Chapter 3 – Conservation Genetic Considerations and Donor Stock Suitability

A primary concern in any reintroduction effort is the preservation of genetic fitness of both the donor stock and newly founded population. Genetic information can significantly enhance the proper selection of a source stock (Williams et al. 1988) and may prove valuable in ensuring the likely future success of the founding population. This chapter summarizes the conservation genetic issues that the CRBTWG considered in evaluating the feasibility of reintroducing bull trout into the Clackamas River. This chapter does not address specific reintroduction strategies. However, an overview of possible reintroduction strategies is given in Appendix C. Appendix C summarizes previous bull trout propagation efforts, other bull trout reintroductions within the State of Oregon, and advantages and disadvantages of three possible reintroduction strategies: artificial propagation, captive rearing, and transplantation. This chapter is not intended to be an all-inclusive summary of conservation genetic issues associated with reintroduction efforts, but rather, it touches on some of the key topics that are central to determining the feasibility of undertaking such an effort in the Clackamas River Subbasin. The following questions are addressed in this chapter:

- Is there a genetically suitable donor stock(s) of bull trout for use in the Clackamas River Subbasin?

- What are the potential genetic impacts to the donor stock(s) as a result of lost individuals?

A donor stock should be comprised of fish that most closely resemble the bull trout that historically inhabited the Clackamas River (e.g., genotype, phenotype, behavior, and life history expression). However, because little is known about the biology and evolutionary history of bull trout that historically occupied the Clackamas River, and no genetic material is available for analysis, the CRBTWG was limited to an assessment of biological information from other local populations, existing studies of the evolution and biogeography of bull trout, information derived from historical creel data from the Clackamas River, and from recent regional bull trout genetic analyses. A synthesis of this information will assist in determining the most appropriate donor stock(s) to consider in a reintroduction of bull trout.

3.1 Life History Strategies Likely Used by Clackamas River Bull Trout

Historically, the closest bull trout populations to the Clackamas River would have been above Willamette Falls in the Santiam, McKenzie, and Middle Fork Willamette Basins; the Lewis River Basin downstream from the confluence of the Willamette and Columbia rivers in Washington; or the Hood, Klickitat and Deschutes rivers at the east-end of the Columbia River Gorge. Willamette Falls, located just above the confluence of the Clackamas and Willamette rivers, was a historic barrier to fish migrating upstream in summer and fall (i.e., coho, fall chinook and summer steelhead), but flows in the winter and spring permitted passage of spring chinook, winter steelhead, and likely bull trout. Bull trout populations still exist in the Lewis, Hood, Klickitat and Deschutes river basins, but they have been extirpated from several subbasins in the Willamette River Basin including the North and South Santiam and the Middle Fork Willamette rivers.

Bull trout exhibit both resident and migratory (i.e., fluvial) life-history strategies, as do many other salmonids. Resident bull trout spend their entire life within the stream or tributary within which they spawn and rear. Migratory bull trout spawn in tributary streams where they rear for up to four years, after which they migrate to either a larger river, lake, reservoir, or coastal waters, where they continue to forage for several years until they make a return migration back to the smaller (usually the natal) tributary to spawn (Rieman and McIntyre 1993). Resident fish may range from 150 to 300 millimeters in length while migratory fish may exceed 600 millimeters (Rieman and McIntyre 1993).

Some migratory bull trout populations have exhibited the ability to convert from fluvial to adfluvial life history forms where large dams have formed reservoirs. Examples of bull trout populations that exhibit this behavior from the lower Columbia River tributaries include the South Fork McKenzie River population above Cougar Dam in the Willamette River Basin, the Laurance Lake population above Clear Branch Dam in the Hood River Basin, the Lake Billy Chinook population above Round Butte Dam in the Deschutes River Basin, and the populations in Swift and Yale reservoirs in the Lewis River Basin.

With two exceptions, the Klickitat River Basin and portions of the Deschutes River Basin, no bull trout populations in the lower Columbia River exhibit a resident life history type, nor is there evidence they existed historically. In the Deschutes River Basin, adfluvial and resident bull trout overlap in the Metolius River upstream of Lake Billy Chinook. The dual life history strategy (i.e., migratory and resident) is likely an important part of the life history strategy of bull trout and other salmonids. Such life history diversity as cited in Rieman and McIntyre (1993) is thought to stabilize populations in highly variable environments or to enable refounding segments of populations that have disappeared. A particular life history strategy may dominate under stable conditions, but another life-history strategy may dominate under a changing or unstable environment (Rieman and McIntyre 1993).

