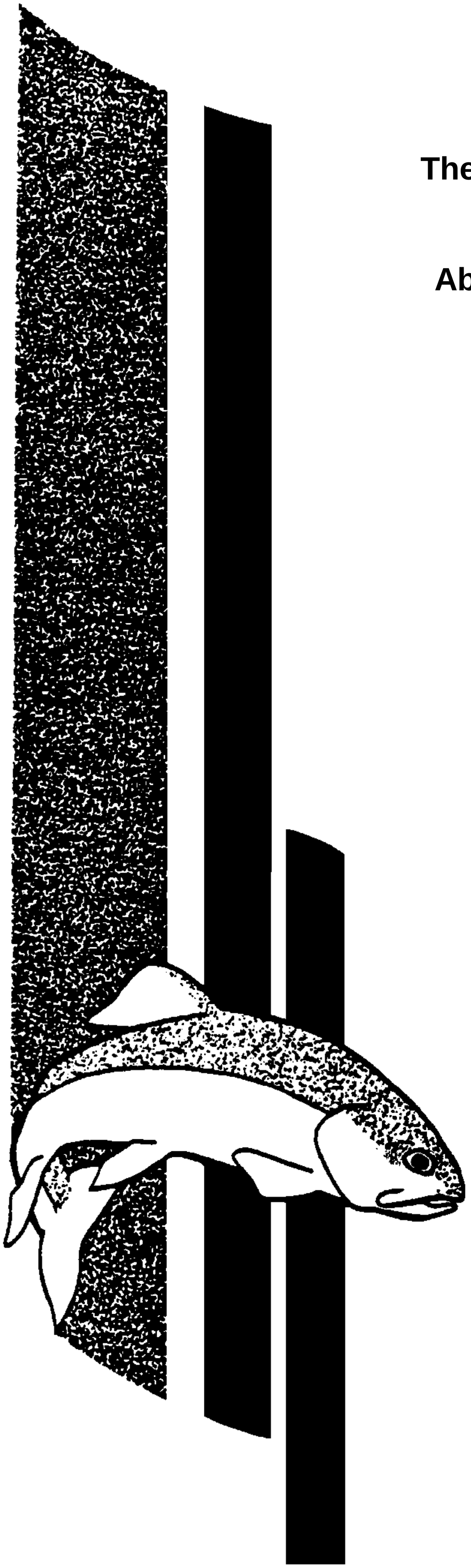

The Status of Bull Trout in British Columbia: A Synthesis of Available Distribution, Abundance, Trend, and Threat Information

by

John Hagen and Scott Decker

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Ecosystems Protection & Sustainability Branch,
Aquatic Conservation Science Section
Victoria, British Columbia

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EXECUTIVE SUMMARY

Conservation and management of bull trout (*Salvelinus confluentus*) in British Columbia have been hindered by the lack of a systematic, province-wide assessment of distribution, abundance, trends in abundance, and threats to the species' long-term persistence. This report provides, for the first time, a comprehensive review of existing bull trout distribution and abundance data for BC, and also presents the results of a province-wide expert judgment exercise designed to capture non-quantitative professional knowledge about bull trout distribution, abundance, trends, and conservation threats. For the latter exercise, we adopted a methodology that has been applied in the US and Alberta, whereby a geographic 'core area' is used as a proxy for the potential meta-population structure, and represents groups of local populations (and their critical habitats) over which demographic and genetic connections, or the potential for them, exist, and which function more or less independently from other core areas.

Sampling records extracted from the Provincial Land and Resources Data Warehouse (LRDW) indicate the presence of bull trout in 26 of the 36 Ecological Drainage Units (EDUs) that have been delineated for BC. Sampling records also suggest that bull trout are present in roughly 1,000 tributary watersheds in the province large enough to support local populations. As a proxy for the number of local populations in BC, this number is highly uncertain due to several sources of error. It is biased high due to error related to a lack of separate species status for bull trout and Dolly Varden (*Salvelinus malma*) in older records, misidentification of the two species in more recent records, and the fact that bull trout are likely transitory in many of the streams and lakes where their presence has been recorded. Conversely, negative bias exists from non-random distribution and gaps in sampling, incomplete reporting of sampling activities to the Province, and low detection probability associated with typical sampling methods. In the interior of the Province, bull trout are widespread and closely associated with mountainous areas, with notable gaps existing in the northwest (Lewes and Teslin EDUs), the Great Plains region east of the Rocky Mountains (Lower Liard and Lower Peace EDUs), small watersheds of the Fraser Plateau (Mid Fraser EDU), and warmwater drainages in the south (Okanagan, Kettle, and Similkameen EDUs). Bull trout are absent from most of the BC coast, but populations descended from a coastal evolutionary lineage are present in the Lower Fraser, Skagit and a limited portion of the South Coastal EDU, while descendants of an interior lineage are present in coastal portions of the Homathko-Klinaklini EDU and some drainages within the Taku, Iskut-Lower Stikine, and Lower Skeena EDUs.

