal Zone 6 | Y | 01 | | | | | | | 21 | | | | 4 | 11 | 13 | 8 | 22 | | | | | | | | | 79 |
| Spring | Tribal Zone 6 | Y | 02 | | | | | | | 17 | 32 | 0 | 0 | 12 | 11 | 11 | 9 | 25 | | | | | | | | | 117 |
| Summer | L River Commercial | N | B | | | | | | | | | | | | | | | 28 | | | 18 | 21 | 9 | 30 | | | 106 |
| Summer | L River Commercial | N | A | | | | | | | | | | | | | | | 34 | | | 39 | 30 | 20 | 31 | | | 154 |
| Summer | L River Commercial | Y | B | | | | | | | | | | | | | | | 20 | | | 7 | 6 | 9 | 18 | | | 60 |
| Summer | L River Commercial | Y | A | | | | | | | | | | | | | | | 16 | | | 11 | 12 | | 7 | | | 46 |
| Summer | L River Sport | Y | B | | | | | | | | | | | | | | | 26 | 49 | | | | | | | | 75 |
| Summer | L River Sport | Y | A | | | | | | | | | | | | | | | 31 | 48 | | | | | | | | 79 |
| Fall | L River Sport | Y | B | | | | | | | | | | | | | | | | | | | | | | 149 | 1 | 150 |
| | Harvest Total | | | 14 | 54 | 97 | 147 | 94 | 108 | 121 | 192 | 183 | 73 | 151 | 114 | 130 | 86 | 202 | 97 | 0 | 75 | 69 | 38 | 86 | 149 | 1 | 2281 |

Note: Statistical week 11 equals 3/10/2014 – 3/16/2014, week 25 equals 6/16/2014 – 6/22/2014, week 31 equals 7/28/2014 – 8/3/2014, week 37 equals 9/8/2014 – 9/14/2014, and week 38 equals 9/15/2014 – 9/21/2014. Regions are shown in Fig. 1. Adipose clip is indicated by "Y" and fin-intact is "N".

Non-tribal fisheries during the spring management period for Chinook salmon are mark-selective based on absence or presence of the adipose fin to distinguish hatchery fish from natural origin fish, respectively. These adipose markings make it possible to have a mark-selective sport and commercial fishery in which only fish with missing adipose fins (hatchery-origin) are legally retained. Fish with intact adipose fins that are caught in these fisheries are released, but mortality rates are unknown from these releases. In addition to sampling hatchery-origin fish from the mark selective commercial and sport fisheries, we were able to obtain samples from unclipped hatchery and natural origin fish from Bonneville Dam and the tribal zone 6 fishery above Bonneville Dam.

Tissues were sampled from sockeye salmon in 2014 from four fishery mixture sources: 1) lower river commercial, 2) lower river sport, 3) Bonneville Dam (results discussed in section 4), 4) the tribal fishery in Zone 6. All samples obtained from the sport and commercial fisheries below Bonneville Dam were analyzed, but due to the large number of samples from Zone 6, we analyzed a subset at a consistent 5% sample rate that was applied across statistical weeks 25 – 29, and ~6% sample rate for harvest prior to week 25, and sample rates 23% and 21% for weeks 30 and 31, respectively. The higher sample rates at the beginning and end of the harvest period were intended to provide higher accuracy for the rare Snake River stock because we have observed this stock to increase in proportion toward the end of the harvest period. Genetic samples were run on 6% of the total tribal catch.

Tissues were sampled from steelhead in 2014 from two fishery mixture sources: 1) Bonneville Dam (results discussed in section 4) and 2) the summer and fall season tribal fishery in Zone 6 (Fig. 1). The tribal fishery was conducted during the A and B Index accounting period (July 1st-October 31st) and was sampled as part of the Yakama Nation fishery monitoring program. This fishery is not mark-selective, and we conducted genetic stock analyses on the subset of samples that were not adipose-clipped (putatively natural-origin). However, there are a few steelhead hatcheries in the Snake River and in the upper Columbia River that release unmarked smolts as part of supplementation efforts and so a proportion of the samples in our dataset were expected to be unmarked hatchery-origin. Fish with adipose clips were analyzed separately by IDFG and a report of those results has been generated with input from IDFG and CRITFC staff. This year we had additional samples that were included in our analysis that were collected from the non-mark selective harvest in Drano Lake.

*Molecular data*

Methods for DNA extraction, DNA amplification, and genotyping of SNP assays using genotyping-in-thousands by sequencing (GT-seq) are available at (https://www.monitoringresources.org/Document/Method/Details/5446). Additional details regarding how 192 SNPs were pared down to 186 SNPs can be found in Hess et al. (2012, 2013). Subsequently, we have reduced our GSI baseline from 186 SNPs to 179 SNPs, because we were unable to transition the full set of 186 SNPs to GT-seq protocols. These 179 SNP markers were used for GSI, and for PBT analyses, we used 95 of the SNPs. We used 180 total SNP markers for GSI of steelhead mixtures and 95 of these were used for PBT (Hess et al. 2013), these are the same as in last year's report because all of them appear to work well in the GT-seq format.

*GSI baselines for Chinook salmon, sockeye salmon, and steelhead*

Chinook salmon GSI analyses were performed using the updated baseline referred to as "Columbia River Basin Chinook salmon GSI baseline version 3.1" and is available on the FishGen website (https://www.fishgen.net). This baseline deviates in a few minor ways from the baseline described in Hess et al. (2013, Section 2). Sixty-one collections were delineated into the following 19 reporting groups: Columbia Rouge "01_YOUNGS", West Cascade spring-run "02_WCASSP", West Cascade fall-run "03_WCASFA", Willamette River spring-run "04_WILLAM", Spring Creek Group Tule fall-run "05_SPCRTU", Klickitat River spring-run "06_KLICKR", Deschutes River spring-run "07_DESCSP", John Day River spring-run "08_JOHNDR", Yakima River spring-run "09_YAKIMA", upper Columbia River spring-run "10_UCOLSP", Tucannon River spring-run "11_TUCANO", Hells Canyon spring-run "12_HELLSC", South Fork Salmon River spring-run "13_SFSALM", Chamberlain Creek spring-run "14_CHMBLN", Middle Fork Salmon River spring-run "15_MFSALM", upper Salmon River spring-run "16_UPSALM", Deschutes River fall-run "17_DESCFA", upper Columbia River summer-/fall-run "18_UCOLSF", and Snake River fall-run "19_SRFALL" (Table 2). Reporting groups were primarily determined by the relative genetic similarity among populations according to a phylogenetic analysis, and our results demonstrate sufficient power to discern three reporting groups (17_DESCFA, 18_UCOLSF, and 19_SRFALL) among the interior ocean-type collections. In one year, we had grouped all interior ocean-type collections into a single reporting group "Interior_Columbia_R_su/fa" (Hess et al. 2013). Genetic distances were computed from allele frequencies based on Nei's (1972) genetic distance, with the PHYLIP v 3.69 (Felsenstein 1989) and 1000 bootstrap replicates were performed. Distances were clustered using the Neighbor – Joining method (Saitou and Nei, 1987), and a consensus tree was constructed (http://evolution.genetics.washington.edu/phylip/).

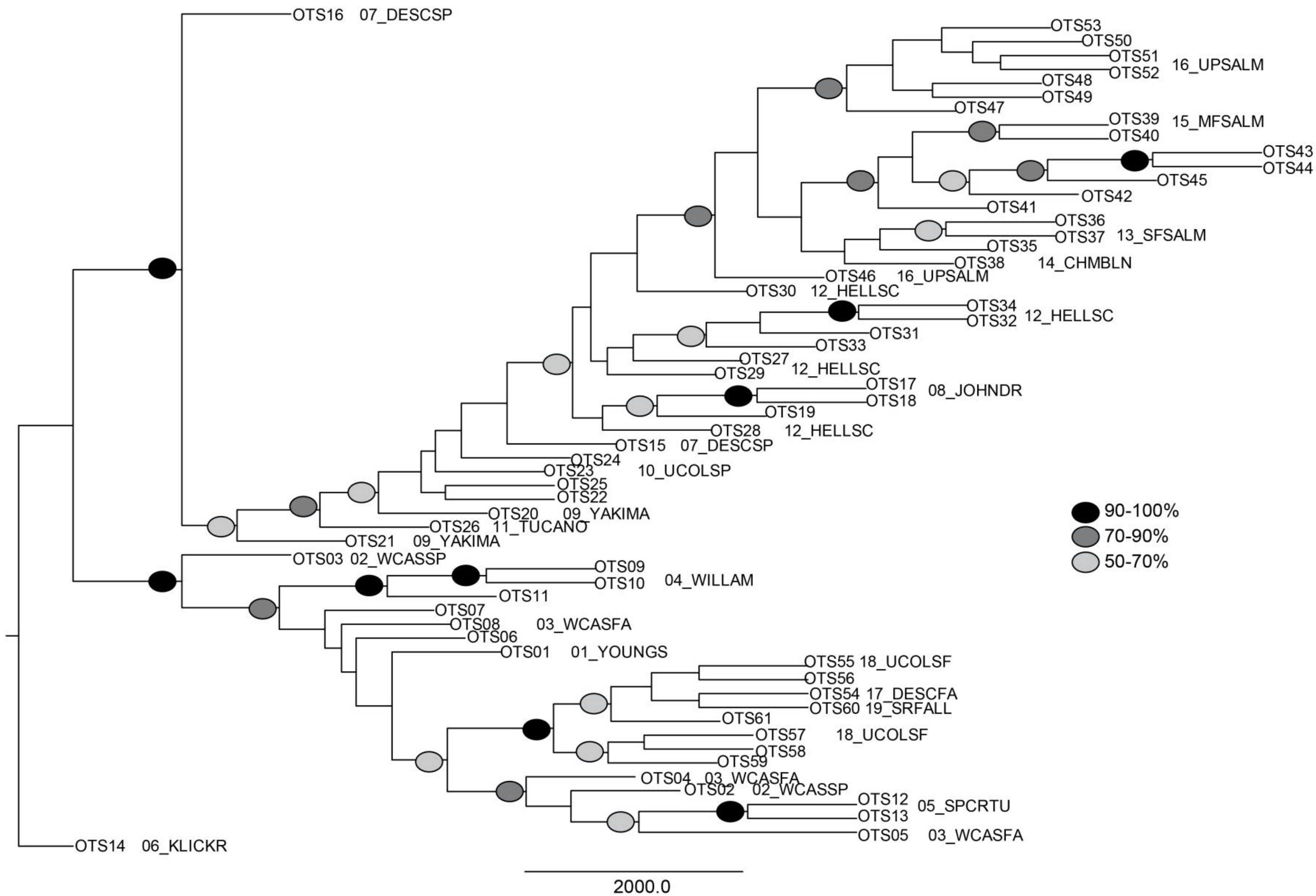


**Figure 2.** Neighbor-joining tree of Chinook salmon baseline populations using Nei's 1972 genetic distance of 179 SNP loci. The clusters are labeled with names of reporting groups used to aggregate the collections based on a combination of factors including

genetic similarity, life history, and geographic proximity. Bootstrap support is shown with shaded ovals. We used a final set of 19 reporting groups for all GSI analyses (Table 2).

The 10_UCOLSP reporting group includes the following Bonneville pool hatchery stocks: Carson stock (Ots22), and Little White Salmon R. (Ots23) because they are genetically indistinguishable from Upper Columbia R. spring Chinook salmon (includes Walla Walla and Umatilla River stocks). This composite group is notable because inclusion of these Bonneville pool stocks explains why a large proportion of fish from the Wind R. sport fishery should assign to this 10_UCOLSP reporting group. The 01_YOUNGS reporting group represents an out-of-basin genetic stock (originating from the Rogue R., OR) that is reared within the Columbia R. at Youngs Bay. Basic QAQC was performed to remove duplicate individuals and strays from the reference populations in the baseline. The baseline and reporting group data is available on FishGen.

**Table 2.** Sample sizes and reporting groups of Chinook salmon baseline populations**.**

| ID | Collection | (n) | Lineage | Reporting Groups | Reporting Group description |
|---|---|---|---|---|---|
| OTS01 | Youngs Bay fall-run | 91 | Rogue | 01_YOUNGS | Youngs Bay- Columbia Rogue stock |
| OTS02 | Cowlitz R spring-run | 90 | LC | 02_WCASSP | West Cascade spring-run |
| OTS03 | Kalama R spring-run | 83 | LC | 02_WCASSP | West Cascade spring-run |
| OTS04 | Cowlitz R fall-run | 82 | LC | 03_WCASFA | West Cascade fall-run |
| OTS05 | Elochoman R fall-run | 86 | LC | 03_WCASFA | West Cascade fall-run |
| OTS06 | Lewis R fall-run | 93 | LC | 03_WCASFA | West Cascade fall-run |
| OTS07 | NF Lewis fall-run | 178 | LC | 03_WCASFA | West Cascade fall-run |
| OTS08 | Sandy R fall-run | 83 | LC | 03_WCASFA | West Cascade fall-run |
| OTS09 | McKenzie R spring-run | 78 | LC | 04_WILLAM | Willamette River spring-run |
| OTS10 | N Santiam R spring-run | 79 | LC | 04_WILLAM | Willamette River spring-run |
| OTS11 | Sandy R spring-run | 48 | LC | 04_WILLAM | Willamette River spring-run |
| OTS12 | White Salmon fall-run | 77 | LC | 05_SPCRTU | Spring Creek tule fall-run |
| OTS13 | Spring Creek NFH tule fall-run | 49 | LC | 05_SPCRTU | Spring Creek tule fall-run |
| OTS14 | Klickitat R spring-run | 84 | ST | 06_KLICKR | Klickitat River spring-run |
| OTS15 | Shitike R spring-run | 93 | ST | 07_DESCSP | Deschutes River spring-run |
| OTS16 | Warm Springs R spring-run | 90 | ST | 07_DESCSP | Deschutes River spring-run |
| OTS17 | John Day R spring-run | 78 | ST | 08_JOHNDR | John Day River spring-run |
| OTS18 | Middle Fork John Day R spring-run | 47 | ST | 08_JOHNDR | John Day River spring-run |
| OTS19 | North Fork John Day R spring-run | 42 | ST | 08_JOHNDR | John Day River spring-run |
| OTS20 | American R spring-run | 76 | ST | 09_YAKIMA | Yakima River spring-run |
| OTS21 | Cle-Elum spring-run | 88 | ST | 09_YAKIMA | Yakima River spring-run |
| OTS22 | Winthrop NFH spring-run | 82 | ST | 10_UCOLSP | upper Columbia River spring-run/ Carson Hatchery spring-run |
| OTS23 | little White Salmon R spring-run | 93 | ST | 10_UCOLSP | upper Columbia River spring-run/ Carson Hatchery spring-run |
| OTS24 | Wenatchee R spring-run | 109 | ST | 10_UCOLSP | upper Columbia River spring-run/ Carson Hatchery spring-run |
| OTS25 | Entiat R spring-run | 98 | ST | 10_UCOLSP | upper Columbia River spring-run/ Carson Hatchery spring-run |
| OTS26 | Tucannon R spring-run | 81 | ST | 11_TUCANO | Tucannon River spring-run |
| OTS27 | Wenaha R spring-run | 179 | ST | 12_HELLSC | Hells Canyon spring-run |
| OTS28 | Lostine R spring-run | 212 | ST | 12_HELLSC | Hells Canyon spring-run |
| OTS29 | Grande Ronde R spring-run | 314 | ST | 12_HELLSC | Hells Canyon spring-run |

| | | | | | |
|---|---|---|---|---|---|
| OTS30 | Imnaha R spring-run | 96 | ST | 12_HELLSC | Hells Canyon spring-run |
| OTS31 | Lolo Cr spring-run | 89 | ST | 12_HELLSC | Hells Canyon spring-run |
| OTS32 | Red R spring-run | 221 | ST | 12_HELLSC | Hells Canyon spring-run |
| OTS33 | Powell R spring-run | 56 | ST | 12_HELLSC | Hells Canyon spring-run |
| OTS34 | Red R weir spring-run | 91 | ST | 12_HELLSC | Hells Canyon spring-run |
| OTS35 | South Forth Salmon R spring-run | 139 | ST | 13_SFSALM | South Fork Salmon River spring/summer-run |
| OTS36 | Johnson Cr spring-run | 137 | ST | 13_SFSALM | South Fork Salmon River spring/summer-run |
| OTS37 | Secesh R spring-run | 252 | ST | 13_SFSALM | South Fork Salmon River spring/summer-run |
| OTS38 | Chamberlain Cr spring-run | 219 | ST | 14_CHMBLN | Chamberlain Creek spring/summer-run |
| OTS39 | Big Cr spring-run | 139 | ST | 15_MFSALM | Middle Fork Salmon River spring/summer-run |
| OTS40 | Camas Cr spring-run | 55 | ST | 15_MFSALM | Middle Fork Salmon River spring/summer-run |
| OTS41 | Loon Cr spring-run | 107 | ST | 15_MFSALM | Middle Fork Salmon River spring/summer-run |
| OTS42 | Sulphur Cr spring-run | 94 | ST | 15_MFSALM | Middle Fork Salmon River spring/summer-run |
| OTS43 | Bear Valley Cr spring-run | 135 | ST | 15_MFSALM | Middle Fork Salmon River spring/summer-run |
| OTS44 | Capehorn Cr spring-run | 214 | ST | 15_MFSALM | Middle Fork Salmon River spring/summer-run |
| OTS45 | Marsh Cr spring-run | 228 | ST | 15_MFSALM | Middle Fork Salmon River spring/summer-run |
| OTS46 | North Fork Salmon R spring-run | 55 | ST | 16_UPSALM | upper Salmon River spring/summer-run |
| OTS47 | Lemhi R spring-run | 96 | ST | 16_UPSALM | upper Salmon River spring/summer-run |
| OTS48 | Pahsimeroi R spring-run | 92 | ST | 16_UPSALM | upper Salmon River spring/summer-run |
| OTS49 | East Fork Salmon R spring-run | 286 | ST | 16_UPSALM | upper Salmon River spring/summer-run |
| OTS50 | Salmon R spring-run | 83 | ST | 16_UPSALM | upper Salmon River spring/summer-run |
| OTS51 | West Fork Yankee Fork spring-run | 75 | ST | 16_UPSALM | upper Salmon River spring/summer-run |
| OTS52 | Valley Cr spring-run | 100 | ST | 16_UPSALM | upper Salmon River spring/summer-run |
| OTS53 | Sawtooth Hatchery weir spring-run | 186 | ST | 16_UPSALM | upper Salmon River spring/summer-run |
| OTS54 | upper Deschutes R fall-run | 252 | OT | 17_DESCFA | Deschutes River fall-run |
| OTS55 | lower Yakima R fall-run | 62 | OT | 18_UCOLSF | upper Columbia River summer/fall-run |
| OTS56 | Hanford Reach fall-run | 93 | OT | 18_UCOLSF | upper Columbia River summer/fall-run |
| OTS57 | Wenatchee R summer-run | 92 | OT | 18_UCOLSF | upper Columbia River summer/fall-run |
| OTS58 | Entiat R summer-run | 51 | OT | 18_UCOLSF | upper Columbia River summer/fall-run |
| OTS59 | Methow R summer-run | 87 | OT | 18_UCOLSF | upper Columbia River summer/fall-run |
| OTS60 | Lyons Ferry weir fall-run | 90 | OT | 19_SRFALL | Snake River fall-run |
| OTS61 | Clearwater R fall-run | 228 | OT | 19_SRFALL | Snake River fall-run |

Note: Chinook salmon baseline collections (n=7083). Lineages are: ST- stream type, OT – ocean type, and LC – Lower Columbia.

Sockeye salmon GSI analyses utilized the baseline described in Hess et al. (2013), and has previously been shown to accurately discriminate among the three major stocks in the Columbia River: Wenatchee, Okanagan, and Snake River sockeye salmon. The transition to GT-seq required omission of several loci due to poor genotyping quality with the new protocols. A total of 90 SNPs were used for these analyses.

Steelhead GSI analyses utilized a similar baseline as described in Hess et al. (2013), however some additional collections were included and some collections were removed. The modified baseline is referred to as “Columbia River Basin steelhead GSI baseline version 3.3” and is available on the FishGen database as part of a multi-agency collaboration (M. Campbell, IDFG, http://www.fishgen.net). This baseline includes 116 baseline collections were delineated into the following 13 Columbia River Basin reporting groups: 02_LOWCOL, 03_SKAMAN, 04_WILLAM, 05_BWSALM, 06_KLICKR, 07_MGILCS, 08_YAKIMA, 09_UPPCOL, 10_SFCLWR, 11_UPCLWR, 12_SFSALM, 13_MFSALM, and 14_UPSALM. In addition, there is a single reporting group (01_WCOAST, Quinault Hatchery) which is an outgroup for the Columbia River collections. The 07_MGILCS reporting group includes the following Snake River stocks: George Cr, Asotin Cr, Alpowa Cr, and Tucannon R as well as the reporting groups from the Grande Ronde, Imnaha, Lower Clearwater and Lower Salmon R.; because they are genetically indistinguishable from other middle Columbia River stocks. It is notable that this group contains part of the Snake River DPS and part of the Mid-Columbia DPS. Other studies (e.g. PIT-tags show high levels of straying of natural-origin fish, J. Bumgarner WDFW pers. comm.) appear to support this lack of distinction among populations that occur in the middle Columbia River and Snake River DPS. We created a map of the geographic distribution of the baseline collections and reporting groups (Fig. 3).

