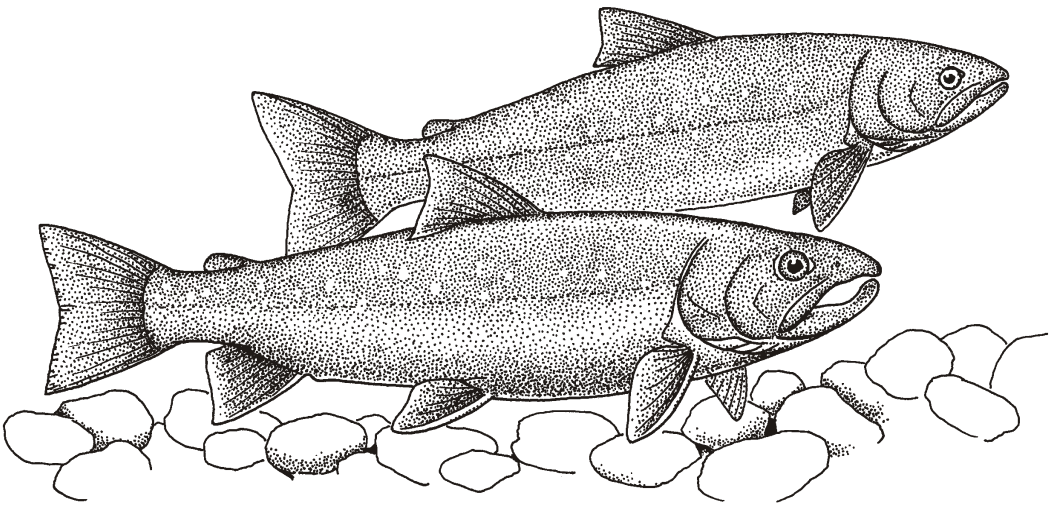
U.S. Fish & Wildlife Service

Draft Recovery Plan for the Coastal-Puget Sound Distinct Population Segment of Bull Trout (*Salvelinus confluentus*)

Volume I (of II)
Puget Sound Management Unit

(including the Chilliwack River and associated tributaries flowing into British Columbia, Canada)



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(May 2004)

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Regional Director, U.S. Fish and Wildlife Service

Date: XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

DISCLAIMER

Recovery plans delineate reasonable actions that are believed necessary to recover and/or protect the species. Recovery plans are prepared by the U.S. Fish and Wildlife Service and, in this case, with the assistance of recovery teams, State and Tribal agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views or the official positions or indicate the approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. Recovery plans represent the official position of the U.S. Fish and Wildlife Service *only* after they have been signed by the Director or Regional Director as *approved*. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

Literature citation of this document should read as follows:

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Electronic copies of this recovery plan are available at:
<http://pacific.fws.gov/ecoservices/endangered/recovery/default.htm> and also at <http://endangered.fws.gov/recovery/index.html>.

Note to readers: A glossary of technical terms is provided in Appendix 5 of this plan. Terms provided in the glossary are denoted with a superscript symbol (†) the first time they appear in the plan.

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EXECUTIVE SUMMARY

The Puget Sound Management Unit is one of two management units† comprising the Coastal-Puget Sound Distinct Population Segment† of bull trout (*Salvelinus confluentus*). The overall recovery implementation strategy for the Coastal-Puget Sound Distinct Population Segment is to integrate with ongoing Tribal, State, local, and Federal management and partnership efforts at the watershed† or regional scales. This coordination will maximize the opportunity for complementary actions, eliminate redundancy, and make the best use of available resources for bull trout and salmon recovery.

Current Species Status

The U.S. Fish and Wildlife Service issued a final rule listing the Coastal-Puget Sound and St. Mary-Belly River Distinct Population Segments of bull trout as threatened on November 1, 1999 (64 FR 58910). This final rule resulted in all bull trout within the coterminous United States being listed as threatened, as three additional distinct population segments had earlier been listed separately (the Klamath River, Columbia River, and Jarbidge River Distinct Population Segments; 63 FR 31647, 64 FR 17110). As provided in the final listing rule, however, we are continuing to refer to the original distinct population segments for the purposes of recovery planning and consultation (64 FR 58910). The Coastal-Puget Sound Distinct Population Segment is significant to the species as a whole because it contains the only anadromous† forms of bull trout in the coterminous United States, thus, occurring in a unique ecological setting. Also unique to this population segment is the overlap in distribution with Dolly Varden, another native char† species extremely similar in appearance to bull trout, but distinct genetically.

The Puget Sound Management Unit includes all watersheds within the Puget Sound basin and the marine nearshore areas of Puget Sound. This management unit also includes the Chilliwack River watershed, a transboundary system flowing into British Columbia and discharging into the Fraser River. Bull trout are distributed throughout most of the major watersheds and associated

tributary systems within the Puget Sound Management Unit, and they exhibit anadromous, adfluvial†, fluvial† and resident† life history patterns. The Puget Sound Management Unit consists of eight core areas† (a core area consists of one or more local populations of bull trout and their habitat), with a total of 57 local populations† and 5 potential local populations† distributed among the core areas (see Table 5).

Recovery Priority

The recovery priority number for bull trout in the coterminous United States is 9C, on a scale of 1C (highest) to 18 (lowest), indicating: 1) taxonomically, we are treating these populations as distinct population segments of the species; 2) the bull trout is subject to a moderate degree of threat; and 3) the potential for recovery is considered high. The "C" indicates the potential for conflict with human activities during recovery (USFWS 1983a, b).

Habitat Requirements and Limiting Factors

Bull trout have more specific habitat requirements than most other salmonids. Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors†. Cold water temperatures play an important role in determining bull trout habitat, as these fish are primarily found in colder streams (below 15 degrees Celsius; 59 degrees Fahrenheit), and spawning habitats are generally characterized by temperatures that drop below 9 degrees Celsius (48 degrees Fahrenheit) in the fall. All life history stages of bull trout are associated with complex forms of cover, including large woody debris†, undercut banks, boulders, and pools. Maintaining bull trout habitat requires stability of stream channels and maintenance of natural flow patterns. Additionally, since bull trout are iteroparous (they survive to spawn year after year) and many populations are migratory, these fish therefore require two-way passage up and downstream, not only for repeat spawning but also for foraging. Therefore even dams or other barriers with fish passage facilities may

be a factor in isolating bull trout populations if they do not provide adequate two-way passage for subadults and adults.

Within the Puget Sound Management Unit, historical and current land use activities have impacted bull trout. Some of the historical activities, especially water diversions, hydropower development, forestry, agriculture, and urban development within the core areas, may have significantly reduced important anadromous populations. Lasting effects from some of these early land and water developments still act to limit bull trout production in core areas. Threats from current activities are also present in all core areas of the Puget Sound Management Unit. Land and water management activities that depress bull trout populations and degrade habitat in this management unit include some aspects of operation and maintenance of dams and other diversion structures, forest management practices, agriculture practices, road construction and maintenance, and residential development and urbanization. Dams and diversion structures impede or limit migration, entrain† individuals, and impair downstream habitat. Forestry activities impact bull trout through decreased recruitable large woody debris†, increased water temperatures from reduced shading, lack of pools and habitat complexity, and increased sedimentation from timber harvesting on unstable slopes and road construction. Agriculture practices impact bull trout through added inputs of nutrients, pesticides, herbicides, and sediment, reduced riparian† vegetation, decreased recruitable large woody debris, and reduced habitat complexity by diking, stream channelization†, and bank hardening. Road construction and maintenance impact bull trout through added channel constrictions, impassible culverts, bank hardening, sedimentation, reduction in riparian shading, contaminant inputs, and impervious surfaces. Development and urbanization impact bull trout through reduced water quality, changed hydrology, reduced riparian shading, sedimentation, and reduced channel complexity from increased bank hardening and channel constrictions. The presence of nonnative species† such as brook trout continue to pose a threat through competition, hybridization†, and potential predation in some core areas.

Recovery Strategy

Presently bull trout are listed as threatened across their range within the lower 48 states (64 FR 58910). Prior to the coterminous listing, five distinct population segments of bull trout were identified. Although these bull trout population segments are disjunct and geographically isolated from one another, they include the entire distribution of bull trout within the United States, therefore a coterminous listing was found to be appropriate in accordance with our policy on the designation of distinct population segments (61 FR 4722). As provided in the final listing rule, we are continuing to use the term "distinct population segments" for the purposes of recovery planning and consultation (64 FR 58910).

A delisting determination can only be made on a "listable entity" under the Endangered Species Act (Act). Listable entities include species, subspecies, or distinct population segments of vertebrate animals, as defined by the Act and U.S. Fish and Wildlife Service Policy (61 FR 4722). Because bull trout were listed at the coterminous level in 1999, currently delisting can only occur at the coterminous level (64 FR 58910). In the future, if warranted by additional information, and if the Coastal-Puget Sound population is reconfirmed as meeting the definition of a distinct population segment under a regulatory rulemaking, delisting may be considered separately for the Coastal-Puget Sound Distinct Population Segment of bull trout once it has achieved a recovered state (61 FR 4722).

The recovery of the Coastal-Puget Sound Distinct Population Segment of bull trout will depend upon the achievement of recovery goals and criteria for the entire distinct population segment. Maintenance of fully functioning core areas across the range of bull trout within the population segment will require that each of the two management units that comprise this distinct population segment contribute to the success of this effort. In keeping with the goal of fostering effective management and recovery of bull trout at the local level, we have developed separate recovery plans for each of these management units, and established specific "recovery targets" for each management unit that will be used to guide bull trout recovery within the distinct population segment as a whole.

Here we define the recovery criteria for the delisting of the Coastal-Puget Sound Distinct Population Segment of bull trout as currently delineated. The site-specific strategies, recovery actions, and recovery targets for the Puget Sound Management Unit are presented in Part II of this plan. The Olympic Peninsula Management Unit is addressed in its own recovery plan.

Recovery Goal for the Coastal-Puget Sound Distinct Population Segment

The goal of this recovery plan is to **ensure the long-term persistence of self-sustaining, complex, interacting groups[†] of bull trout distributed across the Coastal-Puget Sound Distinct Population Segment, so that the species can be delisted.**

Recovery Criteria for the Coastal-Puget Sound Distinct Population Segment

The Coastal-Puget Sound Distinct Population Segment will be considered recovered when all core areas are fully functional, as measured by parameters addressing the distribution, abundance, productivity (stable or increasing adult population trend), and connectivity (including the potential for expression of all life history traits) of bull trout. The recovery actions identified in this plan are designed to sufficiently control or eliminate the threats to bull trout such that the recovery criteria may be attained for the Coastal-Puget Sound Distinct Population Segment. The conditions for recovery are identified in the following criteria:

1. The biological and ecological function of the 14 identified core areas (8 in the Puget Sound Management Unit and 6 in the Olympic Peninsula Management Unit) for bull trout within the distinct population segment has been restored. The components of fully functioning core areas include:

a) Habitat sufficiently maintained or restored to provide for the persistence of broadly distributed local populations supporting the migratory life form within each core area. The term "broadly distributed" implies that local populations are able to access and are actively using habitat that fully provides for spawning, rearing,

foraging, migrating, and overwintering needs at recovered abundance levels. An actual quantitative estimate of the amount of habitat that will be required to meet this criterion is unknown at this time; the adequacy of habitat restoration and management efforts must be measured indirectly by criteria 1b through 1d. The currently identified local populations that will be used as a measure of broad distribution across the distinct population segment are detailed in the recovery targets set for each of the two management units.

b) Adult bull trout are sufficiently abundant to provide for the persistence and viability of core areas; this level of abundance is estimated to be 16,500 adult bull trout across all core areas. Resident life history forms are not included in this estimate, but are considered a research need. As more data is collected, recovered population estimates will be revised to more accurately reflect both the migratory and resident life history components. The recovery team† has initially set abundance targets conservatively if there was limited available information for constituent core areas; these will likely be revised as new information becomes available. The recovered abundance levels for the currently identified core areas in the distinct population segment are detailed in the recovery targets set for each of the two management units.

c) Measures of bull trout abundance within all core areas show stable or increasing trends based on 10 to 15 years (representing at least 2 bull trout generations) of monitoring data. Details are provided in the recovery targets for each of the two management units.

d) Habitat within, and where appropriate, between core areas, is connected so as to provide for the potential of the full expression of migratory behavior (particularly anadromy), allow for the refounding† of extirpated populations, and provide for the potential of genetic exchange between populations. Meeting this criterion requires that passage has been restored or improved, and in

some cases further evaluated, at specific barriers identified as inhibiting recovery (including barriers due to physical obstructions, unsuitable habitat, and poor water quality). Known barriers to passage within the Puget Sound Management Unit include the Bellingham Diversion, Gorge Dam, Ross Dam, Tacoma Headworks diversion dam, and Howard Hansen Dam; the Baker River Dams and Electron and Buckley diversions are also in need of passage improvement. Known barriers to passage within the Olympic Peninsula Management Unit include Cushman Dams 1 and 2, Elwha Dam and Glines Canyon Dam, the Washington Department of Fish and Wildlife Dungeness Fish Hatchery, and U.S. Fish and Wildlife Service Quinault National Fish Hatchery. Details regarding these specific barriers are provided in the recovery targets set for each of the two management units.

Meeting this criterion also requires that conditions in both freshwater and nearshore marine foraging, migration, and overwintering habitats[†] are maintained and/or restored to the level that fully support an adequate prey base, especially for the anadromous forms, as well as the other identified components (distribution, abundance, and trend) for fully functional core areas within the Coastal-Puget Sound population segment.

2. A monitoring plan has been developed and is ready for implementation, to cover a minimum of 5 years post-delisting, to ensure the ongoing recovery of the species and the continuing effectiveness of management actions.

<u>Recovery targets for the Puget Sound Management Unit:</u>

1. **Maintain or expand the current distribution of bull trout in the eight identified core areas[1].** The 57 currently identified local populations (Chilliwack (3), Nooksack (10), Lower Skagit (19), Upper Skagit (8), Stillaguamish (4), Snohomish-Skykomish (4), Chester Morse Lake (4), and Puyallup (5)) will be used as a measure of broadly distributed

[1]This criterion applies only to United States waters within this management unit.

spawning and rearing habitat within these core areas. In addition, distribution within the five identified potential local populations should be confirmed or restored.

2. **Achieve minimum estimated abundance of at least 10,800 adult bull trout spawners among all core areas in the Puget Sound Management Unit. In each of the core areas, the total adult bull trout abundance, distributed among local populations, typically must exceed 1,000 fish.** Recovered abundance targets for the Chilliwack (600), Nooksack (2,000), Lower Skagit (3,800), Upper Skagit (1,400), Stillaguamish (1,000), Snohomish-Skykomish (500), Chester Morse Lake (500), and Puyallup (1,000) core areas were derived using a combination of available data sets, the population guidance discussed earlier, the professional judgement of the recovery team, and estimation of the productive capacity of identified local populations. Resident life history forms are not included in this estimate, but are considered a research need.

3. **Restore adult bull trout to exhibit stable or increasing trends in abundance at or above the recovered abundance target level within the core areas in the Puget Sound Management Unit, based on 10 to 15 years (representing at least 2 bull trout generations) of monitoring data. (Note: generation time varies with demographic variables such as age at maturity, fecundity, frequency of spawning, and longevity, but typically falls in the range of 5 to 8 years for a single bull trout generation).**

4. **Restore connectivity by identifying and addressing specific existing and potential barriers to bull trout movement in the Puget Sound Management Unit.** Connectivity criteria will be met when intact migratory corridors are present among all local populations within each core area, thus providing opportunity for genetic exchange and life history diversity. Several man-made barriers to bull trout migration exist within the management unit, and this recovery plan recommends actions to identify, assess, and reduce barriers to bull trout passage. Although

achieving criteria 1 through 3 is expected to depend on providing passage at barriers (including barriers due to physical obstructions, unsuitable habitat, and water quality) throughout all core areas in the management unit, the intent of this criterion is to note specific barriers to correct or actions that must be performed to achieve recovery.

Recovery Actions

Recovery for bull trout will entail reducing threats to the long-term persistence of populations and their habitats, ensuring the security of multiple interacting groups of bull trout, and providing habitat and access to conditions that allow for the expression of various life history forms. Detailed actions specific to this management unit are provided in this plan; in broad terms, these actions include:

1. Protect, restore, and maintain suitable habitat conditions for bull trout.
2. Prevent and reduce negative effects of nonnative fishes and other nonnative taxa on bull trout.
3. Establish fisheries management goals and objectives for compatibility with bull trout recovery, and implement practices to achieve goals.
4. Characterize, conserve, and monitor genetic diversity and gene flow among local populations of bull trout.
5. Conduct research and monitoring to implement and evaluate bull trout recovery activities, consistent with an adaptive management approach using feedback from implemented, site-specific recovery tasks.
6. Use all available conservation programs and regulations to protect and conserve bull trout and bull trout habitat.
7. Assess the implementation of bull trout recovery by management units and revise management unit plans based on evaluations.

There are a number of research needs that have been identified for this management unit. A high priority goal for the Puget Sound Management Unit is to acquire more complete information on the current distribution and abundance

of bull trout within each core area. Additional information is also needed on bull trout use of and distribution in estuarine and marine waters of Puget Sound.

Total Estimated Cost of Recovery

The total cost of bull trout recovery in the Puget Sound Management Unit is estimated at a minimum of $68 million spread over a 25-year recovery timeframe, or an average of approximately $2.7 million per year. The estimate includes recovery actions associated with the Chilliwack, Nooksack, Lower Skagit, Upper Skagit, Stillaguamish, Snohomish-Skykomish, Chester Morse, and Puyallup core areas as well as core habitats[†] (including nearshore marine areas) and identified research needs (*e.g.*, upper Green River, upper Nisqually River).