Only seven of the 31 abundance datasets that we compiled met the minimum US Fish and Wildlife Service (USFWS) criterion of two generations (14 years) for assessing trend, and only two data sets met the Committee on the Status of Wildlife in Canada (COSEWIC) criterion of three generations (21 years). Abundance and trend data were also poorly distributed geographically (only 10 of the 26 EDUs inhabited by bull trout were represented, and 13 of the 31 datasets were from the Columbia drainage), and may not be representative of population status for the Province as a whole. We were unable to assess the current status of populations relative to that under pristine conditions, as abundance data were only available from the 1980s onward. Among 23 data sets with 5 years or more of data, no trend over time was detected for 13, a positive trend was detected for six, a negative trend was detected for one, and three datasets exhibited both positive and negative trends.

The expert judgment exercise was limited by sparse information for many areas of the Province and uncertainty about species identity for core areas where bull trout occur in sympatry with Dolly Varden, and, as a result, the large majority of core areas were defined imprecisely. The core area assessment was useful nonetheless as it provided systematic and comprehensive coverage for large areas of the Province, particularly in the more heavily populated southern portion that would have otherwise not been possible. We identified 115 putative bull trout core areas for BC based on distribution records and known migration barriers, and telemetry and molecular genetic information in some cases. A combination of data and expert knowledge allowed for categorical assessment of bull trout distribution, abundance, trend, and threats for 71, 32, 24, and 93 core areas, respectively. Four core areas were judged to have 50 or fewer reproductive adults, two to have 50-250 adult bull trout, 18 to have 250-1,000 adults, eight to have >1,000 adults, and one to have >2,500 adults. In 24 core areas where judgments of trend could be made, adult abundance was considered to be severely declining (>70% within 25 years) in no core areas, very rapidly declining (50-70% decline) in two core areas, rapidly declining (30-50%) in no core areas, declining (10-30%) in six core areas, stable in nine core areas, and increasing in seven core areas.

Conservation status ranks (C Ranks) based on a numerical scoring system developed by the USFWS were assigned to 33 core areas for which categorical estimates of distribution and abundance were available (Appendix 4), representing 14 of the 26 British Columbia EDUs known to be inhabited by bull trout (Table 3). C Ranks were C1-High Risk for 4 core areas, C2-At Risk for 11 core areas, C3-Potential Risk for 14 core areas, and C4-Low Risk for 4 core areas. Conservation status ranks evaluated at the EDU

level, based on weighted averages of core area scores within the 14 EDUs, were C1-High Risk for no EDUs, C2-At Risk for 4 EDUs, C3-Potential Risk for 8 EDUs, and C4-Low Risk for 2 EDUs. It is important to note, however, that in several cases EDU-level assignment of a C rank was based on a ranking from a single core area from within the EDU.

Principal recommendations resulting from the review of abundance, distribution, trend, and threat information were for: 1) changes to standard sampling protocol for British Columbia char in order to improve estimates of distribution and population spatial structure, 2) establishment of population monitoring in core areas where the potential for overexploitation exists, 3) adoption of stream temperature as the primary indicator of physical habitat suitability in British Columbia, and wider application of models predicting stream temperature responses to climate change and habitat perturbations, and 4) development of a Provincial monitoring strategy that identifies a more systematic approach for selecting and prioritizing populations for monitoring.

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1.0 INTRODUCTION

Bull trout (*Salvelinus confluentus*) are a char native only to western North America. The management history of the species as a distinct entity has been relatively brief, as they were distinguished from the Dolly Varden (*Salvelinus malma)* only after the taxonomic study of Cavender (1978). General recognition of the two forms by the fisheries management community in British Columbia occurred following the publication of a morphological study by Haas and McPhail (1991), although much confusion remains among the general public regarding distribution and common nomenclature for the two species.

It is widely recognized that bull trout have declined in many parts of their native range, particularly in southern parts of their range in the United States (Rieman et al. 1997) and in Alberta (Paul and Post 2001; Post and Johnston 2002). Declines in the United States were formally recognized by the designation of all bull trout populations in the coterminous US as “threatened” under the Endangered Species Act in 1998 (USFWS 1999; Lohr et al. 2000). Responses to the listing have included: 1) identification of ‘recovery units’ based on population structure (USFWS 2002); 2) drafting of a 5-year status review (USFWS 2005); and 3) significant effort to develop monitoring strategies and methodologies appropriate for continuously evaluating bull trout population status (Peterson et al. 2004; USFWS 2008). The threatened nature of bull trout populations in Alberta has been acknowledged since 1994 by the development of a management and recovery plan (Berry 1994), significant management changes including a province-wide zero-retention angling regulation in 1995, formal recognition of the status of the species as ‘sensitive’ by the Provincial Government, and a 5-year review of the species’ Alberta status in 2001 (Post and Johnston 2002).