Based on the dominant life history characteristics from other lower Columbia River bull trout populations, the CRBTWG believes that the historic bull trout population in the Clackamas River was likely fluvial (i.e., migratory). Historical Clackamas River creel data further confirms this because the relative size and locations of observed bull trout catch is representative of what would be expected for a fluvial population versus a resident population (e.g., large fish observed in medium to large rivers in the subbasin). Furthermore, resident bull trout populations generally reside in headwater areas of river systems that are relatively less impacted by anthropogenic activities that typically impact migratory populations of bull trout such as logging, road building, construction and operation of dams, and over-fishing. If a resident population of bull trout historically existed in the Clackamas River, the CRBTWG expects there to be a higher likelihood it would still be present. However, as discussed in Chapter 1, the possibility of a remnant bull trout population in the Clackamas River has been thoroughly investigated over the last two decades and the CRBTWG has concluded that bull trout are extirpated from the subbasin.

3.2 Spatial Processes

As described in Spruell et al, 2003, bull trout population structure can be divided into at least three major genetically differentiated groups (or lineages) of bull trout. These lineages are depicted in Figure 3.1 and are characterized as: (1) “Coastal,” including the Deschutes River and all of the Columbia River drainage downstream, as well as most coastal streams in Washington, Oregon, and British Columbia; (2) “Snake River,” which includes the John Day, Umatilla, and Walla Walla rivers; and (3) “Upper Columbia River,” which includes the entire basin in Montana and northern Idaho. More detail regarding the three lineages is presented in Appendix D.

Choosing a donor stock, or perhaps multiple stocks, from the “coastal” evolutionary bull trout lineage, which includes populations from the lower Columbia River tributaries including, and downstream of, the Deschutes River, would best preserve and protect the lineage. Based on available genetic and biogeographic information, there is no obvious reason to exclude the possibility of considering any “coastal” bull trout populations for a donor stock, such as populations from the Olympic Peninsula or Puget Sound. However, there is a higher likelihood that bull trout from lower Columbia River tributaries shared genetic material among each other, more so than with other populations north or south of the Columbia River. Nearby bull trout populations would be subject to more similar environmental conditions and likely better adapted to conditions in the Clackamas River Subbasin than more distant populations. The use of bull trout from other lineages (i.e., the upper Columbia or Snake lineages) may undermine the coastal lineage by introducing maladapted fitness traits (i.e., alleles). Any of the coastal lineage local bull trout populations are likely to carry the alleles to preserve and protect the coastal lineage regardless of localized and specific adaptations. Local adaptations confer increased fitness for individuals in a given set of environmental conditions. Although these adaptations are important locally, each of the local populations is likely to contain the evolutionary potential that is characteristic of the coastal evolutionary lineage. This evolutionary potential is important, since it would allow for future adaptations of bull trout specific to the Clackamas River Subbasin.