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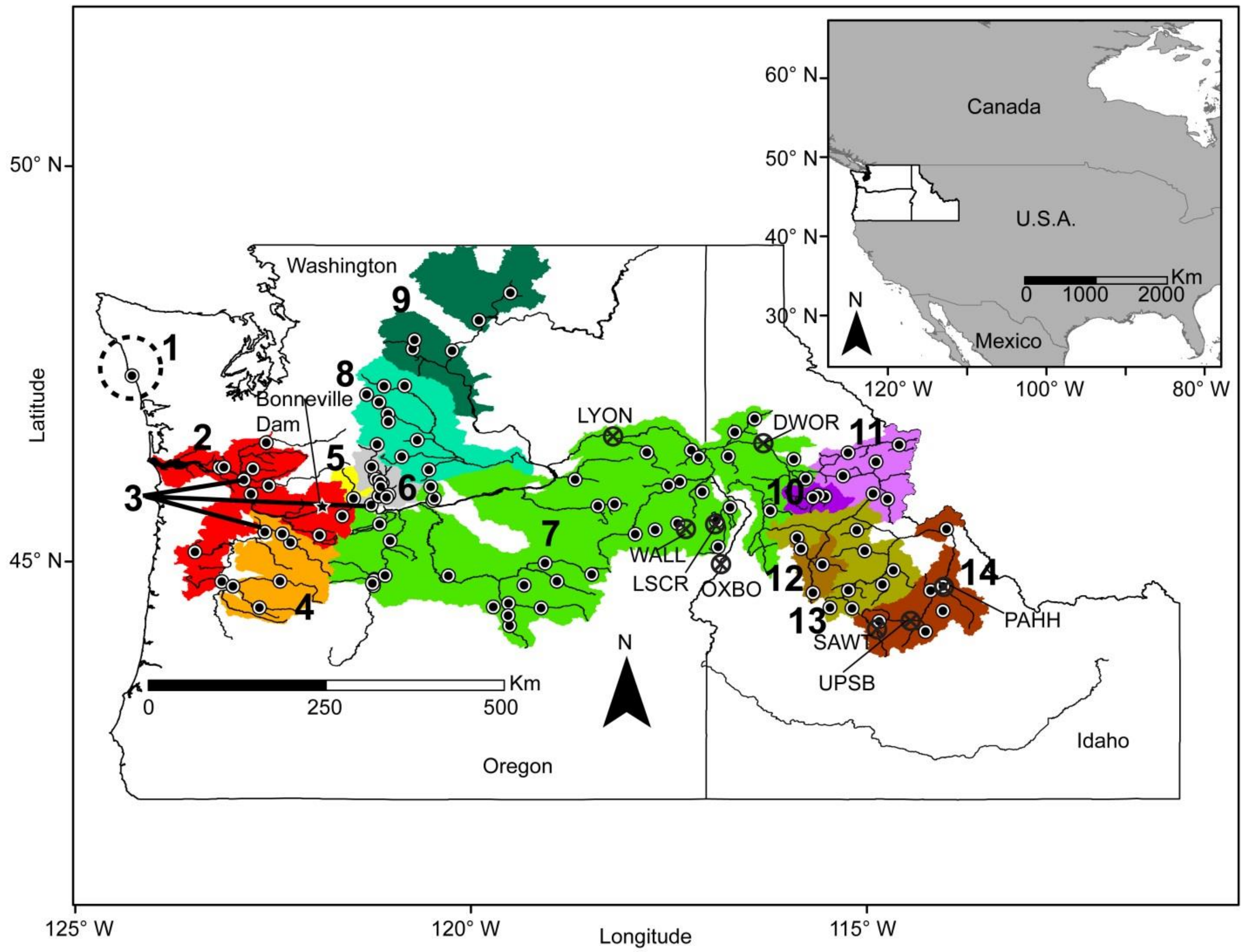



**Figure 3. Geographic distribution of collections represented in the Columbia River steelhead GSI and PBT genetic baselines.** The shape overlay represents the geographic extent of the following 14 reporting groups in the GSI baseline: 1) Quinault (WCOAST), 2) lower Columbia River (LOWCOL), 3) Skamania hatchery releases at three sites in lower Columbia River, Willamette River, and Klickitat River (SKAMAN), 4) Willamette River (WILLAM), 5) Big White Salmon River (BWSALM), 6) Klickitat River (KLICKR), 7) middle Columbia River, Grande Ronde River, Imnaha River, lower Snake River, lower Clearwater River, and lower Salmon River (MGILCS), 8) Yakima River (YAKIMA), 9) upper Columbia River (UPPCOL), 10) South Fork Clearwater River (SFCLWR), 11) upper Clearwater River (UPCLWR), 12) South Fork Salmon River (SFSALM), 13) Middle Fork Salmon River (MFSALM), and 14) upper Salmon River (UPSALM). There are 116 collections (filled circles) categorized into reporting groups. The PBT baseline is

indicated as 8 stocks (crossed circles) corresponding to the following sites where fish are collected and spawned for broodstock: Lyons Ferry Hatchery (LYON), Wallowa (WALL), Little Sheep Creek (LSCR), Oxbow Hatchery (OXBO), Dworshak Hatchery (DWOR), upper Salmon River B-run (UPSB), Sawtooth Hatchery (SAWT), and Pahsimeroi Hatchery (PAHH). Bonneville Dam (star) is the site where fish were non-lethally sampled for the mixed-stock analysis.

*Baseline power analyses*

The accuracy of the Chinook and sockeye salmon and steelhead baselines was characterized using mixture simulations performed by the program ONCOR v1.0 (available at http://www.montana.edu/kalinowski). Method: Predicting the accuracy of genetic stock identification v1.0 (https://www.monitoringmethods.org/Method/Details/1346).

*Combined application of PBT and GSI*

We combined PBT and GSI results together by first accepting all confident PBT assignments to hatchery broodstock for the Chinook salmon and steelhead individuals and then for the remaining individuals, we used the best estimate GSI assignments to provide likely population of origin. Current PBT baselines allowed us to identify the source hatcheries of 3-, 4-, and 5-year old Snake River and Klickitat River spring-run Chinook salmon (2009–2011 broodyears) and the 1-, 2-, and 3-ocean age steelhead from the Snake River (2010–2012 broodyears). For Snake River steelhead the SNPPIT file included brood years 2010–2012 (See methods for Parentage assignments using SNPPIT software v1.0, ID: 1341).

The program ONCOR was used to estimate the most likely population-of-origin for the Chinook salmon and steelhead harvest samples. Individuals were assigned using a "best estimate" approach (Method: Assigning individual samples using Individual Assignment (IA) genetic methods v1.0, ID: 1334). We also used GSIsim for "Mixture modeling to estimate stock proportions v1.0" (ID: 1333).

## Results

*Accuracy testing of 179 SNP Chinook salmon baseline*

The 61 collections were grouped into 19 reporting groups based on the clustering we observed in the phylogenetic analysis (Fig. 2). Results from the leave-one-out analysis showed less than half of the baseline collections displayed greater than 90% correct individual assignment to the reporting group level, however nearly 60% of the collections displayed greater than 80% correct assignment. Reporting groups comprised of collections that averaged less than 80% correct assignment based on leave-one-out analysis include the following: 08_JOHNDR, 10_UCOLSP, 11_TUCANO, 12_HELLSC, 13_SFSALM, and 19_SRFALL. In general, the spring-run (interior stream-type lineage) baseline collections displayed the lowest correct assignment. The values for average correct assignment based on this leave-one-out analysis and average proportions from 100% simulations are provided for each reporting group (Table 3).

Table 3. Average GSI accuracy for Chinook salmon at the reporting group level using 179 SNPs.

| 179 SNP baseline Reporting groups | Leave-1-out | 100% sims |
|---|---|---|
| 01_YOUNGS | 100.00% | 100.00% |
| 02_WCASSP | 80.40% | 99.50% |
| 03_WCASFA | 93.20% | 99.73% |
| 04_WILLAM | 100.00% | 99.84% |
| 05_SPCRTU | 93.05% | 99.96% |
| 06_KLICKR | 97.10% | 99.84% |
| 07_DESCSP | 91.15% | 99.84% |
| 08_JOHNDR | 64.17% | 77.78% |
| 09_YAKIMA | 100.00% | 99.51% |
| 10_UCOLSP | 72.68% | 96.27% |
| 11_TUCANO | 75.70% | 99.36% |
| 12_HELLSC | 73.03% | 96.99% |
| 13_SFSALM | 70.00% | 97.27% |
| 14_CHMBLN | 86.10% | 99.79% |
| 15_MFSALM | 86.69% | 99.22% |
| 16_UPSALM | 85.29% | 98.97% |
| 17_DESCFA | 92.00% | 99.82% |
| 18_UCOLSF | 87.30% | 94.95% |
| 19_SRFALL | 73.45% | 98.09% |
| Grand Total | 83.27% | 97.34% |

Note: Accuracy is based on results from leave-1-out and 100% mixture simulations performed with the program ONCOR.

*Parentage based tagging assignments of spring-run Chinook salmon in harvest and at Bonneville Dam*

The PBT analysis resulted in 1,390 hatchery-origin salmon that could be assigned back to Klickitat and Snake River hatchery broodstock parents that were spawned in 2009 – 2011 (Table 4). These salmon were found to have originated from the following sixteen sources: S.F. Clearwater, Catherine Creek, Dworshak, Grande Ronde, Imnaha, Johnson Creek, Klickitat, Lookingglass Creek, Lostine, McCall, Nez Perce Tribal, Pahsimeroi, Clearwater (Powell), Rapid River, Sawtooth, and Lyons Ferry (Tucannon) hatcheries. Among the 4-year-old fish, the broodstock from Rapid R. 2010 yielded the highest number of assignments (N=385), and multiple broodstocks yielded the least (N=1). There were sixteen 4-year-olds and 3 jacks sampled from the Wind R. fishery that assigned to the following PBT source hatcheries: S.F. Clearwater, Dworshak, Klickitat, Powell, and Rapid R. hatcheries.

Table 4. Summary information on numbers and origins of Chinook salmon that assigned to the PBT baseline.

| | | | Region: | Lower river | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Fishery: | Commercial | Test | | Sport | Bonneville Dam | | Tribal | | Wind | Drano | |
| PBT source hatchery | PBTpop | Tag Rate | Origin: | HOR | HOR | NOR | HOR | HOR | NOR | HOR | NOR | HOR | HOR | Total |
| LSRCP/IDFG - Clearwater (SF) | OtsCLWH10S | 99.5% | | 3 | 6 | | 8 | 26 | 4 | 6 | | 1 | 1 | 55 |
| | OtsCLWH11S | 95.6% | | 2 | 2 | | 1 | 4 | 0 | | | | | 9 |
| LSRCP/ODFW - Catherine Creek | OtsCTHW10S | 89.3% | | | 2 | | 2 | 3 | 0 | 1 | | | | 8 |
| | OtsCTHW11S | 91.7% | | | | | 1 | 0 | 0 | | | | | 1 |
| LSRCP/USFWS - Dworshak | OtsDWOR09S | 98.9% | | | | | 4 | 2 | 0 | | | | | 6 |
| | OtsDWOR10S | 98.5% | | 9 | 22 | | 23 | 64 | 3 | 12 | 1 | 5 | | 139 |
| | OtsDWOR11S | 99.0% | | 4 | 1 | 1 | 4 | 15 | 0 | 1 | | 1 | | 27 |
| LSRCP/ODFW - Grande Ronde | OtsGRUW10S | 98.6% | | | | 1 | 1 | 3 | 4 | 1 | | | | 10 |
| | OtsGRUW11S | 99.5% | | | | | | 3 | 4 | 1 | | | | 8 |
| LSRCP/ODFW - Imnaha | OtsIMNW09S | 97.4% | | | | | | 1 | 0 | 1 | | | | 2 |
| | OtsIMNW10S | 97.6% | | 5 | | | 5 | 9 | 1 | 2 | | | | 22 |
| | OtsIMNW11S | 94.4% | | | | | 4 | 10 | 1 | | 1 | | | 16 |
| Johnson Cr. | OtsJHNW10S | 94.2% | | | | | | 2 | 5 | | | | | 7 |
| | OtsJHNW11S | 97.5% | | | | | | 0 | 2 | | | | | 2 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Klickitat Hatchery | OtsKLKH09S | 99.3% | | 1 | | | | 2 | 0 | | | | | 3 |
| | OtsKLKH10S | 97.5% | | 9 | 6 | | 9 | 23 | 1 | 5 | | 2 | | 55 |
| | OtsKLKH11S | 80.7% | | | | | 3 | 6 | 3 | | | | | 12 |
| LSRCP/ODFW - Lookingglass Creek | OtsLOOK10S | 98.8% | | 1 | 5 | | 5 | 11 | 1 | 4 | | | 1 | 28 |
| | OtsLOOK11S | 97.5% | | | 2 | | | 6 | 0 | | | | | 8 |
| LSRCP/ODFW/ NPT – Lostine | OtsLSTW10S | 94.3% | | 7 | | | 10 | 22 | 0 | 7 | 2 | | | 48 |
| | OtsLSTW11S | 91.5% | | | | | 5 | 5 | 1 | | | | | 11 |
| LSRCP/IDFG - McCall (SFSR) | OtsMCCA09S | 96.2% | | | 1 | | | 0 | 0 | 1 | | | | 2 |
| | OtsMCCA10S | 99.6% | | 29 | | | 31 | 53 | 33 | 19 | 9 | | | 174 |
| | OtsMCCA11S | 99.0% | | 2 | | | 13 | 17 | 13 | 1 | 1 | | | 47 |
| Nez Perce Tribal Hatchery (NPTFH) | OtsNPFH09S | 96.3% | | | | | | 0 | 0 | | 1 | | | 1 |
| | OtsNPFH10S | 98.4% | | | | 4 | | 0 | 8 | | | | | 12 |
| | OtsNPFH11S | 98.9% | | | | | | 0 | 1 | | | | | 1 |
| Idaho Power/IDFG - Pahsimeroi | OtsPAHH10S | 98.9% | | 8 | | | 9 | 19 | 3 | 2 | | | | 41 |
| | OtsPAHH11S | 96.6% | | | | | | 5 | 3 | | | | | 8 |
| LSRCP/IDFG - Clearwater (Powell) | OtsPOWP10S | 97.7% | | | 2 | | 4 | 16 | 2 | 8 | | 2 | 1 | 35 |
| | OtsPOWP11S | 98.7% | | 3 | 1 | | 6 | 10 | 2 | | | 1 | | 23 |
| Idaho Power/IDFG - Rapid River | OtsRAPH08S | 97.7% | | | | | | 0 | 1 | | | | | 1 |
| | OtsRAPH09S | 90.7% | | | 1 | | 6 | 10 | 1 | 3 | | | | 21 |
| | OtsRAPH10S | 99.0% | | 30 | 52 | | 69 | 190 | 7 | 28 | 1 | 6 | 2 | 385 |
| | OtsRAPH11S | 98.4% | | 8 | 8 | | 15 | 42 | 2 | 2 | 1 | 1 | 1 | 80 |
| LSRCP/IDFG - Sawtooth | OtsSAWT09S | 99.6% | | | | | | 1 | 0 | | | | | 1 |
| | OtsSAWT10S | 99.4% | | 8 | 5 | | 10 | 26 | 6 | 7 | 2 | | 1 | 65 |
| | OtsSAWT11S | 97.0% | | | 2 | | 5 | 7 | 1 | | | | | 15 |
| LSRCP/WDFW - L.F. (Tucannon) | OtsTUCW11S | 98.8% | | | | | | 0 | 1 | | | | | 1 |
| | Unassigned | | | 115 | 134 | 52 | 196 | 523 | 858 | 84 | 118 | 145 | 104 | 2329 |
| | Snake PBT avg: | 96.7% | Snake PBT N | 119 | 112 | 6 | 241 | 582 | 110 | 107 | 19 | 17 | 7 | 1320 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total PBT N | 129 | 118 | 6 | 253 | 613 | 114 | 112 | 19 | 19 | 7 | 1390 |
| Sample Total | 244 | 252 | 58 | 449 | 1136 | 972 | 196 | 137 | 164 | 111 | 3719 |
| %Snake of Sample Total | 50.4% | 46.0% | 10.7% | 55.5% | 53.0% | 11.7% | 56.4% | 14.3% | 10.7% | 6.5% | |

Note: PBTpop is the abbreviated hatchery source and the digits indicate the spawn year, e.g. 09S is spawn year 2009. Adipose-clipped (HOR) and adipose unclipped (NOR) categories of fish could be separated for the Test, Bonneville Dam, and Tribal fishery mixtures. All other fishery mixtures were mark-selective (HOR only). The "Snake PBT N" indicates only parentage assignments to Snake River hatcheries, and "PBT N" is the total number of assignments that were identified for Klickitat and Snake River hatcheries. The "%Snake of Sample Total" indicates our estimate of the composition of Snake River hatcheries in each fishery mixture using an expansion factor based on average tagging rate across all Snake River hatcheries. Bonneville Dam includes only fish sampled during statistical weeks 16-25, which is the timeframe of sampling within the spring-run harvest period.

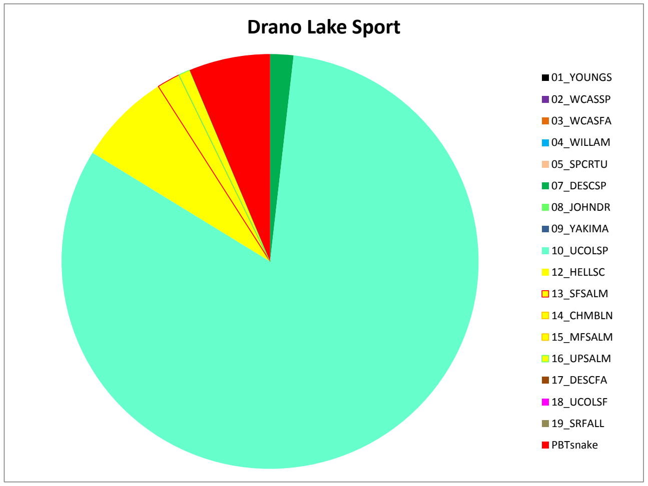
*Wind River spring-run Chinook salmon sport harvest*

Both PBT and GSI assignments were used to analyze the Wind River spring-run Chinook salmon mark-selective sport fishery. We estimated stock composition to investigate how expansion of the Chinook salmon sport fishing "bubble" boundary around the mouth of the Wind River may be affecting proportions of non-local (Carson Hatchery) Chinook salmon that are harvested by using the context of stock proportions in other spring management period fisheries and at Bonneville Dam. The Wind River and Drano Lake sport mark selective Chinook salmon mixtures had relatively low proportions of Snake River hatchery fish (10.7% and 6.5%, respectively, Table 4). The lowest proportion of Snake River hatchery fish that was observed in the other adipose-clipped fishery mixtures was found in a test fishery (46.0%). The natural origin mixtures (adipose-intact fish) from the test fishery, Bonneville Dam, and the zone 6 tribal harvest also had low proportions of Snake River hatchery fish (10.7%, 11.7%, and 14.3%, respectively). The proportion of Snake River hatchery fish in the test fishery adipose-intact mixture was the only value lower than that of the Wind River harvest.

We also applied GSI to examine stock composition at the GSI reporting group level for the Drano Lake and Wind River fishery mixtures, and found that the 10_UCOLSP (includes upper Columbia River hatcheries as well as Carson Hatchery, Walla Walla Hatchery, and Umatilla Hatcheries) was the genetic stock representing the largest proportion of both harvests (82% and 74%, respectively, Fig. 4). PBT would be better suited than GSI for identifying the target stock (Carson Hatchery), and in future years this approach will be possible. From the Snake River, there was 6% and 10% assignment to PBT hatcheries for Drano Lake and Wind River harvests, respectively. Using GSI, 7% of the harvest in the Wind River fishery was identified from the 12_HELLSC, 5% from the 13_SFSALM, and 1% from 16_UPSALM. Assignment of the 12_HELLSC genetic stock can be the result of misassignment that occurs between the two genetically similar stocks: Carson_H/10_UCOLSP versus 12_HELLSC. This misassignment is known to occur based on comparisons of GSI results and coded wire tags. For example, there were 20 coded wire tags that were analyzed with PBT and GSI in the Wind River harvest. Of these 20 coded wire tag origins, 18 of them were concordant with GSI/PBT assignments (90% concordance rate). The 2 misassignments occurred between 10_UCOLSP versus 12_HELLSC stocks. For comparison, in 2013, there were 12 coded wire tags that were analyzed with GSI and represented in the Wind River harvest. Of these 12 coded wire tag origins, 9 of them were concordant with the GSI assignment estimates (75% concordance rate). The 3 misassignments occurred between those same two stocks.

We can compare the numbers of Snake River PBT assignments that have been identified in the Wind River harvest for the past three years of our analysis. For 2012–2014, the Snake River PBT assignments accounted for 3% (10 of 349), 7% (10 of 138), and 10.4% (17 of 164) of the total harvests each year, respectively. Our estimate of the proportion of Snake River hatchery fish in this current report would therefore represent a three-fold increase compared to the estimate in 2012, but is still lower than the proportion of adipose-intact and adipose-clipped Snake River hatchery fish in collections taken from Bonneville Dam (Table 4).

To be clear, this analysis cannot precisely quantify Carson Hatchery fish that are harvested in the bubble fishery nor can it tell how many wild fish from other areas are handled in the fishery. Further, we cannot conclude whether changing the bubble fishery boundary has resulted in any change in impacts compared to previous years with the smaller bubble, because we did not sample in years prior to the bubble expansion.



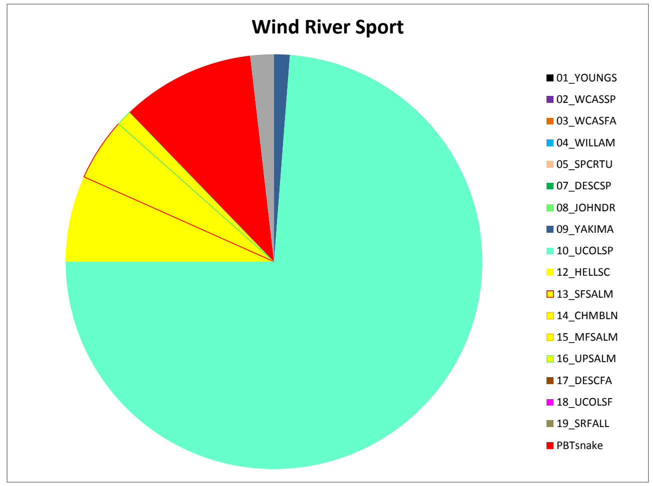




**Figure 4. Genetic stock composition of the Drano Lake and Wind River sport mark-selective harvests in 2014**.

*Comparison of stock composition among spring management period Chinook salmon fisheries*

Analysis of adipose-clipped Chinook salmon from multiple fishery mixtures in the spring management period identified relatively larger proportions of lower Columbia River stocks (LC, composed mostly of Willamette River fish) near the mouth of the Columbia River, such that region B was comprised of a range of 22 – 39% and region A had a range of 3 – 16% of the LC stock in commercial, test, and sport fisheries (Fig. 5). PBT-assignments made it possible to further discriminate fish by their hatchery-of-origin (15 total hatcheries represented), which is a finer scale compared to the larger stock units that are resolved with GSI. Stream-type stocks (ST, i.e. upriver spring-run and Snake River spring/summer-run Chinook salmon) were in highest proportions upstream of region B. Analysis of adipose-intact fishery mixtures showed similar patterns (Fig. 5), however the Snake River PBT-assigned stock (hatchery-origin) was estimated in smaller proportions than in adipose-clipped samples as would be expected since PBT identifies hatchery origin fish.