The BC Government first identified bull trout as a species warranting special management and monitoring in 1994, with the addition of bull trout to the Conservation Data Center’s “Blue List of Species of Special Concern” and the preparation of the “Strategic Plan for Conservation and Management of Char in BC” (BC Environment 1994). Although declines in BC’s char populations were strongly suspected prior to 1994, the listing and development of a management strategy for char were considered precautionary and designed to “avoid the extirpation of stocks and the costly recovery plans necessitated elsewhere” (BC Environment 1994). BC currently appears to be the stronghold for bull trout in North America, encompassing the majority of the species geographic range, retaining abundant coldwater and pristine stream habitats, and having suffered generally lower levels of alien species introductions, interruptions of connectivity among waterbodies due to dam construction, and stream habitat degradation (McPhail 2007). A general perception that BC's bull trout populations are 'healthier' than those in the US and Alberta, may partly explain why, to date, conservation status has only been assessed for select areas of the Province (e.g., Westover and Heidt 2004; Hagen 2008), and never systematically for the Province as a whole.

Population abundance and trends are considered to be essential indices of species viability and recovery (i.e. conservation status) (McElhany 2000; USFWS 2002; COSEWIC 2010). A major obstacle preventing regular assessments of bull trout conservation status in BC has been the lack of a co-ordinated population monitoring plan for the Province, and consequent lack of readily accessible abundance and trend data. The BC Ministry of Environment (MOE) has recognized the need to review and summarize existing bull trout data in order to facilitate assessment of conservation status in the Province. This report provides a review of existing data on bull trout distribution, abundance and abundance trends for BC, and also presents the results of a province-wide expert judgment exercise designed to capture non-quantitative professional knowledge about bull trout distribution, abundance, trends, and threats.

2.0 BACKGROUND

2.1 Life history

While relatively thorough life history reviews emphasizing Canadian bull trout populations are available in other documents (McPhail and Baxter 1996; Post and Johnston 2002; McPhail 2007; Hagen 2008), key life history traits are reviewed briefly here in order to provide background information for later sections of the report.

Molecular genetic and morphological studies indicate the existence of two major evolutionary lineages in bull trout (Taylor et al. 1999; Haas and McPhail 2001): interior and coastal clades that appear to reflect utilization of Columbia and Chehalis refugia, respectively, during the Wisconsin glaciation (McPhail 2007). The present distribution of the coastal lineage encompasses the lower Fraser (below Hell's Gate), upper Skagit (Puget Sound), and Squamish (South Coast) drainages, while interior bull trout have a broad distribution covering mountainous areas of most major BC watersheds east of the Coast Mountains (with the exception of the Similkameen, Okanagan, and Kettle drainages). The interior clade has crossed the continental divide into Alberta and Northeastern BC, and reaches the central and northern BC coasts in large river systems that penetrate through the Coast Mountains (e.g., Homathko, Klinaklini, Skeena; Haas and McPhail 1991; McPhail 2007). In coastal areas north of Puget Sound, bull trout, where present, are typically sympatric with Dolly Varden. This zone of overlap, which is also a zone of hybridization between the two species, is relatively broad in Northern BC, and crosses the continental divide north of the Skeena watershed in the headwaters of the Peace and Liard river systems (Taylor et al. 1999).

In interior regions of western North America, the three general life history forms of bull trout are stream resident, fluvial, and adfluvial. For bull trout of the coastal evolutionary lineage, limited movements into saltwater also occur (anadromy), although few details of these movements are known (McPhail 2007). Stream resident populations are typically separated from migratory populations by an obstacle or barrier to migration, either physical (e.g. waterfalls, dams; Latham 2002), physiological (e.g., unfavorably high temperatures; Rieman and McIntyre 1993; Rieman et al. 1997), or biological (e.g., presence of non-native competitor species; Paul and Post 2001; Nelson et al. 2002).