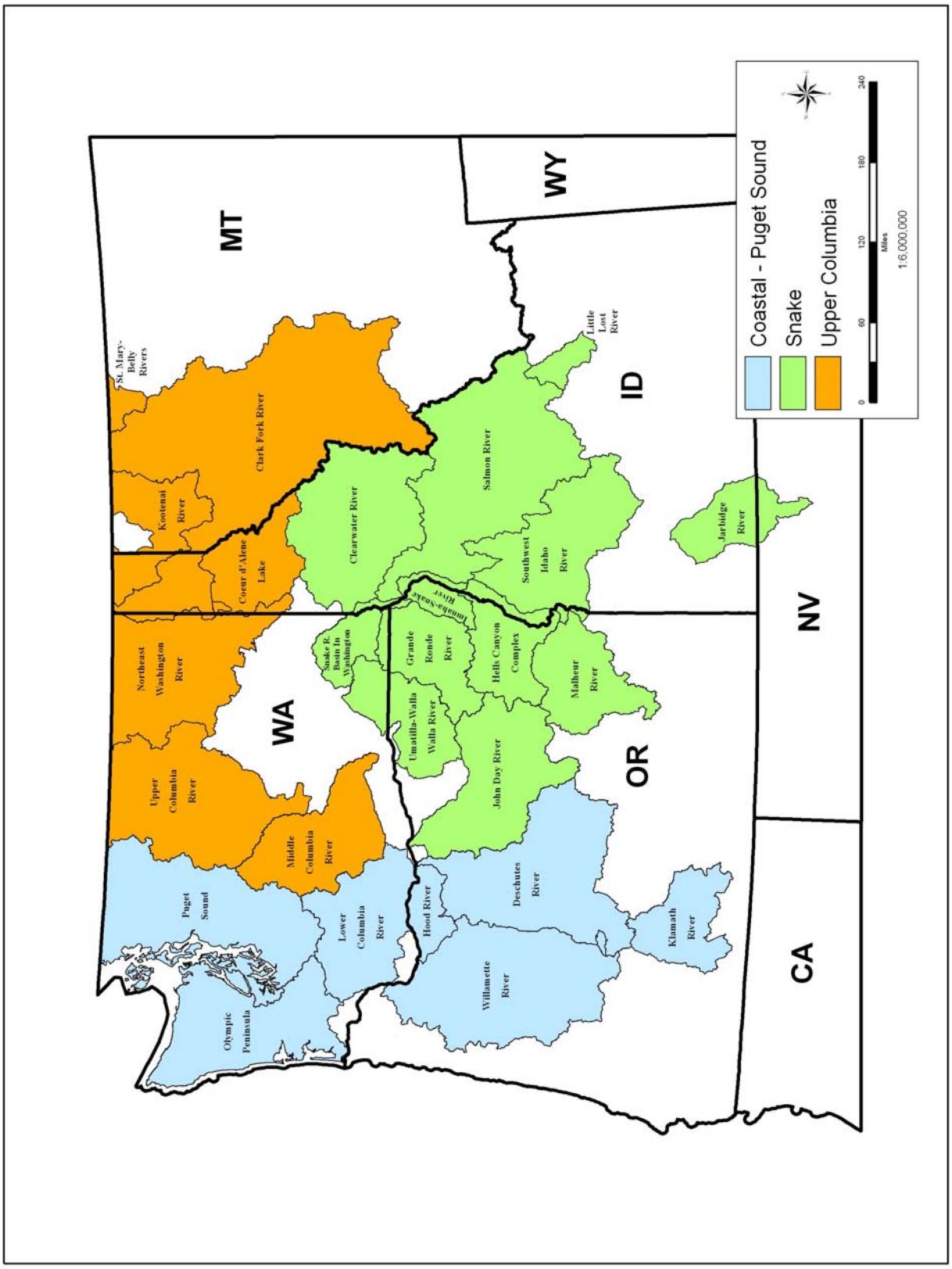

Figure 3.1. Bull Trout Evolutionary Lineages in Oregon, Washington, Idaho, Montana, and Nevada.

The extent to which the lower Columbia River bull trout populations mixed historically is unknown. Aggregations of bull trout populations once may have acted as metapopulations, but may now be too fragmented, depressed, or contracted to be recognized as metapopulations (Whitesel et al. 2004). Bull trout populations are usually connected through low rates of migration and there is evidence of some partially isolated local populations of bull trout that have some degree of gene flow among them (USFWS 2002). Migration and gene flow among local populations ensures that alleles within a metapopulation will be present in most local breeding populations and can be acted upon by natural selection (Allendorf and Leary 1986).

Extant populations in the lower Columbia River included in the "coastal" lineage include bull trout from the Willamette, Lewis, Hood, Klickitat, and Deschutes rivers (Figure 3.2). The dominant life history form of these populations is migratory (fluvial), supporting the CRBTWG's conclusion that the historical bull trout population in the Clackamas River was also fluvial. Although intuitively it seems most appropriate to chose a within-basin donor stock (i.e., Willamette River Basin) for a Clackamas River reintroduction, available information on genetic relationships suggests there are genetic differences among most populations in the lower Columbia River (Spruell et al. 2003), consistent with bull trout throughout their range (Costello et al. 2003; Spruell et al. 2003; Taylor et al. 2001; Whiteley et al. 2003). For example, substantial differentiation has been observed among physically connected habitats in the upper and lower Deschutes River (Spruell 2005), the Clark Fork system (Neraas and Spruell 2001), and the South Fork of the Boise River (Whiteley et al. 2006). Therefore, the historical bull trout population from the Clackamas River may not have been any more closely related to bull trout from the McKenzie River (Willamette River Basin) than to bull trout from the Lewis or Deschutes rivers. From an evolutionary lineage perspective, the best available information suggests no one donor population from lower Columbia River tributaries is better suited than another for a Clackamas River reintroduction. The potential lower Columbia River tributary donor populations of bull trout are depicted in Figure 3.2 and include tributaries of the Willamette, Lewis, Hood, Klickitat, and Deschutes rivers. Each nearby donor stock is located a considerable distance away from the Clackamas River Subbasin and in many cases the presence of migration barriers make natural recolonization highly unlikely. Therefore, a translocation would be necessary in order to reestablish bull trout in the subbasin.

In order to evaluate potential risks to donor stocks, the CRBTWG relied on earlier efforts by the USFWS to provide the necessary background and theoretical basis for describing bull trout evolutionary/genetic theory and maintaining genetic diversity as it relates to long-term persistence of the species. The USFWS's May 2004 publication, "Bull Trout Recovery Planning: A review of the science associated with population structure and size" (Whitesel et al. 2004), contains a synthesis of our current understanding of bull trout conservation genetic issues and is the basis for examining questions associated with the reintroduction feasibility assessment for the Clackamas River Subbasin. Appendix D, Genetic Conservation Considerations, is an excerpt taken from the USFWS's May 2004 publication by Whitesel et al. (2004).