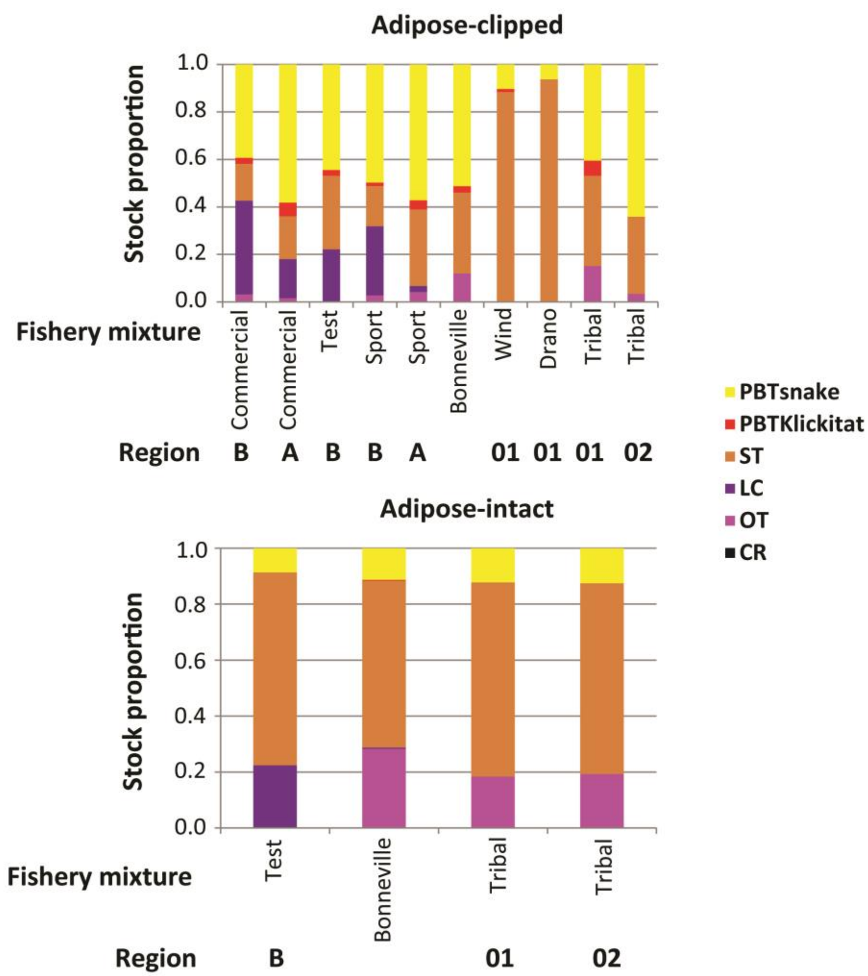
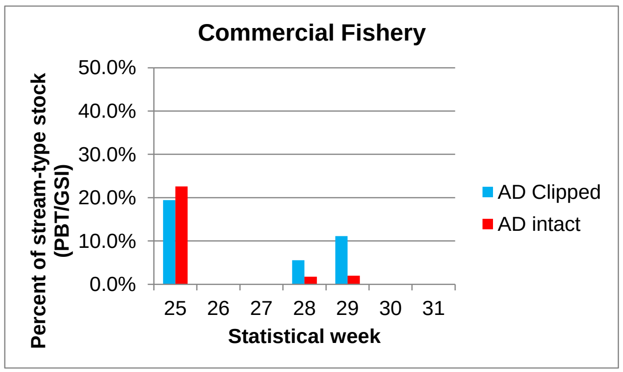



**Figure 5. Stock composition of spring management period Chinook salmon harvest mixtures.** Note: "ST" includes upriver spring run and Snake River spring/summer run Chinook salmon stocks, "LC" includes all lower river stocks (e.g. Willamette, Cowlitz, Lewis, and Sandy stocks), "OT" includes upper Columbia summer and upriver fall Chinook salmon stocks, and "CR" denotes Columbia River Rogue stock reared in Youngs Bay net pens. PBT was used to assign Klickitat and Snake River hatchery spring-run Chinook salmon.

*Comparison of percent stock composition of upriver spring Chinook salmon stocks (ST) among summer-management period Chinook salmon fisheries*

Analysis of Chinook salmon fisheries in the summer management period (June 16 – August 1) addressed the following objectives: 1) estimate stock composition for the mark selective sport fishery and commercial fishery below Bonneville Dam, 2) compare stock composition of adipose-clipped versus adipose-intact fish from the commercial harvest below Bonneville Dam, 3) characterize temporal changes in stock composition across the season. While jack Chinook salmon are not harvested at high rates in fisheries and there are no specific harvest limits for jacks, jack Chinook salmon if sampled could have been incorporated into this analysis. The percentage of upriver adult and jack spring-run stocks (ST) declined in both harvest and Bonneville Dam mixtures over time, but the commercial harvest may have generally included a lower proportion of this group compared with what actually passes the dam in any given week (Fig. 6).



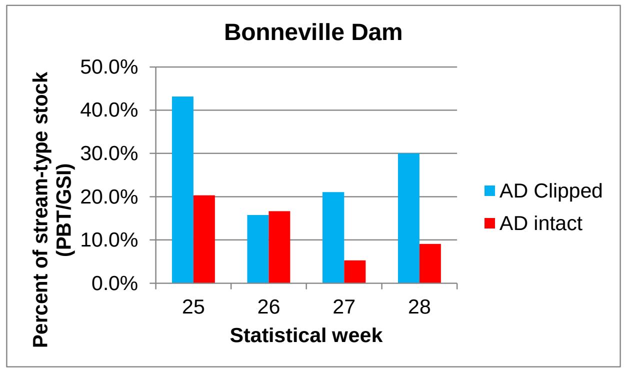




**Figure 6. Temporal patterns of the percent of upriver spring-run stocks (ST) by-catch in adipose-clipped and adipose-intact mixtures of adult and jack Chinook salmon sampled in the lower river commercial fishery and Bonneville Dam during the summer management period in 2014.** Statistical week 25 begins on June 16 and week 31 includes August 1. The commercial fishery did not occur during weeks 26 and 27. Sampling at Bonneville Dam was suspended during weeks 29–32 due to high temperatures.

Table 5. Comparison of stock composition of summer management period Chinook salmon fisheries.

| | | Lower R. | | | | | | Bonneville | |
|---|---|---|---|---|---|---|---|---|---|
| | | Sport | | Commercial | | | | Dam | |
| | | Ad-clip | | Ad-clip | | Ad-intact | | Ad-clip | Ad-intact |
| Method | Genetic stock | B | A | B | A | B | A | | |
| GSI | CR | 0.00% | 0.00% | 0.00% | 0.00% | 1.89% | 0.65% | 0.00% | 0.00% |
| | LC | 9.33% | 3.80% | 45.00% | 30.43% | 15.09% | 7.79% | 0.00% | 1.21% |
| | OT | 66.67% | 50.63% | 45.00% | 60.87% | 74.53% | 87.01% | 68.63% | 84.85% |
| | ST | 2.67% | 8.86% | 0.00% | 0.00% | 3.77% | 3.25% | 8.82% | 7.27% |
| PBT | Klickitat | 1.33% | 2.53% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| | Snake | 20.00% | 34.18% | 10.00% | 8.70% | 4.72% | 1.30% | 22.55% | 6.67% |
| GSI/PBT | Total | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% | 100.00% |
| | Total PBT | 21.33% | 36.71% | 10.00% | 8.70% | 4.72% | 1.30% | 22.55% | 6.67% |
| | Total ST (GSI/PBT) | 24.00% | 45.57% | 10.00% | 8.70% | 8.49% | 4.55% | 31.37% | 13.94% |

Note: Each fishery mixture is categorized by whether fish had clipped or intact adipose fins. Also, the lower river fisheries indicate which region (B or A, Fig. 1) from which the harvest mixture originated. “Total ST” indicates the total proportion of upriver spring and Snake River spring/summer stocks and represents combined analyses of GSI and PBT.

The lower river sport and commercial fisheries below Bonneville Dam were composed of very different proportions of ST stock. “Total ST” stock includes proportions of upriver spring and Snake River spring/summer stocks measured using both GSI and PBT. In the sport fishery, this proportion was greater than 2X the Total ST stock proportions observed in the commercial fishery mixtures (Table 5). This high proportion of the Total ST stock likely owes to the fact that the sport fishery occurred in the first two weeks of the summer management period (Table 1), which is when the ST stock is in highest abundance. Below Bonneville Dam, adipose-clipped mixtures from the commercial fishery were composed of relatively high proportions of lower Columbia stock (LC) compared to the adipose-intact mixtures from this fishery.

We compared changes in % stock composition of ST stocks of adipose-clipped versus adipose-intact fish through time in the lower river commercial fishery, and found that the percentage of upriver adult and jack spring-run stocks (ST) declined in both harvest and Bonneville Dam mixtures over time, but the commercial harvest may have generally included a lower proportion of this group compared with what actually passes the dam in any given week (Fig. 7). There is no obvious explanation for this observed difference

in the composition of the run at Bonneville and the composition in the commercial fishery, but it may partly owe to the areas in which the commercial fishery is conducted in the lower river regions.

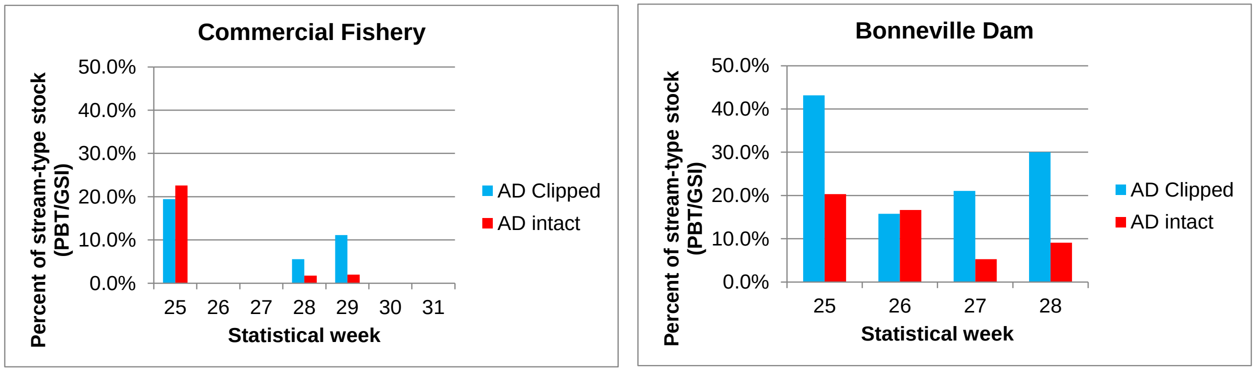



**Figure 7. Temporal patterns of the percent of upriver spring-run stocks (ST) by-catch in adipose-clipped and adipose-intact mixtures of adult and jack Chinook salmon sampled in the lower river commercial fishery and Bonneville Dam during the summer management period in 2014.** Statistical week 25 begins on June 16 and week 31 includes August 1. The commercial fishery did not occur during weeks 26 and 27. Sampling at Bonneville Dam was suspended during weeks 29–32 due to high temperatures.

*Parentage based tagging assignments of harvested summer management period Chinook salmon*

The PBT analysis resulted in 64 hatchery-origin adult and jack salmon that could be assigned back to Klickitat and Snake River hatchery broodstock parents that were spawned in 2009 – 2011 (Table 6). These salmon were found to have originated from the following seven sources: Imnaha, Johnson, Klickitat, Lostine, McCall, Pahsimeroi, and Sawtooth hatcheries. Among the 4-year-old fish, the broodstock from McCall 2010 yielded the highest number of assignments (N=10), however across several broodstock (e.g. Imnaha, Johnson, Lostine, McCall, and Sawtooth), jacks were more numerous than 4-year-olds. Comparisons of the PBT stock composition between the spring-run (Table 4) and summer-run harvests (Table 6) show a clear run-timing effect in which typically late-running stocks predominate in the summer-run harvest. Jack age classes typically run later than 4-year-olds (Hess et al. 2013), which also explains why jacks comprised larger proportions than 4-year-olds in the summer-run harvest versus the spring-run harvest. The broodstock with the highest number of assignments were the jacks from McCall 2011 (N=16), which were nearly twice in number of that stock's 4-year-olds.

Table 6. Parentage assignments of summer management period Chinook salmon fisheries.

| | | | Region: | Lower R. | | | |
|---|---|---|---|---|---|---|---|
| | | | Fishery: | Commercial | | Sport | |
| PBT source hatchery | PBTpop | Tag Rate | Origin: | HOR | NOR | HOR | Total |
| LSRCP/ODFW - Imnaha | OtsIMNW10S | 97.63% | | 2 | | 2 | 4 |
| | OtsIMNW11S | 94.43% | | 3 | | 8 | 11 |
| Johnson Cr. | OtsJHNW11S | 97.47% | | | 2 | | 2 |
| Klickitat Hatchery | OtsKLKH09S | 99.27% | | | 1 | | 1 |
| | OtsKLKH10S | 97.46% | | 1 | | 2 | 3 |
| | OtsKLKH11S | 80.72% | | | | 1 | 1 |
| LSRCP/ODFW/NPT – Lostine | OtsLSTW10S | 94.34% | | | | 1 | 1 |
| | OtsLSTW11S | 91.53% | | | | 7 | 7 |
| LSRCP/IDFG - McCall (SFSR) | OtsMCCA10S | 99.58% | | 1 | 3 | 6 | 10 |
| | OtsMCCA11S | 99.04% | | | 1 | 15 | 16 |
| Idaho Power/IDFG - Pahsimeroi | OtsPAHH10S | 98.91% | | 2 | 1 | 1 | 4 |
| | OtsPAHH11S | 96.62% | | | | 1 | 1 |
| LSRCP/IDFG - Sawtooth | OtsSAWT11S | 96.97% | | 2 | | 1 | 3 |
| | Snake PBT avg: | 95.69% | PBT N | 11 | 8 | 45 | 64 |
| | | Snake Total | | 10 | 7 | 42 | 59 |
| | | %Snake | | 9.86% | 2.81% | 28.32% | 4.41% |
| | | | Total | 106 | 260 | 155 | 1397 |

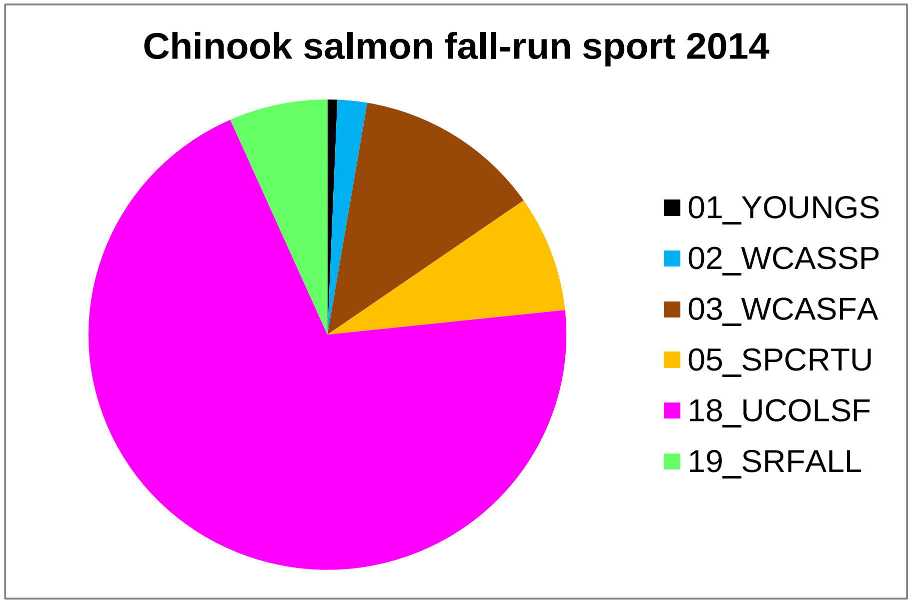
Note:PBTpop is the abbreviated hatchery source and the digits indicate the spawn year, e.g. 09S is spawn year 2009. Adipose-clipped (HOR) and adipose unclipped (NOR) categories of fish could be separated for the Commercial fishery mixtures. The sport fishery is mark-selective (HOR only). The "%Snake" indicates our estimate of the composition of Snake River hatcheries in each fishery mixture using an expansion factor based on average tagging rate across all Snake River hatcheries.

*Stock composition of the fall-run mark-selective Chinook salmon sport fishery*

We estimated stock composition of the mark selective sport fishery in the lower Columbia River in 2014. A single PBT assignment was observed for a fall Chinook from the Klickitat. Major GSI stocks from greatest to least were: Upper Columbia River su/fa (70%), West Cascade fa (13%), Spring Creek Tule (8%), and Snake River fa (7%, Fig. 8). In past years (2012 and 2013), this harvest has had somewhat variable proportions of lower river stocks, e.g., 24% versus 11% of the 03_WCASFA stock for 2012 and

2013 harvests, respectively. The proportion of lower river stocks in 2014 appears consistent with the previous year, 2013. The fall season mark selective fishery was for a short period within the overall fall season fisheries which were mostly full retention fisheries. Results from these fisheries would not be applicable to any other portion of the fall fisheries.

**Figure 8. Genetic stock composition of the lower Columbia River fall-run mark-selective Chinook salmon sport harvest in 2014.**




Note: the assignment of West Cascade spring stock "02_WCASSP" may owe to misassignment between the spring and fall runs from that region, strays from the net pen rearing at Youngs Bay, or other unknown reasons.

*Comparison of stock composition among sockeye salmon fisheries*

Sockeye salmon were sampled from the lower Columbia River below Bonneville Dam in the lower river sport and commercial fishery and Zone 6 tribal fishery, and each fish was assigned to three Columbia River genetic stocks (Table 7). The Zone 6 sport fishery was not sampled. Low sample numbers of Snake River sockeye make it difficult to estimate narrow confidence intervals for estimates of this stock. For the tribal fishery, sockeye were sampled at a higher rate for the gillnet fishery compared to the platform fishery even though the platform fishery generally catches larger numbers of fish. It is not possible to be sure if the proportion of Snake River sockeye in any of the harvests was significantly different than the proportion of Snake River sockeye at Bonneville (Table 8). The lower confidence limit for the Snake River stock in the Zone 6 tribal fishery was 1.3% of that harvest, and the commercial and sport fishery below Bonneville Dam had lower confidence limits of less than 1.0%. However, during the harvest period (weeks 24-31), the proportion of Snake River stock sampled at Bonneville Dam was estimated to be 0.8% with 95% confidence

limit of 0.4 – 1.4% (Table 8). Therefore, the confidence limits of this stock at Bonneville Dam overlap with those of the harvest estimates and are not significantly different.

Table 7. Summary of sample numbers and stock assignments for each sockeye salmon fishery by weekly strata.

| | | Statistical week | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fishery | Stock | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | Total |
| Commercial | Okanagan | | | 35 | | | 6 | 3 | | | 44 |
| | Snake | | | | | | | | | | 0 |
| | Wenatchee | | | 14 | | | 1 | | | | 15 |
| Sport | Okanagan | | | 9 | 40 | 24 | 18 | 5 | 3 | 1 | 100 |
| | Snake | | | | 1 | 1 | | 1 | | | 3 |
| | Wenatchee | | | 6 | 7 | 8 | | 1 | | | 22 |
| Zone6 | Okanagan | 4 | 21 | 47 | 168 | 184 | 360 | 188 | 235 | 53 | 1260 |
| | Snake | | | | 3 | 2 | 10 | 11 | 5 | 2 | 33 |
| | Wenatchee | | 3 | 18 | 135 | 82 | 124 | 61 | 52 | 10 | 485 |
| | Whatcom | | | | | | | | 1 | | 1 |

Table 8. Comparison of stock-specific abundance and percent composition among sockeye salmon fisheries.

| | Mean (95% C.I.) | | | | Stock proportion | | | |
|---|---|---|---|---|---|---|---|---|
| Mixture source | Wenatchee | Okanagan | Snake | Whatcom | Wen | Oka | Snake | Whatcom |
| Commercial | 78 (46 – 115) | 230 (191 – 259) | 0 (0 – 8) | 0 (0 – 10) | 25.42% | 74.58% | 0.00% (0.00% – 2.60%) | 0.00% |
| Sport | 165 (109 – 237) | 750 (673 – 810) | 23 (6 – 59) | 0 (0 – 12) | 17.61% | 79.99% | 2.45% (0.64% – 6.29%) | 0.00% |
| Zone 6 | 9028 (8354 – 9707) | 21358 (20601 – 21951) | 572 (410 – 831) | 5 (6 – 106) | 29.16% | 68.98% | 1.85% (1.32% – 2.68%) | 0.01% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Total Harvest | 9271 (8615 – 9962) | 22338 (21554 – 22946) | 594 (429 – 856) | 5 (9 – 110) | 28.79% | 69.36% | 1.84% (1.33% – 2.66%) | 0.01% |
| Bonneville Dam* | 119744 (105552 – 134434) | 486238 (471279 – 501071) | 5075 (2506 – 8532) | NA | 19.60% | 79.57% | 0.83% (0.41% – 1.40%) | NA |

Note: The mean stock abundance estimate is provided for each fishery harvest and includes 95% confidence intervals.
*Bonneville Dam abundance estimates shown here differ from those in Table 13 since they only include the interval of weeks that coincide with sockeye salmon fisheries (statistical weeks 24-31), and were calculated based on a combination of PIT-tag and genetic data. The total harvest estimates are a summation across all fisheries sampled here.

The timing of the sockeye salmon fisheries may influence the harvested proportion of each stock, and is consistent with run-timing distributions we observed in our previous report, particularly that the Wenatchee stock has relatively early run-timing compared to other stocks. The Snake River stock was only represented by 33 fish in the Zone 6 fishery samples (Table 7) making run-timing estimates imprecise for this stock. Of the 33 Snake River sockeye salmon identified with GSI, the largest number (11) were sampled in week 29 and they were estimated to be in highest relative stock proportion (4%) in that same week (Figure 9). Weeks 25-27 had the highest proportions of Wenatchee stock (Fig. 9). Significant difference in stock representation between Bonneville Dam and the Zone 6 tribal harvest was evident for the Wenatchee stock which was 29% versus 20% in the harvest versus dam, respectively (Table 8).

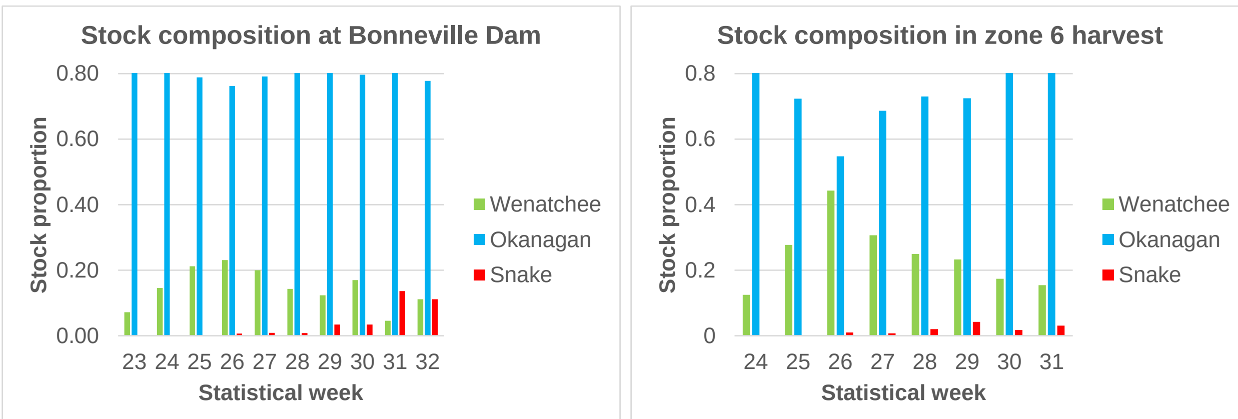


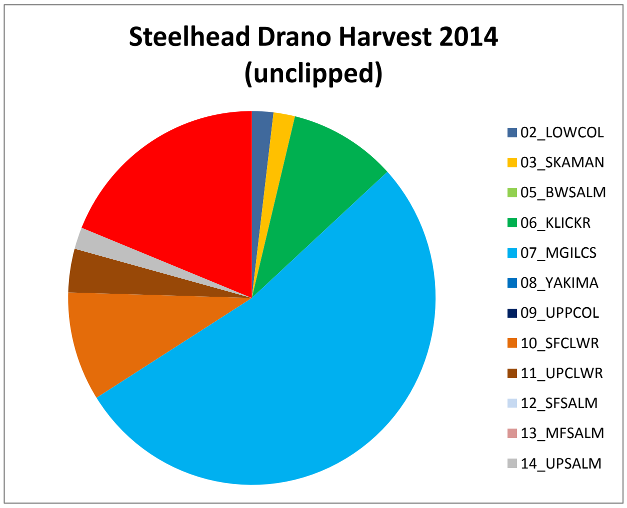
Figure 9. Stock composition at Bonneville Dam and the Zone 6 sockeye harvest on a weekly basis.