All bull trout populations require clean, cold stream reaches of small-to-moderate size for spawning and rearing. Bull trout are clearly coldwater-adapted. Egg development and hatching are related to water temperature, with optimal development and survival for bull trout occurring at 2-4°C (McPhail and Murray 1979). Stream-rearing juvenile bull trout use shallow areas with low current velocities along channel margins, regardless of general habitat type (i.e., pool, riffle, etc.; Saffel and Scarnecchia 1995). Low velocity side channels are particularly valuable for young-of-the-year fry (McPhail and Murray 1979; Saffel and Scarnecchia 1995; Bustard 2004). Large, unembedded substrate appears to be the most important cover component (Oliver 1979; Pratt 1992; Baxter and McPhail 1996), particularly in winter habitat when juveniles conceal themselves in the substrate during the daytime (Thurow 1997; Bonneau and Scarnecchia 1998), but instream wood cover is also important (Fraley and Graham 1981; Fraley and Shepard 1989; Baxter 1995; Jakober et al. 1998). While stream resident populations spend their entire life cycle within individual streams or stream reaches, fluvial and adfluvial bull trout rear in natal tributaries for 1-4 years before undergoing migrations downstream to larger rivers and lakes, respectively, with migration at age-2+ being the most common (McPhail and Murray 1979; Pratt 1992; Downs et al. 2006). Age-0+ fry also emigrate from spawning tributaries, but their survival appears to be very poor (McPhail and Murray 1979; Downs et al. 2006). In large riverine and lacustrine environments bull trout eat primarily fish, with individuals becoming progressively more piscivorous with increasing size.

Pratt (1992) reported that adfluvial bull trout spawners in the interior regions of western North America were 4-9 years old, and Goetz (1989) reports a range in average spawner size among populations of 440-690 mm, with an absolute range of 300-875 mm. Populations in BC frequently include larger and older individuals, with the oldest recorded individual being a 24-year-old male from a fluvial population in the North Thompson River (Hagen and Baxter 1992). Wigwam River spawners, which migrate from Lake Koocanusa Reservoir, are most commonly 7 years old, with observed ages from 5-13 years and sizes from 430-860 mm (mean = 670 mm; Westover and Conroy 1997). Bull trout of up to 14 years of age and 9.1 kg (20 pounds) or more have been captured in the Arrow Lakes Reservoir (Sebastian et al. 2000). In Kootenay Lake, where spawners measured at the Duncan Dam range from 320-970 mm (mean =670 mm; BC Hydro data on file), a 13.6 kg bull trout was captured in 1995 (Sebastian et al. 2000).

In BC, peak migration towards spawning areas occurs between early June and August, and timing is likely related to the distance to be travelled and water temperatures (McPhail and Murray 1979; Swanberg 1997; Westover and Heidt 2004). In coldwater streams found in northern BC and in southern BC watersheds with glacial influence, bull trout may preferentially select larger, lower gradient tributary reaches for spawning that have abundant gravel and cobble substrates. However, in non-glacial systems dominated by rainbow trout or Pacific salmon in their lower reaches, bull trout commonly spawn in the furthest upstream reaches they can access, which are often of higher gradient, and above obstructions that block the migration of other species (Bustard and Schell 2002; Westover and Heidt 2004; Decker and Hagen 2008; Hagen 2008 and references therein). Spawning sites (redds) are not necessarily directly associated with cover, but cover in the form of pools, large wood debris, undercut banks, and overhead vegetation is nevertheless an important attribute of spawning streams, as adult bull trout often reside for a month or more in spawning reaches prior to spawning (McPhail and Murray 1979; Graham et al. 1981; Baxter 1995). Bull trout do not appear to spawn in large mainstem reaches of major river systems (McPhail and Baxter 1996; Westover and Heidt 2004).

Spawning for fluvial and adfluvial stocks in BC appears to occur between mid-August and mid-October, with northern populations spawning earlier (McPhail and Murray 1979; Baxter 1997; Hagen and Taylor 2001; Westover and Heidt 2004). Spawning redds range in size from 0.5-3.0 m^2 (McPhail and Murray 1979; Baxter 1995), depending on the size of the female and the nature of the substrate being utilized. The characteristic form and bright, clean appearance of redds, and the low water conditions generally present during the early fall, allow for counts of redds to be utilized as an index of population abundance. However, a single female may construct more than one redd (Leggett 1980), and the average number of redds per spawner needs to be assessed if redd counts are to be used to estimate the size of the spawning population (Dunham et al. 2001). Precocious males have been observed in the upper Columbia Basin (McPhail and Murray 1979; Decker and Hagen 2008 and in tributaries of the Peace system (Baxter 1997), but it is unknown how widespread this life history strategy is.

