Chapter 4 – Ecological Interactions and Food Web Considerations

Chapter 4 considers food web dynamics and important ecological interactions in the Clackamas River Subbasin, and how these may relate to the reintroduction of bull trout. The key questions addressed in this chapter include:

- What are the potential interactions between bull trout and nonnative brook trout and their implications for reintroduction of bull trout into the Clackamas River?
- What are the potential interactions between bull trout and other native fish species present in the Clackamas River?
- What is the nature of the prey base in the Clackamas River that would be needed to support a bull trout reintroduction?
- What are the fish diseases and pathogens of concern regarding a translocation of bull trout from one or more potential donor stocks into the Clackamas River?

4.1 Potential Interactions Between Bull Trout and Nonnative Brook Trout and Implications to a Reintroduction of Bull Trout in the Clackamas River

Brook trout (*Salvelinus fontinalis*), a char native to eastern North America, have been introduced in cold water streams and lakes throughout western North America (MacCrimmon and Campbell 1969; Meehan and Bjornn 1991) and they have successfully invaded many waters beyond where they were intentionally stocked. The majority of these introductions were intended to provide recreational fisheries (Dunham et al. 2004), especially in high mountain lakes previously devoid of fish, many with outlets to downstream environments inhabited by native trout. A growing body of evidence suggests nonnative trout can substantially change aquatic ecosystems wherever they are present (Simon and Townsend 2003) as well as threaten native fish through competition, predation and hybridization. However, the popularity of recreational fisheries, and the difficulty of eradicating established populations of nonnative species, suggests nonnative trout will remain in many aquatic ecosystems into the foreseeable future (Dunham et al. 2004).

Brook trout are widespread throughout the native range of bull trout and are considered an important threat to the persistence of bull trout (Rieman et al. 1997). The influence of nonnative brook trout on bull trout may depend in part on local habitat features. Rich et al. (2003) examined the influence of habitat features on the distribution and co-occurrence of nonnative brook trout and bull trout. The study suggested that bull trout and brook trout may partition themselves naturally based on habitat type and stream temperature, and that bull trout may be more susceptible to brook trout invasion in small, low-gradient streams where brook trout may have a competitive advantage (Nagel 1991; Paul and Post 2001). Brook trout appear to adapt better to degraded habitats and higher water temperatures than bull trout (Clancy 1993, Dunsmoor 1997, Rich 1996). Yet in areas of clean, cold water with complex habitat, bull trout may successfully compete with brook trout (Paul and Post 2001; Dunham and Rieman 1999; Dunham et al. 1999).

Hybridization is most common where isolated or remnant bull trout populations overlap with brook trout (Cavender 1978; Leary et al. 1983, 1991; Markle 1992). Small resident populations are particularly susceptible to hybridization from co-occurring brook trout because individuals of spawning age are similar in size, and both spawn in the fall and utilize similar spawning habitat.

Stocking of nonnative brook trout for recreational angling began in the Clackamas River in the early 1900s, and continues today in high elevation lakes. Over time, some lakes have developed naturally reproducing populations of brook trout while others require regular stocking. Past stocking in lakes with outlet streams has resulted in self-sustaining populations of brook trout in some streams in the Clackamas River Subbasin.

Specific Areas of Concern with Brook Trout Present

Stream surveys and biological inventories completed by USFS fish biologists over the last two decades provide a reliable source for documenting observations of brook trout in particular river segments and streams. However, little to no quantitative data exists to characterize their abundance relative to that of native species. Given the lack of systematic, quantitative surveys for brook trout, the CRBTWG was only able to map brook trout presence by identifying the river and stream segments where they have been observed (Figure 4.1). Brook trout have been observed in one of the six patches containing suitable bull trout spawning and rearing habitat; Patch 3 Upper Clackamas River (above Cub Creek). Within Patch 3, brook trout have been observed in Squirrel and Ollalie creeks, and in the upper Clackamas River above its confluence with Squirrel Creek, representing approximately six of the 20 miles (30 percent) of suitable bull trout spawning and rearing habitat in this patch. This corresponds to less than 10 percent of the total available bull trout spawning and rearing habitat in the six habitat patches identified in Chapter 2.

Brook trout originated in the river segments and streams shown in Figure 4.1 from historic stocking in headwater, mountain lakes with tributary outlets. Brook trout were repeatedly stocked over many decades by ODFW in various lakes throughout the Ollalie Lakes complex and in other lakes that feed Ollalie and Squirrel creeks. Beginning in 2003, a coordinated effort was begun between ODFW and the USFS that led to a discontinuation of stocking brook trout into lakes with tributary outlets to the upper Clackamas River and its tributaries containing suitable bull trout spawning and rearing habitat.