*Stock composition and PBT of the adipose-intact steelhead from the Zone 6 tribal fishery*

There were 1169 tissues for unclipped steelhead in the Zone 6 harvest mixture, however 42 tissues failed to genotype with less than 10% missing data, and 2 pairs of tissues were found to be duplicate pairs of genotypes. We excluded 44 samples because of these issues. These exclusions left 1072 Zone 6 harvest samples for analysis. Of these 1072 total samples, 119 fish assigned to PBT source hatcheries (Table 9). The twelve hatchery broodstocks were Grande Ronde (Cottonwood), Dworshak/Clearwater, Sawtooth (EFSR), Lyons Ferry, Oxbow F.H., Pahsimeroi F.H., Sawtooth (IDFG & SBT), Sawtooth (USB/Squaw), Touchet, Tucannon, and Wallowa. This hatchery component made up 11% of the stock composition of these unclipped steelhead (Fig. 10). There are many Snake River hatcheries that release unclipped smolts, and so this proportion is expected. The largest proportion of this harvest was derived from the MGILCS reporting group (64%), which is also the most broadly geographically distributed and includes a large area of the mid-Columbia R. and the lower Snake River basin. All other stocks were less than 5%, and only the upper Salmon R. was as large as a 5% proportion.

The PBT assigned fish from the Zone 6 unclipped steelhead harvest were aged according to the year in which their parents were spawned. The 2-ocean age fish were on average higher in abundance (average 1.0% of total harvest) among all PBT source hatcheries as compared to 1-ocean age fish (average 0.4% of total harvest). Among 2-ocean age fish, Dworshak hatchery was the most abundant (5.7% of total harvest) and followed by E.F. Salmon R (1.3%). Among 1-ocean age fish, the Sawtooth was most abundant (0.8% of total harvest), followed by Lyons Ferry hatchery (0.3%).

This year we were also able to analyze the unclipped steelhead from the harvest in Drano Lake (Fig. 10). Of the 53 fish genotyped, there were 10 assigned to PBT source hatcheries (Dworshak and Squaw Creek; N=9 and N=1, respectively). These 10 fish were 2-ocean adults, and the exclusive composition of Dworshak and Squaw stocks in the harvest likely owes to its late timing (i.e. weeks 41-43).



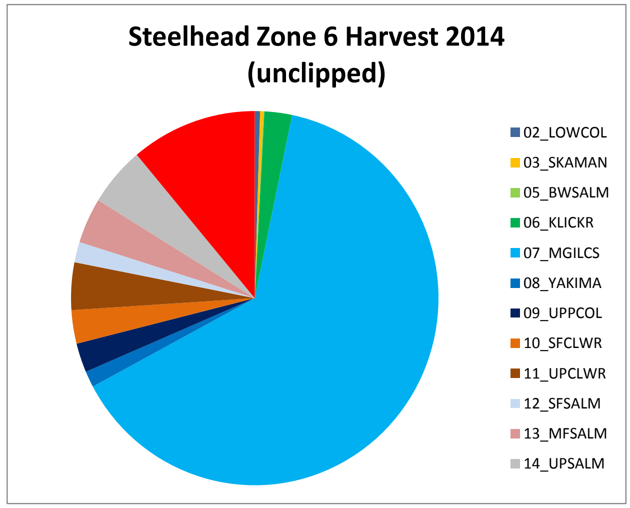




Figure 10. Stock composition of adipose-intact steelhead harvested in 2014 from Zone 6. The following eleven of 13 total stocks in the Columbia River Basin GSI baseline were represented: Skamania “SKAMAN”, Big White Salmon “BWSALM”, Klickitat “KLICKR”, MGILCS (see below), Yakima “YAKIMA”, upper Columbia “UPPCOL”, S.F. Clearwater “SFCLWR”, upper Clearwater “UPCLWR”, S.F. Salmon “SFSALM”, M.F. Salmon “MFSALM”, and upper Salmon “UPSALM”. The MGILCS stock includes the following Snake River stocks: George Cr, Asotin Cr, Alpowa Cr, and Tucannon R as well as the stocks from the Grande Ronde, Imnaha, Lower Clearwater and Lower Salmon R.; and all other middle Columbia River stocks that were not listed above, because this large group of stocks is genetically highly similar.

Table 9. Summary information on numbers and origins of steelhead that were assigned using a combination of GSI and PBT.

| Hatchery | Origin | Genetic stock | Statistical week 25 | 26 | 27 | 28 | 29 | 30 | 31 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Natural-origin | 02_LOWCOL | | | | 1 | | | | 2 | | 1 | | | | | | 1 | 5 |
| | | 03_SKAMAN | | | | | | 1 | | 1 | 1 | | | | | | | | 3 |
| | | 05_BWSALM | | | | | | 1 | | | | | | | | | | | 1 |
| | | 06_KLICKR | 1 | 2 | | | | | 2 | 3 | 7 | 4 | 1 | 1 | 2 | 2 | 1 | | 26 |
| | | 07_MGILCS | 1 | 5 | 13 | 19 | 59 | 65 | 97 | 67 | 34 | 78 | 65 | 57 | 55 | 35 | 22 | 13 | 685 |
| | | 08_YAKIMA | | | 1 | 1 | 2 | 5 | | 1 | 1 | 2 | 1 | | | | 1 | | 15 |
| | | 09_UPPCOL | | | | 3 | 4 | 2 | 2 | 2 | 3 | 1 | 2 | 6 | 1 | 1 | | | 27 |
| | | 10_SFCLWR | | | | | | | | 2 | 1 | 1 | | 6 | 9 | 8 | 4 | | 31 |
| | | 11_UPCLWR | | | | | 1 | | | 2 | 5 | 2 | 1 | 11 | 9 | 6 | 3 | 4 | 44 |
| | | 12_SFSALM | | | | | | | | 1 | 1 | 2 | 4 | 5 | 5 | | 1 | | 19 |
| | | 13_MFSALM | | | | | 3 | 1 | 2 | 3 | 5 | 9 | 9 | 6 | 2 | 1 | | 1 | 42 |
| | | 14_UPSALM | | | | 3 | 5 | 3 | 1 | 5 | 5 | 9 | 4 | 9 | 4 | 3 | 3 | 1 | 55 |
| LSRCP/WDFW-L.F. (G.R. cottonwood) | Snake R. hatchery broodstock | OmyCGRW11S | | | | | | | 1 | | | | 1 | | | | | | 2 |
| LSRCP/IDFG/USFWS Dworshak/C.W. | | OmyDWOR10S | | | | | | | | | | | | 1 | | | | | 1 |
| | | OmyDWOR11S | | | | | | | | | 1 | | 7 | 16 | 15 | 14 | 7 | 1 | 61 |
| | | OmyDWOR12S | | | | | | | | | | | | | 1 | | | | 1 |
| LSRCP/IDFG Sawtooth (EFSR) | | OmyEFSW11S | | | | 1 | | | | 4 | 1 | 1 | 2 | 1 | 1 | 2 | | 1 | 14 |
| LSRCP/WDFW-Lyons Ferry | | OmyLYON12S | | | | | | | | 1 | | | | 1 | | | | 1 | 3 |
| Idaho Power/IDFG,Oxbow F.H. | | OmyOXBO11S | | | | | | | | | 1 | | 1 | | | | | | 2 |
| Idaho Power/IDFG, Pahsimeroi F.H. | | OmyPAHH11S | | | | | | | | 1 | | | 1 | | | | | | 2 |
| | | OmyPAHH12S | | | | | | | | | | | | | | 1 | | 1 | 2 |
| LSRCP/IDFG Sawtooth (IDFG & SBT) | | OmySAWT11S | | | | | | | | 1 | | 3 | | 1 | | | | | 5 |
| | | OmySAWT12S | | | | | | | | | 2 | 2 | 1 | 2 | | 1 | 1 | | 9 |
| LSRCP/IDFG Sawtooth (USB/Squaw) | | OmySQUW11S | | | | | | | | | | | | 1 | | 2 | | | 3 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LSRCP/WDFW-L.F. (Touchet) | OmyTOUW10S | | | | | | | | | | | | | | | 1 | | 1 |
| | OmyTOUW11S | | | | | | 1 | | | | | | | 1 | | 1 | | 3 |
| LSRCP/WDFW-L.F. (Tucannon) | OmyTUCW11S | | 1 | 1 | | 1 | | | | | 1 | 1 | | | 1 | | | 6 |
| LSRCP/ODFW-Wallowa F.H. | OmyWALL11S | | | | | | | | 1 | | | 2 | | | | | 1 | 4 |
| | Grand Total | 2 | 8 | 15 | 28 | 75 | 79 | 105 | 97 | 68 | 116 | 103 | 124 | 105 | 77 | 45 | 25 | 1072 |

Note: The Zone 6 fishery samples could be broken into weekly strata, and statistical week 25 begins 6/16/2014 and week 42 ends on 10/19/2014. Natural-origin individuals were assigned using GSI to the stock with the highest probability (best estimate). Snake River hatchery stocks were assigned using PBT and include brood years from 2010 to 2012. The hatchery sources are abbreviated and the digits indicate the spawn year, e.g. 10S is spawn year 2010.

## Discussion

*Management implications*

This study utilized both genetic stock identification (GSI) and parentage based tagging (PBT) in combination to estimate stock composition of mainstem Columbia River Chinook salmon and steelhead fisheries. This is the second year in which we were able to assign all three major age classes of spring Chinook from Snake River hatcheries and the Klickitat hatchery, which is the only hatchery outside of the Snake River included in the current PBT baseline. Ongoing expansion of the PBT baseline will allow us the ability to assign Snake River hatchery jacks of the fall-run Chinook salmon as well as all other hatchery jacks originating above Bonneville Dam (migration year 2015), and so future years of analyses will include more emphasis on fall-run harvest. Expansion of the PBT baseline to include not only hatcheries of Chinook salmon and steelhead above Bonneville Dam, but also hatcheries throughout the range of these species could eventually lead to replacing the coded wire tag program for monitoring of in-river harvest stock composition of these species if increases in funding were available and fishery managers thought it were needed. This report includes the second genetic analysis on sockeye salmon harvest. Our results demonstrated differences in stock composition of the sockeye salmon harvest as compared to the total run estimated at Bonneville Dam, but there are questions about the validity of the estimates especially at Bonneville given the potential for sampling error around rare stocks like Snake R. sockeye salmon. We will continue to perform GSI on sockeye salmon harvest in the future to gain further insight into these patterns.

One higher level management question was possible to address in this section:

1) **Harvest RM&E: F&W Program Management Question: What are your in-river monitoring results and what are your estimates of stock composition and stock-specific abundance, escapement, catch, and age distribution?**

The in-river estimates of stock composition, stock-specific abundance, escapement, catch, and age distribution were addressed for part of the treaty mainstem spring-management period fisheries Chinook salmon harvests above Bonneville Dam along with fisheries below Bonneville Dam, the non-treaty summer-management fisheries below Bonneville Dam which are a portion of the total non-treaty summer fisheries, part of the fall-run Chinook salmon sport fishery below Bonneville Dam, the mainstem treaty sockeye salmon harvests above and non-treaty harvest below Bonneville Dam, and the summer and fall tribal harvest of steelhead above Bonneville Dam. For the spring management period of Chinook salmon, we continue to observe a spatial pattern for the stock composition of lower Columbia River stocks which appear more abundant downstream from the Willamette River mouth as compared to upstream of this point which is consistent with a long history of CWT data. We observed differences in the composition of hatchery stocks represented in spring versus summer management period adult and jack harvest of Chinook salmon, and run-timing plays an important role in this difference (i.e. late-running stocks appear more abundant among the upriver spring stocks that are caught in the summer management period). This pattern is consistent when compared to known origin PIT tagged adult and jack fish tagged as juveniles. Known origin adult age upriver spring and Snake River spring summer Chinook salmon are almost all past Bonneville by June 15 in most years. However, specific conclusions relative to the harvest impacts on spring or summer Chinook salmon cannot be made from this genetic analysis as jacks are included in the current analysis.

This study also addressed some issues that relate to mark-selective fisheries. For example, we examined stock composition of the Wind River and Drano Lake mark-selective spring-run Chinook salmon sport fisheries and provided context of stock composition observed among other fisheries during this management period. The number of PBT-assigned Snake R. fish that were harvested in the Wind River sport fishery was less than all other fishery samples we analyzed, including the adipose-intact samples from Bonneville Dam and tribal harvests during the same set of weeks. One exception was the adipose-intact lower river test fishery, which had approximately the same proportion of PBT-assigned fish as that estimated for the Wind River harvest. However, it was not possible to conclude whether or not the Wind River sport fishery harvest composition has significantly changed through time given this boundary change.

The mark selective fall-run Chinook salmon sport fishery in the lower Columbia River mainstem was also analyzed. Although stock proportions of the WCASFA stock has been observed to vary across years, the 2014 harvest appears to be consistent with the previous year, 2013.

The sockeye salmon tribal fishery is managed in a way that attempts to harvest as many harvestable sockeye as possible under the allowed harvest rate schedule in the U.S. v. Oregon Management Agreement. This 2014 year of analysis of the sockeye salmon harvest corroborates our 2013 harvest analysis, which suggests there may be some over representation of the Wenatchee sockeye stocks in the Zone 6 harvest as compared to the stock proportions that are present at Bonneville Dam. The results for Snake River sockeye salmon are dependent upon representative sampling at Bonneville Dam, but low sample rate and the rarity of this stock led to uncertainty and high variation around estimates of Snake River sockeye salmon from Bonneville Dam. Sampling protocols at Bonneville Dam may have higher representation of young fish as compared to harvest mixtures. Timing of the fishery may also influence the proportion of each stock, and is consistent with run-timing distributions we observed in previous reports; the Wenatchee stock has relatively early run-timing but the timing of the Snake River stock is uncertain due to inconsistent results between PIT-tag and GSI methods. Future analysis will be needed to examine these patterns for consistency and delve into explanations.

We analyzed a third year of the unclipped steelhead harvested in the Zone 6 fishery. Consistent with last year’s analysis, these steelhead were found be composed of 11% unmarked hatchery-origin fish from the Snake River based on PBT results. Most of these fish were from Snake River hatcheries that share genetic similarity with the large GSI reporting group that spans much of the middle Columbia River and lower Snake River tributaries (MGILSC) which comprised 64% of the harvested unclipped steelhead.

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## Section 4: Characterization of Chinook salmon, sockeye salmon, and steelhead run-timing and abundance at Bonneville Dam

### Introduction

The Columbia River Basin supports ESA listed wild stocks of Chinook salmon and steelhead as well as hatchery supplemented populations. Both Chinook salmon and steelhead have been declining in the Columbia River Basin for several reasons including climate change, habitat degradation, hydropower, hatchery practices, and over-harvesting. Along with abundance estimates, basic information related to the way in which stocks of salmonids are distributed both spatially and temporally are needed by fisheries managers to achieve sustainable fisheries.

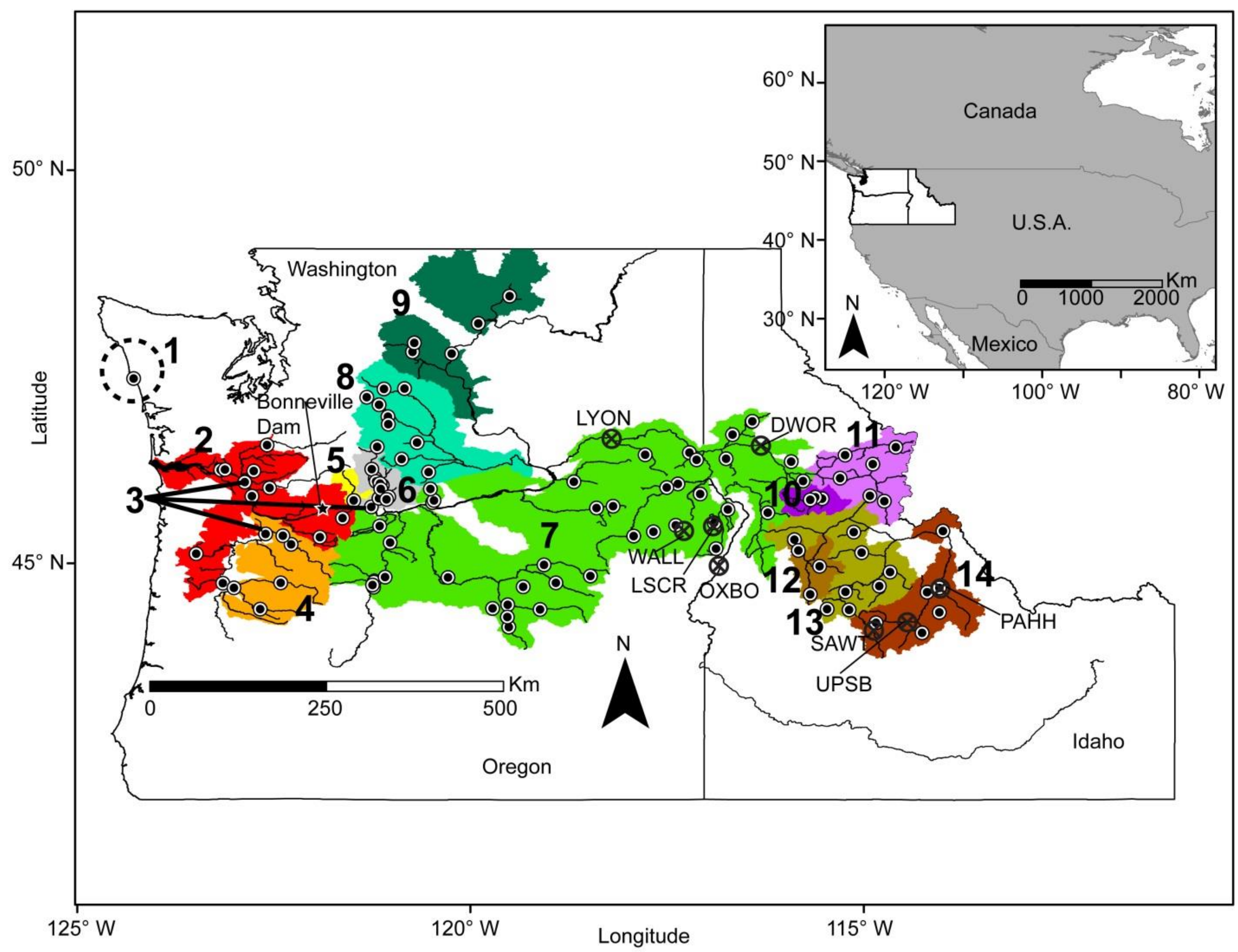


Figure 1. Scope of project includes all stocks of Chinook salmon, sockeye salmon, and steelhead distributed within the Columbia River basin. Shown here are the steelhead reporting groups (i.e. stocks) and collections that comprise the steelhead GSI and PBT baselines.

As evident from the genetic stock identification (GSI and PBT) analyses of Chinook and sockeye salmon and steelhead fisheries harvests in Section 3, certain stocks seem to have strong spatial and temporal associations. However, because the type of fishery gear, harvest regulations, and locations targeted varies considerably among fisheries, samples from a representative mixture of all hatchery- and natural-origin stocks at a fixed location is expected to more accurate to estimate abundance and characterize run-timing distributions of stocks. One potentially ideal fixed location for sampling is Bonneville Dam, but trapping limitations at this location continue to pose a major challenge for sampling. In addition to information on abundance and run-timing, biological data including fork length and age can be examined with estimated stock of origin in order to characterize life history differences among stocks. This type of examination is especially important for steelhead, which has been managed using two life-history categories, A- and B-run. These life-history categories have been observed to be differentially characterized by run-timing at Bonneville Dam (e.g. B-run typically arrives after Aug. 25$^{th}$), fork length (e.g. by definition, B-run fish are greater than 78 cm), and ocean age (e.g. most B-run fish tend to spend 2 or more years in saltwater) and all of these types of data have been collected for steelhead in this study.

*Project objectives and higher level harvest management questions*

Here we analyze fish across the entire run of steelhead and Chinook and sockeye salmon from April to October to estimate temporally stratified proportions of stocks and extrapolate abundance using a daily census that is conducted at the Bonneville Dam fish counting window. We examine steelhead and Chinook salmon using two sets of species-specific SNP assays for a combined total of greater than 180 loci per species. GSI of sockeye salmon requires fewer markers than for other species in this study, and a set of 90 SNP loci can accurately resolve the fewer number of sockeye stocks that are present in the basin relative to other salmonids. Although there are some methodological differences among these species-specific applications (e.g. different temporal strata, combination of PIT-tag data, etc), the general approach to estimating abundance and characterizing run-timing distributions was applied consistently across species. For all three species, we have demonstrated that these genetic baselines are generally accurate for assigning unknown origin fish but genetic similarity of some stocks requires large reporting groups comprised of broad geographic areas (i.e. mid-Columbia R. and lower Snake R. for spring Chinook salmon). Since Bonneville Dam is the most downstream dam on the Columbia River, the fishery mixtures obtained here represent the majority of upriver/interior Columbia River Basin stocks. This ongoing study offers a rare opportunity to monitor populations of multiple species of salmonids from a broad geographic range over several years. This long-term study will allow us to characterize trends in run timing and abundance of steelhead and Chinook and sockeye salmon and provide this data to fisheries managers. However, the genetic stock units ('reporting groups') are not the same units that groups of fish are currently managed for due to levels of genetic differentiation that can be detected among baseline stocks (see results under Objective 2 for details). Thus, fisheries managers continue to explore how to best incorporate genetic monitoring results with more traditional monitoring/tagging programs.