In brief, population structure is often complicated and dynamic. Isolated local populations function autonomously, demographically independent of other local populations. Local populations that are not isolated may exchange genetic material on a regular basis and be structured as part of a larger metapopulation. In addition, relatively large groups of local populations or groups of metapopulations that share an evolutionary trajectory may be structured as evolutionary (or conservation) units. Effective population size is associated with the population unit being considered and has both a temporal and spatial element (Allendorf and Ryman 2002; Waples 2002). When N_e less than 50 for an isolated population, inbreeding depression may be expected to occur over relatively few generations (e.g., 2-5 generations). When N_e less than 500 for an isolated population or single metapopulation, loss of genetic variation due to genetic drift may be expected to occur over tens of generations. When N_e less than 5,000 for an entire species or evolutionary lineage within which some gene flow occurs, loss of evolutionary potential may be expected to occur over hundreds of generations.

Bull trout specific benchmarks have been developed concerning the minimum N_e necessary to maintain genetic variation important for short-term fitness and long-term evolutionary potential. These benchmarks are based on the results of a generalized, age structured, simulation model, VORTEX (Miller and Lacy 1999), used to relate N_e to the number of adult bull trout spawning annually under a range of life histories and environmental conditions (Rieman and Allendorf 2001). In this study, the authors estimated N_e for bull trout to be between 0.5 and 1.0 times the mean number of adults spawning annually. Rieman and Allendorf (2001) concluded that an average of 100 (i.e., 50/0.5 = 100) adults spawning each year would be required to minimize risks of inbreeding in a population and that 1,000 adults (i.e., 500/0.5 = 1,000) are necessary to prevent loss of genetic variation due to genetic drift. This later value of 1,000 spawners may also be reached with a collection of local populations among which gene flow occurs.

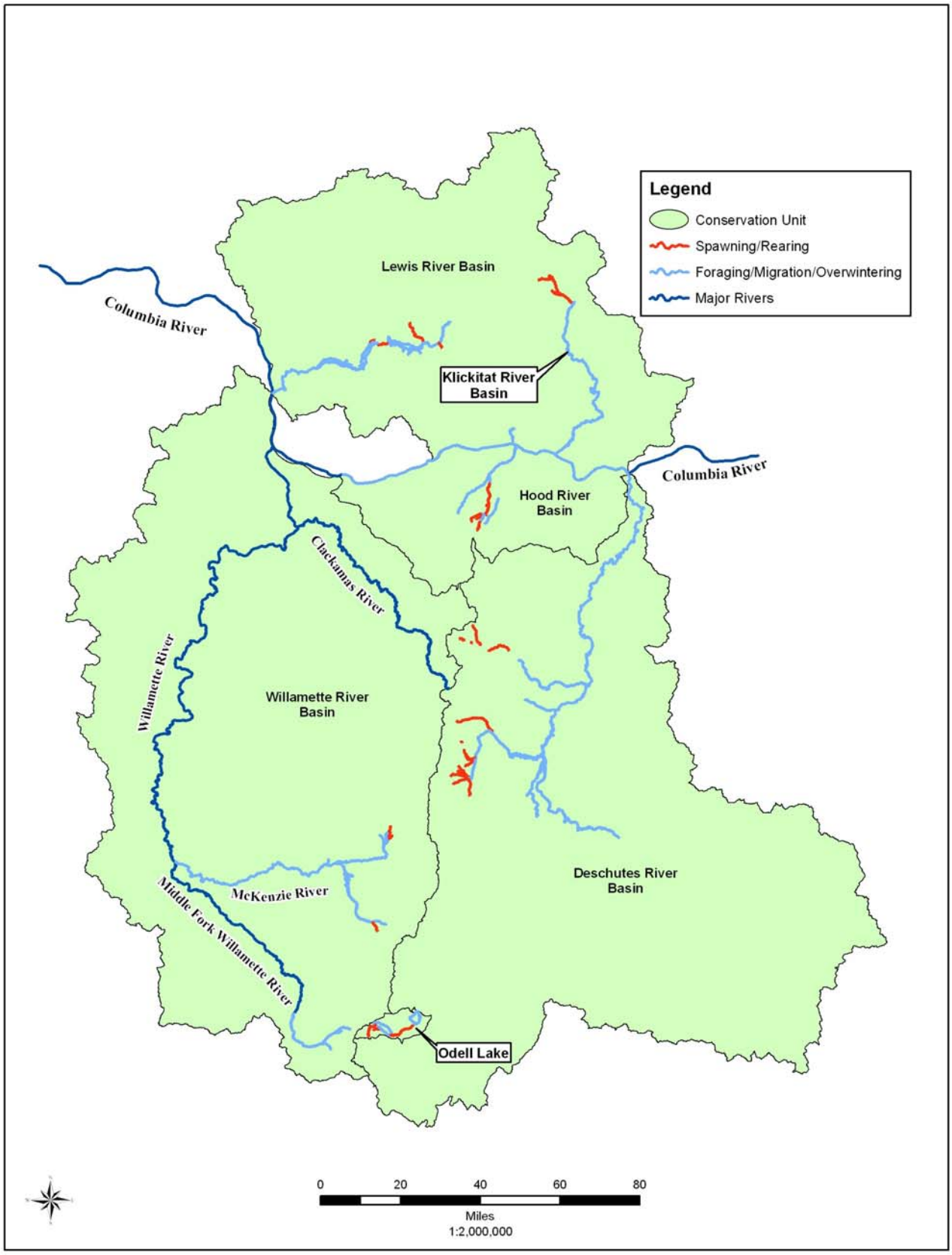

Figure 3.2. Possible Donor Populations for a Potential Reintroduction of Bull Trout to the Clackamas River.