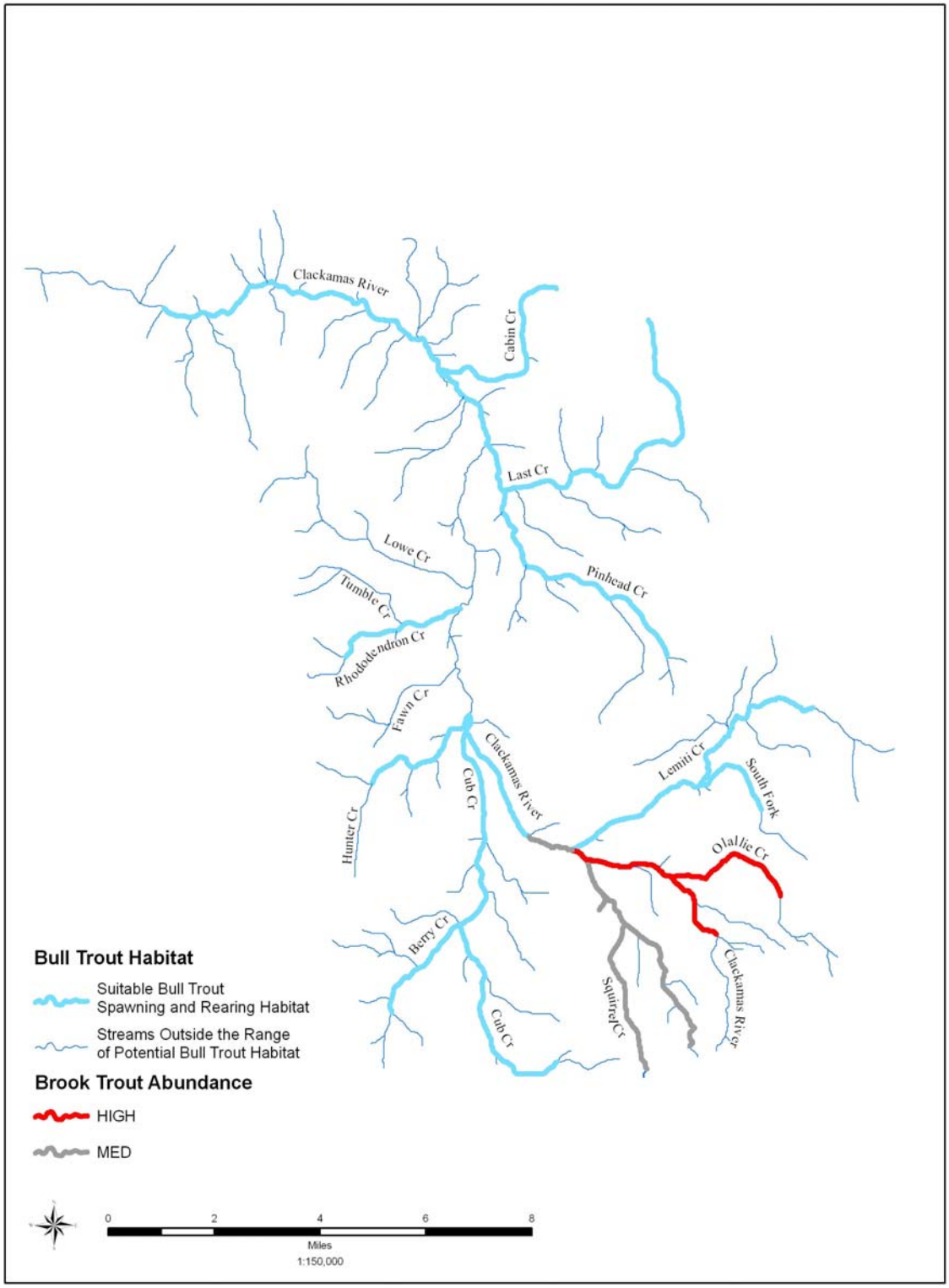

Figure 4.1. Brook Trout Presence in the Upper Clackamas River Subbasin.

4.2 Adequacy of Prey Base to Support a Reintroduced Bull Trout Population

Bull trout are opportunistic feeders and if reintroduced into the Clackamas River would likely prey on a variety of native and nonnative fish species. In many locations, mountain whitefish (*Prosopium williamsoni*) are a preferred bull trout prey species and in the Clackamas River watershed adult mountain whitefish are commonly found in large pool habitats of the Clackamas and Collawash rivers (Murtagh et al. 1992, Ratliff 2003, Beauchamp and Van Tassel 2001, Pratt 1992, Bergamini 2005). Largescale sucker (*Catostomus macrocheilus*) is also common in larger pool habitats in this watershed (Bergamini 2005). Large numbers of anadromous salmonids rear as pre-smolts in the upper Clackamas River. The five year average for smolt outmigrants annually passing North Fork Dam (all anadromous species 2001-2005) was 139,152 smolts (PGE 2001, 2002, 2003, 2004, 2005). Older juvenile and adult bull trout would be expected to prey upon rearing juvenile anadromous salmonids. Resident coastal cutthroat trout (*Oncorhynchus clarki clarki*), sculpin (genus *Cottus),* and a diverse assemblage of aquatic macroinvertebrates are found in abundance in many of the smaller tributary streams within the Clackamas River Subbasin and also would likely be preyed upon by bull trout.

Fish Species Found in the Clackamas River

If reintroduced, bull trout would add to the already highly diverse assemblage of fish species, native and nonnative, found in the Clackamas River Subbasin. The Clackamas River supports naturally reproducing populations of early and late-run stocks of coho salmon (*O. kisutch*), spring Chinook salmon (*O. tshawytscha*), and winter steelhead (*O. mykiss*), all of which are federally listed as threatened under the ESA. A small, remnant run of fall Chinook salmon utilize the lower Clackamas River and a small population of sea-run coastal cutthroat trout also persists in this part of the subbasin. The upper subbasin, above PGE's North Fork Dam, is managed as a wild fish sanctuary and all anadromous salmonids identified as hatchery origin (i.e., those that are adipose fin clipped), are captured at the North Fork Dam fish trap and prevented from migrating past the dam. Pacific lamprey (*Lampetra tridentata*) also occur upstream of North Fork Dam.