**Harvest RM&E: F&W Program Management Questions:**

**What are the status and trend of adult productivity of fish populations?**

**What are your in-river monitoring results and what are your estimates of stock composition and stock-specific abundance, escapement, catch, and age distribution?**

**Can selective fisheries targeting hatchery fish or healthy populations reduce impacts on ESA-listed populations? (Not applicable to this project)**

Analysis of the 2011 dataset by Hess et al. (2012) was the first year we were able to apply an additional genetic tool, referred to as Parentage Based Tagging (PBT), to assign a portion of Snake River hatchery-origin spring-run Chinook salmon and summer-run steelhead back to their hatchery parents (Steele et al. 2011). This new and powerful genetic tool provides the opportunity to obtain additional types of data including accurate age of fish, quantification of the number of unmarked (non-adipose clipped) hatchery fish, and precise assignments of fish to their source hatchery (Steele et al. 2013). The ability of PBT to identify a fish's source hatchery has been shown to be equally accurate as traditional tags such as CWTs (Steele et al. 2013), and PBT provides assignments to specific hatcheries rather than larger reporting groups used in GSI methods. However, these tools can provide the greatest benefit when applied in combination, as GSI has the ability to provide information on wild fish throughout the Columbia River basin, while PBT is most effective for hatchery origin fish. The current PBT baseline only includes Snake River hatcheries but will be expanded to others above Bonneville Dam in the near future. Therefore, GSI is still a necessary tool for both hatchery and wild fish that originate from outside the Snake River basin. This report is the second year in which all major age classes of steelhead (i.e. 1-, 2-, and 3- ocean ages) and Chinook salmon (3-, 4-, and 5-year olds) can be assigned using the PBT baseline of Snake River hatcheries. This study integrates PBT and GSI results to provide the greatest amount of stock information ever available for hatchery and wild steelhead and Chinook salmon passing Bonneville Dam.

As mentioned in previous sections (1, 3), we have transitioned to GT-seq as a protocol for efficiently genotyping large numbers of individuals. This genotyping technology also allows us the ability to add additional markers to the panel with relative ease, which will increase power for GSI and PBT applications. In this section, we demonstrate how increasing the number of SNP loci to ~300 will provide sufficient power to assign individuals to single parents. This is an extremely appealing prospect, as it would increase our chances of detecting candidate offspring even in scenarios where our tag rates for particular broodstocks are low.

Aside from these analyses on salmonids, PBT technology has made it possible to monitor conservation efforts in a non-salmonid species, Pacific lamprey (*Entosphenus tridentatus*). Pacific lamprey (populations are in decline (Close et al. 2002) and are relatively understudied. Research to answer critical biological and management related uncertainties is undertaken by CRITFC and its member tribes. Translocation (i.e. transporting individuals from a source population to a recipient site), artificial propagation, and habitat improvement are all being used to rebuild the Pacific lamprey abundance in the interior Columbia River Basin, where declines have been most severe. Lamprey from the lower Columbia River are a key source for translocation and artificial propagation strategies. We used 94 SNPs (described in Hess et al. 2015b) to perform a parentage analysis as a direct method to validate the reproductive success of translocated adults in Newsome Creek, a tributary of the Clearwater River in the Snake River Basin. Pacific lamprey appear to have been extirpated from this creek and its adjacent tributaries since 2003 (Cochnauer & Claire 2009). Starting in 2007, 50 adults (which had been captured at one or more mainstem dams on the Columbia River and held for at least one winter) were

translocated to Newsome Creek, and subsequently (between 2008 and 2010), 22–25 adults were translocated per year (Ward et al. 2012). We genotyped 100% of the total number of translocated adults from 2007. A screw trap located at the mouth of Newsome Creek was used to collect outmigrating ammocoetes in 2012 - 2014, and parentage assignments showed that these collections of ammocoetes were composed of 99% (Hess et al. 2015), 97% (unpublished), and 95% (unpublished) of offspring from the 2007 translocation event for each of the three years respectively. Our objective in this study was to test whether any of this 2007 cohort could be identified as juvenile mortalities in 2014 on the turbine screen of Lower Granite Dam, nearly 250 km downstream of Newsome Creek. This information would help fill a critical data gap on outmigration timing of juvenile life stages of lamprey.

*Time line for completion of objectives*

Objectives will be ongoing and GSI results updated each year for harvest analyses of salmon and steelhead throughout the accords-funding. As new genetic techniques are developed they will be applied to this project and results will be compared between years to determine the extent of improvements.

**Methods**

*Sample Collection*

Tissue samples were obtained from adult steelhead (n=1,703), Chinook (n = 2,620) and sockeye salmon (n=385, and PIT-tag n=1035) adults in 2014 during migration runs at Bonneville Dam. This sampling effort is covered under Scientific Research Permit #1379 under Section 10 of the ESA (permit included in PISCES attachments).

Sampling for Chinook salmon at Bonneville Dam began during statistical week 16 (April 14, 2014). Sampling occurred at the Adult Fish Facility (AFF) located on the northern end of Bonneville Dam. Fish were sampled 4–5 d per statistical week (except when reduced due to restrictions on trap use or low run size at the beginning and end of the run) and for 4–6 h per day. A picket weir was used to divert migrating fish ascending the Washington shore fish ladder into the AFF collection pool. An attraction flow was used to draw fish through a false weir where they were selected for sampling. After sampling was completed and fish recovered from the anesthetic, they were returned to the Washington shore fish ladder above the picket weir. Just under 2 percent of the total Spring management period adult Chinook salmon count had passed Bonneville by the sampling start date (April 14). While samples were taken from the large majority of the total spring Chinook salmon run, some early timed stocks may be slightly under-estimated in the results. Restrictions imposed by USACE and NMFS on sampling at the Bonneville AFF result in sample rates for Chinook, sockeye, and steelhead that are often very low. The average sample rate (weeks 16–24) for the adult and jack spring Chinook run in 2014 was 1.0%. The average sample rate for adult and jack summer Chinook was 0.4%, but sampling was limited to statistical weeks 25–28.

Based on numbers of fish collected, samples were pooled into weekly strata for Chinook (Table 1) and sockeye salmon (Table 2) and monthly strata for steelhead (Table 3) spanning the majority of the run-year from April to October. We followed a similar protocol as the Monitoring Methods Protocol "Snake River steelhead and Chinook salmon stock composition estimates (2010-026-00) v1.0". In addition, at Lower Granite Dam we processed 377 juvenile mortalities of Pacific lamprey that had been frozen after retrieval from turbine units and after defrosting we dried a piece of tissue for DNA extraction and analysis.

**Table 1. Sample numbers by weekly strata for Chinook salmon that were DNA sampled or tallied for abundance at Bonneville Dam in 2014.**

| | | | | Sample | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Statistical | Fish | Ad-clipped(HOR) | | unclipped(NOR) | | | |
| | | week | count | Non-PBT | PBT | Non-PBT | PBT | Total | rate |
| Management period | Spring | 16 | 11933 | 42 | 43 | 28 | 1 | 114 | 0.96% |
| | | 17 | 28879 | 84 | 105 | 46 | 9 | 244 | 0.84% |
| | | 18 | 70764 | 77 | 84 | 61 | 9 | 231 | 0.33% |
| | | 19 | 42026 | 44 | 69 | 55 | 11 | 179 | 0.43% |
| | | 20 | 24244 | 51 | 80 | 98 | 15 | 244 | 1.01% |
| | | 21 | 18200 | 54 | 85 | 107 | 15 | 261 | 1.43% |
| | | 22 | 16000 | 32 | 53 | 114 | 12 | 211 | 1.32% |
| | | 23 | 20206 | 46 | 44 | 163 | 15 | 268 | 1.33% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 24 | 20472 | 62 | 37 | 130 | 19 | 248 | 1.21% |
| Summer | 25 | 20338 | 31 | 13 | 57 | 7 | 108 | 0.53% |
| | 26 | 20213 | 16 | 3 | 26 | 4 | 49 | 0.24% |
| | 27 | 19381 | 16 | 3 | 38 | 0 | 57 | 0.29% |
| | 28 | 13830 | 16 | 4 | 33 | 0 | 53 | 0.38% |
| | 29 | 9060 | - | - | - | - | - | - |
| | 30 | 5308 | - | - | - | - | - | - |
| | 31 | 3769 | - | - | - | - | - | - |
| Fall | 31 | 2343 | - | - | - | - | - | - |
| | 32 | 3727 | - | - | - | - | - | - |
| | 33 | 11209 | 2 | 0 | 10 | 0 | 12 | 0.11% |
| | 34 | 18074 | - | - | - | - | - | - |
| | 35 | 58883 | - | - | - | - | - | - |
| | 36 | 226589 | 16 | 0 | 32 | 0 | 48 | 0.02% |
| | 37 | 294780 | 22 | 0 | 27 | 0 | 49 | 0.02% |
| | 38 | 189887 | 9 | 0 | 39 | 0 | 48 | 0.03% |
| | 39 | 98695 | 18 | 0 | 32 | 0 | 50 | 0.05% |
| | 40 | 48551 | 9 | 0 | 39 | 0 | 48 | 0.10% |
| | 41 | 20445 | 5 | 0 | 45 | 0 | 50 | 0.24% |
| | 42 | 9829 | 8 | 0 | 40 | 0 | 48 | 0.49% |
| | Total | 1327635 | 660 | 623 | 1220 | 117 | 2620 | 0.54% |

Note: For reference, statistical week 16 is 4/14/14–4/20/14 and 42 is 10/13/14–10/29/14. "Fish count" is based on tallies of Chinook salmon adults and jacks provided by the Fish Passage Center (http://www.fpc.org) as observed by the Corps of Engineers at their fish counting window. This year we subsampled approximately 50 fish per week in the fall due to a lack of funds for genotyping every fish. The total sum of all samples for a given week was used to calculate sample rate. The management periods approximate the date ranges from April to June 15th, June 16th to July 31st, and August 1st to December 31 which are used to categorize spring-, summer-, and fall-run Chinook salmon.

**Table 2. Sample numbers and PIT-tag/genetic stock assignments of sockeye salmon that passed Bonneville Dam in 2014.**

| Statistical week | Fish count | OKA | RED | WEN | Total | rate |
|---|---|---|---|---|---|---|
| 23 | 2308 | 13 | | 1 | 14 | 0.61% |
| 24 | 21004 | 94 | | 16 | 110 | 0.52% |
| 25 | 90607 | 212 | | 57 | 269 | 0.30% |
| 26 | 179519 | 228 | 2 | 69 | 299 | 0.17% |
| 27 | 190940 | 182 | 2 | 46 | 230 | 0.12% |
| 28 | 89770 | 220 | 2 | 37 | 259 | 0.29% |
| 29 | 29833 | 123 | 5 | 18 | 146 | 0.49% |

| | | | | | | |
|---|---|---|---|---|---|---|
| 30 | 7621 | 47 | 2 | 10 | 59 | 0.77% |
| 31 | 1763 | 18 | 3 | 1 | 22 | 1.25% |
| 32 | 555 | 7 | 1 | 1 | 9 | 1.62% |
| Total | 613920 | 1144 | 17 | 256 | 1417 | 0.23% |

Note: For reference, statistical week 23 is 6/02/14–6/08/14 and 32 is 8/4/14–8/10/14. “Fish count” is based on tallies of sockeye salmon adults provided by the Fish Passage Center (http://www.fpc.org) as observed by the Corps of Engineers at their fish counting window. PIT-tag and GSI stocks are Okanagan (OKA), Snake River (RED), and Wenatchee (WEN). The # of samples for a given week was used to calculate sample rate. Very few sockeye salmon were sampled from the Snake River stock (n=17), which greatly limited inferences regarding run-timing and abundance of this stocks.

**Table 3. Sample numbers by monthly strata for steelhead that were DNA sampled or tallied for abundance at Bonneville Dam in 2014.**

| Management period | 4-wk Strata | Bonneville Fish Window Count Clipped | Bonneville Fish Window Count Unclipped | Sample (N) Clipped GSI | Sample (N) Clipped PBT | Sample (N) Unclipped GSI | Sample (N) Unclipped PBT | Total | Sample rate |
|---|---|---|---|---|---|---|---|---|---|
| Skamania Summer | 15_18 | 886 | 306 | 10 | 3 | 7 | 0 | 20 | 1.7% |
| | 19_22 | 1484 | 296 | 23 | 13 | 11 | 1 | 48 | 2.7% |
| | 23_26 | 5680 | 3831 | 27 | 18 | 24 | 0 | 69 | 0.7% |
| A and B Index Summer | 27_30 | 30761 | 38021 | 76 | 173 | 249 | 12 | 510 | 0.7% |
| | 31_34 | 64375 | 47747 | 61 | 209 | 275 | 10 | 555 | 0.5% |
| | 35_38 | 67090 | 29491 | 14 | 72 | 33 | 9 | 128 | 0.1% |
| | 39_42 | 20478 | 8128 | 12 | 262 | 50 | 49 | 373 | 1.3% |
| | Total | 190754 | 127820 | 223 | 750 | 649 | 81 | 1703 | 0.5% |

Note: For reference, statistical week 15 is 4/7/14–4/13/14 and 42 is 10/13/14–10/19/14. "Fish count" is based on tallies of adipose-clipped and unclipped adult steelhead provided by the Fish Passage Center (http://www.fpc.org) as observed by the Corps of Engineers at their fish counting window. The total sum of all samples for a given week was used to calculate sample rate. The management periods approximate the date ranges from April 1st to June 30th and July 1st to October 31st which are used to categorize Skamania and summer steelhead, respectively. The sample numbers were split into two categories according to whether samples had been taken from fish that were adipose clipped or unclipped, and then further split according to the number of samples that were either assigned (PBT) or not assigned (non-PBT) to Snake River hatcheries using PBT.

*Molecular markers*

Genetic markers are provided in Hess et al. 2013 for Steelhead. The GT-seq panel of 298 Chinook salmon are provided in Section 1.

*Statistical analyses*

Snake River Chinook salmon and steelhead and Pacific lamprey were analyzed for Parentage assignments using SNPPIT software v1.0 (ID: 1341) (Published). The program ONCOR was used to estimate the most likely population-of-origin for the sockeye salmon

samples. Individuals were assigned using a "best estimate" approach Assigning individual samples using Individual Assignment (IA) genetic methods v1.0 (ID: 1334) (Published). We used GSIsim for Mixture modeling to estimate stock proportions v1.0 (ID: 1333) (Published) to estimate stock composition of Bonneville Dam mixture strata for Chinook salmon and steelhead. Additional detail regarding the specific application to Bonneville Dam are published in Hess et al. 2013. The juvenile lamprey at Lower Granite Dam were used to estimate effective population size. Inbreeding effective population size estimated using the software program Colony v1.0 (ID: 1342). Analyses to test single parent assignments were performed with Cervus Method: Parentage Analysis using Cervus v1.0 (ID: 1430).

## Results

*Single parent assignment of known parent-offspring Chinook salmon from migration year 2014*

Using the 292 GT-seq SNP loci with complete information we were able to genotype a set of 88 Chinook salmon that migrated through the Bonneville Dam fish ladder in 2014. We also successfully genotyped 90 parents that were known matches to 48 of the year 2014 migrants. Therefore, this dataset represented known parent-offspring pairs that we could use to test the power of the 292 GT-seq SNPs for performing single parent assignment, and we compared this power to smaller sets of loci (179 and 90 SNPs) which were similar in size and content of the SNP panels we use for GSI and PBT, respectively. We simulated 1000 offspring and 100 parents which represented 75% of the "population". The 292 SNPs yielded better separation between the distributions of mismatching SNPs of the true matches and false matches (Fig. 2a). This result can be interpreted as providing better ability to identify a majority of true positives when selecting a threshold of no more than 1 or 2 total mismatches for single parent matches. This separation of mismatch distributions is in contrast to the larger overlap observed for 179 (Fig. 2b) and 90 (Fig. 2c) SNP sets, where even a single mismatch has larger proportions of false matches versus true matches. Further, based on LOD score distributions, the use of 292 SNPs would allow a relatively high LOD threshold (~20) without any false negative assignments. In contrast, fewer numbers of SNPs would increase the number of false negative assignments using a LOD 20 threshold (Fig. 3).

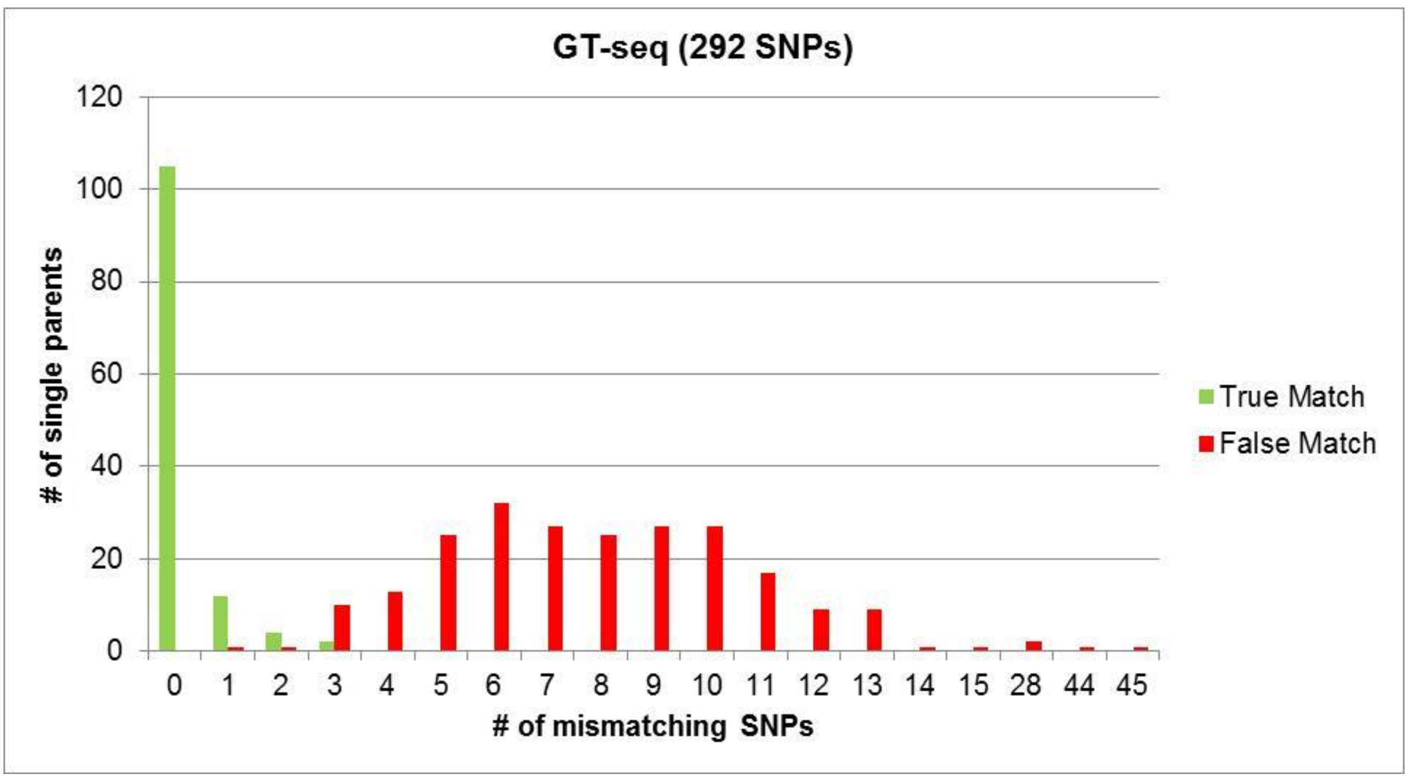


Figure 2a. Number of mismatches for single parent assignments using a panel of 292 SNPs. The true single parent assignments were based on a group of parents (N=90) that were known to

assign to a group of offspring (N=48) based on previous analysis on the Chinook salmon migration year 2014.

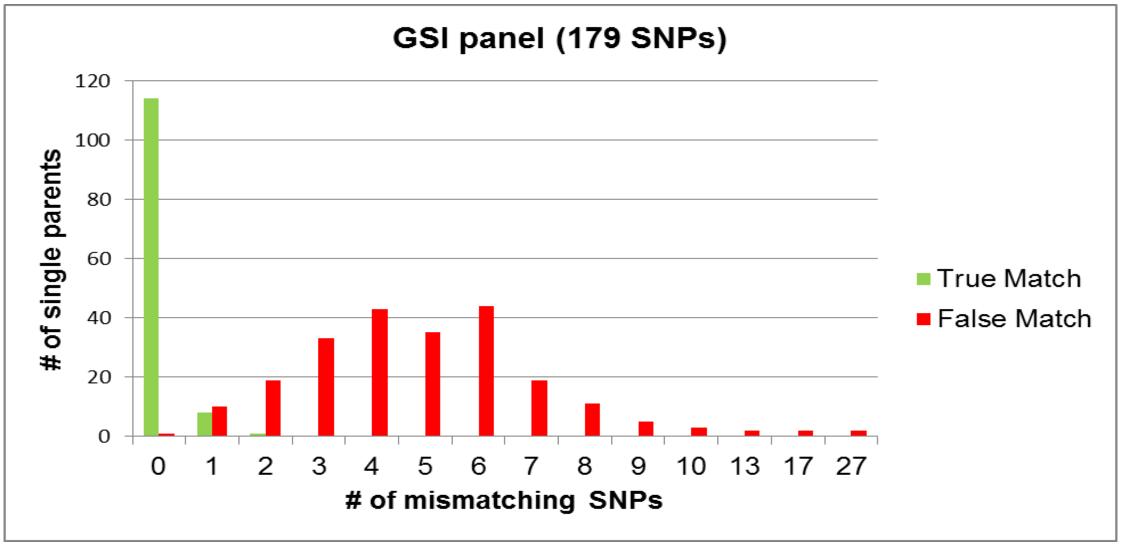


Figure 2b. Number of mismatches for single parent assignments using a panel of 179 SNPs. The true single parent assignments were based on a group of parents (N=90) that were known to assign to a group of offspring (N=48) based on previous analysis on the Chinook salmon migration year 2014.