3.3 Synthesis of Potential Donor Populations

This chapter has thus far described several parameters that may be used for the identification of a suitable donor stock of bull trout for reintroduction into the Clackamas River. These parameters can be thought of as "filters" for narrowing the options among available local populations across the species range. By exploring issues associated with life history strategy, metapopulation dynamics, biogeography, and genetic considerations, the CRBTWG has identified bull trout populations in the "coastal" lineage as the most likely source for a donor population (see Section 3.2). Any of the coastal lineage local bull trout populations are likely to carry the alleles to preserve and protect the coastal lineage regardless of localized and specific adaptations. Although these local adaptations are important, each of the local populations is likely to contain the evolutionary potential that is characteristic of the coastal evolutionary lineage. In a further refinement, local donor populations from Lower Columbia River tributaries would be most appropriate (Figure 3.2). The potential Lower Columbia River donor populations of bull trout include fish in five river basins, the Willamette River, Hood River, Lewis River, Deschutes River, Klickitat River basins.

Acknowledging that Lower Columbia River tributaries are the most likely candidates for further consideration, additional refinement includes considerations regarding the 50/500 rule. In order to utilize the 50/500 rule "filter," an up-to-date synthesis of current information on the five potential donor populations was necessary (i.e., population status, abundance, trend, life history strategies, etc.). Appendix E provides a detailed summary of the donor populations being considered in the Lower Columbia River, and it summarizes information down to the local population level in each river basin where that level of detailed information is available. A summary of the detailed information in Appendix E is provided in Table 3.1. In Table 3.1, the best estimate is made for adult abundance of each local population along with a confidence rating for the data available to arrive at that estimate. Additionally, expected heterozygosity (from Spruell et al. 2003), and population trend (2000 to 2005) information are displayed. Table 3.1 presents data and information as it has been collected, and for several local populations data are refined at a much finer scale.

Table 3.1. Summary of Potential Local Donor Populations from Five River Basins in the Lower Columbia River Portion of the Coastal Evolutionary Group.

Local Population Name	Adult Abundance & Data Confidence Rating (A,B,C)*	Expected Heterozygosity (from Spruell et al. 2003)	Population Trend (2000 to 2005)	Comments **
Willamette River Basin (McKenzie River Subbasin) – three local populations				
Mainstem McKenzie River	130 (A)	.183	Slight Decline	Adult abundance estimate based on 3yr. average (2003 to 2005) generated by redd counts at 2.0 fish p/redd. 61 redds observed in 2005 (Anderson Creek, Olallie Creek and mainstem McKenzie River combined).
South Fork McKenzie River – above Cougar Dam	40 (A)	.106	Slight Increase	Adult abundance estimate based on 3yr. average (2003 to 2005) generated from Vaki Riverwatcher, video, & trapping. 35 redds & 50 individual spawners documented in 2005 (Roaring River).
Upper McKenzie River – above Trail Bridge Dam	38 (B)	Unknown	Slight Increase	Adult abundance estimate based on 3yr. average (2003 to 2005) generated by redd counts at 2.0 fish p/redd. 19 redds observed in 2005 (Sweetwater Creek and McKenzie River above Trail Bridge Dam combined). See Table E2 (and footnote) in Appendix E.
Hood River Basin – two local populations				
Clear Branch – upstream of Clear Branch Dam	42 (B)	.238	Slight Increase	Adult abundance estimate based on 3yr. average (2003 to 2005) generated by redd counts at 2.0 fish p/redd. 31 redds observed in 2005 (Pinnacle and Clear Branch creeks combined).
Hood River – downstream of Clear Branch Dam & tributaries	Unknown (C)	Unknown	Unknown	Bull trout detected in very low numbers, limited information and data available at the local population level.
Lewis River Basin – three local populations				
Pine and Rush Creek Local Populations Combined (Swift Reservoir)	996 (B)	.249	Increasing	Adult abundance estimate based on 3yr. average (2002 to 2004) generated by mark/recapture studies in Swift Reservoir. Adult population estimate combines Pine and Rush creek populations. Adult population size estimated at 1,287 individuals in 2004.
Cougar Creek (Yale Reservoir)	107 (B)	.211	Unknown	Adult abundance estimate based on 3yr. average (2003-2005). Counts generated by weekly snorkel counts in Cougar creek (July-Nov.).