The total cost of bull trout recovery in the Olympic Peninsula Management Unit is estimated at $6.7 million spread over a 25-year recovery period, or an average of approximately $268,000 per year. The estimate includes recovery actions associated with the Skokomish, Dungeness, Elwha, Hoh, Queets, and Quinault core areas as well as core habitats (including nearshore marine areas) and identified research needs (*e.g.*, Satsop River, Hoquiam River).

The total cost of bull trout recovery in the Coastal-Puget Sound Distinct Population Segment is therefore estimated to be approximately $74.7 million over 25 years. If the timeframe for recovery can be reduced, lower estimated costs would occur. Total costs include all funds expended, both public and private, and incorporate estimates of expenditures by local and State governments as well as Federal and private funds. These costs are attributed to bull trout conservation, but other aquatic species will also benefit.

Estimated Date of Recovery

Time required to achieve recovery depends on bull trout status, factors affecting bull trout, implementation and effectiveness of recovery actions, and responses to recovery actions. A tremendous amount of work will be required to restore impaired habitat, reconnect habitat, and eliminate threats from nonnative

species. Three to 5 bull trout generations (15 to 25 years), or possibly longer, may be necessary before recovery is achieved.

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PART I. COASTAL-PUGET SOUND DISTINCT POPULATION SEGMENT OF BULL TROUT

INTRODUCTION AND OVERVIEW

Bull trout (*Salvelinus confluentus*), members of the family Salmonidae, are fish native to the Pacific Northwest and western Canada. Trout and salmon relatives in the genus *Salvelinus*, such as bull trout, are often generally referred to as "char† ." Bull trout occur in five identified distinct population segments† within the lower 48 states. In June 1998, we, the U.S. Fish and Wildlife Service, determined threatened status under the Endangered Species Act (16 United States Code [USC] 1531 *et seq*.) for bull trout in two distinct population segments in the Klamath River (Oregon) and Columbia River (Idaho, Montana, Oregon, and Washington) (63 FR 31647). In April 1999, the Jarbidge River Distinct Population Segment of bull trout (Idaho and Nevada) was also determined to be threatened (64 FR 17110). Two more distinct population segments of bull trout, the Coastal-Puget Sound (Washington) and St. Mary-Belly River (Montana), were also found to be threatened in November, 1999 (64 FR 58910). This final listing resulted in all bull trout in the coterminous United States being listed as threatened. However, as provided in the final listing rule, we are continuing to refer to the original distinct population segments for the purposes of recovery planning and consultation (64 FR 58910). This recovery plan addresses the conservation actions deemed necessary for the recovery of the Coastal-Puget Sound Distinct Population Segment of bull trout in the Puget Sound Management Unit† (Figure 1; also see "Recovery Plan Terminology and Structure" below).

The recovery priority number for bull trout in the coterminous United States is 9C, on a scale of 1C (highest) to 18 (lowest), indicating: 1) taxonomically, we are treating these populations as distinct population segments of the species; 2) the bull trout is subject to a moderate degree of threat; and 3) the potential for recovery is considered high. The "C" indicates the potential for conflict with human activities during recovery (USFWS 1983a,b).

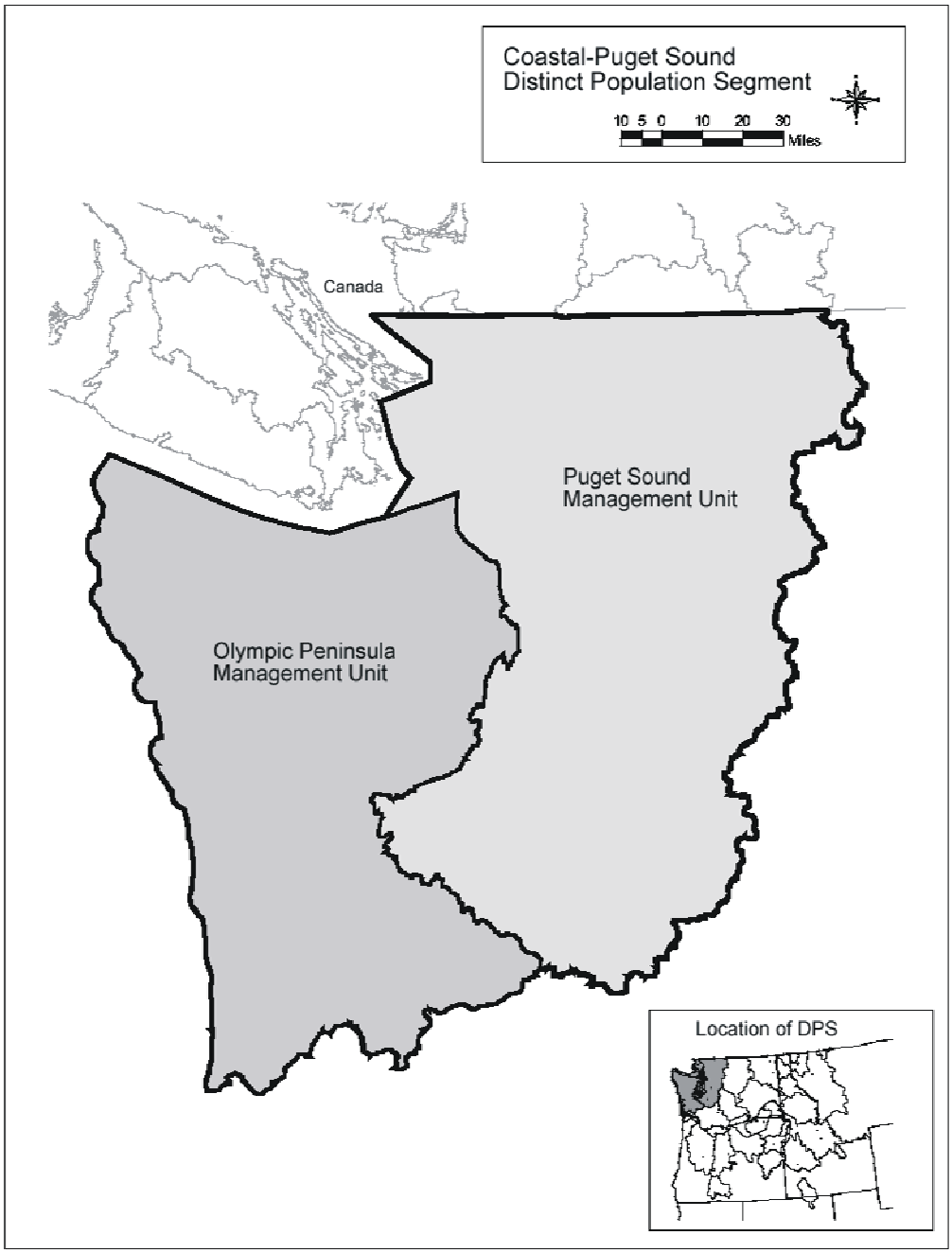

Figure 1. The Coastal-Puget Sound Distinct Population Segment (DPS) of bull trout, showing the division of the population segment into two management units. The inset map shows the location of the DPS within the State of Washington.

In the interest of streamlining, details regarding the ecology of bull trout in the Coastal-Puget Sound and the threats faced by the bull trout populations there are provided in the listing document for this distinct population segment and are not repeated here (64 FR 58910). However, a brief overview of bull trout life history, habitat needs, and reasons for decline is provided below.

General Description and Life History

Bull trout have been defined as a distinct species (Cavender 1978), however, the genetic relationship among various groups of bull trout within the species can be complex (Rieman and Allendorf 2001). Biologists had previously identified bull trout as Dolly Varden (*Salvelinus malma*), largely because of the external similarity of appearance and the previous unavailability of adequate specimens of both species to any one taxonomist. Morphological (form and structure) analyses have confirmed the distinctiveness of the two species in their different, but overlapping, geographic distributions (Haas and McPhail 1991). Several genetic studies have subsequently confirmed the species distinction of bull trout and Dolly Varden (Phillips *et al.* 1989; Crane *et al.* 1994). Both species occur together in western Washington, for example, with little or no interbreeding (Leary and Allendorf 1997). Lastly, bull trout and Dolly Varden each appear to be more closely related genetically to other species of *Salvelinus* than they are to each other (Phillips *et al.* 1989; Greene *et al.* 1990; Pleyte *et al.* 1992). For example, bull trout are most closely related to Japanese char (*S. leucomaenis*) whereas Dolly Varden are most closely related to Arctic char (*S. alpinus*).

Bull trout exhibit both resident† and migratory† life history strategies. Both resident and migratory forms may be found together, and either form may produce offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993). Resident bull trout complete their entire life cycle in the tributary (or nearby) streams in which they spawn and rear. The resident form tends to be smaller than the migratory form at maturity and also produces fewer eggs (Fraley and Shepard 1989; Goetz 1989). Migratory bull trout spawn in tributary streams where juvenile fish rear 1 to 4 years before migrating to either a lake (adfluvial† form), river (fluvial† form) (Fraley and Shepard 1989; Goetz 1989), or saltwater (anadromous†) to rear as subadults or to live as adults

(Cavender 1978; McPhail and Baxter 1996; WDFW *et al.* 1997). Bull trout normally reach sexual maturity in 4 to 7 years and may live longer than 12 years. They are iteroparous (they spawn more than once in a lifetime), and both repeat- and alternate-year spawning has been reported, although repeat-spawning frequency and post-spawning mortality are not well documented (Leathe and Graham 1982; Fraley and Shepard 1989; Pratt 1992; Rieman and McIntyre 1996).

The iteroparous reproductive system of bull trout has important repercussions for the management of this species. Bull trout require two-way passage up and downstream, not only for repeat spawning but also for foraging. Most fish ladders†, however, were designed specifically for anadromous semelparous (fishes that spawn once and then die, and therefore require only one-way passage upstream) salmonids†. Therefore even dams or other barriers with fish passage facilities may be a factor in isolating bull trout populations if they do not provide a downstream passage route.

Growth varies depending upon life-history strategy. Resident adults range from 150 to 300 millimeters (6 to 12 inches) total length, and migratory adults commonly reach 600 millimeters (24 inches) or more (Pratt 1985; Goetz 1989). The largest verified bull trout is a 14.6-kilogram (32-pound) specimen caught in Lake Pend Oreille, Idaho, in 1949 (Simpson and Wallace 1982).

Habitat Characteristics

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993). Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors† (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Howell and Buchanan 1992; Pratt 1992; Rieman and McIntyre 1993, 1995; Rich 1996; Watson and Hillman 1997). Watson and Hillman (1997) concluded that watersheds† must have specific physical characteristics to provide the habitat requirements necessary for bull trout to successfully spawn and rear and that these specific characteristics are not necessarily present throughout these watersheds. Because bull trout exhibit a

patchy distribution, even in pristine habitats (Rieman and McIntyre 1993), fish should not be expected to simultaneously occupy all available habitats (Rieman *et al.*1997).

Migratory corridors link seasonal habitats for all bull trout life histories. The ability to migrate is important to the persistence of bull trout (Rieman and McIntyre 1993; Gilpin, *in litt.* 1997; Rieman et al. 1997). Migrations facilitate gene flow among local populations[†] when individuals from different local populations interbreed, or stray, to nonnatal streams. Local populations that are extirpated by catastrophic events may also become reestablished by bull trout migrants. However, it is important to note that the genetic structuring of bull trout indicates that there is limited gene flow among bull trout populations, which may encourage local adaptation within individual populations, and that reestablishment of extirpated populations may take a very long time (Spruell *et al.* 1999; Rieman and McIntyre 1993).

Cold water temperatures play an important role in determining bull trout habitat, as these fish are primarily found in colder streams (below 15 degrees Celsius; 59 degrees Fahrenheit), and spawning habitats are generally characterized by temperatures that drop below 9 degrees Celsius (48 degrees Fahrenheit) in the fall (Fraley and Shepard 1989; Pratt 1992; Rieman and McIntyre 1993).

Thermal requirements for bull trout appear to differ at different life stages. Spawning areas are often associated with cold-water springs, groundwater infiltration, and the coldest streams in a given watershed (Pratt 1992; Rieman and McIntyre 1993; Baxter *et al.* 1997; Rieman et al. 1997). Optimum incubation temperatures for bull trout eggs range from 2 to 4 degrees Ceslisus (35 to 39 degrees Fahrenheit) whereas optimum water temperatures for rearing range from about 8 to 10 degrees Celsius (46 to 50 degrees Fahrenheit) (McPhail and Murray 1979; Goetz 1989; Buchanan and Gregory 1997). In Granite Creek, Idaho, Bonneau and Scarnecchia (1996) observed that juvenile bull trout selected the coldest water available in a plunge pool, 8 to 9 degrees Celsius (46 to 48 degrees Fahrenheit), within a temperature gradient of 8 to 15 degrees Celsius (46 to 60 degrees Fahrenheit). In a landscape study relating bull trout distribution to

maximum water temperatures, Dunham et al. (2003) found that the probability of juvenile bull trout occurrence does not become high (*i.e.*, greater than 0.75) until maximum temperatures decline to 11 to 12 degrees Celsius (52 to 54 degrees Fahrenheit).

Although bull trout are found primarily in cold streams, occasionally these fish are found in larger, warmer river systems throughout the Columbia River basin (Fraley and Shepard 1989; Rieman and McIntyre 1993, 1995; Buchanan and Gregory 1997; Rieman *et al.* 1997). Factors that can influence bull trout ability to survive in warmer rivers include availability and proximity of cold water patches and food productivity (Myrick *et al.* 2002). In Nevada, adult bull trout have been collected at 17.2 degrees Celsius (63 degrees Fahrenheit) in the West Fork of the Jarbidge River (S. Werdon, U.S. Fish and Wildlife Service, pers. comm. 1998) and have been observed in Dave Creek where maximum daily water temperatures were 17.1 to 17.5 degrees Celsius (62.8 to 63.6 degrees Fahrenheit) (Werdon 2000). In the Little Lost River, Idaho, bull trout have been collected in water having temperatures up to 20 degrees Celsius (68 degrees Fahrenheit); however, bull trout made up less than 50 percent of all salmonids when maximum summer water temperature exceeded 15 degrees Celsius (59 degrees Fahrenheit) and less than 10 percent of all salmonids when temperature exceeded 17 degrees Celsius (63 degrees Fahrenheit) (Gamett 1999). In the Little Lost River study most sites that had high densities of bull trout were in an area where primary productivity increased in the streams following a fire (B. Gamett, U. S. Forest Service, pers. comm. 2002).

All life history stages of bull trout are associated with complex forms of cover, including large woody debris[†], undercut banks, boulders, and pools (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Pratt 1992; Thomas 1992; Rich 1996; Sexauer and James 1997; Watson and Hillman 1997). Maintaining bull trout habitat requires stability of stream channels and maintenance of natural flow patterns (Rieman and McIntyre 1993). Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997). These areas are sensitive to activities that directly or indirectly affect stream channel stability[†] and alter natural flow patterns. For example, altered stream flow in the fall may disrupt

bull trout during the spawning period, and channel instability may decrease survival of eggs and young juveniles in the gravel from winter through spring (Fraley and Shepard 1989; Pratt 1992; Pratt and Huston 1993). Pratt (1992) indicated that increases in fine sediment† reduce egg survival and emergence.

Bull trout typically spawn from August to November during periods of decreasing water temperatures. Preferred spawning habitat consists of low-gradient stream reaches with loose, clean gravel (Fraley and Shepard 1989). Redds† are often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989; Pratt 1992; Rieman and McIntyre 1996). Depending on water temperature, incubation is normally 100 to 145 days (Pratt 1992), and after hatching, juveniles remain in the substrate. Time from egg deposition to emergence of fry† may surpass 200 days. Fry normally emerge from early April through May, depending on water temperatures and increasing stream flows (Pratt 1992; Ratliff and Howell 1992).

Migratory forms of bull trout appear to develop when habitat conditions allow movement between spawning and rearing streams† and larger rivers or lakes where foraging opportunities may be enhanced (Frissell 1993). For example, multiple life history forms (*e.g.*, resident and fluvial) and multiple migration patterns have been noted in the Grande Ronde River (Baxter 2002). Parts of this river system have retained habitat conditions that allow free movement between spawning and rearing areas and the mainstem Snake River. Such multiple life history strategies help to maintain the stability and persistence of bull trout populations to environmental changes. Benefits to migratory bull trout include greater growth in the more productive waters of larger streams and lakes, greater fecundity resulting in increased reproductive potential, and dispersing the population across space and time so that spawning streams may be recolonized should local populations suffer a catastrophic loss (Rieman and McIntyre 1993; MBTSG 1998; Frissell 1999). In the absence of the migratory bull trout life form, isolated populations cannot be replenished when disturbance makes local habitats temporarily unsuitable, the range of the species is diminished, and the potential for enhanced reproductive capabilities are lost (Rieman and McIntyre 1993).

Diet

Bull trout are opportunistic feeders, with food habits primarily a function of size and life-history strategy. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macrozooplankton, and small fish (Boag 1987; Goetz 1989; Donald and Alger 1993). Adult migratory bull trout feed on various fish species (Leathe and Graham 1982; Fraley and Shepard 1989; Brown 1994; Donald and Alger 1993). In coastal areas of western Washington, bull trout feed on Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypomesus pretiosus*) in the ocean (WDFW *et al.* 1997).