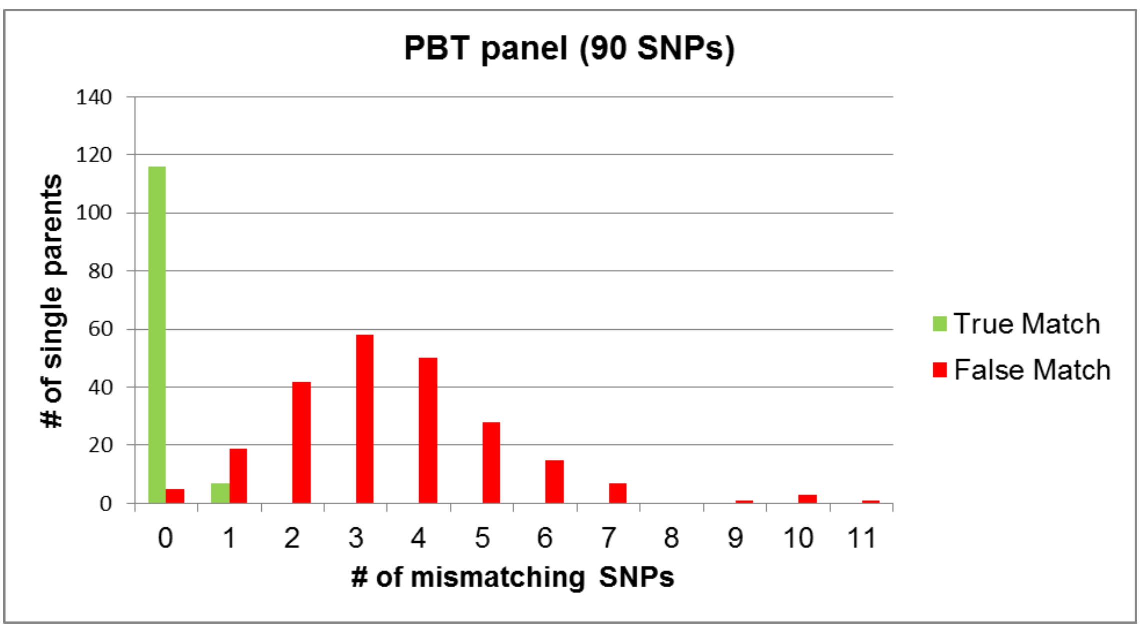


Figure 2c. Number of mismatches for single parent assignments using a panel of 90 SNPs. The true single parent assignments were based on a group of parents (N=90) that were known to assign to a group of offspring (N=48) based on previous analysis on the Chinook salmon migration year 2014.

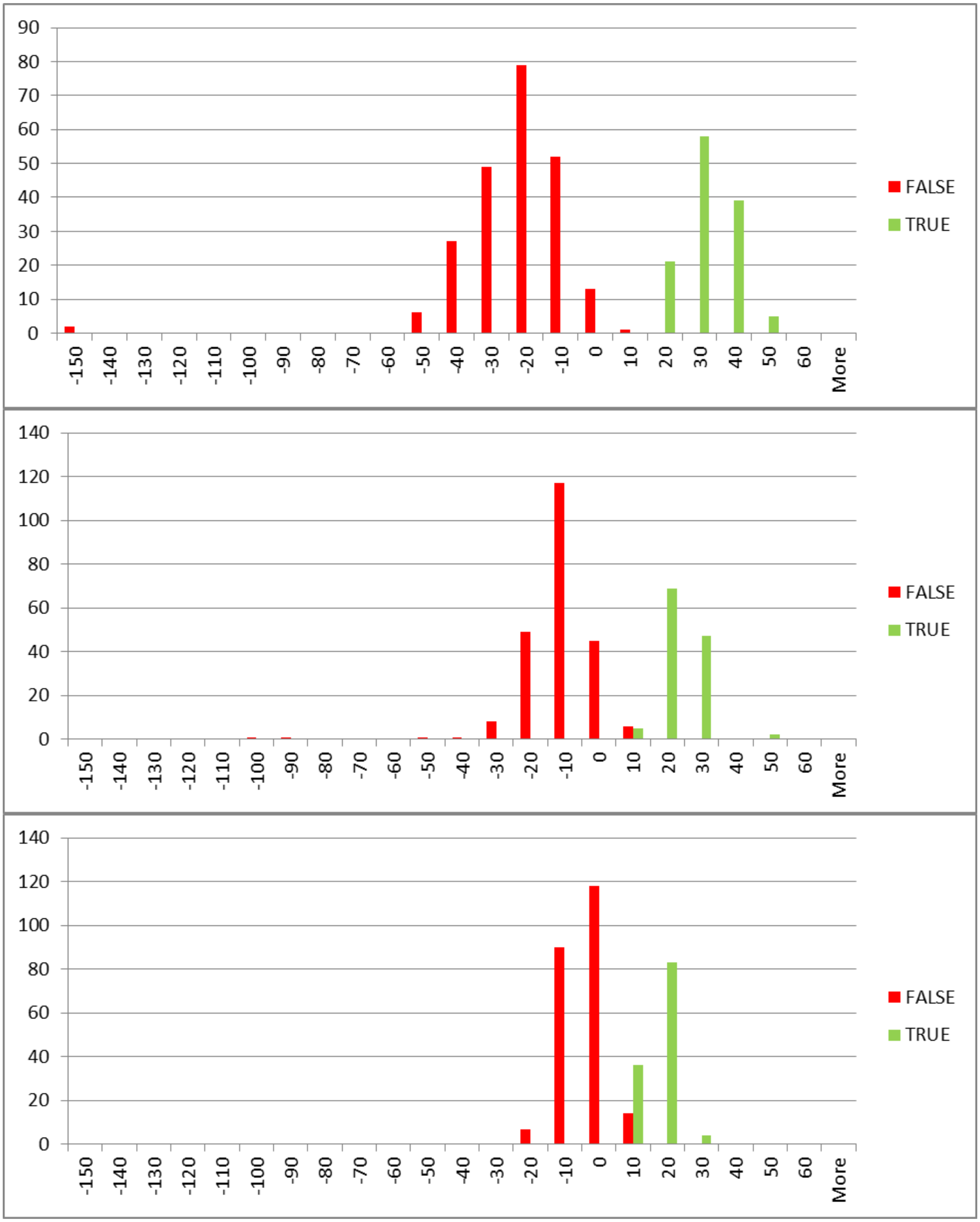


Figure 3. LOD score (x-axis) versus number of single parent matches (false and true, y-axis) for the following subsets of SNP markers: 292 (top panel), 179 (center panel), and 90 (bottom panel).

*Estimated relative abundance of Chinook salmon stocks in 2014*

There were eleven hatchery origin Chinook salmon stocks passing Bonneville Dam that we estimated relative abundance greater than 1,000 fish in the season (Table 4). The eleven major stocks in order of increasing magnitude were 02_WCASSP (2,701), 06_KLICKR (3,910), 07_DESCSP (5,722), 09_YAKIMA (6,373), 16_UPSALM (9,911), 13_SFSALM (14,868), 10_UCOLSP (38,149), 19_SRFALL (38,611), 05_SPCRTU (68,907), 12_HELLSC (86,479), and 18_UCOLSF (211,363). These estimates include relative abundance estimated from PBT-assigned fish that were mostly adipose clipped, however a portion of the PBT-assigned fish were found to have their adipose intact. Therefore, PBT assignments improved our ability to accurately identify hatchery-origin fish and estimate total stock abundance (Table 4). Further, using PBT assignments we can now provide abundance, run-timing, and size and age information at a spatial scale of a particular hatchery (Table 5). The following thirteen hatchery stocks produced greater than 1,000 fish: Nez Perce NPFH (1,513), Grande Ronde GRUW (2,302), Lostine LSTW (2,703), Lookingglass LOOK (3,179), Imnaha IMNW (3,353), Klickitat KLKH (3,397),Pahsimeroi PAHH (3,521), Powell POWP (4,250), Sawtooth SAWT (5,726), Clearwater CLWH (5,897), McCall MCCA (13,142), Dworshak DWOR (13,527), and Rapid RAPH (42,367).

**Table 4. Stock-specific relative abundance and run-timing distributions of hatchery-origin Chinook salmon passing Bonneville Dam in 2014.**

| | Estimated abundance | | | | | Run-timing distribution | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reporting group | mean | Total 95% C.I. | Before 15-Jun | June 16 - July 31 | After August 1 | Median | 1st quartile | 3rd quartile | 5th percentile | 95th percentile | Median date | Interquartile range (d) |
| 01_YOUNGS | 67 | 10 – 3149 | 67 | 0 | 0 | - | - | - | - | - | - | - |
| 02_WCASSP | 2701 | 1 – 5660 | 0 | 0 | 2701 | 253 | 251 | 255 | 251 | 257 | 10-Sep | 4 |
| 03_WCASFA | 533 | 47 – 9723 | 0 | 0 | 533 | 250 | 248 | 253 | 245 | 257 | 7-Sep | 5 |
| 04_WILLAM | 0 | 10 – 6505 | 0 | 0 | 0 | - | - | - | - | - | - | - |
| 05_SPCRTU | 68907 | 50672 – 110773 | 0 | 0 | 68907 | 257 | 250 | 263 | 245 | 270 | 14-Sep | 13 |
| 06_KLICKR† | 3910 | 2579 – 8175 | 3724 | 186 | 0 | 142 | 130 | 151 | 125 | 166 | 22-May | 21 |
| 07_DESCSP | 5722 | 4174 – 9887 | 5722 | 0 | 0 | 124 | 118 | 132 | 107 | 152 | 4-May | 14 |
| 08_JOHNDR | 563 | 93 – 6869 | 563 | 0 | 0 | 134 | 132 | 137 | 112 | 143 | 14-May | 5 |
| 09_YAKIMA | 6373 | 4879 – 12070 | 6035 | 338 | 0 | 129 | 122 | 137 | 117 | 181 | 9-May | 15 |
| 10_UCOLSP | 38149 | 35678 – 46467 | 37334 | 815 | 0 | 121 | 116 | 125 | 108 | 145 | 1-May | 9 |
| 11_TUCANO† | 101 | 0 – 3033 | 101 | 0 | 0 | - | - | - | - | - | - | - |
| 12_HELLSC† | 86479 | 82693 – 96682 | 83838 | 2641 | 0 | 122 | 118 | 130 | 110 | 159 | 2-May | 12 |
| 13_SFSALM† | 14868 | 13098 – 21037 | 9567 | 5301 | 0 | 160 | 149 | 172 | 136 | 188 | 9-Jun | 23 |
| 14_CHMBLN | 73 | 10 – 3587 | 73 | 0 | 0 | - | - | - | - | - | - | - |
| 15_MFSALM | 56 | 176 – 10730 | 56 | 0 | 0 | - | - | - | - | - | - | - |
| 16_UPSALM† | 9911 | 8260 – 21255 | 8295 | 1616 | 0 | 138 | 127 | 159 | 116 | 183 | 18-May | 32 |
| 17_DESCFA | 205 | 17 – 3597 | 0 | 0 | 205 | - | - | - | - | - | - | - |
| 18_UCOLSF | 211363 | 165375 – 248242 | 8662 | 19069 | 183632 | 252 | 249 | 257 | 169 | 272 | 9-Sep | 8 |
| 19_SRFALL | 38611 | 2041 – 57169 | 44 | 877 | 37690 | 252 | 250 | 257 | 245 | 270 | 9-Sep | 7 |
| Total | 488592 | | 164079 | 30845 | 293668 | | | | | | | |

Note: These summary statistics of run-timing distributions were calculated using a method to estimate abundance of each stock based on weekly stock proportions and total numbers of Chinook salmon that were observed passing Bonneville Dam at the fish counting window. †Combined with PBT estimated abundance. The run-timing distributions are characterized by ordinal days for the median date, inter-quartile dates, and 5th and 95th percentile dates. The distributions were based on the weekly estimated reporting group

proportions that were applied to the daily tallies of Chinook salmon at the Bonneville Dam fish counting window. This method for estimating run-timing distributions minimizes bias imposed by uneven sampling. Hatchery-origin run-timing distributions include stock abundance estimated from PBT and GSI assigned fish. Note that although the John Day R. and Middle Fork Salmon R. reporting groups are listed here, there are no hatchery programs that exist in these tributaries and their estimated abundance (less than 1000 fish) was likely due to misassignment error in GSI.

**Table 5. Hatchery broodstock-specific relative abundance and run-timing distributions of unclipped and clipped PBT-assigned Chinook salmon passing Bonneville Dam in 2014.**

| | | Estimated abundance | | | | | Run-timing distribution | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Broodstock collection | Tag rate | Total | 95% C.I. | Before 15-Jun | Jun. 16 - Jul. 31 | After Aug. 1 | Median | 1st Quar-tile | 3rd Quar-tile | 5th % | 95th % | Median date | Inter-quartile range (d) |
| OtsCLWH10S | 99.48% | 5544 | 3554 – 7715 | 5544 | 0 | 0 | 121 | 117 | 125 | 112 | 133 | 1-May | 8 |
| OtsCLWH11S | 95.61% | 353 | 73 – 708 | 353 | 0 | 0 | 137 | 134 | 141 | 132 | 145 | 17-May | 7 |
| OtsCTHW10S | 89.29% | 528 | 0 – 1186 | 528 | 0 | 0 | - | - | - | - | - | - | - |
| OtsDWOR09S | 98.87% | 225 | 0 – 559 | 225 | 0 | 0 | - | - | - | - | - | - | - |
| OtsDWOR10S | 98.48% | 11448 | 8707 – 14203 | 11448 | 0 | 0 | 121 | 116 | 125 | 108 | 138 | 1-May | 9 |
| OtsDWOR11S | 98.99% | 1853 | 836 – 2956 | 1853 | 0 | 0 | 131 | 127 | 139 | 125 | 151 | 11-May | 12 |
| OtsGRUW10S | 98.63% | 1598 | 382 – 2863 | 1598 | 0 | 0 | 122 | 120 | 126 | 116 | 131 | 2-May | 6 |
| OtsGRUW11S | 99.53% | 704 | 215 – 1337 | 704 | 0 | 0 | 139 | 129 | 147 | 125 | 152 | 19-May | 18 |
| OtsIMNW09S | 97.44% | 78 | 0 – 236 | 78 | 0 | 0 | - | - | - | - | - | - | - |
| OtsIMNW10S | 97.63% | 1060 | 415 – 1934 | 1060 | 0 | 0 | 160 | 123 | 163 | 119 | 166 | 9-Jun | 40 |
| OtsIMNW11S | 94.43% | 2215 | 1064 – 3539 | 745 | 1471 | 0 | 173 | 163 | 182 | 144 | 191 | 22-Jun | 19 |
| OtsJHNW10S | 94.20% | 570 | 174 – 996 | 570 | 0 | 0 | 152 | 147 | 161 | 141 | 165 | 1-Jun | 14 |
| OtsJHNW11S | 97.47% | 278 | 0 – 700 | 85 | 193 | 0 | - | - | - | - | - | - | - |
| OtsKH09S | 99.27% | 146 | 0 – 371 | 146 | 0 | 0 | - | - | - | - | - | - | - |
| OtsKH10S | 97.46% | 2289 | 1330 – 3322 | 2289 | 0 | 0 | 142 | 131 | 151 | 117 | 163 | 22-May | 20 |
| OtsKH11S | 80.72% | 961 | 290 – 1769 | 961 | 0 | 0 | 141 | 130 | 149 | 125 | 156 | 21-May | 19 |
| OtsLOOK10S | 98.75% | 2484 | 1104 – 4096 | 2484 | 0 | 0 | 122 | 119 | 127 | 114 | 135 | 2-May | 8 |
| OtsLOOK11S | 97.47% | 695 | 203 – 1400 | 695 | 0 | 0 | 134 | 129 | 138 | 125 | 149 | 14-May | 9 |
| OtsLSTW10S | 94.34% | 2069 | 1251 – 2990 | 1670 | 399 | 0 | 150 | 142 | 164 | 133 | 172 | 30-May | 22 |
| OtsLSTW11S | 91.53% | 634 | 173 – 1193 | 428 | 206 | 0 | 162 | 152 | 168 | 147 | 173 | 11-Jun | 16 |
| OtsMCCA10S | 99.58% | 7760 | 6196 – 9417 | 6552 | 1208 | 0 | 154 | 145 | 162 | 135 | 177 | 3-Jun | 17 |
| OtsMCCA11S | 99.04% | 5383 | 3702 – 7149 | 1742 | 3640 | 0 | 171 | 163 | 177 | 149 | 190 | 20-Jun | 14 |
| OtsNPFH10S | 98.39% | 1275 | 413 – 2413 | 1275 | 0 | 0 | 120 | 116 | 122 | 112 | 139 | 30-Apr | 6 |
| OtsNPFH11S | 98.88% | 237 | 0 – 715 | 237 | 0 | 0 | - | - | - | - | - | - | - |
| OtsPAHH10S | 98.91% | 2431 | 1437 – 3518 | 1787 | 644 | 0 | 152 | 137 | 167 | 125 | 191 | 1-Jun | 30 |
| OtsPAHH11S | 96.62% | 1090 | 415 – 1861 | 545 | 545 | 0 | 167 | 145 | 182 | 140 | 186 | 16-Jun | 37 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OtsPOWP10S | 97.67% | 3067 | 1599 – 4624 | 3067 | 0 | 0 | 120 | 115 | 125 | 109 | 131 | 30-Apr | 10 |
| OtsPOWP11S | 98.69% | 1183 | 572 – 1911 | 992 | 191 | 0 | 137 | 134 | 145 | 132 | 172 | 17-May | 11 |
| OtsRAPH08S | 97.71% | 77 | 0 – 232 | 77 | 0 | 0 | - | - | - | - | - | - | - |
| OtsRAPH09S | 90.69% | 1855 | 832 – 3248 | 1855 | 0 | 0 | 119 | 109 | 122 | 105 | 131 | 29-Apr | 13 |
| OtsRAPH10S | 98.98% | 35513 | 31694 – 39804 | 35513 | 0 | 0 | 121 | 117 | 125 | 108 | 136 | 1-May | 8 |
| OtsRAPH11S | 98.35% | 4923 | 3540 – 6470 | 4923 | 0 | 0 | 134 | 130 | 137 | 125 | 145 | 14-May | 7 |
| OtsSAWT09S | 99.59% | 119 | 0 – 357 | 119 | 0 | 0 | - | - | - | - | - | - | - |
| OtsSAWT10S | 99.44% | 4499 | 2790 – 6175 | 4499 | 0 | 0 | 129 | 125 | 137 | 117 | 156 | 9-May | 12 |
| OtsSAWT11S | 96.97% | 1108 | 343 – 2207 | 681 | 426 | 0 | 163 | 142 | 176 | 133 | 179 | 12-Jun | 34 |
| OtsTUCW11S | 98.75% | 101 | 0 – 302 | 101 | 0 | 0 | - | - | - | - | - | - | - |
| Total | | 106353 | | 97430 | 8923 | 0 | | | | | | | |

Note: These summary statistics of run-timing distributions were calculated using a method to estimate abundance of each stock based on stock proportions and total numbers of Chinook salmon that were observed passing Bonneville Dam at the fish counting window.

There were thirteen non-adipose-clipped Chinook salmon stocks estimated with relative abundance greater than 1,000 fish (Table 6). These non-adipose clipped stocks in order of increasing magnitude were 07_DESCSP (1,653), 05_SPCRTU (1,974), 02_WCASSP (6,643), 15_MFSALM (4,696), 16_UPSALM (8,157), 08_JOHNDR (8,538), 13_SFSALM (10,410), 09_YAKIMA (10,670), 17_DESCFA (14,174), 12_HELLSC (18,024), 10_UCOLSP (20,552), 19_SRFALL (90,861), and 18_UCOLSF (540,107). These stock abundance estimates were based on the stock proportions that were estimated in GSI_sim across weekly strata, and were multiplied with the total abundance of Chinook salmon that was tallied on a daily basis at the Bonneville Dam fish counting window (Table 1). The summer run and fall run stocks should be considered a subtotal abundance, because we only analyzed statistical weeks during the 25–28 week interval and 33, and 36 – 42 week interval for summer and fall management periods respectively. The missing weeks could not be analyzed because we were not able to sample at those times due to restrictions at Bonneville Dam, and so abundance for those periods were omitted from our relative abundance estimates.

**Table 6. Relative abundance and run-timing distributions of unclipped (natural origin) Chinook salmon stocks passing Bonneville Dam in 2014.**

| | Estimated abundance | | | | | Run-timing distribution | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reporting group | mean | Total 95% C.I. | Before 15-Jun | June 16 - July 31 | After August 1 | Median | 1st quartile | 3rd quartile | 5th percentile | 95th percentile | Median date | Interquartile range (d) |
| 01_YOUNGS | 0 | 0 – 3245 | 0 | 0 | 0 | - | - | - | - | - | - | - |
| 02_WCASSP | 6643 | 642 – 24227 | 99 | 528 | 6016 | 253 | 251 | 255 | 182 | 257 | 10-Sep | 4 |
| 03_WCASFA | 174 | 185 – 9301 | 174 | 0 | 0 | - | - | - | - | - | - | - |
| 04_WILLAM | 0 | 9 – 7593 | 0 | 0 | 0 | - | - | - | - | - | - | - |
| 05_SPCRTU | 1974 | 162 – 8579 | 0 | 0 | 1974 | 267 | 266 | 269 | 265 | 271 | 24-Sep | 3 |
| 06_KLICKR | 0 | 0 – 2921 | 0 | 0 | 0 | - | - | - | - | - | - | - |
| 07_DESCSP | 1653 | 679 – 6456 | 1271 | 382 | 0 | 134 | 125 | 164 | 109 | 179 | 14-May | 39 |
| 08_JOHNDR | 8538 | 4347 – 14307 | 6460 | 2078 | 0 | 127 | 121 | 145 | 110 | 180 | 7-May | 24 |
| 09_YAKIMA | 10670 | 7177 – 13965 | 9122 | 1547 | 0 | 129 | 121 | 143 | 114 | 178 | 9-May | 22 |
| 10_UCOLSP | 20552 | 13501 – 24542 | 16082 | 4470 | 0 | 127 | 120 | 142 | 110 | 178 | 7-May | 22 |
| 11_TUCANO | 293 | 0 – 2866 | 293 | 0 | 0 | - | - | - | - | - | - | - |
| 12_HELLSC | 18024 | 13503 – 28097 | 15683 | 2340 | 0 | 137 | 121 | 156 | 112 | 177 | 17-May | 35 |
| 13_SFSALM | 10410 | 9040 – 18487 | 9324 | 1086 | 0 | 149 | 136 | 159 | 120 | 182 | 29-May | 23 |
| 14_CHMBLN | 952 | 504 – 4210 | 952 | 0 | 0 | 150 | 142 | 160 | 134 | 165 | 30-May | 18 |
| 15_MFSALM | 4696 | 2985 – 15250 | 4541 | 155 | 0 | 128 | 120 | 140 | 114 | 159 | 8-May | 20 |
| 16_UPSALM | 8157 | 5464 – 17300 | 6941 | 1216 | 0 | 146 | 129 | 158 | 118 | 189 | 26-May | 29 |
| 17_DESCFA | 14174 | 5820 – 25726 | 0 | 0 | 14174 | 267 | 264 | 273 | 258 | 282 | 24-Sep | 9 |
| 18_UCOLSF | 540107 | 490375 – 592931 | 17397 | 27872 | 494838 | 255 | 250 | 263 | 181 | 277 | 12-Sep | 13 |
| 19_SRFALL | 90861 | 38716 – 131171 | 304 | 1243 | 89315 | 253 | 249 | 260 | 229 | 268 | 10-Sep | 11 |
| Total | 737879 | | 88645 | 42917 | 606317 | | | | | | | |

Note: These summary statistics of run-timing distributions were calculated using a method to estimate abundance of each stock based on stock proportions and total numbers of Chinook salmon that were observed passing Bonneville Dam at the fish counting window. Abundance and run-timing estimates for fall stocks is inaccurate due to data gaps in the fall portion of the run.