Downstream of North Fork Dam, hatchery produced spring Chinook, coho, and winter and summer steelhead are released each year at a number of locations. Other fish species present throughout the subbasin include resident and fluvial cutthroat trout, rainbow trout, mountain whitefish, largescale sucker, Pacific lamprey, sculpin, mountain sucker (*C. platyrhynchus*), longnose dace (*Rhinichthys cataractae*), western brook lamprey (*L. richardsoni*), northern pikeminnow (*Pytchocheilus oregonensis*), chisel mouth (*Acrocheilus alutaceus*), redside shiner (*Richardsonius balteatus*), threespine stickleback (*Gasterosteus aculeatus*), and peamouth (*Mylocheilus caurinus*). Introduced exotic fish species, such as bluegill (*Lepomis macrochirus*), pumpkinseed (*L. gibbosus*), brown bullhead (*Ameiurus nebulosus*), American shad (*Alosa sapidissima*), smallmouth bass (*Micropterus dolomieu*) and other species are encountered in some habitats in the lower watershed below Rivermill Dam (Murtagh et al. 1992).

Recovery of Anadromous Species in the Upper Clackamas River Subbasin During the Early 1900s After the Rebuilding of Cazadero Fish Ladder

Salmon and steelhead populations in the Clackamas River declined dramatically in the early 1900s as a result of intense pressure from commercial fisheries, egg-taking practices for hatchery supplementation, and hydropower development. The most significant declines resulted from failure of the fish ladder at Cazadero Dam in 1917, which resulted in a complete blockage of passage into the upper portion of the subbasin. The original fish ladder at Cazadero partially functioned to pass fish from 1905 to 1917, although it was racked by local hatchery managers for egg-taking purposes. Most of the egg-taking focused on Chinook, and it is not clear from records and documentation whether coho and steelhead were allowed to pass. It is possible that few, if any, fish passed into the upper Clackamas River Subbasin between 1905 and 1917, and there was no passage from 1917 to 1939 (Cramer and Cramer 1994).

In 1939, the fish ladders at Cazadero and Rivermill dams were re-built, restoring passage to historic spawning and rearing areas in the upper subbasin (Taylor 1999). Restoration of passage, combined with reductions in egg-taking for hatchery production, greatly increased the number of adult salmon and steelhead that successfully reached natural spawning habitat in the upper subbasin. Cazadero Dam failed in January 1965 and was rebuilt later in the year and renamed Faraday Diversion Dam (Cramer and Cramer 1994).

PGE constructed the North Fork Dam along with the 1.7 mile long North Fork fishway in 1958. The fishway allows fish to migrate past both the Faraday Diversion Dam and North Fork Dam. At North Fork Dam, downstream migrants are diverted into a juvenile bypass pipeline that provides passage around the North Fork, Faraday, and Rivermill dams. Downstream migrants that are not diverted into the bypass pipeline must pass through turbines or over the spillways at the dams. The construction of North Fork Dam and the associated fish ladder and downstream migrant pipeline substantially increased anadromous fish production in the upper portion of the subbasin (Cramer and Cramer 1994).

Despite modifications to hatchery operations and improvements implemented at the mainstem hydroelectric dams, a large amount of land development in the lower Clackamas and Willamette rivers began in the 1940s and is thought to have limited the recovery of anadromous fish due to habitat degradation. Increases in road construction and development in the upper portion of the subbasin also occurred during this timeframe, and also reduced the amount and quality of spawning and rearing habitat available. Development of new roads into the upper subbasin was coupled with large increases in the harvesting of timber. By 1954, timber harvest occurred on more than 29 percent of the upper subbasin and, combined with other development activities, reduced the quality and quantity of fish habitat (Taylor 1999).

By the 1950s, anadromous salmonid runs began to rebuild primarily through natural production in the upper subbasin. Coho salmon and steelhead recovered more quickly than spring Chinook since they were not the focus of hatchery production and had more opportunity to utilize habitat in the lower subbasin below hatchery egg racks and hydroelectric dams. The USFWS operated a fish trap at the exit of Rivermill Fish Ladder for five years beginning in 1950 and documented the improving fish runs (Taylor 1999). During the five-year period, coho counts numbered 416, 741, 1,378, 1,122, and 1,155, respectively; steelhead counts numbered 1,484, 1,954, 1,559, 1,616, and 950, respectively; and Chinook counts numbered 366, 496, 668, 533, and 407, respectively (Taylor 1999). Figure 4.2 shows counts of winter and summer steelhead from the period of 1963 through 2005. Figure 4.3 shows counts of spring Chinook and coho from the period of 1950 through 2005.