Bull trout migrations and life history strategies are closely related to their feeding and foraging strategies. Optimal foraging theory can be used to describe strategies fish use to choose between alternative sources of food by weighing the benefits and costs of capturing one choice of food over another. For example, prey often occur in concentrated patches of abundance ("patch model"; Gerking 1998). As the predator feeds the prey population is reduced, and it becomes more profitable for the predator to seek a new patch rather than continue feeding on the original one. This can be explained in terms of balancing energy acquired versus energy expended. In the Skagit River system, anadromous bull trout make migrations as long as 195 kilometers (121 miles) between marine foraging areas in Puget Sound and headwater† spawning grounds, foraging on salmon eggs and juvenile salmon along their migratory route (WDFW *et al*. 1997). Anadromous bull trout also use marine waters as migratory corridors to reach seasonal habitats in non-natal watersheds to forage and possibly overwinter (Brenkman, *in litt*., 2003; Brenkman and Corbett, *in litt*., 2003; Goetz, *in litt*., 2003a,b).

A single optimal foraging strategy is not necessarily a consistent feature in the life of a fish, but this foraging strategy can change from one life stage to another. Fish growth depends on the quantity and quality of food that is eaten (Gerking 1994) and as fish grow their foraging strategy changes as their food changes in quantity, size, or other characteristics. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macrozooplankton, mysids† and small fish (Shepard *et al*. 1984; Boag 1987; Goetz 1989; Donald and Alger 1993). Bull trout 110 millimeters (4.3 inches) long or longer commonly

have fish in their diet (Shepard *et al*. 1984), and bull trout of all sizes have been found to eat fish half their length (Beauchamp and Van Tassell 2001). Migratory bull trout begin growing rapidly once they move to waters with abundant forage that includes fish (Shepard *et al*. 1984; Carl 1985). As these fish mature they become larger bodied predators and are able to travel greater distances (with greater energy expended) in search of prey species of larger size and in greater abundance (with greater energy acquired). In Lake Billy Chinook as bull trout became increasingly piscivorous† with increasing size, the prey species changed from mainly smaller bull trout and rainbow trout for bull trout less than 450 millimeters (17.7 inches) in length to mainly kokanee for bull trout greater in size (Beauchamp and Van Tassell 2001).

Migration allows bull trout to access optimal foraging areas and exploit a wider variety of prey resources. Bull trout likely move to or with a food source. For example, some bull trout in the Wenatchee basin were found to consume large numbers of earthworms during spring runoff in May at the mouth of the Little Wenatchee River where it enters Lake Wenatchee (USFWS 2003, in prep.). In the Wenatchee River radio-tagged bull trout moved downstream after spawning to the locations of spawning chinook and sockeye salmon and held for a few days to a few weeks, possibly to prey on dislodged eggs, before establishing an overwintering area downstream or in Lake Wenatchee (USFWS 2003, in prep.).

Reasons for Decline

Throughout their range in the lower 48 states bull trout have been negatively impacted by the combined effects of a variety of factors, including habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, fisheries management practices, entrainment†, and the introduction of nonnative species†. Habitat alteration, primarily through the construction of impoundments, dams, and water diversions, has fragmented habitats, eliminated migratory corridors, and isolated bull trout in the headwaters of tributaries (Rieman et al. 1997; Dunham and Rieman 1999; Spruell *et al.* 1999; Rieman and Dunham 2000). The combination of such factors has resulted in rangewide declines in bull trout distribution, abundance, and habitat quality, as well as the

reduction or elimination of migatory bull trout. Threats specific to bull trout within the Coastal-Puget Sound Distinct Population Segment are identified in the listing rule (64 FR 58910).

Populations of migratory bull trout require abundant fish forage and it is likely that many bull trout populations have been affected by declines in salmon populations. Bull trout are a piscivorous fish whose existence and historical abundance throughout much of their range was historically connected with, and most likely dependent on, healthy salmon populations (Armstrong and Morrow 1980; Brown 1994; Nelson and Caverhill 1999; Baxter and Torgerson, *in litt*., 2003). In parts of their range, especially in the Coastal-Puget Sound Distinct Population Segment, salmon continue to provide an important food source (Kraemer, *in litt*., 2003). Food resources provided by salmon include dislodged eggs, emergent and migrating fry, and smolts[†]. In addition, bull trout benefit from the increased productivity supplied by the decomposing carcasses of adult salmon.

Recent publications have documented the recent declines and low abundance of Pacific salmon populations throughout much of their range within the coterminous United States (WDF *et al*. 1993; NMFS 1991; NOAA, *in litt*., 2003). In 1991, the American Fisheries Society published a status list of 214 naturally spawning stocks[†] of salmon, steelhead, and cutthroat trout from California, Oregon, Idaho and Washington. Their assessment included 101 stocks at high risk of extinction, 58 stocks at moderate risk of extinction, 54 stocks of special concern, and one classified as threatened under the Endangered Species Act (Nehlsen *et al*. 1991).

Detailed information on specific threats to bull trout in the Puget Sound Management Unit (see “Recovery Plan Terminology and Structure,” below) is provided in Part II of this plan.

SIGNIFICANCE OF THE COASTAL-PUGET SOUND DISTINCT POPULATION SEGMENT

The full array of bull trout resident and migratory life history forms are found in the Coastal-Puget Sound Distinct Population Segment. Bull trout occurring here may be residents, or they may exhibit one of several migratory behaviors. Adfluvial bull trout migrate from tributary streams to a lake or reservoir to mature, and return to a tributary to spawn, and fluvial bull trout migrate from tributary streams to larger rivers to mature and then return to tributaries to spawn.

Of particular significance, the Coastal-Puget Sound Distinct Population Segment supports the only known anadromous form~~s~~ of bull trout within the coterminous United States. These fish hatch in freshwater, migrate to and from the ocean to grow and live as adults, and then return to freshwater to spawn.

The restoration and preservation of the migratory life history forms of bull trout will be an important factor in providing for the recovery of the species. Migratory barriers that have resulted in the loss of the migratory forms have been shown to negatively impact bull trout by increasing the probability of losing individual local populations (Rieman and McIntyre 1993), increasing the probability of hybridization† with introduced brook trout (Rieman and McIntyre 1993), reducing the potential for movements in response to developmental, foraging, and seasonal habitat requirements (MBTSG 1998), reducing reproductive capability by eliminating the larger, more fecund migratory form (MBTSG 1998; Rieman and McIntyre 1993), and reducing the geographic range of the species. Restoring and maintaining migratory corridors will ensure the persistence of migratory bull trout and allow individuals access to unoccupied but suitable habitats, foraging areas, and refuges from disturbances (Saunders *et al.* 1991). Furthermore, maintenance of migratory corridors for bull trout is essential to provide connectivity† among local populations, and enables the reestablishment of extirpated† populations. Where migratory bull trout are not present, isolated populations cannot be replenished when a disturbance makes local habitats temporarily unsuitable (Rieman and McIntyre 1993; USDA and USDI 1997).

Of the five distinct population segments of bull trout, only the Coastal-Puget Sound Distinct Population Segment provides the opportunity to conserve all known life history forms of the species. In the final listing rule, we determined that the Coastal-Puget Sound Distinct Population Segment of bull trout occurs in a unique ecological setting because it supports the only known anadromous forms of bull trout in the coterminous United States. In addition, it was determined that the loss of this population segment would significantly reduce the overall range of the taxon (64 FR 58910). Since the original listing, mitochondrial DNA data has revealed genetic differences between coastal populations of bull trout, including the lower Columbia and Fraser rivers, and inland populations in the upper Columbia and Fraser river drainages east of the Cascade and Coast Mountains (Williams *et al.* 1997; Taylor *et al.* 1999). This divergence is likely based on recolonization patterns associated with glacial refugia 10,000 to 15,000 years ago (Haas and McPhail 2001; Costello *et al.* 2003; Spruell *et al.* 2003), and suggests the existence of two or more genetically differentiated lineages of bull trout, each with a unique evolutionary legacy. Although this recent genetic evidence suggests some degree of shared evolutionary potential between all coastal populations of bull trout, these major assemblages are further subdivided at the level of major river basins (Spruell *et al.* 2003) and this, in conjunction with the unique occurrence of anadromy within the Coastal-Puget Sound Distinct Population Segment, suggests that it is appropriate to continue to focus our recovery efforts on this distinct population segment as we evaluate the potential implications of recent genetic analyses on the organization of bull trout recovery efforts.

RECOVERY PLAN TERMINOLOGY AND STRUCTURE

The bull trout is a wide-ranging species with multiple life history forms and a complex population structure reflecting a high degree of local site fidelity (Kanda and Allendorf 2001) and substantial genetic divergence between breeding populations (Dunham and Rieman 1999; Spruell *et al.* 2003). Furthermore, it has been suggested that maintaining variability in life history strategies and dispersal over many habitats may be as important to bull trout conservation as maintaining genetic variability (Rieman and Allendorf 2001). In order to preserve the diverse array of life histories and genetic variability exhibited by bull trout across their

range, this recovery plan utilizes the concept of "core areas[†]." A **core area** represents a combination of suitable habitat and one or more **local populations** (the smallest group of fish that are known to represent an interacting reproductive unit) that function as one demographic unit due to occasional gene flow between them; essentially, most core areas function as metapopulations[†] (Meffe and Carroll 1994; Hanski and Gilpin 1997; Dunham and Rieman 1999). A **metapopulation** can be defined as a collection of relatively isolated, spatially distributed local populations bound together by occasional dispersal between them. Local populations may be extirpated, but can be reestablished by individuals from other local populations, although, as stated earlier, genetic analysis indicates this will likely take a very long time. In general, the characteristics of most bull trout populations appear to be consistent with the metapopulation concept, although the exact structure of bull trout metapopulations is not well understood (Rieman and McIntyre 1993).

For the purposes of recovery, we defined core areas – which represent both suitable habitat as well as a demographically dependent grouping of local populations – as the most biologically meaningful population units to work with to ensure the long-term viability of bull trout. The key to bull trout recovery lies in providing an interconnected continuum of complex habitats which support diverse life histories and life cycles to maintain gene flow and genetic variation and facilitate metapopulation dynamics within core areas. To achieve this goal, we developed a hierarchical approach to bull trout recovery, and further subdivided the Coastal-Puget Sound Distinct Population Segment into two individual **management units**, the Puget Sound Management Unit and the Olympic Peninsula Management Unit. Focusing recovery on these smaller areas is advantageous because bull trout are broadly distributed, use a variety of habitats, and the factors affecting them vary widely at the scale of the distinct population segment. A narrower scope allows recovery actions to be tailored to specific areas and encourages the implementation of actions by local interests. The delineation of these management units was based on presumed shared genetic characteristics (*i.e.*, groupings of bull trout within isolated basins, major river basins, or collections of basins with potential for current or historical gene flow) as well as jurisdictional and logistical concerns (*e.g.*, the international boundary with Canada represents the northern boundary of the management units). The

intent of the management units is to foster effective management and promote local management decisions regarding bull trout as well as to preserve the evolutionary legacy shared between the multiple bull trout core areas that comprise each of the units.

The recovery of the Coastal-Puget Sound Distinct Population Segment of bull trout will depend upon the achievement of recovery goals and criteria for the entire distinct population segment. Maintenance of fully functioning core areas across the range of bull trout within the population segment will require that each of the two management units that comprise this distinct population segment contribute to the success of this effort. In keeping with the goal of fostering effective management and recovery of bull trout at the local level, we have developed separate recovery plans for each of these management units, and established specific "**recovery targets**" for each management unit that will be used to guide bull trout recovery within the distinct population segment as a whole.

Presently bull trout are listed across their range within the coterminous United States (64 FR 58910). Prior to the coterminous listing in 1999, five distinct population segments of bull trout were identified. Although the bull trout distinct population segments are disjunct and geographically isolated from one another, they include the entire distribution of bull trout in the coterminous United States. In accordance with our Distinct Population Segment policy (61 FR 4722), a coterminous listing was found to be appropriate when all five distinct population segments were determined to warrant listing. As provided in the final listing rule, however, we continue to refer to these populations as distinct population segments for recovery planning purposes (64 FR 58910).

A delisting determination can only be made on a "listable entity" under the Endangered Species Act; listable entities include species, subspecies, or distinct population segments of vertebrate animals, as defined by the Endangered Species Act and U.S. Fish and Wildlife Service policy (61 FR 4722). Because bull trout were listed at the coterminous level in 1999, currently delisting can only occur at the coterminous level (64 FR 58910). In the future, if warranted by additional information, and if the Coastal-Puget Sound population is reconfirmed

as meeting the definition of a distinct population segment under a regulatory rulemaking process, delisting may be considered separately for the Coastal-Puget Sound Distinct Population Segment of bull trout once it has achieved a recovered state.

Here we define the recovery criteria for the delisting of the Coastal-Puget Sound Distinct Population Segment of bull trout as currently delineated. The site-specific strategies, recovery actions, and recovery targets for the Puget Sound Management Unit are presented in Part II of this plan. The Olympic Peninsula Management Unit is addressed in its own recovery plan.

RECOVERY GOALS AND OBJECTIVES

Recovery Goal

The goal of this recovery plan is to **ensure the long-term persistence of self-sustaining, complex, interacting groups[†] of bull trout distributed across the Coastal-Puget Sound Distinct Population Segment so that the species can be delisted.** To accomplish this goal, recovery objectives addressing distribution, abundance, habitat and genetics were identified.

Recovery Objectives

The recovery objectives for the Coastal-Puget Sound Distinct Population Segment are as follows:

- Maintain the current distribution of bull trout anadromy and restore migratory life history forms in some of the previously occupied areas.

- Maintain stable or increasing trends in abundance of bull trout.

- Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies with an emphasis on anadromy.

- Conserve genetic diversity and provide opportunity for genetic exchange to conserve migratory life history forms.

Recovery Criteria

Achieving recovery criteria and making formal delisting decisions are two separate processes. Delisting requires that a five factor analysis[2] in a regulatory rulemaking process demonstrates that the threats to the species have been reduced or eliminated to the point that the species no longer requires the protections of the Endangered Species Act. The recovery criteria established in a recovery plan for a threatened species, such as the bull trout, are intended to serve as clear, measurable guidelines for assessing the conditions under which such a five factor analysis would likely result in a determination that the species warrants delisting (*i.e.*, that it no longer meets the definition of "threatened," which is "any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range"). A delisting decision therefore considers both the attainment of the recovery criteria as defined in a recovery plan and the outcome of a formal five factor analysis in a regulatory rulemaking.

The Coastal-Puget Sound Distinct Population Segment will be considered recovered when all core areas are fully functional, as measured by parameters addressing the distribution, abundance, productivity (stable or increasing adult population trend), and connectivity (including the potential for expression of all life history traits) of bull trout. The conditions for recovery are identified in the criteria below. The recovery actions identified in this plan are designed to sufficiently control or eliminate the threats to bull trout such that the recovery

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[2] The five factors considered in delisting decisions are the same as those considered in the initial listing process for a species: a) the present or threatened destruction, modification, or curtailments of its habitat or range; b) overutilization for commercial, recreational, scientific, or educational purposes; c) disease or predation; d) the inadequacy of existing regulatory mechanisms; and e) other natural or manmade factors affecting its continued existence.

criteria may be attained for the Coastal Puget Distinct Population Segment of bull trout.

Recovery criteria for the Coastal-Puget Sound Distinct Population Segment:

1. The biological and ecological function of the 14 identified core areas (8 in the Puget Sound Management Unit and 6 in the Olympic Peninsula Management Unit) for bull trout within the distinct population segment has been restored. The components of fully functioning core areas include:

a) **Habitat sufficiently maintained or restored to provide for the persistence of broadly distributed local populations supporting the migratory life form within each core area.** The term "broadly distributed" implies that local populations are able to access and are actively using habitat that fully provides for spawning, rearing, foraging, migrating, and overwintering needs at recovered abundance levels. An actual quantitative estimate of the amount of habitat that will be required to meet this criterion is unknown at this time; the adequacy of habitat restoration and management efforts must be measured indirectly by criteria 1b through 1d. The currently identified local populations that will be used as a measure of broad distribution across the distinct population segment are detailed in the recovery targets set for each of the two management units.

b) **Adult bull trout are sufficiently abundant to provide for the persistence and viability of core areas; this level of abundance is estimated to be 16,500 adult bull trout across all core areas.** Resident life history forms are not included in this estimate, but are considered a research need. As more data is collected, recovered population estimates will be revised to more accurately reflect both the migratory and resident life history components. The recovery team[†] has initially set abundance targets conservatively if there was limited available information for constituent core areas; these will likely be revised as new information becomes available. The recovered abundance levels for the currently identified core areas in the distinct

population segment are detailed in the recovery targets set for each of the two management units.

c) **Measures of bull trout abundance within all core areas show stable or increasing trends based on 10 to 15 years (representing at least 2 bull trout generations) of monitoring data.** Details are provided in the recovery targets for each of the two management units.

d) **Habitat within, and where appropriate, between core areas, is connected so as to provide for the potential of the full expression of migratory behavior (particularly anadromy), allow for the refounding† of extirpated populations, and provide for the potential of genetic exchange between populations.** Meeting this criterion requires that passage has been restored or improved, and in some cases further evaluated, at specific barriers identified as inhibiting recovery (including barriers due to physical obstructions, unsuitable habitat, and poor water quality). Known barriers to passage within the Puget Sound Management Unit include the Bellingham Diversion, Gorge Dam, Ross Dam, Tacoma Headworks diversion dam, and Howard Hansen Dam; the Baker River Dams and Electron and Buckley diversions are also in need of passage improvement. Known barriers to passage within the Olympic Peninsula Management Unit include Cushman Dams 1 and 2, Elwha Dam and Glines Canyon Dam, the Washington Department of Fish and Wildlife Dungeness Fish Hatchery, and U.S. Fish and Wildlife Service Quinault National Fish Hatchery. Details regarding these specific barriers are provided in the recovery targets set for each of the two management units.