*Run-timing of Chinook salmon stocks in 2014*

We were able to obtain sufficient sample sizes to characterize the run-timing distributions of eleven hatchery-origin adipose-clipped adult and jack Chinook salmon spring-run stocks (Table 4). We included all PBT-assigned Chinook salmon in this abundance estimate regardless of whether they were adipose-clipped or not. The Chinook salmon management periods divide the run into the following three date ranges: April to June 15th (Spring-run), June 16th – July 31st (Summer-run), and August 1st- October (Fall-run). The following four hatchery-origin stocks were found to terminate within the Spring management period (i.e. the 95th percentile of their run distribution occurred on or before June 15th): 06_KLICKR, 07_DESCSP, 10_UCOLSP, and12_HELLSC. The following three hatchery-origin stocks were found to terminate within the summer management period (i.e. the 95th percentile of their run distribution occurred after June 15th and on or before July 31st): 09_YAKIMA, 13_SFSALM, and 16_UPSALM. The run-timing of the remaining summer and fall-run hatchery-origin stocks were estimated with median dates after September (05_SPCRTU, 18_UCOLSF, and 19_SRFALL). In addition, we observed a relatively large (>2000) abundance of 02_WCASSP stock which had relatively late run timing (median date September 10). This stock may be due to some misassignment of the spring and fall stocks in this West Cascade region (below Bonneville Dam) or this could be explained by delayed run timing of a stock that is utilizing new habitat in the Hood River (M. Hess, CRITFC, personal communication).

The run distributions of 13 natural-origin non-adipose-clipped adult and jack Chinook salmon spring-run stocks were similarly characterized (Table 6). A single natural-origin stock was found to terminate within the Spring management period (i.e. the 95th percentile of their run distribution occurred on or before June 15th): 15_MFSALM. The following seven natural-origin stocks were found to terminate within the summer management period (i.e. the 95th percentile of their run distribution occurred after June 15th and on or before July 31st): 07_DESCSP, 08_JOHNDR, 09_YAKIMA, 10_UCOLSP, 12_HELLSC, 13_SFSALM, and 16_UPSALM. The run-timing of the four summer and fall-run natural-origin stocks were all estimated with median dates in September: 05_SPCRTU, 17_DESCFA, 18_UCOLSF, and 19_SRFALL. However, one spring-run stock, 02_WCASSP, was found to terminate its run after the July 31st date, and September 10 was its median run date. Similar to the hatchery-origin component of this stock, there may be some fish utilizing newly available habitat in the Hood River, but other explanations may also apply, such as misassignment to the 03_WCASFA stock. Although these categories differ in composition of stocks depending whether we examine hatchery- or natural-origin fish, comparison to previous analyses of these stocks demonstrates some consistent patterns, e.g. combined adult and jack Salmon R. stocks have relatively late runs. It may be of interest to managers that we observed more than 13,000 natural-origin and 10,000 hatchery-origin fish from spring-run Chinook salmon reporting groups (mostly Snake R. origin) that are estimated to return during the summer management (Tables 4, 6). Data from known origin PIT tagged fish which were PIT tagged as juveniles shows similar patterns.

Using the PBT-assigned adult and jack Chinook salmon, we also characterized the run-distributions at a very fine scale according to hatchery and spawn year (Table 5). Among relatively abundant broodstocks (i.e., >1000 fish), the following 9 broodstock sources were found to terminate within the summer management period (i.e. the 95th percentile of their run distribution occurred after June 15th and on or before July 31st): Imnaha (OtsIMNW10S,

OtsIMNW11S), Lostine (OtsLSTW10S), McCall (OtsMCCA10S, OtsMCCA11S), Pahsimeroi (OtsPAHH10S, OtsPAHH11S), Powell (OtsPOWP11S), and Sawtooth (OtsSAWT11S). The fish that assigned to the remaining 12 major (>1000 fish) broodstock sources terminated within the spring management period. One pattern worth noting is that the 3-year-old jack Chinook salmon (fish that assigned to broodstock that were spawned in 2011), were found to arrive later than the 4-year-old salmon from the same hatchery source which is the same pattern seen with PIT tag data (PITAGIS). There were 7 hatcheries which had >1000 fish estimated for both age classes (3- and 4- year old), and for all seven of these hatcheries, the 3-year old fish had a later median day relative to the 4-year olds (Table 5).

*Parentage based tagging analyses of Chinook salmon in 2014*

We were able to assign 740 adult and jack Chinook salmon sampled at Bonneville Dam in 2014 to the 2008 - 2011 spring-run Chinook salmon broodstock from fifteen different Snake River hatcheries and the Klickitat Hatchery (Table 7). The fifteen Snake River hatchery sources identified by PBT were aggregated into the appropriate GSI reporting group in order to integrate the relative abundance estimates from this analysis with relative abundance estimates from GSI analyses. Tucannon hatchery was placed in the 11_TUCANO reporting group. Johnson Cr. and McCall hatcheries were placed in the 13_SFSALM reporting group. Pahsimeroi and Sawtooth were placed in the 16_UPSALM reporting group, and all other hatcheries were grouped into the 12_HELLSC reporting group. Adipose marking rates vary across source hatcheries, for the eleven hatcheries with sample sizes above 15 fish assignments, there were 5 hatcheries in which the adipose marking rate was below 10% unmarked. The following three hatcheries were above 15% unmarked: McCall (40%), Pahsimeroi (19%), and Sawtooth (17%) hatcheries. Sex (determined by a genetic marker) and length information were available for these PBT-assigned fish and can be used to further characterize the broodstock sources.

Table 7. Summary information on the PBT Chinook salmon source hatcheries and numbers of assignments

| | | | | Adipose clip | | |
|---|---|---|---|---|---|---|
| PBT source hatchery | PBTpop | Tag Rate | Age | Y | N | Total |
| Klickitat Hatchery | OtsKH09S | 99.3% | 5 | 2 | | 2 |
| | OtsKH10S | 97.5% | 4 | 23 | 1 | 24 |
| | OtsKH11S | 80.7% | 3 | 6 | 2 | 8 |
| LSRCP/IDFG - Clearwater (SF) | OtsCLWH10S | 99.5% | 4 | 26 | 4 | 30 |
| | OtsCLWH11S | 95.6% | 3 | 4 | | 4 |
| LSRCP/ODFW - Catherine Creek | OtsCTHW10S | 89.3% | 4 | 3 | | 3 |
| LSRCP/USFWS - Dworshak | OtsDWOR09S | 98.9% | 5 | 2 | | 2 |
| | OtsDWOR10S | 98.5% | 4 | 64 | 3 | 67 |
| | OtsDWOR11S | 99.0% | 3 | 15 | | 15 |
| LSRCP/ODFW - Grande Ronde | OtsGRUW10S | 98.6% | 4 | 3 | 4 | 7 |
| | OtsGRUW11S | 99.5% | 3 | 3 | 4 | 7 |
| LSRCP/ODFW - Imnaha | OtsIMNW09S | 97.4% | 5 | 1 | | 1 |
| | OtsIMNW10S | 97.6% | 4 | 9 | 1 | 10 |
| | OtsIMNW11S | 94.4% | 3 | 12 | 2 | 14 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Johnson Cr. | OtsJHNW10S | 94.2% | 4 | 2 | 5 | 7 |
| | OtsJHNW11S | 97.5% | 3 | | 2 | 2 |
| LSRCP/ODFW - Lookingglass Creek | OtsLOOK10S | 98.8% | 4 | 11 | 1 | 12 |
| | OtsLOOK11S | 97.5% | 3 | 6 | | 6 |
| LSRCP/ODFW/NPT – Lostine | OtsLSTW10S | 94.3% | 4 | 22 | | 22 |
| | OtsLSTW11S | 91.5% | 3 | 5 | 1 | 6 |
| LSRCP/IDFG - McCall (SFSR) | OtsMCCA10S | 99.6% | 4 | 55 | 33 | 88 |
| | OtsMCCA11S | 99.0% | 3 | 20 | 16 | 36 |
| Nez Perce Tribal Hatchery (NPTFH) | OtsNPFH10S | 98.4% | 4 | | 8 | 8 |
| | OtsNPFH11S | 98.9% | 3 | | 1 | 1 |
| Idaho Power/IDFG - Pahsimeroi | OtsPAHH10S | 98.9% | 4 | 20 | 3 | 23 |
| | OtsPAHH11S | 96.6% | 3 | 6 | 3 | 9 |
| LSRCP/IDFG - Clearwater (Powell) | OtsPOWP10S | 97.7% | 4 | 16 | 2 | 18 |
| | OtsPOWP11S | 98.7% | 3 | 10 | 2 | 12 |
| Idaho Power/IDFG - Rapid River | OtsRAPH08S | 97.7% | 6 | | 1 | 1 |
| | OtsRAPH09S | 90.7% | 5 | 10 | 1 | 11 |
| | OtsRAPH10S | 99.0% | 4 | 190 | 7 | 197 |
| | OtsRAPH11S | 98.3% | 3 | 42 | 2 | 44 |
| LSRCP/IDFG - Sawtooth | OtsSAWT09S | 99.6% | 5 | 1 | | 1 |
| | OtsSAWT10S | 99.4% | 4 | 26 | 6 | 32 |
| | OtsSAWT11S | 97.0% | 3 | 8 | 1 | 9 |
| LSRCP/WDFW - L.F. (Tucannon) | OtsTUCW11S | 98.8% | 3 | | 1 | 1 |
| | | | | 623 | 117 | 740 |

*Estimated relative abundance of steelhead stocks in 2014*

There were five major stocks (abundance > 1000) represented in the total estimated relative abundance (N=205,482) of hatchery steelhead passing Bonneville Dam in 2014. These stocks in order of increasing magnitude were SKAMAN (7171), UPPCOL (12074), UPSALM (51,000), SFCLWR (61,066), and MGILCS-mega complex (72,357) (Table 8). These estimates include relative abundance estimated from PBT-assigned fish that were mostly adipose clipped, however a large portion of the PBT-assigned fish were found to have their adipose intact. Therefore, PBT assignments improved our ability to accurately identify hatchery-origin steelhead and estimate total stock relative abundance, particularly for three reporting groups MGILCS, SFCLWR, and UPSALM. Further, using PBT assignments we can now provide relative abundance, run-timing, and size and age information at a spatial scale of a particular hatchery (Table 9). At the level of hatchery broodstock, the following 13 hatchery broodstocks were estimated to be greater than 1,000 fish: Little Sheep Cr. [LSCR11 (3,264), LSCR12 (5,422)], Lyons Ferry [(LYON11 (17,388), LYON12 (17,878)], Wallowa [WALL11 (9,685), WALL12 (6,702)], Dworshak [DWOR11 (58,301)], Oxbow [OXBO11 (10,870), OXBO12 (1,652)], Pahsimeroi [PAHH11 (8,225), PAHH12 (15,135)], and Sawtooth [SAWT11 (15,135), SAWT12 (9,434)]. These hatchery stocks could also be classified into the larger stock groups utilized by GSI analyses,

such that the MGILCS reporting group would include Little Sheep Cr., Lyons Ferry, and Wallowa hatchery stocks. The SFCLWR reporting group would include the Dworshak and Squaw Creek hatchery stock; and the UPSALM reporting group would include Oxbow, Pahsimeroi, and Sawtooth hatchery stocks.

**Table 8. Stock-specific relative abundance and run-timing distributions of hatchery-origin steelhead stocks passing Bonneville Dam in 2014.**

| | Estimated abundance | | | | Run-timing distribution | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Management period | | | | | | | | |
| Reporting group | mean | Total 95% C.I. | Skamania Summer Apr. 1 - Jun. 30 | Summer A/B Index Jul. 1 - Oct. 31 | Median | 1st quartile | 3rd quartile | 5th percentile | 95th percentile | Median date | Interquartile range (d) |
| WCOAST | 0 | 0 – 97 | 0 | 0 | - | - | - | - | - | - | - |
| LOWCOL | 644 | 282 – 1235 | 570 | 74 | 119 | 107 | 164 | 99 | 267 | 29-Apr | 57 |
| SKAMAN | 7171 | 5879 – 8456 | 4334 | 2838 | 176 | 162 | 200 | 128 | 225 | 25-Jun | 38 |
| WILLAM | 0 | 0 – 455 | 0 | 0 | - | - | - | - | - | - | - |
| BWSALM | 0 | 0 – 139 | 0 | 0 | - | - | - | - | - | - | - |
| KLICKR | 0 | 0 – 643 | 0 | 0 | - | - | - | - | - | - | - |
| MGILCS† | 72357 | 64450 – 80707 | 3343 | 68965 | 221 | 206 | 232 | 183 | 259 | 9-Aug | 26 |
| YAKIMA | 0 | 0 – 652 | 0 | 0 | - | - | - | - | - | - | - |
| UPPCOL | 12074 | 7880 – 16996 | 224 | 11850 | 223 | 206 | 238 | 188 | 260 | 11-Aug | 32 |
| SFCLWR† | 61066 | 53752 – 67864 | 0 | 61031 | 259 | 250 | 268 | 239 | 279 | 16-Sep | 18 |
| UPCLWR | 692 | 36 – 2547 | 0 | 692 | 252 | 246 | 258 | 239 | 263 | 9-Sep | 12 |
| SFSALM | 0 | 0 – 331 | 0 | 0 | - | - | - | - | - | - | - |
| MFSALM | 477 | 0 – 916 | 2 | 475 | 218 | 209 | 226 | 190 | 233 | 6-Aug | 17 |
| UPSALM† | 51000 | 44246 – 59130 | 155 | 50930 | 227 | 213 | 249 | 192 | 263 | 15-Aug | 36 |
| Total | 205482 | | 8628 | 196854 | | | | | | | |

Note: These summary statistics of run-timing distributions were calculated using a method to estimate abundance of each stock based on stock proportions and total numbers of steelhead that were observed passing Bonneville Dam at the fish counting window during the sampling period. † These estimates were combined with PBT-estimated stock abundance.

**Table 9. Hatchery broodstock-specific relative abundance and run-timing distributions of unclipped and clipped PBT-assigned steelhead passing Bonneville Dam.**

| GSI reporting group | Broodstock collection | Tagging rate | Estimated abundance Total | 95% C.I. | Skamania Apr. 1 - Jun. 30 | Summer Jul. 1 - Oct. 31 | Run-timing distribution Median | 1st quartile | 3rd quartile | 5th percentile | 95th percentile | Median date | Interquarti range (d |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MGILCS | LSCR10 | 88.4% | 266 | 0 – 800 | 0 | 266 | 224 | 215 | 227 | 210 | 233 | 12-Aug | 12 |
| | LSCR11 | 100.0% | 1813 | 831 – 3016 | 14 | 1799 | 210 | 199 | 224 | 187 | 232 | 29-Jul | 25 |
| | LSCR12 | 95.6% | 5422 | 3173 – 8056 | 19 | 5403 | 222 | 210 | 230 | 191 | 256 | 10-Aug | 20 |
| | LYON11 | 98.2% | 17388 | 13067 – 22060 | 2792 | 14597 | 218 | 197 | 238 | 157 | 260 | 6-Aug | 41 |
| | LYON12 | 99.7% | 17878 | 14237 – 21857 | 340 | 17539 | 218 | 205 | 227 | 188 | 254 | 6-Aug | 22 |
| | WALL11 | 98.3% | 9685 | 6273 – 13621 | 103 | 9582 | 226 | 211 | 246 | 190 | 262 | 14-Aug | 35 |
| | WALL12 | 99.2% | 6702 | 4625 – 9024 | 31 | 6671 | 217 | 206 | 226 | 189 | 233 | 5-Aug | 20 |
| SFCLWR | DWOR11 | 97.8% | 58301 | 51236 – 65131 | 0 | 58301 | 259 | 250 | 268 | 239 | 279 | 16-Sep | 18 |
| | DWOR12 | 96.6% | 865 | 393 – 1414 | 0 | 865 | 270 | 267 | 277 | 265 | 279 | 27-Sep | 10 |
| | SQUW11 | 100.0% | 228 | 0 – 532 | 0 | 228 | 270 | 267 | 277 | 265 | 279 | 27-Sep | 10 |
| UPSALM | OXBO11 | 91.6% | 10870 | 6748 – 15568 | 20 | 10849 | 238 | 219 | 253 | 197 | 264 | 26-Aug | 34 |
| | OXBO12 | 98.4% | 1652 | 612 – 2863 | 6 | 1645 | 220 | 209 | 227 | 191 | 236 | 8-Aug | 18 |
| | PAHH11 | 94.4% | 8225 | 5105 – 11899 | 28 | 8197 | 225 | 211 | 243 | 191 | 261 | 13-Aug | 32 |
| | PAHH12 | 98.1% | 15135 | 10659 – 20254 | 29 | 15106 | 232 | 217 | 252 | 197 | 264 | 20-Aug | 35 |
| | SAWT11 | 99.8% | 3887 | 2069 – 6118 | 27 | 3861 | 214 | 201 | 232 | 187 | 260 | 2-Aug | 31 |
| | SAWT12 | 99.6% | 9434 | 6229 – 13065 | 27 | 9407 | 226 | 213 | 244 | 193 | 266 | 14-Aug | 31 |
| | Total | | 167751 | | 3436 | 164314 | | | | | | | |

Note: GSI reporting groups indicate which group the broodstock sources are most genetically similar. Collection abbreviations can be found in Table 11. The date ranges listed under "Skamania" and "Summer" were chosen by steelhead fishery managers, and for each hatchery source stock we provide the abundance that has passed within these time periods.

There were eleven major stocks (abundance > 1000) represented in the total estimated relative abundance (n=113,092) of wild steelhead (Table 10). These stocks in order of magnitude were LOWCOL (1,086), SKAMAN (1,507), SFSALM (2,543), KLICKR (3582), YAKIMA (3,736), MFSALM (3,943), UPCLWR (4,404), UPSALM (4,473), SFCLWR (4,562), UPPCOL (9,663), MGILCS (73,574).

*Run-timing of steelhead stocks in 2014*

We characterized the run-timing distributions of the 5 major hatchery steelhead stocks and 11 major wild steelhead stocks in 2014 (Tables 8, 10). Results for the hatchery stocks indicate three main run-timing categories of stocks. An early run-timing category has been observed previously to primarily include Skamania summer-run SKAMAN (Median date Jun. 25). An intermediate run-timing category includes the following three major hatchery steelhead stocks (ordered by median dates): MGILCS (Aug. 9), upper Columbia R. UPPCOL (Aug. 11), and upper Salmon R. UPSALM (Aug. 15). Finally, a late run-timing category consists of the South Fork Clearwater R. SFCLWR (Sep. 16) stock. The late run-timing category is typically thought to be characteristic of B-run steelhead that return after August 25$^{th}$ at Bonneville Dam.

**Table 10. Stock-specific relative abundance and run-timing distributions of natural-origin (adipose unclipped) steelhead passing Bonneville Dam in 2014.**

| | Estimated abundance | | | | Run-timing distribution | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Management period | | | | | | | | |
| Reporting group | mean | Total 95% C.I. | Skamania Apr. 1 - Jun. 30 | Summer Jul. 1 - Oct. 31 | Median | 1st quartile | 3rd quartile | 5th percentile | 95th percentile | Median date | Interquartile range (d) |
| WCOAST | 0 | 0 – 76 | 0 | 0 | - | - | - | - | - | - | - |
| LOWCOL | 1086 | 708 – 2691 | 257 | 829 | 200 | 184 | 213 | 104 | 229 | 19-Jul | 29 |
| SKAMAN | 1507 | 617 – 2066 | 1230 | 277 | 176 | 169 | 180 | 119 | 223 | 25-Jun | 11 |
| WILLAM | 0 | 0 – 480 | 0 | 0 | - | - | - | - | - | - | - |
| BWSALM | 18 | 0 – 115 | 18 | 0 | 144 | 138 | 149 | 127 | 152 | 24-May | 11 |
| KLICKR | 3582 | 1520 – 6603 | 163 | 3419 | 248 | 238 | 256 | 184 | 263 | 5-Sep | 18 |
| MGILCS | 73574 | 71055 – 84005 | 2324 | 71250 | 212 | 200 | 226 | 185 | 254 | 31-Jul | 26 |
| YAKIMA | 3736 | 1372 – 4796 | 279 | 3457 | 222 | 210 | 232 | 177 | 260 | 10-Aug | 22 |
| UPPCOL | 9663 | 5006 – 12754 | 14 | 9649 | 221 | 211 | 229 | 192 | 256 | 9-Aug | 18 |
| SFCLWR | 4562 | 2004 – 7823 | 2 | 4560 | 254 | 244 | 263 | 205 | 279 | 11-Sep | 19 |
| UPCLWR | 4404 | 2043 – 7720 | 0 | 4404 | 255 | 246 | 265 | 237 | 279 | 12-Sep | 19 |
| SFSALM | 2543 | 752 – 5272 | 1 | 2542 | 250 | 240 | 258 | 205 | 267 | 7-Sep | 18 |
| MFSALM | 3943 | 1935 – 6317 | 169 | 3774 | 223 | 202 | 247 | 183 | 262 | 11-Aug | 45 |
| UPSALM | 4473 | 944 – 5443 | 210 | 4263 | 212 | 199 | 226 | 182 | 268 | 31-Jul | 27 |
| Total | 113092 | | 4668 | 108424 | | | | | | | |

Note: These summary statistics of run-timing distributions were calculated using a method to estimate relative abundance of each stock based on stock proportions and total numbers of steelhead that were observed passing Bonneville Dam at the fish counting window.

The wild steelhead stocks (Table 10) generally fit the same run-timing categories as characterized for hatchery steelhead. The 11 major wilds stocks ordered by median date were SKAMAN (Jun. 25), LOWCOL (Jul. 19), MGILCS (Jul. 31), UPSALM (Jul. 31), UPPCOL (Aug. 9), YAKIMA (Aug. 10), MFSALM (Aug. 11), KLICKR (Sep. 5), SFSALM (Sep. 7), SFCLWR (Sep. 11), and UPCLWR (Sep. 12).

Using the PBT-assigned steelhead, we also characterized the run-distributions at a very fine scale according to hatchery and spawn year (Table 9). This analysis of broodstock sources allowed us to group the 13 major ones (>1000 fish) into categories according to their median date. The following broodstock sources all had median dates before August: Little Sheep Cr. 2011. Broodstock sources with median dates between August 1st – 24th were: Lyons Ferry 2011-2012, Sawtooth 2011-2012, Oxbow 2012, Pahsimeroi 2011-2012, Little Sheep Cr. 2012, and Wallowa 2011-2012. Finally, broodstock sources with median dates occurring after August 25th were the following: Oxbow 2011 and Dworshak 2011.