2.2 Population limitation and threats

Bull trout are limited by habitat conditions, by the abundance of prey and competitor species, and by their own population dynamics. Water temperature and interference competition from other species, which also appears to be mediated by temperature, are arguably the most important determinants of juvenile bull trout distribution and abundance. Bull trout are generally not present in streams where maximum daily temperatures exceed 15°C (Haas 2001; Fraley and Shepard 1989; Saffel and Scarnecchia 1995). Competition with rainbow trout also appears to limit bull trout distribution and productivity in BC, with rainbow trout generally dominant in streams with maximum temperatures exceeding 13°C (Parkinson and Haas 1996). In streams supporting fluvial or adfluvial populations, Bustard and Schell (2002) and Decker and Hagen (2007) observed much higher densities of juvenile bull trout upstream of passable waterfalls compared to downstream areas that were dominated by juvenile rainbow trout or steelhead, suggesting that difficult access to spawning habitat may also provide bull trout a competitive advantage over other salmonids. Within suitable reaches, density-dependent survival appears to limit production of age-1+ bull trout parr to mean densities of $\approx$8 fish/100 m^2 or less (Hagen 2008 and references therein). Density-dependent survival at the juvenile life stage can also be an important determinant of abundance at later life stages (Johnston et al. 2007). The distribution of sub-adult and adult bull trout in lakes and larger streams also appears to be strongly affected by water temperature: areas where water temperatures exceed 15°C for extended periods are generally avoided (Pratt 1992; McPhail and Baxter 1996; Swanberg 1997; Westover and Heidt 2004). The composition of prey fish communities may be a factor affecting bull trout growth and survival in these environments as well. The introduction of kokanee into lacustrine environments, in particular, may enhance productive capacity for bull trout. Bull trout spawners captured in the Wigwam River in 1996 were more abundant and 140 mm longer on average than those captured in 1978, when introduced kokanee were not yet established in Koocanusa Reservoir, the principal adult foraging habitat for this population (Westover and Conroy 1997). Introductions of kokanee to Kinbasket Reservoir during 1982-1985 may have had a similar effect (Hagen 2008). Given that lake trout (*Salvelinus namaycush*) are known to competitively displace bull trout (Donald and Alger 1993), native (and introduced) lake trout presence likely influences bull trout distribution and abundance in lakes as well. Many larger lakes of BC should support large populations of bull trout based on habitat and temperature suitability; instead lake trout appear to dominate (e.g. Quesnel Lake).

Human activities can also result in severe reductions in productivity that can threaten the long-term persistence of bull trout populations. Habitat degradation, introductions of non-native fish, overharvest, and fragmentation of watersheds through dam construction have all led to declines in bull trout populations (Rieman and McIntyre 1993; Post and Johnston 2002). Increased stream temperatures are a common result of watershed developments, forest harvesting in particular (Holtby 1988; Johnson and Jones 2000), but also agriculture, urbanization, mining, fossil fuel extraction, and linear developments when they result in loss of riparian vegetation (Post and Johnston 2002). Even small shifts in stream temperature regimes may be highly significant with respect to habitat suitability for bull trout. Populations in southern BC, or in watersheds lacking glaciers or permanent snowfields, are often highly vulnerable to water temperature increases resulting from watershed development or climate change (Porter and Nelitz 2009). Degraded watersheds may have a reduced habitat capability for bull trout even if stream temperatures remain below threshold values, due to potential losses of riparian vegetation and stream habitat complexity, increases in sediment transport and associated channel destabilization, and channel widening with associated reduction of bed material size and stream depth (Saffel and Scarnecchia 1995; McPhail and Murray 1979; Pratt 1992; Fraley and Shepard 1989).

Competition and hybridization with brook trout (*Salvelinus fontinalis*) have been identified as major threats to bull trout populations in the United States and Alberta (Ratliff and Howell 1992; Rieman and McIntyre 1993; Paul and Post 2001; Rich et al. 2003). Although current stocking policy in BC is designed to minimize the risks of competitive exclusion and hybridization with brook trout, naturalized brook trout populations exist in many watersheds. Bull trout appear to have increased resistance to invasion by brook trout in colder stream reaches with minimal habitat degradation and high interconnectivity with other suitable habitats (Paul and Post 2001; Rich et al. 2003). As suggested above, the introduction of lake trout (*Salvelinus namycush*) can also result in the competitive exclusion of bull trout in lacustrine environments (Donald and Alger 1993). Other introductions of non-native fish in British Columbia may also threaten bull trout where habitat use overlaps, although direct links have yet to be made between bull trout and these species. Examples are northern pike and walleye in the Columbia River, smallmouth bass in the Quesnel system, and numerous non-native species present in the lower Fraser system.

Overharvest, to which bull trout are particularly susceptible, has been implicated in population declines in the United States and Alberta (Rieman et al. 1997; Post and Johnston 2002). This is due in part to their tendency to be slow growing and late maturing, particularly in Canada, where rearing environments are typically cold and relatively unproductive (Post and Johnston 2002; Hagen 2000). Their vulnerability to even modest levels of angling effort also stems from their aggressive feeding behavior and their tendency to concentrate in specific areas for lengthy periods during their spawning migrations (McPhail 2007; Post and Johnston 2002).