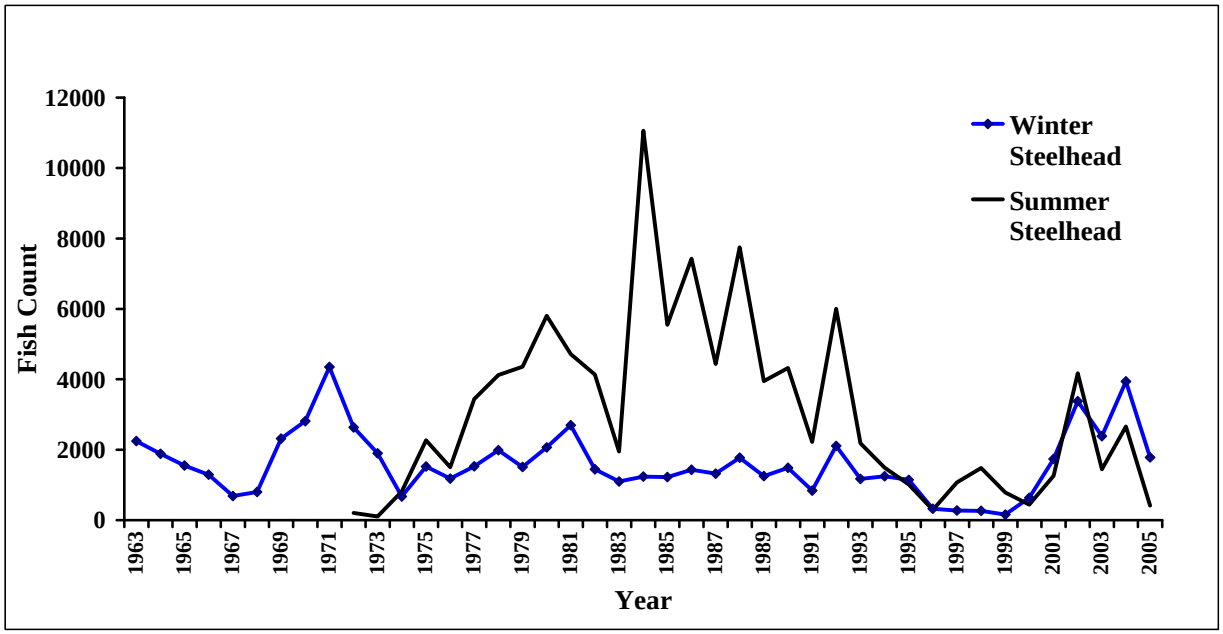

Figure 4.2. Adult Steelhead Fish Counts at North Fork Fish Ladder from 1963 to 2005. [Winter steelhead were counted by run year from November to October, and summer steelhead are counted by calendar year. Summer steelhead were not counted prior to 1972, since they were introduced in 1970.]

Winter Steelhead

The number of adult winter steelhead passing North Fork Dam peaked in the early 1970s with 4,349 fish passing in 1971. Winter steelhead numbers declined between 1971 and 1999 with a low of 156 winter steelhead passing in 1999. The dramatic decline in returning adults is likely due to a combination of harvest and freshwater habitat-related impacts combined with extremely poor ocean survival. Recent returns have rebounded in part due to protections afforded by the ESA listing of steelhead in 1998. Improved ocean survival also played a role in the increase of adult winter steelhead that passed North Fork Dam since 1999. Over the past five years, an average of 1,187 winter steelhead passed North Fork Dam with a maximum of 2,073 fish passing in 2004. Despite recent gains between 2001 and 2005, only 429 wild winter steelhead were seen at the North Fork fish trap in 2006.

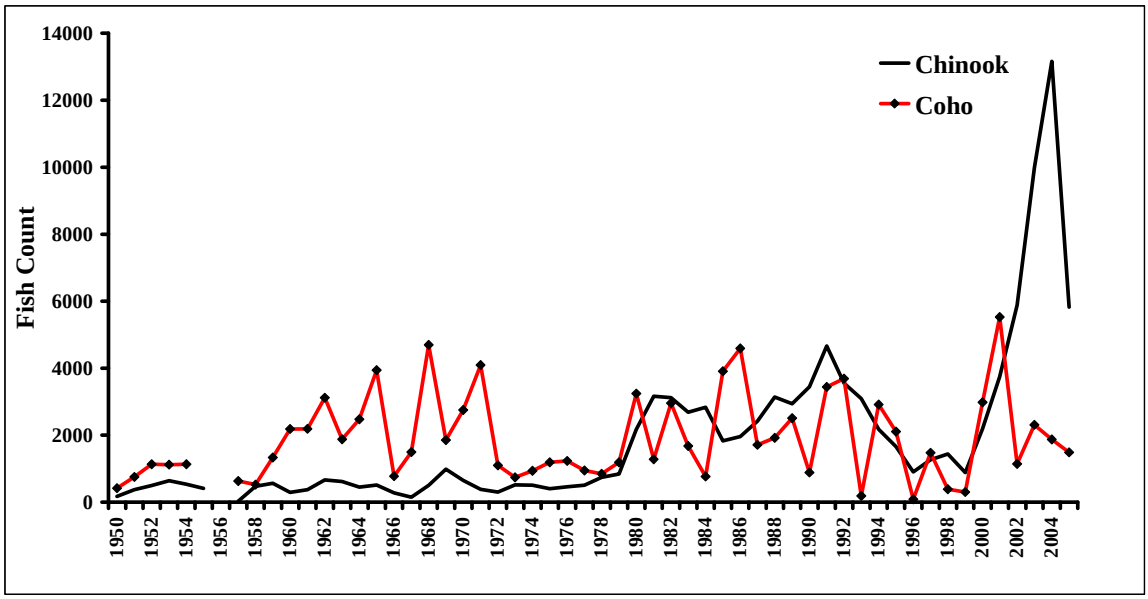

Figure 4.3. Adult Spring Chinook and Coho Fish Counts at North Fork Fish Ladder from 1950 to 2005. [Spring Chinook runs for each year are counted from August to July; coho are counted from March to April. No data available for 1956.]

Spring Chinook

Spring Chinook did not recover for a number of years after passage was restored to the upper Clackamas River Subbasin. Between 1950 and 1979, the number of spring Chinook passing North Fork Dam averaged 393 fish, with a low count of 25 adults in 1957 and a high count of 909 adults in 1969. The low escapement of spring Chinook was likely due to a number of reasons, including intense harvest pressure from commercial and sport fisheries, hatchery egg-taking procedures, degradation of habitat, and poor out-migrant survival.

Adult spring Chinook escapement began to increase substantially after 1980, when the first adult returns from the present-day Clackamas River fish hatchery returned to the subbasin. In 1980, the combination of hatchery and wild spring Chinook adults passing North Fork Dam was 2,188 fish. Hatchery and wild fish could not be distinguished from one another until 2002 due to the lack of external marking on all hatchery produced fish. Combined returns of hatchery and wild spring Chinook counted at North Fork Dam between 1980 and 2001 averaged 2,437 fish, with a low count of 888 adults in 1996 and a high count of 4,584 adults in 1991. Between 2002 and 2005, the number of wild spring Chinook averaged 3,447 fish, with a low count of 2,170 adults in 2002 and a high count of 5,236 adults in 2004. During the same time period, the number of hatchery origin spring Chinook counted at North Fork Dam averaged 5,088 fish, with a low count in 2005 and a high count in 2004.