*Parentage based tagging analyses of steelhead in 2014*

We were able to assign 831 steelhead sampled at Bonneville Dam in 2014 to the 2010-2012 steelhead broodstock from eight different Snake River hatcheries (Table 11). The largest portion of the PBT-assigned fish originated from the Dworshak Hatchery (n=324, 39%), and the next greatest portions originated from the Lyons Ferry (23%), Pahsimeroi (11%), Wallowa (9%), and Sawtooth (8%) hatcheries. Using these known hatchery-of-origin steelhead, we compared the individual assignments based on GSI analysis and used these assignments to help classify them into the most genetically similar reporting group (Table 11). Those groupings were used to combine results of PBT-hatchery abundance estimates with the GSI estimated abundance of hatchery stocks (Table 9). Adipose marking rates did not vary much across source hatcheries. There were 7 hatcheries with sample sizes above 15 fish assignments, and all but two of them had adipose marking rates below 5% unmarked. The exceptions were Dworshak and Sawtooth hatcheries which had a 16% and 19% unmarked, respectively (Table 11).

We examined which of the hatchery sources were contributing the size range of fish typically classified as B-run steelhead (Table 12). Fish with a fork length greater than or equal to 78 cm were found to primarily originate from the Dworshak broodstock source, and most of these were from the 2011 spawn year (2-ocean age). The 2-ocean age is typical of B-run life history. Further, the regions of the South Fork and Upper Clearwater R. and Middle Fork and South Forth Salmon R. are generally thought to be the largest sources of B-run steelhead. Dworshak and Squaw broodstock fit within the South Fork Clearwater R. genetic stock and so are expected to produce large, older steelhead. However, this year, Oxbow hatchery fish were comprised of greater than 5% of fish that were greater than or equal to 78 cm length.

Table 11. Summary information for Snake River steelhead broodstock sources and numbers of assignments of Bonneville Dam steelhead in 2014.

| GSI reporting group | PBT source hatchery | Broodstock source abbreviation | Average Tagging rate | Age of PBT assigned adults | Adipose clip Y | Adipose clip N |
|---|---|---|---|---|---|---|
| MGILCS | LSRCP/ODFT - Little Sheep Cr. FH | OmyLSCR10S | 88.4% | 3-ocean | 1 | |
| | | OmyLSCR11S | 100.0% | 2-ocean | 10 | 1 |
| | | OmyLSCR12S | 95.6% | 1-ocean | 24 | |
| | LSRCP/WDFW-Lyons Ferry | OmyLYON11S | 96.0% | 2-ocean | 89 | 7 |
| | | OmyLYON12S | 98.6% | 1-ocean | 93 | 1 |
| | LSRCP/ODFW-Wallowa F.H. | OmyWALL11S | 98.3% | 2-ocean | 40 | 1 |
| | | OmyWALL12S | 99.2% | 1-ocean | 35 | 1 |
| SFCLWR | LSRCP/IDFG/USFWS Dworshak/C.W. | OmyDWOR11S | 98.1% | 2-ocean | 262 | 51 |
| | | OmyDWOR12S | 96.3% | 1-ocean | 10 | 1 |
| | LSRCP/IDFG Sawtooth (USB/Squaw) | OmySQUW11S | 100.0% | 2-ocean | | 3 |
| UPSALM | Idaho Power/IDFG,Oxbow F.H. | OmyOXBO11S | 92.0% | 2-ocean | 37 | |
| | | OmyOXBO12S | 98.4% | 1-ocean | 9 | |
| | Idaho Power/IDFG, Pahsimeroi F.H. | OmyPAHH11S | 79.5% | 2-ocean | 31 | 2 |
| | | OmyPAHH12S | 97.8% | 1-ocean | 56 | 1 |
| | LSRCP/IDFG Sawtooth (IDFG & SBT) | OmySAWT11S | 99.8% | 2-ocean | 13 | 8 |
| | | OmySAWT12S | 99.5% | 1-ocean | 40 | 4 |
| | | | | | 750 | 81 |

Note: The GSI reporting group is the group that is most genetically similar to the listed hatchery broodstock sources. The hatchery abbreviations include digits that indicate the spawn year, e.g. 11S = 2011 spawn year. The tagging rate is the percent of broodstock parents that were genotyped. Adipose clipped fish (Y) and non-clipped fish (N) refer to the number of adult steelhead passing Bonneville Dam in 2014 that were assigned to parents from a particular broodstock source.

Table 12. Sex and size attributes of Snake River hatchery steelhead passing Bonneville Dam steelhead in 2014.

| Broodstock | Sex and size | | | | | | |
|---|---|---|---|---|---|---|---|
| | Female | | Male | | Total | | |
| collection | % | >78cm length | % | >78cm length | N | >78cm length | Ocean- age |
| LSCR10 | 100.0% | 0.0% | 0.0% | - | 1 | 0.0% | 3 |
| LSCR11 | 72.7% | 0.0% | 27.3% | 0.0% | 11 | 0.0% | 2 |
| LSCR12 | 33.3% | 0.0% | 66.7% | 0.0% | 24 | 0.0% | 1 |
| LYON11 | 72.9% | 0.0% | 27.1% | 3.8% | 96 | 1.0% | 2 |
| LYON12 | 44.7% | 0.0% | 55.3% | 0.0% | 94 | 0.0% | 1 |
| WALL11 | 73.2% | 0.0% | 26.8% | 0.0% | 41 | 0.0% | 2 |
| WALL12 | 30.6% | 0.0% | 69.4% | 0.0% | 36 | 0.0% | 1 |
| DWOR11 | 55.9% | 55.2% | 44.1% | 87.7% | 313 | 69.6% | 2 |
| DWOR12 | 27.3% | 0.0% | 72.7% | 0.0% | 11 | 0.0% | 1 |
| SQUW11 | 66.7% | 0.0% | 33.3% | 100.0% | 3 | 33.3% | 2 |
| OXBO11 | 70.3% | 0.0% | 29.7% | 18.2% | 37 | 5.4% | 2 |
| OXBO12 | 33.3% | 33.3% | 66.7% | 0.0% | 9 | 11.1% | 1 |
| PAHH11 | 87.9% | 0.0% | 12.1% | 0.0% | 33 | 0.0% | 2 |
| PAHH12 | 42.1% | 0.0% | 57.9% | 0.0% | 57 | 0.0% | 1 |
| SAWT11 | 71.4% | 0.0% | 28.6% | 0.0% | 21 | 0.0% | 2 |
| SAWT12 | 38.6% | 0.0% | 61.4% | 0.0% | 44 | 0.0% | 1 |
| Total | 464 | | 367 | | 831 | | |

*Concordance between PIT-tag and genetic methods for stock identification of sockeye salmon*

An ongoing study employing PIT-tags for fish tagged as adults to estimate sockeye salmon escapement relies on detection of tagged fish at upstream dams in order to identify stocks (Fryer et al. 2014). For example, detections at Tumwater, Wells, and Lower Granite dams provide identification of Wenatchee, Okanagan, and Snake River sockeye stocks, respectively. However, in many years there is a portion of fish that cannot be assigned due to failure to tag, tag loss, or for reasons related to detection failure (either mortality of the fish, lock passage or equipment sensitivity at the dam detection arrays). In 2014, there were 385 unassigned sockeye salmon (27%) out of the total 1420 that were PIT-tagged. Therefore, GSI can provide the stock information missing for over a quarter of the fish sampled at the Adult Fish Facility at Bonneville Dam. The concordance between methods has been previously determined to be high, e.g. 97.9% to 99.5% for Wenatchee and Okanagan stocks, respectively (Hess et al. 2013). These concordance results allow us to combine the stock identification results from both PIT-tag and genetic methods. For example, we primarily relied on PIT-tag stock ID, and in the absence of this PIT-tag ID, we utilized the genetic stock ID. The results from combining PIT-tag and genetic stock ID provided stock information for the entire set of 1,420 fish sockeye salmon (n=385, and PIT-tag n=1035) that were sampled at the Adult Fish Facility in 2014.

**Table 13. Stock-specific relative abundance and run-timing distributions of sockeye salmon passing Bonneville Dam in 2014.**

| Reporting group | Sample size | Estimated relative abundance | 95% C.I. | Run-timing distribution: Median | 1st quartile | 3rd quartile | 5th percentile | 95th percentile | Median date | Interquartile range (d) |
|---|---|---|---|---|---|---|---|---|---|---|
| Wenatchee | 256 | 119971 | 105797-134764 | 180 | 175 | 186 | 169 | 193 | 29-Jun | 11 |
| Okanogan | 1144 | 488813 | 473980-503567 | 181 | 175 | 187 | 168 | 196 | 30-Jun | 12 |
| Snake | 17 | 5136 | 2517-8691 | 186 | 181 | 196 | 175 | 209 | 5-Jul | 15 |
| Total | 1417 | 613920 | | - | - | - | - | - | - | - |

Note: The estimated relative abundance was calculated based on weekly proportions of each stock using a combined PIT-tag and Genetic stock ID, and these proportions were multiplied by the total number of sockeye counted at Bonneville Dam in a particular week (sampled time period from statistical week 23-32). The run-timing distributions are indicated by ordinal day of passage in which a specific proportion of the total abundance was estimated to have passed Bonneville Dam. The interquartile range is marked in days.

*Estimated relative abundance and run-timing of sockeye salmon stocks in 2014*

Abundance was estimated during a span of eight statistical weeks in which sample numbers were 9 or greater per week (Table 2). The PIT-tagged sockeye salmon stocks passing Bonneville Dam were estimated with the following abundance in decreasing magnitude: Okanagan (488,813), Wenatchee (119,971), and Snake River (5,136) (Table 13). Genetic assignments of fish from three stocks (Okanagan, Wenatchee, and Snake River) were utilized in cases in which it was not possible to assign them with PIT-tag data due to lack of detections of fish at their terminal dam. These genetic assignments typically has the most significant impact on the proportion of Snake River sockeye, however, sample sizes of this rare stock are very low and difficult to accurately measure.

We characterized the run-timing distributions of the three main genetic stocks of sockeye salmon (Table 13). These stocks could be ordered by median date as follows: Wenatchee (Jun. 29), Okanagan (Jun. 30), and Snake River (Jul. 5).

*Parentage based tagging analyses of Pacific lamprey*

We have been tracking one particular cohort of Pacific lamprey that are offspring of translocated adults that spawned in 2007 in Newsome Creek, a tributary in the Snake River basin. Juveniles collected in a screw trap in 2012 at the mouth of Newsome Creek were found to be comprised of 99.2% offspring of the translocation spawners from 2007 (Hess et al. 2015). From the next year, 2013, we analyzed 98 juveniles collected in the same screw trap and found that 96.9% were offspring of the 2007 translocation. In neither 2012 or 2013 were any of the individuals observed to have developed eyes, and so they were not macropthalmia, but they were estimated to be 5-year-olds and 6-year-olds in 2012 and 2013, respectively, based on the year that their parents were known to have spawned (2007). Further downstream of Newsome Creek, we have been collecting juveniles at Lower Granite Dam from 2011 – 2014. These juveniles are mostly macropthalmia but their ages are mostly unknown, because up until 2014, none of them have been found to assign to parents that we have genotyped (such as the translocated adults from Newsome Creek in 2007). However, 2014 marks the first year that we identified a translocation offspring among the Lower Granite Dam juveniles (N=377). A macropthalmia (length=142 mm) was collected on February 25, 2014 from Turbine Unit#6 North at Lower Granite Dam and was identified to be an offspring from one of the families that had been identified from Newsome screw trap samples (i.e. family cross#19, Hess et al. 2015). We will continue to monitor these juveniles each year in expectation that the parentage assignments to the Newsome Creek 2007 translocated adults will continue to increase to a peak in abundance corresponding to the peak migration timing of this life stage. This discovery of a peak migration timing would help confirm ages of juveniles passing the dam. In the meantime, we can also estimate effective population size ($N_e$) for each year of juveniles collected at this dam. Estimation of the effective number of spawners represented by these migration year 2014 LGR juveniles yielded 508 (95% CI 441–595), which is relatively low given that it would represent the effective spawner abundance of nearly the entire Snake River Basin.

## Discussion

Parentage based tagging (PBT) and genetic stock identification (GSI) may be considered as methods that could replace the central functions of the coded wire tag program and could be a replacement for adipose fin marking to identify hatchery origin fish. However, this replacement would be contingent on securing a higher level of funding to genotype a greater number of samples both from hatchery broodstock, Bonneville Dam, and from harvest; further, most hatcheries throughout the range of Chinook salmon would have to contribute broodstock samples to this PBT baseline, in order for the method to serve ocean fisheries management and the need to monitor total fishery impacts for stocks including Columbia River stocks harvested in ocean fisheries. The genetic methods provide a substantial amount of information when they are combined and used to analyze Columbia River Chinook salmon and steelhead passing Bonneville Dam. PBT improves the accuracy for defining hatchery-origin and by subtraction, total natural-origin stocks. Genetic monitoring combining PBT and GSI is one of a number of possible tools that can be used to identify hatchery and natural fish at various resolutions. Other methods include, CWT's, PIT tags, VIE tags, and otolith marks. Adipose fin clips can be used to differentiate hatchery fish from wild fish either when fish are clipped at 100% or through expansions if stocks are not clipped at 100%. PBT can further discriminate among hatchery stocks within the reporting groups that we use for GSI analyses, and so we can now characterize different age-classes from particular hatcheries by run-timing distributions and estimate their abundance at Bonneville Dam. GSI continues to provide information that would not be possible with PBT, which is identification of all non-Snake River hatchery stocks as well as all natural-origin stocks.

This long-term study will allow us to characterize trends in run timing and abundance of steelhead and Chinook and sockeye salmon and provide this data to fisheries managers. We were able to address the following **F&W Program Management Questions:**

**What are the status and trend of adult productivity of fish populations?**

**What are your in-river monitoring results and what are your estimates of stock composition and stock-specific abundance, escapement, catch, and age distribution?**

Trapping at Bonneville can only be done at very low rates due to restrictions placed on trap operations by USACE and NFMS. Low sample rates inhibit getting a representative sample of various stocks of fish. Higher sample rates would improve the precision of the estimates of fish at Bonneville Dam. Some fisheries were also sampled at very low rates.

We identified eleven hatchery stocks and thirteen wild stocks of Chinook salmon estimated to have relative abundance greater than 1,000 fish pass Bonneville Dam in 2014. It may interest fisheries managers to know that the run-timing of the "spring-run" stocks contributed to the total abundance of adult and jack Chinook salmon that pass through the Columbia River mainstem in two management periods, spring and summer. In fact, we observed more than 13,000 natural-origin and 10,000 hatchery-origin fish from spring-run adult and jack Chinook salmon reporting groups (mostly Snake R. origin) that are estimated to return during the summer management (June 16 – July 31). Data from fish PIT tagged as juveniles suggest the majority of these late timed fish are jacks. There were some consistent run-timing results with those from previous analyses, e.g. Salmon R. stocks have relatively late runs compared to other

spring stocks.  Our GSI accuracy allows us to distinguish the following five stocks of fall-run Chinook: West Cascade, Spring Creek tule, and Deschutes R., upper Columbia R. summer/fall-run, and Snake R. stocks; and unlike our method of analysis of the migration year 2013, this year we subsampled most weeks in the fall management period to provide more accurate estimates of the total abundance of these stocks.  PBT analysis has allowed us to demonstrate consistent run-timing difference between jacks and 4-year olds from the same hatchery.  In all cases in which the two age classes could be compared from a single hatchery the jacks were found to come later than the 4-year olds which is the same pattern as is typically observed for fish PIT tagged as juveniles.

For steelhead, we identified eleven wild- and five hatchery- steelhead stocks with an estimated relative abundance greater than 1000 fish passing Bonneville Dam in 2014.  We found that genetic stocks seemed to fit well into the historical management categories, especially the hatchery stocks.  Genetic stocks included an early Skamania summer-run, an intermediate run-timing category that contains most wild and hatchery steelhead stocks, and a late run-timing category with stocks that exhibit median dates after August 25$^{th}$ and includes South Fork Clearwater R. (Dworshak Hatchery), as well as wild stocks from upper Clearwater R, Klickitat, and SF Salmon R.  Characteristics of the steelhead that assigned to Snake River steelhead hatchery broodstock sources generally support the typical A-run and B-run steelhead life history categories.  The relatively large (greater than 78 cm) steelhead were found primarily to originate from Dworshak hatchery broodstock.  These fish were also relatively old (2-ocean-age) and were derived from the Clearwater R. which is one of the regions expected to produce “B-run” steelhead.  This analysis did not specifically address run sizes of A or B Index steelhead (steelhead smaller or larger than 78cm) which is currently used to manage fall season fisheries, although the U.S. v. Oregon Technical Advisory Committee utilizes the same steelhead data collected at the Bonneville AFF trap to estimate these run sizes.  It is also notable that the MGILCS reporting group represents some fish both within and outside the Snake River steelhead DPS, but does not represent all of the fish within the Snake River DPS.

This was the third year we were able to analyze sockeye salmon using GSI, and our results provided some useful insight.  Sockeye salmon relative abundance can be estimated with a mark-recapture (recapture via detection arrays) approach using PIT-tagging of adults at Bonneville Dam. However, each of the PIT-tagged fish must survive and be detected at its terminal dam for the method to successfully assign all individuals to a particular stock. Therefore, there is often an “unknown” group of fish that cannot be assigned to stock using this PIT-tag method alone, which provides a potentially useful role that GSI can fill.  In this study, the additional information that GSI provided for the “unknown” category of fish helped to improve abundance estimates on the three sockeye populations from the Okanagan River, Wenatchee River, and Snake River.  We were able to use stock composition estimates of sockeye salmon at Bonneville Dam to compare to the stock proportions estimated in the harvest in fisheries (Section 3).  However, Snake River sockeye represent such a small proportion of the run and sample rates at Bonneville and in the fisheries were so low that it is difficult to draw conclusions about the number of Snake River sockeye at Bonneville or in the harvest.  The relatively large number of fish that comprises the Wenatchee stock does allow more precision on our stock estimates, and we did observe a significant difference between the estimates of abundance of Wenatchee stock at Bonneville Dam and the zone 6 harvest.

This was the second year we were able to analyze Pacific lamprey with parentage analysis and utilize this tool to track offspring from a translocation event. For the first time, we have identified an offspring (7-year-old) from translocated adults from Newsome Creek among the juvenile lamprey that were sampled from Lower Granite Dam in 2014. We will continue to perform this analysis for subsequent years. We expect that the 2007 cohort of juveniles reared in Newsome Creek will continue to work their way downstream and so will likely be identified in even greater numbers via parentage at Lower Granite Dam. This detection is likely the first direct observation of a genetically-aged lamprey at this large distance from its natal site (i.e. ~250 km downstream). In addition, our genetic analysis of juvenile lamprey at Lower Granite Dam allows us to estimate effective number of spawners for the entire Snake River basin. As such, this method can provide a means for monitoring adult abundance of lamprey for this large and important region of its native range.

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## Overall Conclusion

This project combines four inter-related studies from the Fish & Wildlife Program Accords that address the following current and future objectives: 1) discover and evaluate SNP markers in salmon and steelhead and other anadromous fishes; 2) expand and create genetic baselines for multiple species including Chinook salmon, steelhead, sockeye salmon and kokanee, and coho salmon; 3) implement Genetic Stock Identification (GSI) programs for mainstem Chinook salmon, sockeye salmon, and steelhead fisheries and 4) GSI of fish passing Bonneville Dam (steelhead, sockeye, and Chinook salmon) and juvenile Pacific lamprey passing Lower Granite Dam.

SNP discovery and evaluation goals (Objective 1) were achieved with a total of five projects that included one project each on Chinook salmon, steelhead, Coho salmon, Sockeye salmon, and Pacific lamprey which developed existing and newly identified SNP markers for use in Genotyping-in-Thousands by sequencing (GT-seq) technology. This new genotyping protocol has greatly increased our laboratory's efficiency by allowing large numbers of fish to be genotyped with large numbers of SNP loci but at lower costs. For genetic baseline expansion (Objective 2), the 96-SNP baseline for sockeye salmon and kokanee was expanded with the addition of kokanee collections. In addition, two RAD-seq projects have been initiated and will provide high density geographic coverage of Chinook salmon and steelhead populations in the Columbia River Basin. SNPs identified through these latter efforts will be useful in characterizing genetic diversity of hatchery and wild Chinook salmon and steelhead stocks. This study included two broad applications of GSI; namely, stock composition of Chinook salmon, sockeye salmon, and steelhead fisheries (Objective 3), and stock composition of Chinook salmon, sockeye salmon, and steelhead passing Bonneville Dam and juvenile Pacific lamprey passing Lower Granite Dam (Objective 4). Chinook salmon and steelhead fishery applications of GSI were integrated with the new genetic technology of parentage based tagging (PBT). The challenge imposed by long histories of exogenous stock transfers from specific hatchery programs often prevents effective application of GSI in assigning hatchery fish. However, as the role of PBT is expanding to tag all hatchery fish, the role of GSI will be focused on identifying stocks of natural-origin fish.

Our GSI analyses of harvest included stock composition results for the spring, summer, and fall management periods of Chinook salmon fisheries in the lower Columbia River mainstem. Among selective fisheries issues, we addressed a recent concern of fishery managers related to an expansion of the Chinook salmon sport fishing boundary around the mouth of the Wind River. Although our results could not be used to conclude that the Wind River sport fishery continues to primarily target its intended stock despite the boundary change; we did find that the composition of this harvest was quite different from other fisheries conducted during the spring management period. We also estimated stock composition for the mark-selective fall-run Chinook salmon sport fishery and observed an increase in estimated proportion of upriver stocks relative to the W_Cascade_fa stock from the lower Columbia River, as compared to the first year of analysis.

Sockeye salmon and steelhead fisheries were analyzed and our stock composition results will provide additional information to managers of these fisheries. However, the sockeye salmon results indicate an increase in sample size may be warranted to make accurate estimates of rare stocks such as Snake River sockeye salmon. Although it was possible to estimate stock proportions of Snake River sockeye salmon, the low sample sizes precluded our ability to conclude whether there are significant differences in proportions of this stock among fisheries

and at Bonneville Dam.  For steelhead, we quantified unmarked hatchery stocks that were present among unclipped steelhead caught in Zone 6.  These data will be combined into a data analysis that includes clipped steelhead that were harvested in Zone 6 and the lower Columbia and will be reported by IDFG (in collaboration with CRITFC and WDFW).

For Objective 4, we used a combination of GSI and PBT to estimate run-timing distributions and relative abundance of hatchery and wild Chinook salmon and steelhead stocks in 2013.  We also combined PIT-tag and genetic analyses to estimate run-timing distributions and abundance of sockeye salmon stocks.  The stock-specific data on abundance and run-timing of these species were used as a context for interpreting harvest stock composition.

Lastly, Pacific lamprey juveniles were collected as mortalities on the screens of turbine units at Lower Granite Dam (LGR) in 2014.  Objective 4 included an analysis to test whether any of the juveniles from the dam could assign to adult lamprey that were translocated in the Snake River basin in the year 2007.  A single individual estimated to be a 7-year-old juvenile was identified as an offspring of translocated adults, and represented our first positive identification to date. These juveniles from the 2014 sample represented a total of 508 effective spawners that contribute to total lamprey production from the entire Snake River Basin.