Dam construction has also had a major impact on bull trout populations (Rieman et al. 1997; Post and Johnston 2002; Hagen 2008). Many of the dams that have been constructed in watersheds occupied by bull trout in the United States and Canada lack provisions to allow for the passage of migrating adults or juveniles. This has resulted in fragmented populations and barriers between productive juvenile and adult rearing environments (Hagen 2008), which may compromise a population's chance of long-term survival due to the loss of demographic support and genetic exchange from adjacent populations (Rieman and McIntyre 1993). Some bull trout populations in BC have adapted well to living in large reservoirs, and in some cases where kokanee have been introduced as a prey fish base growth and survival may be greater than in pre-existing riverine conditions (Hagen 2008). However, in a number of cases in BC, river impoundment has resulted in the replacement of hundreds of kilometers of diverse tributary stream habitat within a large river basin with a single, monomorphic reservoir environment, and this is likely to have resulted in breakdown of population structure and perhaps the loss of populations and genetic diversity (e.g. loss of fluvial form) as well (Hagen 2008).

3.0 STUDY METHODS

3.1 Status assessment by Ecological Drainage Unit

Both the United States Endangered Species Act (ESA) and Canada's COSEWIC (Committee on the Status of Endangered Wildlife in Canada) recognize the importance of conservation and management of biodiversity at the sub-specific level (reviewed in McPhail 2007). The 'designatable unit' concept of COSEWIC (Green 2005 as cited in McPhail 2007) identifies designatable units (DUs) as infraspecific units that are distinguishable from, and have different extinction probabilities than, the species as a whole. McPhail (2007) suggests that the coastal and interior lineages of bull trout qualify as DUs. However, much ecological and evolutionary divergence in bull trout, which includes significant morphological variance and adaptation identified in Haas & McPhail (2001), as well as instances of colonization across major drainage basin/continental divides, would not be recognized in such a coarse-scale classification. The BC system of Ecological Aquatic Units (Ciruna et al. 2007) is a hierarchical classification system incorporating ecological conditions and evolutionary history, and allows for classification at a finer scale. Five 'Freshwater Ecoregions' (North Pacific Coastal, Interior, Columbia Glaciated, Mackenzie) have been proposed based on patterns of fish re-colonization following glaciation, and are the primary classification level. The second level of classification accounts for zoogeographic, climatic, and physiographic patterns nested within the primary classification, and is comprised of 36 'Ecological Drainage Units,' or EDUs (Table 1; Figure 1). EDUs represent distinct major drainage basins that contain unique fish assemblages, and can be considered major adaptive zones for freshwater fauna. Bull trout are a species whose distribution and phylogenetic patterns have been utilized to help define the EDU structure (Ciruna et al. 2007). We assumed, therefore, that the EDU structure provides a good basis for organizing bull trout adaptive diversity in BC within the coastal and interior evolutionary lineages. In this report the EDU is the scale at which bull trout abundance, trends, and threats are summarized, rather than according to the nine Fish and Wildlife management region boundaries that determine jurisdiction and regulation of the species in British Columbia.

3.2 Bull trout distribution

Presence and distribution of bull trout within EDUs and individual watersheds were assessed primarily using GIS software, ArcGIS 9.3 and the provincial fish observation and fish obstacles layers populated from the BC Land and Resources Data Warehouse (LRDW). The LRDW is the primary collection of the Province's natural resource data and integrates all relevant past and present fisheries databases including the BC Field Data Information System (FDIS), the joint BC Environment/Fisheries and Oceans Canada (FOC) Fish Information Summary System (FISS) and the Fish Habitat Inventory and Information Program (FHIIP), and the BC Lakes Database. A small amount of distribution information from outside the LRDW was also collected during our review of BC bull trout literature for abundance information, and also during interviews with regional biologists (see Section 3.3).

During the GIS search, streams with bull trout records were not tabulated individually if they did not contain sufficient accessible length (e.g. record exists for mouth of stream only, and migration barrier identified immediately upstream) or were not thought to be sufficiently large (>2 m wetted width; see Section 2.1) to support spawning and rearing and the existence of a local population. Streams tabulated at this geographic scale were typically large enough to have a gazetted or local name, and could have numerous feeder tributaries for which bull trout records existed also. It is important to note, however, that no attempt was made to discriminate which bull trout life history stages made use of a particular stream. Resident populations were identified if records were located above fish obstacles of 5 m or higher (i.e., unequivocal barrier) identified on the fish observations layer on the LRDW.