Table 3.1 Summary of Potential Local Donor Populations from Five River Basins in the Lower Columbia River Portion of the Coastal Evolutionary Group (continued).

Local Population Name	Adult Abundance & Data Confidence Rating (A,B,C)*	Expected Heterozygosity (from Spruell et al. 2003)	Population Trend (2000 to 2005)	Comments**
Lower Deschutes River Basin – two local populations				
Warm Springs River	100 to 150 (A)	.256	Stable – but significant 2005 decline in redd #s.	Adult abundance estimate generated by redd counts, weir trapping & video. Though 5-year trend is stable, the 2005 redd count (n=56) was the lowest since surveys began in 1998. CTWSR biologists estimate the current adult population to be approximately 100 to 150 individuals.
Shitike Creek	200 to 250 (A)	.082	Stable – but significant 2005 decline in redd #s.	Adult abundance estimate generated by redd counts, weir trapping & video. Though 5-year trend is stable, the 2005 redd count (n=27) was the lowest since surveys began in 1998. Video recorded 238 adult fish entering Shitike Creek March-September 2005. However, 100 were recorded moving out of Shitike Creek prior to spawning perhaps due to artificial passage barriers) The 2005 redd count represents a decline of 86.8% from the 2002 high of 204 redds
Lower Deschutes River Basin (Metolius River Subbasin) – three interacting local populations				
Whitewater River	50 (B)	.106	Unknown	Whitewater Creek was not surveyed for redds in 2005 due to poor water clarity during spawning season. Last accurate redd counts occurred in 1998 (n=14) and 1999 (n=30). CTWSR biologists estimate the current adult population to be approximately 50 individuals.
Jefferson, Candle, and Abbot River Complex Jefferson Creek	299 (A)	.207	Increasing	Adult abundance estimate based on 5yr. average (2001 to 2005) generated by redd counts (2.3 fish p/redd). 92 redds were observed in 2005.
Candle Creek	340 (A)	Unknown	Increasing	Adult abundance estimate for Candle Creek based on 5yr. average (2001-2005) generated by redds counts (2.3 fish p/redd). 124 redds were observed in 2005.
Canyon, Jack, Heising, and Mainstem Metolius River Complex Canyon Creek	374 (A)	Unknown	Increasing	Adult abundance estimate based on 5yr. average (2001 to 2005) generated by redd counts (2.3 fish p/redd). 146 redds were observed in 2005.
Roaring Creek	318 (A)	Unknown	Increasing	Adult abundance estimate based on 5yr. average (2001 to 2005) generated by redd counts (2.3 fish p/redd). 196 redds were observed in 2005.
Jack Creek	508 (A)	.158	Increasing	Adult abundance estimate based on 5yr. average (2001 to 2005) generated by redd counts (2.3 fish p/redd). 221 redds were observed in 2005.
Heising Cr./Spring	86 (A)	Unknown	Increasing	Adult abundance estimate based on 5yr. average (2001 to 2005) generated by redd counts (2.3 fish p/redd). 65 redds were observed in 2005.
Metolius River mainstem	34 (A)	Unknown	Stable	Adult abundance estimate based on 5yr. average (2001 to 2005) generated by redd counts (2.3 fish p/redd). 22 redds were observed in 2005.

Table 3.1 Summary of Potential Local Donor Populations from Five River Basins in the Lower Columbia River Portion of the Coastal Evolutionary Group (continued).

Local Population Name	Adult Abundance & Data Confidence Rating (A,B,C)*	Expected Heterozygosity (from Spruell et al. 2003)	Population Trend (2000 to 2005)	Comments**
Klickitat River Basin				
West Fork Klickitat River	Unknown (C)	Unknown	Unknown	Little data currently available. Bull trout juveniles have been observed in the West Fork of the Klickitat River as recently as 2001. Bull trout in the Klickitat Basin may exhibit resident behavior, rather than fluvial.

* A =High Confidence (comprehensive redd counts, weir/screw trap counts on spawning tributaries, use of PIT tagging, video and/or VAKI fish counters).

B = Moderate Confidence (redd counts on index reaches, mark/recapture studies, some extrapolation of data to reach estimated abundance.

C = Low Confidence (very little survey data or redd counts, few observations of adult fish, little or no documented spawning.

** Where possible, adult abundance estimates were generated from redd counts utilizing established fish per redd ratios (i.e., South Fork McKenzie and Metolius bull trout populations). However, if fish per redd data were not available, then a default of 2.0 fish per redd was used (Hood River, mainstem McKenzie River and Trail Bridge bull trout populations).