Coho Salmon

Two separate stocks of coho salmon occur in the Clackamas River Subbasin. The early-run stock is present throughout the subbasin and is likely descended from hatchery releases primarily from the Eagle Creek National Fish Hatchery. The early-run stock spawns from October through November. Early-run coho juveniles or adults have not been released in the Clackamas River above North Fork Dam since 1980 and 1972, respectively (Murtagh 1992). The late-run, or wild stock, is separated spatially and temporally from the early-run stock. The late-run stock spawns in the upper portion of the subbasin above North Fork Reservoir from December through March.

The number of coho adults passing North Fork Dam from 1950 through 1958 averaged about 1,100 fish. Coho counts at North Fork Dam increased to an average of 2,088 adults after production from the Eagle Creek National Fish Hatchery began to return to the subbasin. The number of returning coho has been highly variable over the past 50 years, averaging 1,889 adults with a low count of 87 adults in 1996 and a high count of 5,530 adults in 2001. Adult coho counts reached an extremely low level in the late-1990s due to poor ocean survival combined with harvest effects from the commercial and sport fisheries. However, adult coho counts rebounded by 2001, reaching the highest recorded. One major change has been a shift in the overall contribution of the two coho stocks. The late-run coho stock used to be the stronger of the two stocks, dominating the overall returns. However, the early-run stock presently comprises a greater proportion of the overall return. It is believed the early-run stock takes advantage of an expanded spawning distribution in the Big Bottom area resulting from warmer water temperatures throughout the upper subbasin during mid-fall months.

Fall Chinook

Historically, the Clackamas River is believed to have had a substantial run of fall Chinook salmon (Fulton 1968). There are limited references to fall Chinook likely due to the overwhelming importance of spring Chinook salmon in the subbasin and confusion over identification of fall versus spring Chinook at hatcheries and counting stations (Murtagh 1992).

Fall Chinook are known to have spawned above the town of Estacada prior to development of the North Fork Hydroelectric Project (Fulton 1968). The impacts from loss of upstream fish passage at Cazadero Dam in the early 1900s, combined with extensive harvest in lower Columbia and Clackamas river terminal fisheries, likely reduced the fall Chinook population to very low numbers. Native fall Chinook in the Clackamas River Subbasin were likely extirpated during this time period but have since been replaced with a “tule” stock, first released in the subbasin in 1952 (Murtagh 1992). Currently, it is estimated that between 300 and 600 “tule” fall Chinook naturally reproduce in the lower subbasin below Rivermill Dam.

Cutthroat Trout

Very little is known about the status and life history of sea-run cutthroat trout in the Clackamas River Subbasin (Murtagh 1992). There is limited evidence of sea-run cutthroat trout passing upstream at Rivermill or North Fork dams according to historic documentation and trap counts by PGE staff. However, there is some evidence of sea-run cutthroat trout presence in tributaries to the lower subbbasin, based on smolt trap monitoring of Clear, Deep, and Eagle creeks by the USFS. Unfortunately, there has been little effort made to monitor the life history and population trends of cutthroat trout.

4.3 Potential Bull Trout Interactions with Native Fish Species, Predatory Behavior, Dietary Composition, and Consumption Rates of Bull Trout

Bull Trout Interactions with Native Fish Species in the Clackamas River

The intent of this section is to provide information on potential interactions between a reintroduced population of bull trout and other native fish species within the Clackamas River, with emphasis on interactions between bull trout and other salmonids (i.e., coastal cutthroat trout, rainbow trout, steelhead, Chinook, and coho). The focus on interactions between bull trout and other native salmonids in the Clackamas River is driven not only by the recreational and economic values put on these species by the general public, but also by concerns regarding recovery of other ESA listed fish species in the subbasin.

Unfortunately our current understanding of predator/prey relationships between bull trout and other species is limited, as is information on general interactions between bull trout and anadromous fish. Underwood (1995) examined interactions between Chinook, steelhead, and bull trout. However, the life history strategy utilized by the bull trout population studied was resident (piscivory was not the primary feeding strategy) and no predator/prey relationships were noted. Instead the study focused on examining and confirming habitat partitioning between the three species, a trait common among species that evolve together. Habitat partitioning among sympatric species allows the utilization of different resources thereby reducing direct competition. This strategy was documented in several studies investigating interactions between bull trout and cutthroat trout (Marnell 1985; Nakano et al. 1992) and bull trout and rainbow trout (McPhail and Baxter 1996).

Although few studies have attempted to quantify bull trout predation impacts on sympatric fish species, the reputation of bull trout as an apex predator is not undeserved as there is an abundance of literature noting the aggressive piscivorous nature of this species. This reputation led to fish management actions that for many years included bounties, rotenone treatments, and trap and removal that ultimately extirpated many populations and in part led to a federal ESA listing of the species as threatened. Despite these actions there were no attempts that the CRBTWG is aware of to quantify impacts of bull trout predation on anadromous or resident fish populations, relative to the array of other variables that determine population sizes such as predation by other piscivorous fish and birds, sport and commercial angling, habitat conditions, migratory conditions, water quality and ocean conditions to name a few.