Meeting this criterion also requires that conditions in both freshwater and nearshore marine foraging, migration, and overwintering habitats† are maintained and/or restored to the level that fully support an adequate prey base, especially for the anadromous forms, as well as the other identified components (distribution, abundance, and trend) for fully functional core areas within the Coastal-Puget Sound population segment.

2. A monitoring plan has been developed and is ready for implementation, to cover a minimum of 5 years post-delisting, to ensure the ongoing recovery of the species and the continuing effectiveness of management actions.

PART II. PUGET SOUND MANAGEMENT UNIT

INTRODUCTION

Management Unit Designation

As described in Part I of this plan, two management units, the Puget Sound and the Olympic Peninsula, have been designated in the Coastal-Puget Sound Distinct Population Segment of bull trout based on presumed biological and genetic factors common to bull trout within specific geographic areas (Figure 1). Although genetic data informing population structure in this area is incomplete, we believe that bull trout populations in watersheds originating from the Olympic Peninsula are likely different from those populations in watersheds originating from the West Cascades flowing into Puget Sound. Although these two management units are connected by marine waters, there is currently no evidence indicating that bull trout from one unit migrate to the other. Recent studies suggest that migrations through marine waters, at least currently, are more localized in nature (Kraemer 1994; F. Goetz, U.S. Army Corps of Engineers, pers. comm. 2002).

The Puget Sound and Olympic Peninsula Management Units for bull trout differ slightly from Washington State's salmon recovery regions described in the 1999 draft statewide strategy to recover salmon, "Extinction Is Not An Option" (WGSRO 1999). The salmon recovery strategy includes Hood Canal watersheds and some Strait of Juan de Fuca watersheds in the Puget Sound region.

The Puget Sound Management Unit encompasses the geographic area of the Puget Sound region bounded by the Cascade crest on the east, the Kitsap Peninsula on the west, and Canadian border to the north. The management unit

includes all watersheds within the Puget Sound basin and the marine nearshore areas of Puget Sound. This management unit also includes the Chilliwack River watershed, a transboundary system flowing into British Columbia and discharging into the Fraser River.

Based on survey data and professional judgement, the Puget Sound Recovery Team identified eight core areas (Chilliwack, Nooksack, Lower Skagit, Upper Skagit, Stillaguamish, Snohomish-Skykomish, Chester Morse Lake, and Puyallup) in the management unit (Figure 2). Core areas consist of core habitat[†] that could supply all the necessary elements for every lifestage of bull trout (*e.g.*, spawning, rearing, migration, overwintering, foraging), and have one or more local populations of bull trout. The demographically linked populations of bull trout and their associated habitat in core areas form the basic units upon which recovery will be gauged within the management unit. In addition, the Puget Sound Recovery Team also identified the Samish River, Lake Washington system, Lower Green River, Lower Nisqually River, and marine areas of Puget Sound as containing important foraging, migration, and overwintering habitat necessary for bull trout recovery (Figure 2). Although there is currently insufficient information available to assign each of these important foraging, migration, overwintering habitats to a specific core area(s), they are believed to be critical to the persistence of the anadromous life history form, unique to the Coastal-Puget Sound population segment. These habitats currently outside of designated core areas support the unique and complex migratory behaviors and requirements of anadromous bull trout. Once sufficient information is gathered on anadromous bull trout movements within the management unit, the current core area boundaries should be revised to depict the relationship between the individual core areas and these important foraging, migration, and overwintering habitats.

The Puget Sound Management Unit includes reservation land, Tribally-owned lands, or Tribal fishing areas of the Lummi Nation, Muckleshoot Tribe, Nisqually Tribe, Nooksack Tribe, Puyallup Tribe, Samish Indian Nation, Sauk-Suiattle Tribe, Snoqualmie Tribe, Squaxin Island Tribe, Stillaguamish Tribe, Suquamish Tribe, Swinomish Tribe, Tulalip Tribes, and Upper Skagit Tribe.

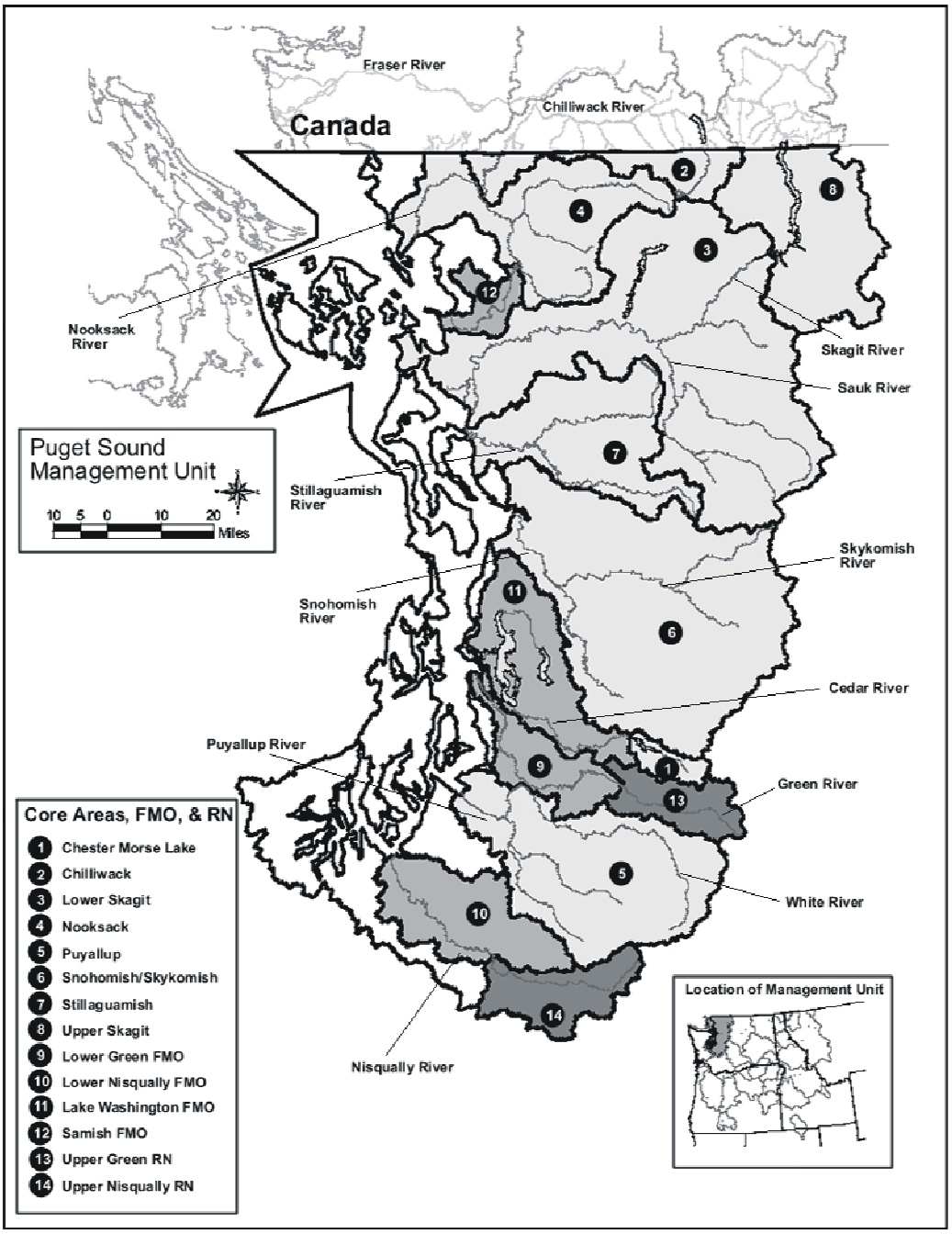

Figure 2. Puget Sound Management Unit showing the eight identified core areas; important foraging, migration, and overwintering habitats (FMO); and research needs areas (RN) for bull trout.

Geographic Description of Management Unit

The Puget Sound Management Unit encompasses the geographic area of the Puget Sound region and includes all watersheds within the Puget Sound basin and the marine nearshore areas of Puget Sound (Figure 2). This management unit also includes the Chilliwack River watershed, a transboundary system flowing into British Columbia and discharging into the Fraser River. Historically, these watersheds have been an important area for anadromous salmon (*Oncorhynchus* spp.), steelhead (*O. mykiss*), and bull trout production.

The Puget Sound basin is bounded on the east by the Cascade Range and on the west by the Olympic Mountains, extending north to British Columbia and south to the low hills of the Coast Range near Olympia (Kruckeberg 1991). There are 19 watersheds in the Puget Sound basin. River systems originating from the westside of the Cascades flow westerly and discharge into Puget Sound, the second largest estuary in the United States. The U-shaped valleys of the Puget Sound watersheds were formed primarily during the Vashon glaciation and by the subsequent effects of mountain glaciers. The rivers, creeks, and lowland lakes of the Puget Sound region are the remains of the Vashon glacier and its retreat. Considerable evidence indicates that climate in the Puget Sound region is cyclical, with warm, dry periods and cold, wet periods occurring at decadal intervals (Ebbesmeyer and Strickland 1995).

The Puget Sound basin can be divided, by precipitation and other climatic factors, into two natural provinces: the Puget Sound Province, and Cascade Mountains Province (Campbell 1962). The Puget Sound Province extends from British Columbia south to Oregon and is a lowland region that is mostly less than 305 meters (1,000 feet) in altitude. This province experiences moderate rainfall, ranging from 71 to 140 centimeters (28 to 55 inches) annually. Bedrock consists mostly of Tertiary sedimentary formations and lavas from the numerous volcanos. Vegetation within the province is dominated by Douglas fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*). Bigleaf maple (*Acer macrophyllum*) and red alder (*Alnus rubra*) are common hardwoods found within the region. Ferns and mosses provide ground cover, while vine maple (*Acer circinatum*) is a significant understory

species. The Cascade Mountains Province divides eastern and western Washington. The Cascade Mountain range is approximately 161 kilometers (100 miles) wide in the northern part of the State with peaks generally about 2,400 meters (8,000 feet) above sea level. Mount Rainier, Mount Baker, and Glacier Peak, all above 3,048 meters (10,000 feet), are the principal volcanic peaks found within the Puget Sound Management Unit and Cascade Mountains Province. River systems originating from the Cascades are typically fed by snowmelt or glacier runoff, and by precipitation. The west slope of the Cascades has a temperate marine type of climate that is characterized by mild wet winters and cool summers. The mountains receive high annual snowfall; precipitation may exceed 350 centimeters (140 inches) on the west slope of the Cascades Mountain Range. In the North Cascades, Paleozoic and Mesozoic sedimentary rocks and granite are found, while younger sedimentary and volcanic rocks predominate in the southern portion of the Cascades. Vegetation within the Cascades varies widely with precipitation and elevation. Pacific silver fir (*Abies amabilis*) and noble fir (*A. procera*) dominate at higher elevations, while Douglas fir and western hemlock are less common. Douglas fir, western hemlock, and western red cedar dominate the middle and lower elevations of the western slopes of the Cascades, where precipitation is high. Hardwoods, such as the bigleaf maple (*Acer macrophyllum*), vine maple, red alder, madrone (*Arbutus menziesii*), black cottonwood (*Populus trichocarpa*), and Oregon ash (*Fraxinus latifolia*), grow near streams and in other wet areas.

Major rivers within the Puget Sound Management Unit include the Skagit, with a drainage area of approximately 8,011 square kilometers (3,093 square miles), and the Snohomish River, with a drainage area of approximately 3,973 square kilometers (1,534 square miles). The other river systems within the management unit range in drainage area from the Samish River, with 228 square kilometers (88 square miles), to the Puyallup River, with 2,455 square kilometers (948 square miles). Two annual runoff peaks are common in the river systems within the mountainous terrain of the Pacific Northwest: one in the spring/summer due to snowmelt, and one in the autumn/winter due to prolonged or intense rainfall or rain on snow events (Millard *et al.* 2002).

Puget Sound is a fjord-like estuary and covers an area of about 2,330 square kilometers (900 square miles), including 3,700 kilometers (2,300 miles) of coastline. This body of water is subdivided into five regions: 1) North Puget Sound; 2) Main Basin; 3) Whidbey Basin; 4) South Puget Sound; and 5) Hood Canal. The average depth of Puget Sound is 62.5 meters (205 feet) at mean low tide, the average surface water temperature is 12.8 degrees Celsius (55 degrees Fahrenheit) in summer and 7.2 degrees Celsius (45 degrees Fahrenheit) in winter (Staubitz *et al.* 1997). It was designated as an "Estuary of National Significance" by the U.S. Environmental Protection Agency in 1988 (Kruckeberg 1991). Steep cliffs, largely made of glacial deposits, dominate most of the shoreline, with narrow beaches occurring at the toe of the bluffs and headlands. Extensive tidal flats are located at the river deltas.

Nearly 4 million people, 70 percent of Washington State's population, reside in the Puget Sound Basin (Ebbert *et al.* 2000). By 2020, the population is expected to increase by 1.1 million people, with growth focused in urban and suburban areas. Land use and cover is predominantly forest in the foothills and mountains, while urban and agricultural land uses are concentrated in the lowlands. Generally, heavy industry is located on the shores of urban bays and along the lower reaches of their tributaries, such as Elliott Bay and the Duwamish Waterway and Commencement Bay and the Puyallup River. More than half of the agricultural acreage in the basin is located in Whatcom, Skagit, and Snohomish Counties.

Within the State of Washington, the number of fish species is generally low in headwater streams at high elevations and increases downstream in larger streams and rivers with more diverse habitats (Beecher *et al.* 1988). Within the Puget Sound Management Unit, more than 35 species of native freshwater fishes exist (Table 1). Several nonnative fish species occur within the management unit that are known or suspected to have impacts to bull trout, including brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), and westslope cutthroat trout (*O. clarki lewisi*). Marine and estuarine species within the management unit known to be important prey for bull trout include sandlance (*Ammodytes hexapterus*), surf smelt (*Hypomesus pretiosus*), Pacific herring (*Clupea pallasi*), and shiner perch (*Cymatogaster aggregata*). Chinook salmon (*O. tshawytscha*)

Table 1. Native fish species inhabiting freshwater within the Puget Sound Management Unit (Wydoski and Whitney 2003).

Common name	Scientific name	Occurrence
Pacific lamprey	*Lampetra tridentata*	Anadromous
River lamprey	*L. ayresi*	Anadromous
Western brook lamprey	*L. richardsoni*	Freshwater
White sturgeon	*Acipenser transmontanus*	Anadromous; Freshwater
Coastal cutthroat trout	*O. clarki clarki*	Anadromous; Freshwater
Pink salmon	*O. gorbuscha*	Anadromous
Chum salmon	*O. keta*	Anadromous
Coho salmon	*O. kisutch*	Anadromous
Steelhead/rainbow trout	*O. mykiss*	Anadromous; Freshwater
Kokanee/sockeye salmon	*O. nerka*	Freshwater; Anadromous
Chinook salmon	*O. tshawytscha*	Anadromous
Pygmy whitefish	*Prosopium coulteri*	Freshwater
Mountain whitefish	*P. williamsoni*	Freshwater
Bull trout	*Salvelinus confluentus*	Freshwater; Anadromous
Dolly Varden	*S. malma*	Freshwater; Anadromous?
Longfin smelt	*Spirinchus thaleichthys*	Anadromous; Freshwater
Eulachon	*Thaleichthys pacificus*	Anadromous
Olympic mudminnow	*Novumbra hubbsi*	Freshwater
Lake chub	*Couesius plumbeus*	Freshwater

Table 1 (continued). Native fish species inhabiting freshwater within the Puget Sound Management Unit (Wydoski and Whitney 2003).

Common name	Scientific name	Occurrence
Peamouth	*Mylocheilus caurinus*	Freshwater
Northern pikeminnow	*Ptychocheilus oregonensis*	Freshwater
Longnose dace	*Rhinichthys cataractae*	Freshwater
Umatilla dace	*R. umatilla*	Freshwater
Speckled dace	*R. osculus*	Freshwater
Redside shiner	*Richardsonius balteatus*	Freshwater
Longnose sucker	*Catostomus catostomus*	Freshwater
Largescale sucker	*C. macrocheilus*	Freshwater
Three-spine stickleback	*Gasterosteus aculeatus*	Marine; Freshwater
Shiner perch	*Cymatogaster aggregata*	Marine; Freshwater
Coastrange sculpin	*Cottus aleuticus*	Freshwater
Prickly sculpin	*C. asper*	Freshwater
Shorthead sculpin	*C. confusus*	Freshwater
Riffle sculpin	*C. gulosus*	Freshwater
Reticulate sculpin	*C. perplexus*	Freshwater
Torrent sculpin	*C. rhotheus*	Freshwater
Pacific staghorn sculpin	*Leptocottus armatus*	Marine; Freshwater
Starry flounder	*Platichthys stellatus*	Marine; Freshwater

are currently listed as a threatened species under the Endangered Species Act within the management unit (March 24, 1999; 64 FR 14308), and coho salmon (*O. kisutch*) in the management unit are identified as a species of concern. More than 30 anadromous salmonid production facilities that produce and release Chinook, coho, chum (*O. keta*), and sockeye salmon (*O. nerka*) and steelhead exist in the management unit. Dolly Varden (*Salvelinus malma*) have been

proposed for listing as a threatened species within Washington State, based on their similarity of appearance to bull trout (January 9, 2001; 66 FR 1628).