In the zone of bull trout sympatry with Dolly Varden, the two species are discriminated only in some (not all) recent LRDW records, making positive identification of bull trout presence difficult[1]. In sympatry, bull trout appear have an exclusively migratory life history (adfluvial or fluvial), while Dolly Varden appear to form only non-migratory resident populations (Hagen 2000; Hagen and Taylor 2001). Within the overlapping portions of the two species' geographic ranges, Dolly Varden are usually also present in bull trout streams (potentially in the same sites), but they also inhabit very small streams, off-channel areas such as wetlands, and small lakes in which large-bodied migratory bull trout are rarely found (D. Bustard, fisheries consultant, Smithers, BC, pers. comm.). For areas within the range of Dolly Varden, we attempted to partially mitigate this source of potential overestimation bias by including only those watersheds that were within the known distribution of bull trout (Lower Fraser EDU, Skagit EDU, Squamish watershed within the South Coastal EDU, coastal portion of the Homathko-Klinaklini EDU, all EDUs in the interior portion of Region 6, and some coastal watersheds in the Taku, Iskut-Lower Stikine, and Lower Skeena EDUs in Region 6; Figure 1), and were of sufficient size and accessibility to support a migratory population.

3.3 Bull trout abundance and trends

Abundance and population growth rate (trend) are two key criteria for evaluating salmonid population viability (McElhany et al. 2000). At very small population sizes, the extirpation risks posed by environmental and demographic stochasticity, and genetic processes (inbreeding depression and long-term genetic losses and genetic drift) are greatly magnified (Simberloff 1988; Nunney and Campbell 1993). Based on estimates of effective population size (how many individuals are contributing their genes to the next generation) and the commonly cited "50/500" rule in conservation biology (Franklin 1980, as cited in Nunney and Campbell 1993), for bull trout the US Fish and Wildlife Service has suggested a minimum of 1,000 reproductive fish per core area (genetically related and demographically interconnected group of local populations) and 100 per local population (USFW 2002; USFWS 2008).

Quantitative criteria utilized by COSEWIC to guide the status assessments for wildlife species are based on criteria provided by the International Union for the Conservation of Nature (IUCN revised red

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[1] Note that the two species generally cannot be discriminated by untrained observers who don't have the support of morphological or molecular genetic analysis of voucher specimens.

list categories; IUCN 2001, as cited in COSEWIC 2010). While not specific to individual species, COSEWIC criteria suggest that species may generally be considered threatened if total abundance in Canada is <1,000 mature individuals, or if total abundance is <10,000 and populations are declining (other criteria may also be considered to modify the status assessment).

Sustained, negative abundance trends obviously threaten a population's viability. USFWS (2002) conservation criteria for bull trout are considered met if the number of spawning fish is stable or increasing for two generations at or above the target abundance level. Trends are similarly evaluated by COSEWIC (2010), whereby status is determined by changes in total numbers of mature individuals over the preceding 10 years or 3 generations, whichever is longer. The seven-year average age of Wigwam River spawners (Westover and Conroy 1997) may be an appropriate benchmark of mean generation time for bull trout populations in BC. Based on this value, the COSEWIC and USFWS criteria suggest evaluating bull trout trends over time spans of at least 21 and 14 years, respectively.

We considered only indices of adult abundance in our assessment of abundance and trends for bull trout populations in British Columbia. While juvenile bull trout sampling data in the LRDW was highly valuable in assessing distribution, and is potentially of high value in understanding production dynamics (Johnston et al. 2007; Hagen 2008), we considered it to be inappropriate for evaluating bull trout conservation status in the Province at this point in time. A principal reason for this is that the above abundance and trend criteria are based on the number of mature individuals, and there are difficulties in extrapolating between juvenile and adult bull trout abundance (USFWS 2008; Hagen and Decker 2009). Furthermore, adequately precise estimates of juvenile bull trout density and population size are more difficult to acquire (Peterson et al. 2004; USFWS 2008; Decker and Hagen 2007) and currently rare in British Columbia (notable exceptions: Allan 2001; Bustard and Schell 2002; Decker and Hagen 2007; Decker 2008; Bustard 2010) relative to adult monitoring data. Juvenile bull trout density in critical rearing habitats appears to be limited to ≈8 fish/100 m^2 or less (see '2.2 Population limitation and threats'), suggesting a potential criterion for evaluating habitat saturation. However, bull trout are often distributed such that critical rearing habitats comprise only a fraction of the total available habitat (Bustard and Schell 2002; Decker and Hagen 2007), meaning that such a criterion may not be widely applicable to sampling data from studies not designed to evaluate bull trout abundance specifically. Importantly, abundance of juvenile bull trout may not be a good indicator of the effects of serious mortality factors operating at later life stages, because density-dependent juvenile survival may mask low or declining adult abundance until populations have fallen to levels too low to seed available habitats, at which point population status would already be of significant conservation concern.