Bull trout are opportunistic feeders and prey on whatever fish species or aquatic organisms (e.g., crayfish, aquatic macroinvertebrates, etc.) are present and in the most abundance. In many rivers within the native range of bull trout, juvenile anadromous salmonids historically, and in many cases currently, provide the most significant forage base for bull trout. Over the last century, the decline in abundance and distribution of anadromous salmonids in many rivers in the western United States precipitated a forage base shift for many bull trout populations to other fish species. The reduction, and in many cases complete loss of juvenile anadromous fish within portions of the range of bull trout has had unknown consequences. In some areas other species may have filled the niche previously occupied by anadromous fish and bull trout may not have been negatively affected. Conversely, the forage base in other areas may not have been replaced by other species and bull trout populations may have responded accordingly by reductions in abundance and distribution.

Within the native range of bull trout, many populations historically and currently overlap with the distribution of anadromous Pacific salmon. In Oregon, bull trout, Chinook salmon and steelhead trout co-occur in a number of rivers including the McKenzie (Willamette River Basin), Hood, John Day, Warm Springs (Deschutes River Basin), Wenaha, Minam, Lostine and other tributaries of the Grand Ronde River in northeast Oregon, and in the Walla Walla and Umatilla rivers. The status of Pacific salmon and bull trout in each of these river systems ranges from healthy to depressed. Although the CRBTWG is not aware of any studies assessing interactions between bull trout and anadromous fish in these watersheds, it likewise is unaware of any premise that bull trout within these watersheds are a limiting factor in anadromous fish production.

A reintroduction of bull trout to the Clackamas River would require a Section 7 ESA consultation between the USFWS and NMFS due to the presence of federally listed anadromous fish in the Clackamas River that may be impacted by the reintroduction. The biological assessment and biological opinion developed as part of the consultation process would provide a more in-depth analysis of potential effects to anadromous fish than is possible in this feasibility assessment. The CRBTWG anticipates that a biological opinion by NMFS would include recommendations and guidance for monitoring.

Predatory Behavior and Feeding of Bull Trout

Large bull trout are widely recognized as predators of fish but because of their diverse life history forms (resident, anadromous, fluvial, and adfluvial) and habitats that range from small mountain lakes to large turbid, northern Canadian rivers, it is best not to generalize too greatly about food preferences of these char (Budy et al. 2004; Goetz et al. 2004; Johnston 2005; McPhail and Baxter 1996; Post and Johnston 2002; Wilhelm et al. 1999). Bull trout appear to be opportunistic in their feeding behavior and prey items range from midges to small mammals. Another element in bull trout feeding behavior is their increased activity during periods of low light (Goetz et al. 2004, Muhlfeld et al. 2003). For example, hydro-acoustic surveys of Lake Chester Morse by the Seattle Water Department indicated peak activity on dark, moonless nights and little activity by bull trout during the day (McPhail and Baxter 1996). Bull trout generally appear to be most visible at night during snorkeling surveys and during day time far fewer bull trout are typically visible (Spangler and Scarnecchia 2001; Peterson et al. 2002).

Juvenile Diet and Feeding Behavior

During night snorkeling in Idaho, Spangler and Scarnecchia (2001) found age-0 bull trout rearing in shallow, low velocity stream margin habitats in the summer. A possible advantage listed for summer shallow water feeding by small juvenile bull trout (less than 66 mm) was avoiding encounters with larger piscivorous bull trout and other aquatic predators. Fraley and Shepard (1989) also found young-of-the-year bull trout distributed more often along stream margins and in side channel locations in the Flathead River Basin, feeding on *Diptera* and *Ephemeroptera* aquatic invertebrates. Another Idaho study reported juvenile bull trout (70-170 mm) using pools more frequently than riffle habitat. In this study, other bull trout were apparently not feeding during the day and could be found hiding in the substrate or resting on the bottom (Bonneau and Scarnecchia 1998).

Juvenile bull trout are generally consumers of aquatic insects (Goetz et al. 2004; Budy et al. 2004; Fraley and Shepard 1989). Fraley and Shepard (1989) found that bull trout greater than 110 mm in the upper Flathead River consumed small trout and sculpin. Underwood et al. (1995) found bull trout (less than 200 mm) from three southeast Washington streams feeding on a wide range of food sources including mayfly nymphs, midge larva, rainbow trout, and frogs.

Sub-adult Diet and Feeding Behavior

In general, juvenile and sub-adult fluvial and adfluvial bull trout start to migrate to larger river or lake habitats after age-2 or 3 and begin feeding on larger prey with fish becoming an increasing part of their diets (Pratt 1992; Ratliff and Howell 1992). Ratliff et al. (1996) found most Metolius River bull trout spawned for the first time at age 5 and were at least 450 mm long. Some Metolius River bull trout did not become adfluvial but reared in the river system in a fluvial life history pattern and spawned earlier at age-4. Some of the age-2 and older bull trout in the Metolius River system did not continue to disperse downstream from early juvenile rearing habitats but instead moved into adjacent warmer tributaries not utilized by bull trout for spawning. Ratliff et al. (1996) suggests that bull trout movement into these warmer tributaries is apparently for feeding opportunities on abundant sculpin.

In the upper Flathead River in winter, sub-adult bull trout (less than 400 mm) were observed concealed in deep pools and runs during daylight. At night these same fish were observed leaving the former habitats and utilizing shallow, low-velocity stream margin habitats during full darkness. The observers believed that these sub-adult bull trout were feeding on juvenile mountain whitefish or other small fish found in the shallow margin habitat (Muhlfeld et al. 2003). In the Flathead River, areas with concentrations of yearling whitefish often were the same locations where sub-adult bull trout were captured (Pratt 1992).