Although adult abundance is useful in examining population status, N_e is a more informative metric to consider. Recall from section 3.2 and Appendix D, the best estimate of N_e for most bull trout populations is thought to be between 0.5 and 1.0 times the mean number of adults returning to spawn (Rieman and Allendorf 2001). This correlates to adult spawning abundances of 100 and 1,000 (using the more conservative value of $N_e/0.5$). Thus, one hundred spawning adults are needed to reduce the risks of inbreeding and 1,000 spawning adults are needed to maintain genetic variation (i.e., reduce genetic drift). Unfortunately, little information exists to accurately determine N_e for Lower Columbia River bull trout populations. The best available information (i.e., spawning adult abundance as a function of redd count data) and how population abundances were determined is displayed in the comments column of Table 3.1.

The CRBTWG evaluated each local population and groups of interacting local populations of bull trout within the five river basins in the Lower Columbia River as a potential donor based on current status and trend (Table 3.1). Bull trout from two of the five river basins, Lewis River and Deschutes River, contain groups of interacting local populations that meet or exceed abundance criteria (approximately 1,000 spawning adults, see Table 3.1) and would confer a low level of genetic risk due to reduced effective population size (Ne). For the Lewis River Basin, this includes the combined Pine Creek and Rush Creek local populations that occur above Swift Dam. For the Deschutes River Basin, this includes the three interacting local populations present in the Metolius River Subbasin.

In a local population or group of interacting local populations that contain a total spawner abundance in excess of 1,000 individuals, there is lower "genetic" risk (i.e., loss of unique alleles or reduction in heterozygosity to the donor population) associated with removal of an appropriate number of individuals. In the case of the Pine Creek and Rush Creek local populations in the Lewis River Basin, this low risk assumes that the donor population is able to maintain its current abundance while serving as a donor stock. The Pine Creek and Rush Creek local populations display an abundance trend with a positive trajectory since 1994, increasing the CRBTWG's confidence in the genetically low risk ranking for these two combined local populations. Furthermore, the expected heterozygosities observed in bull trout samples from the Lewis River Basin are comparable to values observed for bull trout elsewhere (Neraas & Spruell 2004, Spruell et al. 2003). That is, there are relatively low levels of intrapopulation variation, but high levels of interpopulation variation. In particular, the expected heterozygosity for the combined Pine Creek and Rush Creek local populations was found to be 0.249 (see Table 3.1) (Spruell et al. 2003) and in a more recent study, 0.330 (Neraas & Spruell 2004). For the loci examined, the expected heterozygosity is the highest of all the lower Columbia River tributaries for which there is data available. Although bull trout sampled from two different local populations, Pine Creek and Rush Creek, show differentiation (Fst = 0.188, Neraas & Spruell 2004), this level of discreteness is not unexpected given that Pine Creek experienced significant mudflows during the eruption of Mt. St. Helens in 1980. Bull trout in Pine creek likely experienced a severe genetic bottleneck due to extremely low numbers of individuals (i.e., the founder effect). In a population structure estimate using the program STRUCTURE, 11 to 18.5 percent of individuals were assigned to the opposite creek (i.e., bull trout collected in Pine Creek were assigned/grouped to individuals in Rush Creek and the converse) (Nerass & Spruell 2004). Even after this catastrophic event, the expected heterozygosity of bull trout sampled from Pine and Rush creeks were 0.277 and 0.240, respectively, and are still among the most genetically diverse and resilient local populations of bull trout in the Lower Columbia River Basin.

Having information regarding potential gene flow (i.e., migration and exchange of alleles between local populations) can significantly alter how to view the level of genetic risk associated with serving as a donor. Table 3.1, divides the Deschutes River Basin into Lower Deschutes River Basin and Lower Deschutes River Basin (Metolius Subbasin). The Metolius River Subbasin contains three interacting local populations, for which there is likely gene flow between these local populations given their close geographic proximity. Because bull trout typically display low levels of intrapopulation variation there is reason to expect that there is gene flow among the three Metolius River Subbasin local populations. As part of a larger study of Metolius River bull trout (Ratliff et al. 1996), a radio-tagging effort was implemented that revealed information regarding spawning fidelity. Of 127 recaptures of spawning adults tagged during previous spawning migrations, eight bull trout were documented changing spawning tributaries. Although spawning tributary fidelity was not the goal of the study, the results suggest that at least six percent of bull trout strayed during the study period (1993-1994). This straying provides additional support that there is gene flow among the three bull trout local populations in the Metolius River Subbasin even in the presence of high natal stream fidelity.

For the above reasons, it is likely the metapopulation dynamics of the Metolius River Subbasin bull trout result in an adult abundance value that is a combination of all three local populations (i.e., adult abundance of approximately 2,009 adults). Because there is likely significant connectivity among the Metolius River Subbasin local populations, the reproducing adult abundance value (higher than any other in the coastal lineage) suggests that the Metolius River Subbasin bull trout are the least "at risk" of the potential donors and would likely serve as an acceptable donor stock with a very low chance of adverse impacts genetically. To verify this conclusion, the USFWS along with other partners are implementing a study that will characterize the genetic discreteness of each of the Metolius River Subbasin local populations of bull trout. Study results are expected in the winter of 2007.