Description of Core Areas

Chilliwack core area. The Chilliwack River basin is a transboundary system flowing from the United States into British Columbia, Canada. Its major tributary, the Sumas River, occupies a long flat valley bordered on the southeast by Vedder Mountain and on the northwest by Sumas Mountain. It begins in Whatcom County and flows across the border to Canada and into the Vedder River, which flows to the Fraser River at the mouth of the Vedder Canal (Healey 1997). Upstream from the confluence with the Chilliwack River, approximately half (83.8 square kilometers; 52.1 square miles) of the Sumas watershed's total area is located in the United States. This U.S. portion is zoned approximately 48.6 percent agriculture, 28.0 percent forestry, 20.2 percent rural, and 3.4 percent urban (Blake and Peterson 2002). The Canadian portion of the watershed exists mostly within the District of Abbotsford, British Columbia, and is physically characterized as a low-lying floodplain[†] referred to as the Sumas Prairie, bordered by steep mountains on both sides.

The Chilliwack River occupies a broad, west-trending valley. It is also a tributary to the Fraser River in British Columbia, while its upper reaches originate in Washington State. Subbasins of the Chilliwack River in general have steep valley sidewalls with narrow valley floors (Millard *et al.* 2002). Stream channels within subbasins tend to be deeply incised. Tributaries to the Chilliwack River include Damfino Creek, Frost Creek and Silesia Creek. Tomyhoi Creek is a tributary to Damfino Creek.

The Chilliwack River flows through mountainous, forested terrain in Washington State, crosses the Canadian border and flows into Chilliwack Lake. Chilliwack Lake, located in Chilliwack Lake Provincial Park, approximately 48 kilometers (30 miles) southeast of the town of Chilliwack, is 12 square kilometers (4.6 square miles) in size, with a mean depth of 67 meters (220 feet) and a maximum depth of 114 meters (374 feet). It is 625 meters (2,050 feet) above sea level and drains into the Vedder River. From there the river flows into the Sumas

River which drains into the Fraser River (Cleary 2001). The Chilliwack watershed is approximately 314 square kilometers (121 square miles) in size with an elevation range of 550 to 1,740 meters (1,804 to 5,709 feet). The Chilliwack River is the most productive system in the Fraser-Delta area (Swain *et al.* 1985). The Chilliwack valley experiences heavy precipitation during the winter and relatively warm, moist summers; average annual precipitation is 113 centimeters (44 inches).

Nearly the entire portion of the Chilliwack River (99 percent) within Washington State is in the North Cascades National Park and has been managed as designated Wilderness. Under the U.S. Northwest Forest Plan the Chilliwack River is a Tier 1 Key Watershed in the Aquatic Conservation Strategy (USDA 1994a, b). The upper reaches of Silesia Creek, the largest tributary to Chilliwack River, also lie in the Park, while downstream reaches are contained within the Mount Baker-Snoqualmie National Forest. The Washington State reaches of Tomyhoi and Damfino Creeks flow through National Forest lands, while the lands within the United States section of Frost Creek watershed are privately owned timber lands. In Canada, this watershed has been managed for multiple consumptive resource use such as logging, road building, recreation, fish hatcheries, and other activities.

The Chilliwack River has significant anadromous salmon populations (sockeye, coho, and Chinook salmon, native char, and steelhead), as well as resident fish populations, including native char that may be Dolly Varden or bull trout, rainbow trout (*O. mykiss*), cutthroat trout, kokanee (*O. nerka*), and mountain whitefish (*Prosopium williamsoni*). There are two naturally occurring adfluvial bull trout populations within the management unit, one of which is associated with Chilliwack Lake in the upper Chilliwack River drainage.

Nooksack core area. The Nooksack River is located within Whatcom (88 percent) and Skagit (6 percent) Counties within the United States, and within British Columbia, Canada (6 percent), and is the fourth largest tributary to Puget Sound. The Nooksack River Basin drains approximately 2,036 square kilometers (786 square miles) of land, of which 127 square kilometers (49 square miles) is in British Columbia, and consists of two hydrologic provinces: the uplands where

streams have steep gradients and cut through bedrock, and the lowlands where streams have low gradients and cut through glacial and interglacial sediments and alluvium (USGS 1969).

In the uplands east of the City of Deming, the Nooksack River has three major forks: the North Fork, Middle Fork, and South Fork. The North and Middle Forks originate from the glaciers and snowfields of Mount Baker and are typically turbid with moderate summer flows due to glacial melt. The Middle Fork enters the North Fork at river mile 40.5 (Williams *et al.* 1975). The South Fork drains snowpack from the Twin Sisters Mountain, with low flows during the summer, and meets the North Fork to form the mainstem at river mile 36.6 (Williams *et al.* 1975) and has a mean annual discharge† of 746 cubic feet per second (near Wickersham, Washington; water years 1934 to 1977) (USGS 2001). The North Fork generally experiences peak flows† in June and low flows in March, while the South Fork most frequently peaks in May and December, with low flows in August, resulting in divergent flow and water temperature patterns. Mean annual discharge of the North Fork downstream from Cascade Creek is 781 cubic feet per second (water years 1938 to 2001) (USGS 2001). The mean annual discharge for the Middle Fork is 495 cubic feet per second (15 water years from 1921 to 2001) (USGS 2001). Water temperatures in the North Fork are colder than the South Fork.

Streamflows in each of the forks combine just east of Deming, forming the mainstem of the Nooksack River. Here, the mean annual discharge is 3,331 cubic feet per second (59 water years from 1936 to 2001) (USGS 2001). From here, the Nooksack River flows to Bellingham Bay in Puget Sound. In the lowlands, tributaries such as Anderson, Smith, Fishtrap, and Tenmile Creeks, and many others discharge into the Nooksack River.

Natural vegetation within the basin includes western hemlock, western red cedar, red alder, Sitka spruce (*Picea sitchensis*), black cottonwood, Douglas fir, and grand fir (*Abies grandis*). Zoned land use for the Nooksack watershed is about 40 percent Federal, 33 percent forestry, 12 percent agriculture, 11 percent rural, 3 percent urban, 0.7 percent commercial and industrial, and 0.2 percent water and open space (Blake and Peterson 2002).

Water is diverted via a pipeline from the Middle Fork of the Nooksack River to Lake Whatcom, which is used as the municipal water supply for the City of Bellingham (USGS 2001). Lake Whatcom is in the Whatcom Creek watershed, which is separate from the Nooksack River watershed and drains directly into Bellingham Bay. Uses of surface waters from the Nooksack River system include agriculture, industry, municipal water supply, and recreation (USGS 2003).

The surface-water system of the Nooksack Basin lowlands has been extensively altered. In its natural condition, large areas of the lowlands were wetlands. Drainage systems have been installed to lower the water table and dry the land ever since farming by settlers started in the area, in about 1850. Parts of the drainage systems consist of open ditches that are easily identified, while other parts consist of underground structures not visible from the surface. Other alterations to the surface-water system include the diking, leveeing, and redirecting of the Nooksack River, to minimize damage from periodic flooding (USGS 2003). Historically the greater Nooksack delta included distributaries[†] (natural branches from the main channel) to both Lummi Bay and Bellingham Bay, with extensive estuarine, and riverine-tidal freshwater wetlands, especially on the side of Lummi Bay (Collins and Sheikh 2002). The Lummi Bay distributary was formerly the major channel, and it was closed off from the river in the mid-1880's. Dikes closed delta distributaries and blind tidal channels, meanders were cut off in the lower river, and tributary creeks were ditched (Collins and Sheikh 2002). Much of the Lummi Bay wetlands were diked and drained for agriculture, and Bellingham Bay has had substantial filling of wetlands (WSCC 2002a). The mainstem and lower South Fork Nooksack River historically had very large, full spanning logjams, and the upper mainstem and much of the forks have been transformed from anastomosing channel patterns (a channel which has major distributaries that branch and then rejoin it) to much wider, braided channels[†] (Collins and Sheikh 2002). The Nooksack River Basin supports all five species of Pacific salmon and is the northern extent of the range for the Nooksack dace (*Rhinichthys* sp.).

Skagit River Basin (encompassing the Lower Skagit and Upper Skagit core areas). The Skagit River is the largest watershed in Puget Sound. It is

located within the Cascades (upper watershed) and Puget Lowlands (lower watershed) ecoregions and drains a total of 8,011 square kilometers (3,093 square miles) of land, including 1,036 square kilometers (400 square miles) in British Columbia (USGS 1969). The Skagit Basin is composed of two geographic regions: the lower Skagit River and the upper Skagit River (USGS 2001). The river has an extensive delta in Skagit County.

The Skagit River Basin is located within Skagit (51 percent), Whatcom (30.9 percent), and Snohomish (18.1 percent) Counties. The majority of the watershed is under Federal (67.0 percent) ownership, followed by private (27.3 percent), State (5.3 percent), and Tribal (0.3 percent). Ownership in the lower Skagit Basin is predominately private (83.9 percent), while the majority (86.8 percent) of the upper watershed is Federal. Forestry is the major land use (65.9 percent) in the Skagit Basin, followed by range (9.9 percent), water (6.9 percent), agriculture (4.0 percent), and urban (0.9 percent), with other land uses making up the remaining 12.4 percent. The lower Skagit River watershed has more agriculture (17 percent versus 0 percent), and less forest (49 percent versus 71 percent) and range (3 percent versus 12 percent) use than the upper watershed.

Lower Skagit core area. The Lower Skagit core area includes all of the Skagit basin downstream of the Diablo Dam located at river mile 101 and encompasses approximately 5,260 square kilometers (2,030 square miles). This area includes all of the mainstem Skagit River downstream of Diablo Dam (including Gorge Lake), Cascade, Sauk, Suiattle, White Chuck, and Baker Rivers (including the lake systems upstream from Lower and Upper Baker Dams) and the estuary and nearshore marine areas (*e.g.*, Skagit Bay, Port Susan). Two large reservoirs, Lake Shannon (river mile 1.2) and Baker Lake (river mile 9.3), were created by hydroelectric dams, Lower and Upper Baker Dams, on the Baker River. Gorge Lake, created by Gorge Dam (river mile 96.6), is located on the mainstem Skagit River.

The geology of the lower Skagit River includes rolling moraines and foothills, and floodplains with the surface material of silt loam and gravel/sand loam (WDOE 2000). The geology of the upper Skagit River is glaciated ridges and plateaus, and U-shaped valleys with the surface material of deep

sandy-gravelly loams and bare rock and rubble. Natural vegetation includes western hemlock, western red cedar, red alder, and Douglas fir in the lower watershed and Pacific silver fir, subalpine fir (*Abies lasiocarpa*), Douglas fir and other mixed conifers in the upper watershed. Mean annual precipitation in the lower Skagit Basin is 94 centimeters (37 inches) with mean temperatures of 2.2/7.8 degrees Celsius (36.0/46.0 degrees Fahrenheit) in the winter and 11.1/16.7 degrees Celsius (52.0/62.0 degrees Fahrenheit) in the summer (WDOE 2000). Agriculture, urbanization, channel modifications have significantly changed the lower Skagit Valley. Much of the river below Sedro-Woolley has been extensively channelized[†], leveed and armored with riprap[†]. Low flows in the system typically occur in September. Stream flows are also greatly affected by the operations of five reservoirs, three on the upper Skagit River and two on the Baker River. The Skagit River system supports all five species of Pacific salmon and the rare Salish sucker (*Catostomus* sp.).

The Skagit River delta was one of the first in Puget Sound to be converted from tidal wetlands to agriculture (Beechie *et al*. 1994), resulting in the loss of approximately 96 square kilometers of estuarine habitat (37 square miles), or 93 percent of its historical coverage (Dean *et al.* 2000). The Skagit River passes around Fir Island discharging into Skagit Bay. Padilla Bay is a National Estuarine Research Reserve located to the north of Skagit Bay, connected to the southern delta by the Swinomish Channel. There are nearly 32 square kilometers (12.5 square miles) of eelgrass (*Zostera* spp.) in Padilla Bay. Although Padilla Bay is not currently connected to the Skagit River system, historically it was connected periodically through flood flows. One of the alternatives being studied for flood control in the lower Skagit River would permanently connect the river to Padilla Bay.

Upper Skagit core area. The Upper Skagit core area includes the Skagit Basin upstream of Diablo Dam, including Diablo Lake, Ross Lake (created by Ross Dam at river mile 105.2), and the upper Skagit River drainage in British Columbia. The Upper Skagit River core area has a total drainage area of about 2,900 square kilometers (1,125 square miles), including the upper 1,036 square kilometers (400 square miles) of the drainage in British Columbia, Canada. A large portion of this watershed is located within North Cascades National Park,

Pasayten Wilderness, Skagit Valley Provincial Park, and Manning Provincial Park.

Mean annual precipitation in the upper Skagit Basin is approximately 254 centimeters (100 inches) with mean temperatures of -10.6/2.2 degrees Celsius (13.0/36.0 degrees Fahrenheit)[3] in the winter and 7.2/21.1 degrees Celsius (44.0/70.0 degrees Fahrenheit) in the summer. Mean annual flow of the lower Skagit River, near Mount Vernon, Washington (river mile 15.9), is 16,710 cubic feet per second with highest flows occurring in June associated with spring/summer snowmelt (USGS 2001). In the upper Skagit, mean annual flow, near Concrete, Washington (river mile 54.9), is 15,040 cubic feet per second with highest flows occurring in the late spring/early summer associated with snowmelt. A second peak flow typically occurs in December associated with fall/winter rain events.

Stillaguamish core area. The Stillaguamish River is the fifth largest tributary to Puget Sound, with a drainage basin of 1,774 square kilometers (685 square miles) (WSCC 1999a). The watershed is mostly within the boundaries of Snohomish County. Above Arlington (river mile 17.4; 804 meters elevation; 2,638 feet), the Stillaguamish River has two major forks: the North Fork and the South Fork. The North Fork drains 42 percent or 736 square kilometers (284 square miles) of the watershed. The South Fork drains 37 percent or 660 square kilometers (255 square miles) of the watershed. The mean annual discharge for the North Fork near Arlington is 1,892 cubic feet per second (73 water years from 1929 to 2001) (USGS 2001). Below the confluence of the forks, the valley gradually slopes westward towards Puget Sound. Pilchuck, Deer, and Canyon Creeks are the three largest tributaries within the basin. Near the mouth of the Stilliguamish River, the mainstem divides into two distributary channels before entering Puget Sound: Hat Slough and Stillaguamish Channel.

The geology of the Stillaguamish watershed is a combination of continental and alpine glacial deposits, and marine and non-marine interglacial

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[3] Mean temperatures are presented in pairs representing the mean low temperature/mean high temperature.

deposits (WSCC 1999a). Mean annual rainfall ranges from 76 cm (30 inches) in the western lowlands to more than 356 cm (140 inches) in the eastern region, with approximately 75 percent of it occurring between October and March. The highest streamflows occur during autumn and winter, while the lowest streamflows occur from July to September. Excess sedimentation, mostly from landslides associated with human land uses, exist within the basin. Conifers comprise most of the vegetation within the basin, consisting of western hemlock, Douglas fir, western red cedar, Sitka spruce, and mountain hemlock (*Tsuga mertensiana*). Within the floodplain, deciduous trees, such as alder, bigleaf maple, willow (*Salix* spp.), cottonwood, and vine maple, predominate.

There are no large hydroelectric or flood control dams within the watershed (WSCC 1999a). However, two diversion structures exist within the watershed, the Cook Slough Weir and the Granite Falls fishway. Side channels and sloughs within the watershed have been disconnected from the main river channel, resulting in a decrease of these habitats by 31 percent from historical levels. Currently, the total freshwater wetland area within this watershed is estimated to be 2,537 hectares (6,268 acres), or 22 percent of the historical level.

Land use within the basin consists of 76 percent forest, 17 percent rural residential, 5 percent agriculture, and 2 percent urban (WSCC 1999a). The predominant land uses in the upper watershed are timber production and dispersed recreation. Agricultural use is concentrated in the valley bottoms along the mainstem, forks, and the larger tributaries. Much of the Stillaguamish Estuary has been converted to agriculture. In addition, nonnative cordgrasses (*Spartina* spp.) have invaded the estuary. Many lakes in the Stillaguamish watershed have been stocked with nonnative and native fish species.

Snohomish-Skykomish core area. The Snohomish-Skykomish core area includes the Snohomish River, its two major tributaries, the Skykomish and Snoqualmie Rivers, and all their tributaries. The Snohomish River Basin, located northeast of Seattle, Washington, is the second largest Puget Sound basin, draining approximately 3,973 square kilometers (1,534 square miles) of land (USGS 1969). The Skykomish and Snoqualmie Rivers originate in steep, narrow valleys in the Cascade Mountains, flow downstream through broad alluvial[†]

floodplains, and merge with the mainstem of the Snohomish River near the city of Monroe (Haas and Collins 2001). From there, the river flows for 34.5 kilometers (21.4 miles) through a valley formed by glaciers and empties into Possession Sound between the city of Everett and the Tulalip Indian Reservation.

The Skykomish River Basin drains a total of 1,386 square kilometers (535 square miles) of land (USGS 1969). The mean annual discharge for the Skykomish River near Gold Bar is 3,946 cubic feet per second (73 water years from 1929 to 2001) (USGS 2001). The mean annual discharge for the Snoqualmie River near Carnation is 3,730 cubic feet per second (72 water years from 1930 to 2001) (USGS 2001). The mean annual discharge for the Snohomish River at the confluence of the Snoqualmie and Skykomish Rivers is 9,625 cubic feet per second (Haas and Collins 2001).

Average annual rainfall ranges from 89 to 457 cm (35 to 180 inches) per year (WSCC 2002b). Western hemlock, Douglas Fir, western red cedar, and Sitka spruce are the dominant conifer species present. Deciduous trees present include red alder, black cottonwood, and bigleaf maple.