The opportunistic feeding behavior of sub-adult bull trout also apparently includes cannibalism of bull trout fry and juveniles (Goetz 1989, Post and Johnson 2002). Observations by Horner in 1978 of bull trout actually digging into the stream substrate to prey on juvenile bull trout and cutthroat was cited in Spangler and Scarnecchia (2001). In the South Fork Walla Walla and North Fork Umatilla rivers, the rate of bull trout cannibalism was found to be relatively high (Budy et al. 2004) despite information suggesting that bull trout in both systems feed on a high proportion of aquatic insects. In Lake Billy Chinook, as much as 10 percent of identifiable prey in sub-adult bull trout stomachs was cannibalized smaller bull trout (Beauchamp and Van Tassel 2001).

Adult Diet and Feeding Behavior

Goetz et al. (2004) considers large adult, migratory bull trout "apex predators" that feed opportunistically based on what food items are most available at any one time or location. This may include cannibalism of other bull trout by larger adults (Beauchamp and Van Tassel 2001, Spangler and Scarnecchia 2001). In northern Canada, large adult bull trout are found in big turbid rivers such as the mainstem Peace and Laird rivers, feeding as wandering fluvial migrants. McPhail and Baxter (1996) presumed that the small numbers of widely scattered, large bull trout (some exceeding 900 mm) in these northern mainstem rivers was attributable to their position as top predators in these riverine habitats, where their diet includes suckers, grayling, red backed voles and mice. Adult bull trout diets can differ greatly depending on the ecosystems and locations they are found in. In Alberta's Harrison Lake, where bull trout are the only fish present, their diet was primarily small insects and zooplankton, even for adults (Wilhelm et al. 1999).

Other evidence suggests that adult bull trout change their diet as prey abundance varies. The large adfluvial bull trout of Lake Billy Chinook Reservoir in Oregon, have a diet largely of fish, with kokanee salmon and other salmonids (including whitefish) showing the highest percentages as prey items. Longnose dace, sculpins, and suckers were also prey species regularly selected. Bull trout utilization of the above prey varied in abundance seasonally. For example, adult bull trout in autumn preyed heavily on age-2 and age-3 kokanee salmon, while in summer adult bull trout primarily consumed mountain whitefish (Beauchamp and Van Tassell 2001). Goetz et al. (2004) in studies of anadromous bull trout in Puget Sound reported, "…anadromous bull trout opportunistically utilize forage fish species (surf smelt, Pacific herring, and Pacific sand lance) almost exclusively when they are present in the nearshore marine environments." Goetz et al. (2004) further concluded that bull trout feeding habits vary according to prey abundance, season, size, and competition and that bull trout will adjust to utilize the prey sources that are available.

Piscivory By Other Native Fish Species

Although adult bull trout are known for a diet large on fish, it is also important to remember the context of the other fish they are cohabitating with. Bull trout consume other fish that are capable themselves of being piscivorous predators. Sculpin, rainbow/steelhead trout, cutthroat trout and other salmonid species of the Clackamas River are also piscivorous and are known to consume other fish, including anadromous salmon fry and juveniles. During USFS smolt trapping in the Clackamas in 2007, wild coho juveniles were documented cannabilizing coho fry. In addition, juvenile rainbow trout/steelhead smolts were documented foraging on coho fry (Tom Horning, biologist, USFS, personal comm., 2007). At the yearling stage, coho salmon are known in some rivers to supplement their insect diets by cannibalizing their own fry or fry of other species. In California, Chinook salmon fry have been known to be eaten in large numbers by yearling coho outmigrants. In some locations coho less than 30 mm were heavily preyed upon by torrent sculpins (Groot and Margolis 1991). Mobrand et al. (2005) in a review of hatchery effects on natural fish populations, determined that yearling hatchery coho, stream-type Chinook, and steelhead smolts are the most likely predators on wild salmonid fry because of their larger size when released.

4.4 Disease Considerations Associated with an Out-of-Basin Transfer of Bull Trout to the Clackamas River

Unwanted parasites and diseases frequently have been introduced through fish transfers (Hoffman and Schubert 1984). To avoid these unintended consequences, translocations of fishes between major river basins should be preceded by a thorough investigation into the potential transfer of pathogens from the donor source, as well as the resistance of the donor stock to any known pathogens present in the receiving habitat.

The development of a bull trout reintroduction plan for the Clackamas River would include a thorough investigation into the potential impact of pathogens on the success of the effort, as well as an assessment of risk to other fish species in the receiving watershed (Clackamas River). The USFWS' Lower Columbia Fish Health Center (LCFHC) has offered to provide assistance to the CRBTWG in addressing fish health concerns if a future reintroduction of bull trout to the Clackamas River were to occur (Susan Gutenberger, Lower Columbia Fish Health Center, personal communication, August 2006). In addition to working with the Lower Columbia Fish Health Center, the CRBTWG would work closely with fish pathologists from the states of Oregon and Washington to examine, and if necessary collect, relevant disease information.

In considering disease issues in a reintroduction, the transfer of wild stocks within their native ranges presents lower risks (Minckley 1995) due to previous exposure and resistance capabilities to potential pathogens. All potential donor stocks investigated in this assessment inhabit the lower Columbia River and thus historically were equally exposed to the same suite of pathogens. However, artificial propagation and widespread stocking of native and nonnative salmonids throughout the lower Columbia River over the last century have resulted in unintended introductions of nonnative pathogens.

In the lower Columbia River, a number of bull trout populations have been isolated for many years above impassable dams, including potential donor populations in the Deschutes (Metolius), Hood, and Lewis river basins. In many cases their isolation from anadromous fish and other stocked resident salmonids protected them from exposure to pathogens recently introduced, but not native, to the lower Columbia River and its tributaries. The isolation of bull trout in the Metolius River above the Pelton Round Butte Dam Complex provides an example of how fragmentation of the environment, combined with the biology of the fish pathogens, can influence the character of disease transmission within a watershed.