The majority of local populations examined for use as potential donor stock have a higher risk of reduced genetic fitness associated with the removal of individuals. Within these higher risk local populations there is a higher level of concern in regard to negatively impacting the genetic fitness of the donor population and there is greater uncertainty in regard to whether enough donors would be available to confer long-term persistence for the newly founded population in the Clackamas River (i.e., loss of fitness through inbreeding depression/founder effects). Local populations included in this higher risk category include: South Fork McKenzie River, Upper McKenzie River, Clear Branch, Hood River, Cougar Creek, and West Fork Klickitat River. Many of the potential local populations currently have a high level of risk for reduced genetic fitness and fail to meet the minimum criteria necessary to preclude the immediate negative effects of inbreeding depression (i.e., less than 100 spawning adults derived from the 50/500 rule).

As expected, there are also potential local populations that are intermediate to the low and high risk populations. Local populations included in this intermediate risk category include: Mainstem McKenzie River, Warm Springs River, and Shitike Creek. These local populations have adult abundance levels between 100 and 1,000. These intermediate-risk potential local populations require further consideration as there is much variability within the category. For example, the Mainstem McKenzie River Local Population is estimated at approximately 130 spawning adults, which is more than the 100 adult criteria that may be considered at an elevated risk for experiencing accelerated rates of inbreeding depression or loss of diversity as the result of removing individuals. On the other hand, the Shitike Creek Local Population is larger and estimated between 200 and 250 adults. In contrast, the Shitike Creek Local Population would be less likely to experience the loss of unique alleles or experience a reduction in heterozygosity as a result of removing a discrete number of individuals. There is a gradient of risk associated with each local population of bull trout that fall in the adult abundance category of 100 to 1,000 individuals, with risk decreasing as adult abundance approaches 1,000 individuals.

It is also important to consider factors other than reproducing adult abundance (100/1,000) or other surrogates of N_e. Adult abundance trends or trajectories observed for local populations are an important consideration. Keeping with the example above, the Mainstem McKenzie River Mainstem Local Population has been experiencing a slightly downward trend over the past five years. Trends in abundance help further refine the level of risk associated with use of a local population or groups of interacting local populations as a donor stock. Information regarding risk can also be informed by examining the expected levels of heterozygosity for each local population (Spruell et al. 2003) found in Table 3.1, or by other metrics such as F_{st} which is the reduction in heterozygosity of a local population due to genetic drift (Hartl 1988) and can be used as an indicator of relative levels of gene flow. This information can provide insight regarding the dynamics or interactions between local populations.

3.4 Summary and Conclusions

After considering the information regarding the evolutionary lineage of bull trout, current demographic trends, connectivity, potential for gene flow, and expected levels of heterozygosity within bull trout local populations, two river basins contain interacting local populations that likely contain the necessary characteristics and associated low level of risk (both demographically and genetically) to serve as donor stocks for a reintroduction into the Clackamas River. The purpose of this chapter is not to rank potential donor stocks for reintroduction into Clackamas River, but rather, highlight the theoretical basis and current synthesis of information in such a manner to identify relative levels of risk to each donor.

The two river basins containing local populations that likely have the lowest level of genetic risk (i.e., loss of unique alleles or reduction in heterozygosity) associated with serving as donors include bull trout from the Lewis River Basin (Pine Creek and Rush Creek local populations) and the Lower Deschutes River Basin, Metolius River Subbasin (Whitewater River; Jefferson, Candle, and Abbot River Complex; and Canyon, Jack, Heising, and Mainstem Metolius River Complex local populations). It is important to note that the Metolius River Subbasin local populations are considered at low risk for detrimental genetic effects only if they are grouped together, which appears to be appropriate as described in Section 3.4. As such, any efforts utilizing Metolius River Subbasin bull trout as a donor stock must include a carefully crafted implementation strategy that does not place a disproportionate amount of pressure (i.e., extraction) on a single local population. If a reintroduction effort into the Clackamas River is pursued, these options will need to be further evaluated depending on the specific strategy of implementation.

In addition to the low risk potential donor populations, the synthesis provided herein also suggests there are local populations of bull trout in the costal lineage that have an elevated level of risk associated with serving as donor stocks. At intermediate level of risk for harmful genetic drift are the following local populations: Mainstem McKenzie River, Warm Springs River, and Shitike Creek. At higher risk, and likely not suitable for serving as donor stocks include the following local populations: South Fork McKenzie River, Upper McKenzie River, Clear Branch, Hood River, Cougar Creek, and West Fork Klickitat River. Not only might there be an elevated level of concern in regard to negatively impacting the genetic fitness of these higher risk local populations, but it is likely that not enough individuals would be available to confer long-term persistence for the newly founded local population in the Clackamas River.