Chester Morse Lake core area. The Chester Morse Lake core area is located in southeast King County in the upper Cedar River watershed above a natural migration barrier, Lower Cedar Falls. This core area consists of the mountainous upper portion of the Cedar River drainage system within the Cedar River Municipal Watershed. It extends upstream from Lower Cedar Falls (river mile 34.4), through a 2.3-kilometer (1.4-mile) ‘canyon reach' to the Masonry Dam (river mile 35.7) at the west end of the Chester Morse Lake/Masonry Pool reservoir complex and approximately 26 kilometers (16 miles) eastward to the crest of the central Cascades. The hydrographic drainage of the core area is 213 square kilometers (82 square miles) and encompasses five major tributary basins: Chester Morse Lake (47 square kilometers; 28 square miles), upper Cedar River (62 square kilometers; 24 square miles), Rex River (59 square kilometers; 23 square miles), North Fork Cedar River (25 square kilometers; 10 square miles), and South Fork Cedar River (18 square kilometers; 7 square miles), as well as the ‘canyon reach' in the Lower Cedar River major tributary basin (1.8 square kilometers; 0.7 square miles).

The entire hydrographic drainage of the core area is within the 366.4 square kilometer (141.5 square mile) municipal watershed, owned and managed by the City of Seattle. This watershed serves as the major source of water for the City of Seattle and surrounding communities, and has had restricted public access since 1908 to maintain high water quality. The Cedar River watershed above Cedar Falls has a drainage area of 218 square kilometers (84 square miles). The largest water body in the upper Cedar River watershed is Chester Morse Lake, originally called Cedar Lake, which was naturally formed by glaciers. It is approximately 6.4 kilometers (4 miles) long and one kilometer (0.6 miles) wide with an area of about 6.2 square kilometers (2.4 square miles). The water elevation of the lake was raised 9.8 meters (32 feet) following the construction of Crib and Masonry Dams to provide storage for the City of Seattle's water supply. The western end of Chester Morse Lake, Masonry Pool (2.3-kilometer long, 0.8 square kilometers; 1.4-mile miles long, 0.3 square miles), is connected to the main body of the lake by a narrow channel flowing through a terminal glacial moraine. Chester Morse Lake currently has a maximum depth of 41.1 meters (135 feet) at full pool, while Masonry Pool has a depth of approximately 20.4 meters (67 feet) at maximum operating capacity. Masonry Pool is physically separated from Chester Morse Lake during periods of drawdown by a small concrete dam (Crib Dam). The two major tributaries flowing into Chester Morse Lake are the upper Cedar River and Rex River. The upper Cedar River is the larger of these tributaries, having a drainage area of 106 square kilometers (41 square miles). The Rex River has a drainage area of 36 square kilometers (14 square miles).

Only four fish species inhabit the Chester Morse Lake/Masonry Pool reservoir: bull trout, shorthead sculpin (*Cottus confusus*), rainbow trout, and pygmy whitefish (*Prosopium coulteri*) (Wyman 1975; Wydosky and Whitney 2003). The Cedar River Municipal Watershed is dominated by coniferous forest (94.4 percent) typical of the west slope and foothills of the central Washington Cascade Mountain Range (WSCC 2001). Much of this watershed has supported commercial timber harvest for the last 120 years, yielding a mosaic of multi-seral stage[†] forest today. The steep landscape is dominated by second-growth conifer forest with primarily 60 to 69 year old forest up to an approximate elevation of 762 meters (2,500 feet). Patchy, regenerating forest ranging from 20 to 70 years

old is found at mid-slope and in some cases to ridge tops. Young forest (*e.g.*, 0 to 9 and 10 to 19 years old) and old forest (190+ years) exist as fragmented and isolated patches along the ridgelines at elevations of about 1,219 meters (4,000 feet) (WSCC 2001). Small patches of mixed coniferous/deciduous forest and/or deciduous forest (mostly red alder) persist adjacent to small tributary drainages and in areas with poor soil drainage.

Puyallup core area. The Puyallup River Basin is the third largest tributary to Puget Sound. It encompasses approximately 272,767 acres (674,000 acres) and is located in the Cascades (upper watershed) and Puget Lowlands (lower watershed) ecoregions (WDOE 2000). The Puyallup core area includes the following major rivers and their tributaries: the Puyallup, Mowich, Carbon, and the White Rivers including the Clearwater, Greenwater, and West Fork White Rivers, and Huckleberry Creek. The Mowich River drains the North and South Mowich and Flett Glaciers and enters the upper Puyallup at river mile 42.3. The Carbon River drains the Carbon and Russel Glaciers and flows westerly to join the mainstem Puyallup River near river mile 18. The White River, the largest tributary to the lower Puyallup River, drains Emmons, Inter, Winthrop and Frying Pan Glaciers on the northeast flank of Mount Rainier located in Mount Rainier National Park. The White River then flows through the Mount Baker-Snoqualmie National Forest and converges with the lower Puyallup River at river mile 10.4. The Puyallup River drains the Tahoma and the Puyallup glaciers on Mount Rainier and flows generally northwest to Commencement Bay. Commencement Bay is approximately 2,307 hectares (5,700 acres) in size and has been substantially altered from its historical condition (WSCC 1999b).

Mean annual precipitation is approximately 165 centimeters (65 inches) with mean temperatures of 0.5/7 degrees Celsius (33/44 degrees Fahrenheit) in the winter and 10/25 degrees Celsius (50/78 degrees Fahrenheit) in the summer. Mean annual flow of the Puyallup River, near Puyallup, Washington (river mile 6.6), is 3,328 cubic feet per second with highest flows occurring from late spring/early summer period associated with spring/summer snowmelt (USGS 2001). Low flows occur in September. Stream flows on the Puyallup River are affected by the diversion at river mile 41.7, which serves Puget Sound Energy's Electron facility, and on the White River by the operations of Mud Mountain

Dam (river mile 29.6) for flood control and the Puget Sound Energy's Buckley diversion dam at river mile 24.2.

The geology of the Puyallup River includes the lowlands (floodplains and terraces) and U-shaped glaciated mountains. Surface materials include silt- and clay-loam, gravelly clay loam, and cobbly loam. Natural vegetation includes western hemlock, western red cedar, red alder, and Douglas fir.

The Puyallup River Basin is located within Pierce (87 percent) and King (13 percent) Counties. Land ownership consists primarily of private lands (57.4 percent), followed by Federal (38.8 percent), Tribal (3.2 percent), and State (0.6 percent). Land use in the Puyallup River Basin includes: forestry (66 percent), urban (8 percent), range (4 percent), agriculture (4 percent), water (3 percent), and other (15 percent). Many of the headwater reaches of the Puyallup Basin are within either Mount Rainier National Park or designated Wilderness areas (WSCC 1999b). Extensive urban growth, heavy industry, a large marine port, revetments[†] and levees, and agriculture have altered the lower landscape. Commencement Bay is surrounded on three sides by industry, commercial and residential influences (WSCC 1999b). Dredging, filling, and diking of the habitat have largely eliminated historical, off-channel distributary channels and sloughs. For example, an estimated 72 of the original 850 hectares (180 of the original 2,100 acres) of historical intertidal mudflat remains today.

Samish River foraging, migration, and overwintering habitat. The Samish River Basin is located north of the Skagit River Basin and drains a total of 228 square kilometers (88 square miles) of land (USGS 1969). Lake Samish is located on Friday Creek, a tributary to Samish River, 10.5 kilometers (6.5 miles) southeast of Bellingham. Mean annual discharge for the Samish River, near Burlington, is 246 cubic feet per second (1944 to 2001) (USGS 2001). During very high flows (over 146,000 cubic feet per second) at Mount Vernon, a portion of the Skagit River can overflow to the Samish River and Bay. Land use in the floodplain is primarily rural with some suburban development.

Lake Washington foraging, migration, and overwintering habitat. The Lake Washington foraging, migration, and overwintering habitat consists of the lower

Cedar River, the Sammamish River, Lakes Washington, Sammamish and Union, the Lake Washington Ship Canal, and all accessible tributaries and lakes. The upper Cedar River Watershed above Cedar Falls is a separate core area and not included in this description.

Lake Washington is a large monomictic (one regular period of mixing) lake with a total surface area of 95 square kilometers (37 square miles), a mean depth of 33 meters (108 feet), and approximately 129 kilometers (80 miles) of shoreline (WSCC 2001). The lake typically stratifies from June through October. Surface water temperatures range from 4 to 6 degrees Celsius (39 to 43 degrees Fahrenheit) in winter to over 20 degrees Celsius (68 degrees Fahrenheit) in summer. Residential land use comprise over 78 percent of the shoreline. During winter (December to February) the lake level is kept low at an elevation of 6.1 meters (20 feet). Starting in late February the lake level is slowly raised to 6.6 meters by May 1 and 6.7 meters (21.6 and 22.0 feet) by June 1. The Ballard Locks, located at the downstream end of the Ship Canal, controls the lake level.

The major tributary to Lake Washington is the Cedar River which enters the lake at the south end. The river originates at approximately 1,220 meter (4,002 feet) elevation and over its 80 kilometer (50 mile) course falls 1,180 meters (3,871 feet) in elevation. Prior to 2003, Landsburg Dam, a water diversion structure, prevented fish from migrating upstream of river mile 21.8.

Beginning in 1912, drainage patterns of the Cedar River and Lake Washington were extensively altered (Weitkamp and Ruggerone 2000). Most importantly, the Cedar River was diverted into Lake Washington from the Duwamish River watershed, and the outlet of the lake was rerouted through the Ship Canal. Lake Sammamish is within the Lake Washington basin and is located just east of Lake Washington. Lake Sammamish has a surface area of 19.8 square kilometers (7.6 square miles) and a mean depth of 17.7 meters (58 feet). Most of the shoreline is in residential land use. Issaquah Creek is the major tributary to the lake and enters the lake at the south end.

The Ship Canal is a 13.8 kilometer (8.6 mile) artificial waterway that is located between Lake Washington and Puget Sound. The Ship Canal consists of five sections, Montlake Cut, Portage Bay, Lake Union, Fremont Cut, and the Salmon Bay waterway. The largest part of the Ship Canal is Lake Union which is 2.4 square kilometers (0.9 square miles) in size and has a mean depth of 9.8 meters (32 feet). The shorelines of Portage Bay and Lake Union are highly developed with numerous marinas, commercial shipyards, and house boat communities. The Fremont Cut is a steep riprap channel that connects Lake Union to Salmon Bay. There are 24 known nonnative fish species in the Lake Washington watershed (WSCC 2001).

Lower Green River foraging, migration, and overwintering habitat. The Green/Duwamish River watershed originates in the Cascade Mountains approximately 48 kilometers (30 miles) northeast of Mount Rainier and flows into Puget Sound at Elliott Bay in Seattle (KCDNR and WSCC 2000). Historically, the White, Green, Black, and Cedar Rivers flowed into the Duwamish River, with a drainage basin of over 4,144 square kilometers (1,600 square miles). In the early 1900's, the White, Black, and Cedar Rivers were diverted to other systems, reducing the Green/Duwamish drainage current area to 1,440 square kilometers (556 square miles).

The basin can currently be divided into four physiogeographic parts: 1) the upper Green River consisting of the headwaters to the Howard Hanson Dam at river mile 64.5; 2) the middle Green River from Howard Hanson Dam to the Soos Creek confluence at river mile 32; 3) the lower Green River from Soos Creek confluence to the Black River confluence at river mile 11; and 4) the Duwamish River watershed below river mile 11. Annual precipitation within the watershed varies widely from 90 centimeters (35 inches) in Seattle to over 254 centimeters (100 inches) in the Cascade foothills.

The upper Green River watershed contains approximately 45 percent of the Green/Duwamish watershed area and includes the Sunday, Sawmill, Champion, Smay, and Charlie Creeks, and the North Fork Green River. In this area, the river flows west and northwest through densely forested and steep and narrow valleys. The upland vegetation is a checkerboard of old-growth, second-

growth, and recently logged areas. Immediately downstream of the North Fork Green River confluence at river mile 64.5 is Howard Hanson Dam, constructed in 1961 as a flood control facility. A well field, operated by Tacoma Public Utilities, is located in the North Fork Green River. Within the middle Green River watershed, a water supply diversion facility that blocks anadromous fish migration is maintained at river mile 61. Downstream of the diversion, the river flows through mostly forested, steep and narrow valleys to approximately river mile 46.4. At this point, the river flows through a largely forested, broad and gently sloped valley. The lower Green River watershed flows through increasingly urbanized areas within the cities of Auburn, Kent, and Tukwila. The mean annual flow in the lower Green River near Auburn is 1,350 cubic feet per second. Downstream of the Black River confluence at river mile 11, which is the upstream limit of tidal influence, the Green River is called the Duwamish River. The Duwamish River flows through a heavily industrialized area, scattered with urban parks and residences. The Duwamish River and Elliott Bay have been extensively modified, including the filling of 97 percent of their original wetlands and shallow subtidal habitats.

Lower Nisqually River foraging, migration, and overwintering habitat. The Nisqually River foraging, migration, and overwintering habitat consists of the Nisqually River estuary, McAllister Creek, and lower Nisqually River. The Nisqually River basin drains a total of 1,339 square kilometers (517 square miles) of land (USGS 1969) and has the largest estuary in south Puget Sound (Nisqually EDT Work Group 1999). Although the Nisqually River estuary is considered to be largely undisturbed, it has been modified by dikes and reduced in size by approximately 30 percent (Glass and Salminen 2002). The Nisqually River originates from glaciers and streams on the south side of Mount Rainier in the National Park and flows westerly to Alder Reservoir created by Alder Dam. Downstream of Alder Dam is LaGrande Dam from which the river flows northwesterly to south Puget Sound. LaGrande Dam, located at river mile 42.5 and completed in 1910, limits anadromous fish migration. A natural barrier may have historically existed near the location of this dam. Tributaries to the Nisqually River located below LaGrande Dam contribute approximately 40 percent of the total flow in the lower mainstem of the Nisqually River (Glass and

Salminen 2002). These tributaries include Muck Creek, Murray Creek, Toboton Creek, Tanwax Creek, Powell Creek, Ohop Creek and the Mashel River.

The majority of the basin is below 305 meters (1,000 feet) in elevation (Glass and Salminen 2002). The geology of the Nisqually River includes the lowlands (floodplains and terraces) and U-shaped glaciated mountains. The western portion of the watershed is covered by unconsolidated glacial deposits, while the eastern portion generally consists of sedimentary and volcanic rock. Mean temperature ranges from 1.1/7.8 degrees Celsius (34/46 degrees Fahrenheit) in winter to 8.3/15.5 degrees Celsius (47/78 degrees Fahrenheit) in summer. Mean annual precipitation within the watershed ranges from 84 to 127 centimeters (33 to 50 inches) in the lower watershed to 178 centimeters (70 inches) in the upper watershed. The wettest months are November through January, with June through August being the driest months. Natural vegetation includes western hemlock, western red cedar, Douglas fir, prairies, and some oak (*Quercus* spp.) woodland.

The McAllister subbasin includes McAllister Creek, and its tributaries, Medicine Creek, and Little McAllister Creek (Glass and Salminen 2002). McAllister Creek is a low gradient stream originating at McAllister Springs and flowing 8.8 kilometers (5.5 miles) to enter the Nisqually River delta southwest of the mouth of the Nisqually River.

Land use within the Nisqually Basin is diverse. The estuary is largely under Federal, Tribal, and State ownership. The lower Nisqually River is under Tribal and military ownership (Nisqually EDT Work Group 1999). The Nisqually River is bordered on the south bank by The Nisqually Indian Reservation from approximately river mile 3.7 to 10.6. The Fort Lewis Military Reservation borders the Nisqually River on the north bank from river mile 2.4 upstream to approximately river mile 21.0. The lower portion of the basin is primarily rural residential (49 percent), followed by forest (22 percent), forest/prairie (18 percent), and agriculture (4 percent), while the upper part is primarily forested (Glass and Salminen 2002). Two anadromous fish hatchery facilities currently operate within the Nisqually Basin.

Marine foraging, migration, and overwintering habitat. The "marine" foraging, migration, and overwintering habitat includes portions of Puget Sound and associated nearshore and estuarine areas. Puget Sound can be subdivided into five regions: 1) North Puget Sound; 2) Main Basin; 3) Whidbey Basin; 4) South Puget Sound; and 5) Hood Canal (NMFS 2000). The Hood Canal basin is part of the Olympic Peninsula Management Unit and is not discussed in this volume. The average depth of Puget Sound is 62.5 meters (205 feet) at mean low tide, the average surface water temperature is 12.8 degrees Celsius (55.0 degrees Fahrenheit) in summer and 7.2 degrees Celsius (44.0 degrees Fahrenheit) in winter (Staubitz *et al*. 1997). Estuarine circulation in Puget Sound is driven by tides, gravitational forces, and freshwater inflows. Significant variability in tidal heights occurs throughout Puget Sound. The major sources of freshwater are the Skagit and Snohomish Rivers located in Whidbey Basin. Fresh water flows into the Sound at an average rate of 4 billion cubic meters (140 billion cubic feet) per year. On average, the waters of Puget Sound are effectively replaced twice a year.

Nearshore and estuarine habitats are highly productive due to the complexity of habitats and nutrient inputs. Tidelands, salt marshes, sand- and mud flats, blind tidal channels, eelgrass, kelp and intertidal algal beds and marine shoreline areas within the photic zone are examples of nearshore and estuarine habitat (STAG 2002). Kelp beds and eelgrass meadows cover the largest area of Puget Sound, almost 1,000 square kilometers (386 square miles) (NMFS 2000). Other major habitats include subaerial and intertidal wetlands (176 square kilometers; 68 square miles), and mudflats and sandflats (246 square kilometers; 95 square miles). The extent of some of these habitats has markedly declined over the last century. The nearshore habitat of Puget Sound has been modified by channelization, bank protection and land use in the estuarine zone. Overall losses since European settlement, by area, of intertidal habitat is estimated to be 58 percent for Puget Sound (Hutchinson 1988). The Duwamish, Lummi, Puyallup, and Samish river deltas have lost greater than 92 percent of their intertidal marshes (Simenstad *et al*. 1982; Schmitt *et al*. 1994). Substantial declines of mudflats and sandflats have also occurred in the deltas of these estuaries (Levings and Thom 1994).