The Pelton Round Butte Dam Complex was completed in 1964, effectively cutting off migration of anadromous salmonids into the Metolius, Deschutes and Crooked rivers above the dam. After several years of failed efforts to move anadromous fish up and down over the two dams, transport was abandoned in 1968 in favor of operating a hatchery facility below the dams. In the late 1990s, studies were initiated to examine the possibility of reintroducing anadromous fish above the dams. As part of the effort, ODFW conducted a fish disease risk analysis to assess the risk to native resident fish from reintroducing anadromous fish and their associated organisms into waters above the Pelton Round Butte Dam Complex (Engelking 2003).

The study concluded that certain pathogens, in particular, Type 2 strain infectious hematopoietic cecrosis (IHN) and *M. cerebralis* (whirling disease) are now present in fish below the dams but not in fish sampled above them, and that if these pathogens were introduced above the dams native fish stocks may be at risk. The study noted additional evaluations are underway to further assess the risk of these pathogens to native fish above the dams.

The information presented in Engelking (2003) underscores the importance of a rigorous disease evaluation prior to implementing a fish reintroduction, even when returning fish to historic habitat. An abundance of information exists on fish pathogens in the Deschutes River Basin due to the ODFW analysis discussed above, as well as other disease studies associated with the federal relicensing of the Pelton Round Butte Project dams and the effort to restore anadromous fish production above the project. This level of information is not available in other basins inhabited by potential donor stocks for a Clackamas River bull trout reintroduction. However, before selection of a donor stock and moving forward with implementing a reintroduction, additional analysis would likely be needed to satisfy state and federal requirements, as well as to provide the best chance of a successful reintroduction and to ensure the least risk to other fish in the reintroduction area.

4.5 Summary and Conclusions

The evidence that nonnative brook trout can have significant negative effects on bull trout distribution and abundance is highly variable. In some places, brook trout appear to have a strong negative impact, whereas in others there is no apparent impact – a situation paralleling impacts of brook trout on native cutthroat trout (Dunham et al. 2002). The Clackamas River has abundant cold water, including water temperatures cold enough to potentially limit the success of brook trout relative to bull trout (Rieman et al. 2006; Benjamin et al. 2007). Although brook trout are found in the Upper Clackamas River, their distribution is limited to less than 10 percent of the identified bull trout spawning and rearing habitat where a reintroduction could take place. Brook trout presence in one of six bull trout habitat patches could influence where translocated bull trout would be stocked, but the CRBTWG does not believe the limited presence of brook trout would deter the success of an attempted bull trout reintroduction in the Clackamas River.

Bull trout coexisted with a many of other native fish species in the Clackamas River for thousands of years, likely feeding on a variety of different species. Historically, anadromous Pacific salmon were likely the most abundant fish in the subbasin and they probably comprised a significant portion of the bull trout diet. However, current abundance and distribution of anadromous salmon in the subbasin is reduced from historic levels. Bull trout, if reintroduced, may be more dependent upon other native species as a prey base, such as mountain whitefish and largescale sucker, both of which are present and abundant along with other potential prey such as dace, sculpin, northern pike minnow, and several species of trout. Available information on bull trout populations from other areas in the Lower Columbia River Basin suggest that, while possibly important, bull trout persistence is not dependent upon the presence of anadromous salmon.

Despite evidence that bull trout prey on juvenile anadromous salmonids when they are available, no data were found that suggests predation is a factor in the status of Pacific salmon across the hundreds of watersheds where they co-occur in the western United States. Although the distribution and abundance of Pacific salmon in the Clackamas River is reduced from historical levels, the remaining native fish assemblage is assumed to be healthy. For these reasons, the CRBTWG believes there is a sufficient forage base to support a bull trout reintroduction in the Clackamas River.

Review of available information on interactions between bull trout and other sympatric fish species suggests it will be exceedingly difficult to predict in advance the food web effects of a reintroduction of bull trout into the Clackamas River. The CRBTWG fully anticipates that if a reintroduction occurs and is successful, that some predation of juvenile anadromous fish by bull trout will occur. However, given that bull trout will also be eating other predators of juvenile anadromous fish (i.e. resident rainbow and cutthroat trout, pike minnow, and sculpin), it is uncertain whether the overall impact to anadromous fish will be negative or positive.

Other uncertainties also make predicting food web effects difficult. Although the amount of bull trout spawning and rearing habitat was quantified in Chapter 2, the carrying capacity of the system for bull trout (i.e., future abundance) cannot be predicted with any certainty. The actual abundance and distribution of bull trout within the Clackamas River Subbasin, if reintroduced, and its use of the watershed for rearing, foraging and overwintering also present additional uncertainty in regard to predicting food web effects. Finally, the expression of life history form (e.g., resident, fluvial, adfluvial, or combinations thereof) creates even further uncertainty.

Although the CRBTWG acknowledges a significant amount of uncertainty regarding the food web effects of a reintroduction of bull trout into the Clackamas River, the best available information suggests the impact to listed anadromous fish and other native fish in the subbasin is unlikely to be significant. Furthermore, we believe accurately measuring food web effects from a reintroduction of bull trout would be a difficult, if not impossible endeavor. However, should a means be identified to accurately measure food web effects, and in particular predation effects to listed anadromous fish, than the CRBTWG would further explore this type of monitoring. If a reintroduction of bull trout into the Clackamas River takes place and is later identified through monitoring as a limiting factor in the recovery of anadromous salmonids, the CRBTWG believes the reintroduction effort is reversible.