The North Puget Sound region is demarcated to the north by the United States-Canadian border, to the west by a line due north of the Sekiu River, to the south by the Olympic Peninsula, and to the east by a line between Point Wilson (near Port Townsend) and Partridge Point on Whidbey Island and the mainland between Anacortes and Blaine, Washington (NMFS 2000). The region is bordered primarily by rural areas with a few localized industrial developments (PSWQA 1988). About 71 percent of the area draining into North Sound is forested, 6 percent is urbanized, and 15 percent is used for agriculture. The main human population in this area centers around Port Angeles (2000 population census: 18,397), Port Townsend (8,334), Anacortes (14,557), and Bellingham (67,171). An estimated 21 percent of the shoreline in this area has been modified by human activities (WDNR 1998). Eelgrass is the primary vegetation in the intertidal areas of the Strait of Juan de Fuca, covering on average 42.2 percent (range 15 to 69.4 percent) of the intertidal area, and green algae is the second most common, covering on average 4.4 percent (range 0.7 to 8.1 percent) of the intertidal area (Bailey *et al*. 1998). About 45 percent of the shoreline of this region consists of kelp habitat, compared to only 11 percent of the shoreline of the other four Puget Sound regions (Shaffer 1998). Eelgrass is found in protected areas, such as Samish and Padilla Bays, while the densest kelp beds in Puget Sound are found in the Strait of Juan de Fuca.

The 75 kilometer (47 mile) long Main Basin is delimited to the north by a line between Point Wilson (near Port Townsend) and Partridge Point on Whidbey Island, to the south by Tacoma Narrows, and to the east by a line between Possession Point on Whidbey Island and Meadow Point (near Everett) (NMFS 2000). The Main Basin includes Sinclair and Dyes inlets, Colvos and Dalco passages and the large embayments, Elliott and Commencement Bays. Approximately 30 percent of the freshwater flow into the Main Basin is derived from the Skagit River. Seattle, Tacoma, and Bremerton border the Main Basin. Human population sizes for these cities are about 563,374, 193,556, and 37,259, respectively (2000 census). Approximately 70 percent of the drainage area in this basin is forested, 23 percent is urbanized, and 4 percent is used for agriculture (Staubitz *et al*. 1997). An estimated 52 percent of the shoreline in this area has been modified by human activities (WDNR 1998). The Main Basin has a relatively small amount of intertidal vegetation, with an average of 28.3 percent

(range 17.9 to 38.7 percent) of the intertidal area containing predominantly green algae and eelgrass vegetation (Bailey *et al*. 1998). Most of the eelgrass is located on the western shores of Whidbey Island and the eastern shores of the Kitsap Peninsula (PSWQA 1987).

The Whidbey Basin includes the marine waters east of Whidbey Island and is delimited to the south by a line between Possession Point on Whidbey Island and Meadowdale, west of Everett. The northern boundary is Deception Pass at the northern tip of Whidbey Island (NMFS 2000). The Skagit River (the largest single source of freshwater in Puget Sound) enters the northeastern corner of the Basin, forming a delta and the shallow waters (less than 20 meters; 66 feet) of Skagit Bay. Most of the Whidbey Basin is surrounded by rural areas with low human population densities. About 85 percent of the drainage area of this Basin is forested, 3 percent is urbanized, and 4 percent is in agricultural production. The primary urban and industrial center is Everett, with a population of 78,000. Most waste includes discharges from municipal and agricultural activities and from a paper mill. An estimated 36 percent of the shoreline in this area has been modified by human activities (WDNR 1998). Vegetation, predominantly green algae, eelgrass, and salt marsh, covers an average of 23.6 (range 14.8 to 32.4 percent) of the intertidal area of the Whidbey Basin (Bailey *et al*. 1998). Eelgrass beds are most abundant in Skagit Bay and in the northern portion of Port Susan (PSWQA 1987).

The Southern Basin includes all waterways south of Tacoma Narrows (NMFS 2000). This basin is characterized by numerous islands and shallow (generally less than 20 meters; 66 feet) inlets with extensive shoreline areas. The largest river entering the basin is the Nisqually River which enters just south of Anderson Island. About 85 percent of the area draining into this basin is forested, 4 percent is urbanized, and 7 percent is in agricultural production. The major urban areas around the South Sound include Tacoma, University Place, Steilacoom, and Fircrest, with a combined population of about 100,000. Other urban centers in the South Sound Basin include Olympia with a population of 41,000 and Shelton with a population of 7,200. An estimated 34 percent of the shoreline in this area has been modified by human activities (WDNR 1998). Among the five regions of Puget Sound, the Southern Basin has the least amount

of vegetation in its intertidal area (average of 12.7 percent coverage, range 0 to 28.2 percent), with salt marsh (average of 9.7 percent coverage, range 0 to 24.4 percent) and green algae (average of 2.1 percent coverage, range 0.2 and 4 percent) being the most common types (Bailey *et al*. 1998).

DISTRIBUTION AND ABUNDANCE

Status of Bull Trout at the Time of Listing

In the final listing rule (64 FR 58910), we identified 16 bull trout subpopulations† in the area now delineated as the Puget Sound Management Unit of the Coastal Puget Sound Distinct Population Segment: Chilliwack River-Selesia Creek, lower Nooksack River, upper Middle Fork Nooksack River, Canyon Creek, lower Skagit River, Gorge Reservoir, Diablo Reservoir, Ross Reservoir, Stillaguamish River, Snohomish River-Skykomish River, Chester Morse Reservoir, Sammamish River-Issaquah Creek, Green River, lower Puyallup, upper Puyallup River, and Nisqually River (USFWS 1999). We considered five of these subpopulations to be depressed, one strong, and the remaining were of undetermined status. Habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, harvest, and introduced nonnative species were identified as the greatest threats to bull trout in the Puget Sound Management Unit. Although subpopulations were an appropriate unit upon which to base the 1999 listing decision, this recovery plan has revised the biological terminology to better reflect both our current understanding of bull trout life history and conservation biology theory. Therefore, subpopulation terms will not be used in this plan. Instead, recovery of the bull trout will be based on bull trout "core areas" as described above in Part I, Recovery Plan Terminology and Structure.

Current Distribution and Abundance

Bull trout are distributed throughout most of the large rivers and associated tributary systems within the Puget Sound Management Unit (WDFW 1998). With the probable exception of the Nisqually River, where only a few observations have been reported in the recent past, bull trout continue to be

present in nearly all major watersheds where they likely occurred historically in this management unit. Generally, bull trout distribution has contracted and abundance has declined in the southern part of the management unit. Bull trout in this management unit exhibit anadromous, adfluvial, fluvial, and resident life history patterns. The anadromous, or technically the "amphidromous" life history form is unique to the Coastal-Puget Sound Distinct Population Segment. Unlike strict anadromy, amphidromus individuals often return seasonally to freshwater as subadults, sometimes for several years, before returning to spawn (Wilson 1997). Anadromous bull trout have been documented throughout the current distribution within the management unit, and it is believed that fluvial forms are present in most populations as well. There are two naturally occurring adfluvial bull trout populations within the management unit; one is associated with Chester Morse Lake in the upper Cedar River drainage, and the other is associated with Chilliwack Lake in the upper Chilliwack River drainage. Prior to modification of Baker Lake in the Skagit River system, it is unknown to what degree the adfluvial life history was naturally expressed by bull trout in the Baker River watershed. As a result of dam construction, adfluvial populations now exist in Gorge, Diablo, and Ross Lakes in the upper Skagit River drainage.

There are currently a total of 59 local populations distributed among the eight identified core areas (Chilliwack, Nooksack, Lower Skagit, Upper Skagit, Stillaguamish, Snohomish-Skykomish, Chester Morse Lake, Puyallup). Nine additional local populations where identified in the portions of the Chilliwack and Upper Skagit core areas that extend into British Columbia. The recovery team also identified five potential local populations[†], one in the Upper Skagit core area, two in the Lower Skagit core area, one in the Chester Morse Lake core area, and one in the Puyallup core area. A potential local population is defined as a local population (a group of bull trout that spawns within a particular stream or portion of a stream system) that likely exists but has not been adequately documented, or that is likely to develop in the foreseeable future. Development of a local population is likely to occur if spawning habitat or connectivity is restored in that area or if bull trout recolonize or are reintroduced in an area. A population identified as a potential local population is considered necessary for recovery.

Bull trout and Dolly Varden are known to occur together only within the area of the Coastal Puget Sound Distinct Population Segment and in British Columbia, Canada. Although these two species of native char were previously considered a single species, the bull trout and the Dolly Varden have now been formally recognized as two separate species for many years (Cavender 1978; Robins *et al*. 1980; Bond 1992). Currently, genetic analyses can distinguish between the two species (Crane *et al*. 1994; Baxter *et al*. 1997; Leary and Allendorf 1997). Although morphometrics (measurements) and meristic variation (variation in characters that can be counted) can also be used successfully to distinguish the two species (Haas and McPhail 1991), there can be significant error associated with the application of this methodology by improperly trained users (Haas and McPhail 2001). Haas and McPhail (2001) determined that bull trout were much more likely to be misidentified as Dolly Varden (48 percent of the time), than Dolly Varden were to be misidentified as bull trout (2.5 percent of the time) when this methodology was applied. In the Puget Sound Management Unit, Dolly Varden have been confirmed only in the Upper Skagit and Nooksack core areas (McPhail and Taylor 1995; Spruell and Maxwell 2002). Although hybridization resulting in fertile offspring has been documented between the two species in other parts of their range, they appear to be able to maintain distinct genomes (Baxter *et al*. 1997), indicating they can coexist together. It has been hypothesized that resulting hybrids are selected against because they are intermediate in their behavior, ecology and morphology, and therefore cannot compete effectively against their parental forms (McPhail and Taylor 1995). McPhail and Taylor (1995) noted that upper Skagit River Dolly Varden, which are generally a stream resident, small in size, and drift feeders, predominate in tributary streams. In contrast, bull trout are migrants, much larger in size and piscivorous, and appear to predominate the main rivers. Current evidence suggests that the Dolly Varden in Washington tend to be distributed as isolated tributary populations above natural anadromous barriers, while bull trout are distributed below these barriers and are often anadromous (WDFW 1998; Spruell and Maxwell 2002). Dolly Varden may also be present in the Lower Skagit core area, but this has not been confirmed. In all other core areas within the management unit, only bull trout have been identified genetically. Based on the this information, all native char observed in accessible anadromous reaches are believed to be bull trout.

Anadromous and fluvial life history forms of bull trout typically have widely distributed foraging, migration, and overwintering habitat. In freshwater, important forage includes loose salmon eggs, salmon fry and smolts, sculpins, whitefish, and other small fish. Foraging juvenile and subadult bull trout can migrate throughout a core area looking for these feeding opportunities. Freshwater foraging habitat may be found anywhere in the core area downstream of spawning areas (local populations) and accessible to anadromous salmonids. Bull trout also use nonnatal watersheds to forage, migrate, and potentially overwinter. In marine waters, the principal forage is surf smelt and other small schooling fish (*e.g.*, sandlance, herring). Although foraging bull trout may tend to concentrate in forage fish spawning areas, they can be found throughout accessible estuarine and nearshore habitats. The maintenance of these prey species and marine foraging areas is key to maintaining the anadromous life form.

For most areas in the Puget Sound Management Unit, both freshwater floodplain habitats and tidally influenced areas are believed to play an important role in maintaining fluvial and anadromous populations of bull trout. Juvenile bull trout, particularly young-of-year, have very specific habitat requirements. In large rivers, the highest abundance of juveniles can be found near rocks, along the stream margin, or in side channels (Pratt 1984, 1992; Goetz 1994). Juveniles show preferential use of side channels based on their size and the distance from their point of emergence with fry using smaller side channels, age 1+ fish using slightly larger channels within natal streams, while age 2+ and age 3+ juveniles can be found at a significant distance from natal areas in moderate to large off-channel habitat areas in larger streams and major rivers. These areas may exhibit extremely high concentrations of older juveniles and subadults. In a comprehensive summer survey of all tributary rearing areas in the Metolius River basin, Oregon, the highest density of age 2+ and age 3+ juvenile bull trout was found at night in a wall-based channel (channel, often spring-fed, located near the base of a valley wall). This channel flowed into a beaver pond complex. Over 30 juvenile bull trout were found close to the confluence of the springs feeding the pond. No juvenile bull trout were observed in this area during a daytime survey (Goetz 1994).

Migratory (fluvial, adfluvial, and anadromous) bull trout use of off-channel habitats in floodplain areas (freshwater and tidally influenced) has been little studied in larger mainstem rivers. Prior to 2002, reports of bull trout use of floodplain habitats in western Washington were generally unavailable. However, recent review of the grey literature (primarily agency reports) and personal contacts shows that there is increasing information available demonstrating subadult and adult bull trout use of lower elevation floodplain habitats in freshwater and tidally influenced areas. In the Hoh River (Olympic Peninsula Management Unit), the highest concentration of spawning bull trout was found in a side channel in a reach of the upper river (S. Brenkman, Olympic National Park, pers. comm. 2001). Further downstream, three subadult bull trout were observed at the outlet to a wall-based pond complex in May and within the pond complex in August (Goetz, *in litt*. 2003a). The outlet of this pond had just been restored for fish passage in the previous months. In April 2000, in the Chehalis River basin, a single subadult bull trout was captured in a tidal slough restoration site near Ann's Slough (Jeanes *et al*. 2003). In the Puget Sound Management Unit, other observations of bull trout use of freshwater floodplain areas have been recorded in the lower end of the South Fork Nooksack River. These include the Black Slough (Nooksack Tribe, *in litt*. 2002), an unnamed South Fork slough (WDFW, *in litt*. 1994), and a mainstem Nooksack River side channel having combined flow from Anderson Creek (Nooksack Tribe, *in litt*. 2003). Use has also been recorded in the North Fork Nooksack River, where spring-fed waters enter a Glacier Creek overflow channel (B. Green, U.S. Forest Service, pers. comm. 2003); the North Fork Stillaguamish River, in a slough at the mouth of McGovern Creek; the Skagit River; and in the Upper Skagit, at Park and Newhalem Sloughs near Newhalem (USFWS, *in litt*. 2003). In tidally influenced floodplain areas of Puget Sound, subadult bull trout have been observed or captured in restored (3 locations) and natural tidal channels (2 locations), and larger distributary channels. These include the South Fork of the lower Skagit River, in Deepwater Slough, a moderate-sized tidal channel in a floodplain area previously isolated from the river and tides until reconnection occurred in October 2000 as part of a estuary restoration project (J. Klochak, Skagit System Cooperative, pers. comm. 2002); the Snohomish River, in two small tidal channels off Ebey Slough, a large distributary channel (Rowse, *in litt*. 2002); the Snohomish River, in Union Slough, in the spring of the year immediately

following dike removal and restoration of a previously isolated floodplain area on Spencer Island (Tanner *et al*. 2002); the Skagit River, where adult and subadult bull trout have been recorded migrating through both forks during upstream and downstream migratory movements (Goetz, *in litt*. 2003b); and the Snohomish River, where subadult and adult bull trout have used portions of all three distributary channels (*i.e.*, Union, Steamboat, and Ebey Sloughs) in upstream and downstream migratory movements during spring, summer and fall, 2002 (Goetz, *in litt*. 2003b).

Regarding abundance, we must emphasize that there are currently no data to confidently estimate bull trout abundance for the entire management unit. However, a few core areas have been monitored through redd counts and adult counts at a level where estimates can be made at the local population or core area level. It is important to note that current data on distribution and abundance in the Puget Sound Management Unit is limited and has been collected by a variety of methods. Sources of data include historical reports, incidental bull trout counts obtained during other fish surveys, smolt and adult trap counts, creel survey data, redd count data, and adult counts. It is likely that spawner distribution and abundance is underestimated, and that some spawning and rearing areas have not been located and thus have been omitted. As new information on core areas is gathered, it will be used to update distribution and abundance information described below.

Chilliwack core area. The Chilliwack core area is delineated around those portions of the Chilliwack River and its major tributaries (Silesia Creek, Tomyhoi Creek, and Sumas River) contained within the United States (Figure 3). However, a significant portion of the Chilliwack River drainage lies within Canada and is functionally part of this core area. It is a transboundary system that flows from the United States northwest into British Columbia where it discharges into the lower Fraser River. Those reaches of the Chilliwack River and Silesia Creek (spelled “Slesse” in Canada) within the United States are contained within North Cascades National Park and the Mount Baker Wilderness, respectively. The short section of the Chilliwack River extending from the United States-Canada border up to and including Chilliwack Lake is within the boundaries of Chilliwack Lake Provincial Park in British Columbia. Although Chilliwack Lake

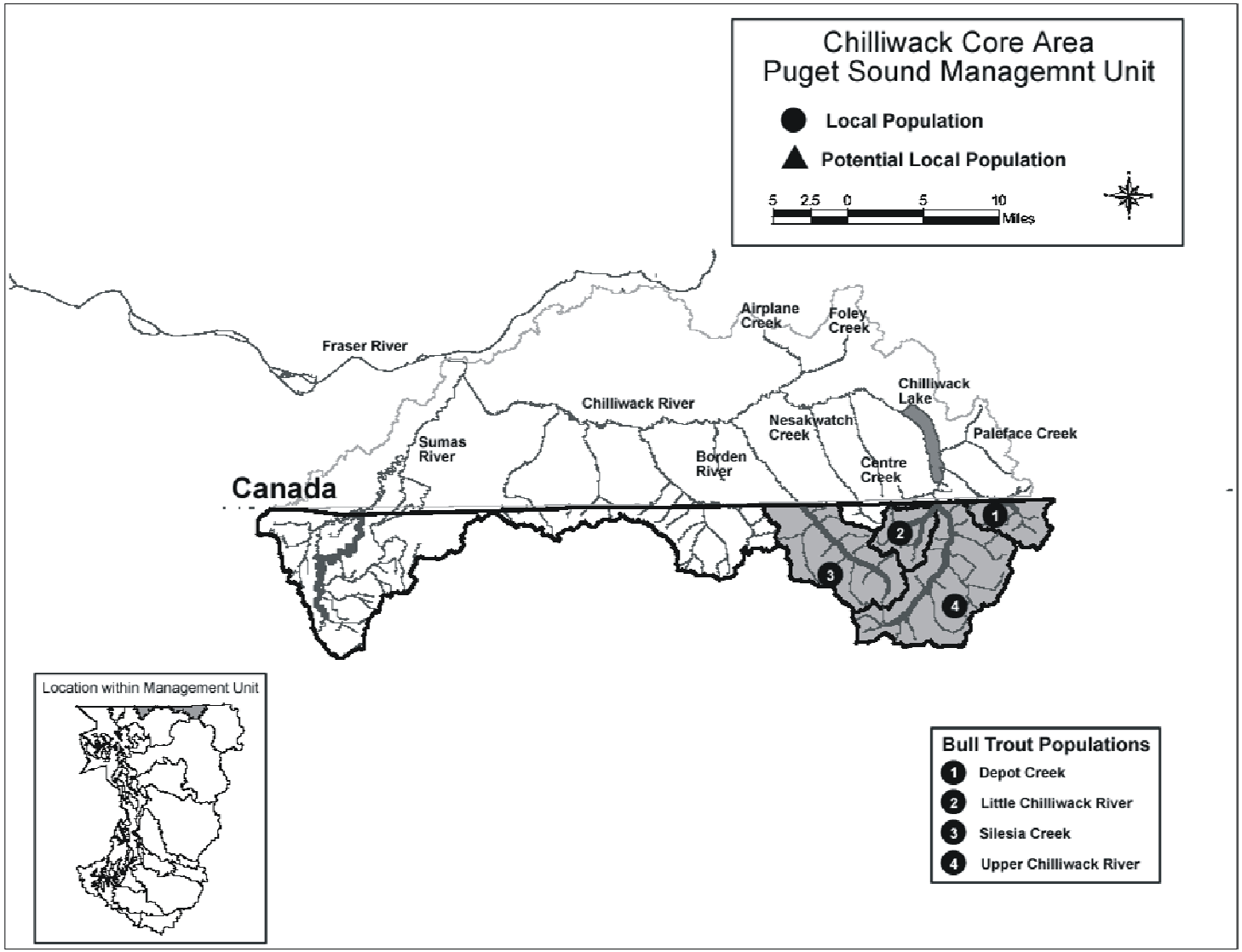

Figure 3. Chilliwack core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

is now entirely within the Chilliwack Lake Provincial Park, two of its major tributaries, Paleface and Depot Creeks, are extensively outside of the provincial park boundary with the exception of their lower reaches. The headwater reaches of Depot Creek fall within North Cascades National Park in the United States. Silesia Creek and Tomyhoi Creek (spelled "Tamihi" in Canada) and one of its tributaries, Damfino Creek, initiate from the Mount Baker Wilderness in the United States, eventually entering the Chilliwack River downstream of Chilliwack Lake. The Chilliwack River flows west eventually becoming the Vedder River, where it is then joined by the Sumas River (at Vedder Canal) before discharging into the Fraser River. In British Columbia, the status of the Chilliwack River stock of bull trout is categorized as at "presumed conservation risk" (*i.e.*, current threats are believed to be significantly affecting the population or the population is considered to be at risk) (BCMWLAP 2002).

Samples collected from Chilliwack Lake have been identified as bull trout based on genetic analysis, although Dolly Varden are also known to exist within the Fraser River system (Nelson and Caverhill 1999). The bull trout within the Chilliwack system are believed to express fluvial, adfluvial, and potentially resident and anadromous life histories (D. Jesson, Ministry of Water, Land and Air Protection, pers. comm. 2002a). An isolated resident population of native char has also been identified in Tomyhoi Creek; however, it has not been determined whether these are bull trout or Dolly Varden. Since this population is isolated above a complete anadromous barrier (Teskey, *in litt*. 1986), it may be designated as a separate core area in the future if these native char are determined to be bull trout. This population is currently believed to be Dolly Varden based on their isolation above a natural barrier, which is a comparable situation to Dolly Varden populations found in the upper Skagit and Nooksack Rivers. Tomyhoi Creek and one of its tributaries, Damfino Creek, initiate from the Mount Baker Wilderness in the United States and flow northwest into Canada.

An extensive survey effort for bull trout has not yet occurred within the upper Chilliwack River system, making it difficult to estimate spawner abundance for this core area (R. Glesne, National Park Service, pers. comm. 2002). However, limited survey efforts have helped determine distribution and the identification of current local populations (M.A. Whelen and Associates Ltd. and

TSSHRC 1996; Nelson and Caverhill 1999; Doyle *et al*., *in litt*. 2000). A total of three local populations, Upper Chilliwack River (which includes Easy, Brush, and Indian Creeks), Little Chilliwack River, and Selesia Creek have currently been identified in the U.S. portion of this core area, with seven additional local populations (Paleface Creek, Depot Creek, Airplane Creek, Foley Creek, Borden Creek, Centre Creek, and Newakwatch Creek) identified within British Columbia. The upper extent of bull trout spawning and rearing use in Depot Creek is currently uncertain since neither fish nor habitat surveys have been conducted in reaches within the United States. Accessible habitat occurs upstream as far as the United States-Canada border (M.A. Whelen and Associates Ltd and TSSHRC 1996), while topographic maps indicate approximately 3.2 kilometers (2 miles) of additional accessible habitat upstream of this point.

In the upper Chilliwack River, rearing bull trout (juveniles) have been observed in the mainstem Chilliwack River from Chilliwack Lake upstream to approximately Easy Creek (R. Glesne, pers. comm. 2002). Limited spawning has also been documented in the mainstem of Chilliwack River above Chilliwack Lake (Doyle *et al*., *in litt*. 2000), and suitable spawning habitat in the mainstem is believed to span from approximately 3.2 kilometers (2 miles) above Chilliwack Lake upstream to an area just above Easy Creek (R. Glesne, pers. comm. 2002). Accessible habitat on the mainstem Chilliwack River ends approximately 3.2 kilometers (2 miles) upstream from Easy Creek, near the confluence with Copper Creek. In 1999, a bull trout was observed in Indian Creek during limited National Park Service surveys (Doyle *et al*., *in litt*. 2000). Although bull trout were not observed within Bear Creek and Brush Creek during recent limited survey efforts, habitat in their lower reaches is clearly accessible and likely provides some spawning and rearing habitat. Bull trout were observed near the mouth of Bear Creek, within the lower reaches of Brush and Easy Creeks, and throughout Indian Creek in the mid 1970's (Glesne, *in litt*. 1993). Although native char presence has been documented in Little Chilliwack River, spawning has not yet been confirmed in this tributary (R. Glesne, pers. comm. 2002). The Little Chilliwack River is thought to be accessible to approximately river mile 6 and river mile 3.5 on its major tributary, the Little Fork, however, this has not been verified with field surveys (S. Zyskowski, National Park Service, pers. comm. 2003a). Habitat is essentially pristine, and likely supports some level of spawning. Spawning and

rearing distribution is incomplete for Silesia Creek. Juvenile and young-of-year bull trout have been observed in British Columbia reaches, while spawning and rearing is assumed to extend upstream to all accessible reaches in the United States. It is unknown what proportion of the Silesia Creek population spawns within Washington, and since no population surveys have been conducted at this time, no estimates of abundance are currently available for this system.

In British Columbia, spawning is also believed to occur in Depot and Paleface Creeks based on the juvenile life stages (young-of-year and age 1+) that have been documented rearing in these streams (D. Jesson, pers. comm. 2002b). Individual estimates of adult abundance for Depot and Paleface Creeks are currently not available. However, creel census data for Chilliwack Lake can provide a conservative minimum combined estimate for these two local populations and the Little Chilliwack and Upper Chilliwack Rivers, assuming that the majority of bull trout captured in the lake spawn in one of these four systems. In 1998, a lake angler survey conducted by LGL Limited Environmental Research Associates estimated that 731 bull trout were captured during their May 23 to September 29 sampling period. It was noted, however, that a key spring fishery on bull trout that occurs in April and May was missed by the sample period, so overall annual catch may be significantly higher. Length-frequency distribution of bull trout sampled in the survey (n=166) show that 90 percent of those captured were greater than 350 millimeters (13.8 inches) in length (Nelson and Caverhill 1999). Assuming that bull trout equal to or greater than 350 millimeters (13.8 inches) are likely sexually mature, then approximately 658 mature adults were caught during the sample period. Based on this estimate, we believe the Depot Creek, Paleface Creek, Little Chilliwack River, and Upper Chilliwack River local populations support in aggregate at least 1,000 adult spawners annually, and the Chilliwack core area (excluding British Columbia local populations) could likely support a minimum of between 500 and 750 adult spawners when including the Selesia Creek local population. Habitat and spawner surveys need to be conducted on Selesia Creek to confirm this estimated potential spawner abundance and to determine the current spawner abundance in this local population.

The other local populations identified in British Columbia (Foley Creek, Borden Creek, Centre Creek, and Newakwatch Creek) are all tributaries to the mainstem Chilliwack River between Silesia Creek and the outlet of Chilliwack Lake. The exception is Airplane Creek, which is a major tributary to Foley Creek. Both young-of-year and age 1+ juvenile bull trout have been observed in all these tributaries (M.A. Whelen and Associates Ltd and TSSHRC 1996).

Migratory bull trout in this system spend all or part of their subadult and adult lives either in the mainstem of the Chilliwack River, Chilliwack Lake, and Fraser River. If anadromous forms exist in this population, they would also use nearshore waters of the Strait of Georgia. All of these areas provide foraging, migration, and overwintering habitat; however, Chilliwack Lake appears to be very important to the majority of local populations in this system. Both sockeye and kokanee use the lake to rear, and either the lake's tributaries (kokanee) (Nelson and Caverhill 1999) or Upper Chilliwack River system (kokanee and sockeye) to spawn (Doyle *et al*., *in litt*. 2000; B. Fanos, Department of Fisheries and Oceans Canada, pers. comm. 2003), providing an important source of forage for bull trout in this part of the Chilliwack River basin. Migratory bull trout may potentially forage within the Sumas River and other tributaries that are accessible to migratory forms, but distribution and extent of use within these systems is not well known. Native char have been reported in the Sumas River tributary, Lonzo Creek, within British Columbia (Norecol, Dames & Moore, Inc. 1999). Although the Sumas River is a highly productive anadromous salmon system, it is unlikely that bull trout spawning or rearing occurs in the Sumas River or its tributaries given the relatively low elevation of this drainage.

Nooksack core area. The Nooksack core area consists of the Nooksack River and its tributaries, including the North, Middle and South Forks (Figure 4). The Nooksack River is the northernmost major river system draining directly to Puget Sound in the contiguous United States. The North and Middle Forks of the Nooksack River are glacially influenced, while the South Fork is fed primarily by snowmelt. The accessible lengths of many tributaries to the various river forks can vary over time, depending on where the active river channels are located within their channel migration areas, and the presence of intermittent passage blockages. Known spawning of bull trout occurs in all three forks of the

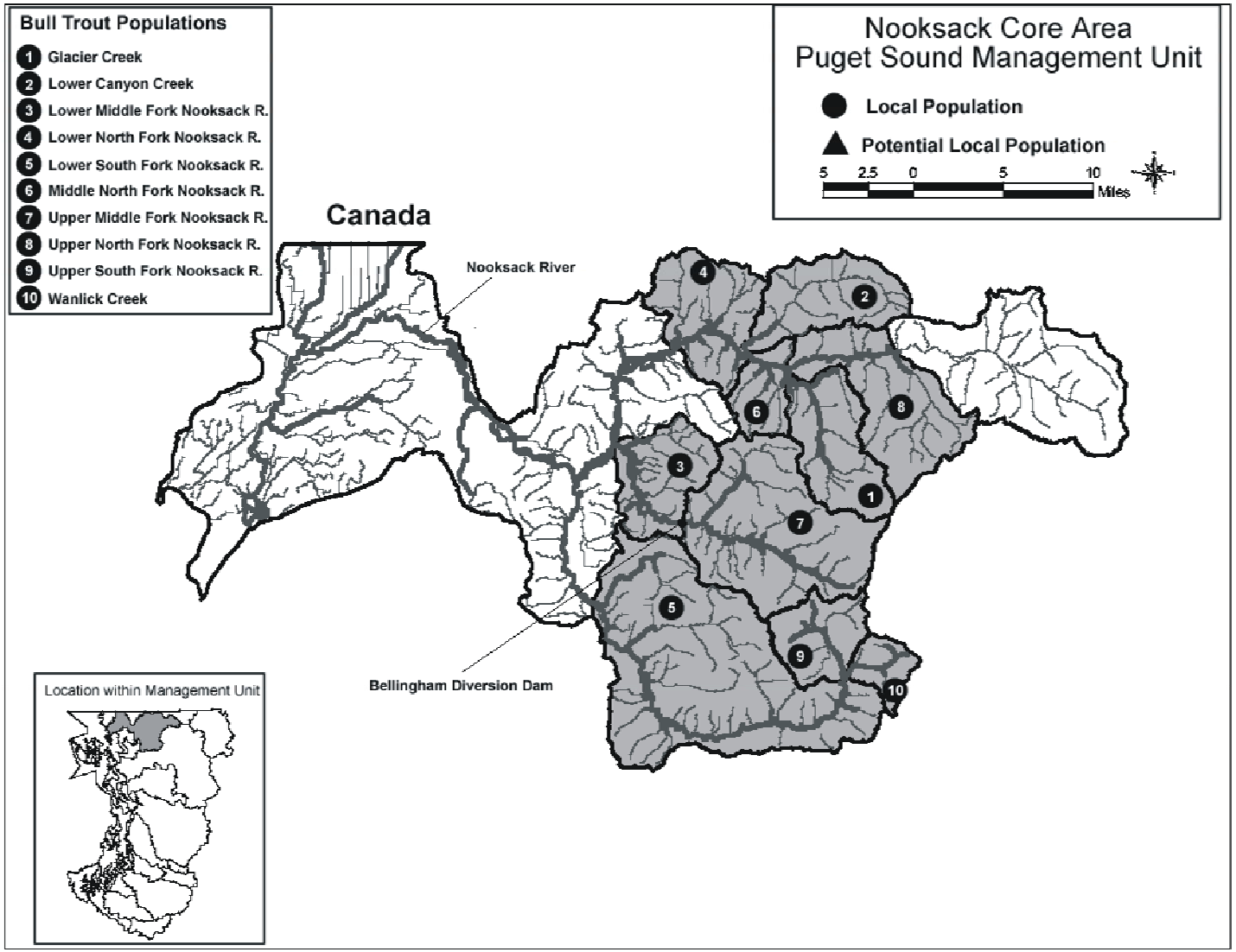

Figure 4. Nooksack core area for bull trout. Highlighted streams are key freshwater habitat for recovery.

Nooksack River and in tributaries to them, while post dispersal rearing and subadult and adult foraging is believed to occur throughout the anadromous reaches. For example, juvenile to subadult sized bull trout (140 to155 millimeters; 5.5 to 6.1 inches) were recorded in lower Smith Creek and in lower Black Slough in November, 2001 (Nooksack Tribe, *in litt*. 2002). Overwintering likely occurs primarily in the lower mainstem reaches of the three forks and in the Nooksack River. The anadromous life history form is known to be present

(Lummi Nation, *in litt*. 2003; Maudlin *et al*. 2002), and fluvial and possibly resident life history forms also occur within this core area. Outmigrants have been caught in the lower mainstem from early April through mid-July. The anadromous life history form uses estuarine and nearshore marine areas in and near Bellingham Bay (Ballinger, *in litt*. 2000) and likely use areas further north and south of these areas similar to other anadromous populations.

The Nooksack core area contains populations of both bull trout and Dolly Varden, however there is currently an incomplete understanding about the level of interaction between the two species and degree of overlap in their distribution. Limited genetic analysis and observational data suggest Dolly Varden in this core area inhabit stream reaches above anadromous barriers. Native char collected from the Nooksack River within reaches currently or historically accessible to anadromous salmonids have been identified as bull trout, based on genetic analysis of a small number of samples collected from the upper South Fork (S. Young, Washington Department of Fish and Wildlife, pers. comm. 2003), and also on morphometric and meristic analysis by Dr. Gordon Haas of individuals collected in the upper Middle Fork (STS Heislers Creek Hydro L.P. 1994; M. Barclay, Framatome ANP, pers. comm. 2003). Genetic analysis of native char from an isolated resident population located upstream of a barrier falls in Canyon Creek (North Fork Nooksack River) determined them to be Dolly Varden (Leary and Allendorf 1997). Additional tissue samples collected from native char in upper Canyon Creek (upstream of barrier falls), one of its tributaries named Kidney Creek, and from a resident population in the South Fork headwater stream, Bell Creek (upstream of barrier falls), were also determined to be Dolly Varden (Spruell and Maxwell 2002). Additionally, genetic analysis of a small number of samples collected from a resident population in another tributary to the