We acquired information about adult bull trout abundance in EDUs, core areas (see Section 3.4), and individual streams through a major literature review, through detailed information requests sent to regional BC Government biologists (and private consultants in two instances; see Acknowledgments), and through telephone and in-person interviews with BC Government fisheries biologists with specific knowledge about bull trout populations in their management regions. Our literature review was aided by a recent compilation of reports containing information on bull trout that extracted from the BC Aquatic Reports Catalogue (EcoCat) and other electronic libraries and summarized by Ministry of Environment staff (MOE, data on file). We also obtained and reviewed some additional, and important, literature that was not available from EcoCat, but was identified during interviews with regional staff from the MOE and the Ministry of Forests, Lands, and Natural Resource Operations (MNRO), or was previously known to us. We considered redd counts, aerial surveys, snorkeling surveys, counts of migrating adults at weirs and resistivity counters, and creel surveys (catch per unit effort, total catch or harvest) as relevant indices of adult abundance and for assessing trend over time. Approximations of total abundance ranges for individual core areas are summarized in Section 6, and were based on the above quantitative information as well as qualitative information provided by regional biologists.

For populations for which time series of abundance data were available, we also assessed trend in abundance. For this analysis, we included only datasets from studies where survey methodology and survey area were consistent from year to year. An exception was made for the time series of creel data for Kootenay Lake (an access point survey was conducted during 1962-1986, whereas a mail-out questionnaire was used during 1990-2008; see Table 2) because this was the longest dataset available, and there were some obvious trends that likely superseded any bias related to the change in survey type. We examined trend in abundance over time for all datasets with five years or more years of data using graphical plots. We tested for significant ($P < 0.05$) positive or negative trends using simple linear regression. Data were transformed where necessary to address non-normality. Strong reversing trends (e.g., negative trend followed by positive trend) were evident across the time series for several datasets. No statistical tests were applied in these cases, but trends were noted. We summarized information for all of the datasets we were able to obtain in Table 2, including those with less than 5 years of data. The latter datasets were included to provide some indication of how many time series of bull trout abundance will be available in the future, as many of these will be expanded by additional surveys in upcoming years. Abundance trends are summarized in Section 5.

3.4 Core area analysis

The US Fish and Wildlife Service has adopted the 'core area' as the appropriate spatial scale for monitoring bull trout abundance and applying conservation status criteria (USFWS 2002, 2005, 2008). Core areas are coarse estimates of the potential meta-population structure (Rieman and McIntyre 1993), and can be defined as groups of local populations (and their critical habitats) over which demographic and genetic connections, or the potential for them, exist, and which function more or less independently from other core areas (USFWS 2005). Additionally, the USFWS has developed a methodology for application to bull trout core areas that is designed to capture population and threat information available in a variety of non-standard formats (USFWS 2005 Appendix A). The methodology was applied to all 121 core areas identified for the contiguous US as part of a 5-year bull trout conservation status review (USFWS 2005). It has also been adopted and applied to 47 core areas in Alberta (S. Pollard, MOE, Victoria, pers. comm. 2011).

Upon review of the core area assessment methodology for potential application in BC, we recognized that that relatively sparse information about bull trout populations and their spatial structure would mean that most core areas would have highly uncertain boundaries and unknown population information. We nonetheless decided that the methodology was worth applying in the Province, as a means of: 1) presenting a preliminary estimate of the core area structure; 2) organizing and synthesizing data and expert judgments or other non-quantitative information about bull trout populations; 3) encouraging managers to focus on the entire geographic range of bull trout in BC, and to evaluate the status of the species based on available information for the province as a whole; 4) facilitating comparisons of bull trout population 'health' in BC with that in other jurisdictions (Alberta and the US); and 5) allowing bull trout population status to be evaluated using criteria intended for application at the metapopulation level.

As the first step of our application of the method in BC, a putative core area structure for the Province was estimated in a two-part process. First, the likely range of core area sizes was approximated based on a review of representative radio-telemetry, tagging, and molecular genetic studies conducted in BC that contained information related to population spatial structure (Aquafor Consulting 1997; Burrows et al. 2001; Bahr 2002; O'Brien 2001; Oliver 2001; Latham 2002; Costello et al. 2003; Pillipow and Williamson 2004; Westover and Heidt 2004; Taylor and Clarke 2007; Taylor and

Costello 2006; E.B. Taylor, UBC Fisheries Centre, pers. comm.). Data were insufficient for detailed estimates of meta-population structure, but as a proxy for metapopulation structure we coarsely estimated that populations distributed over a geographic scale of 100-250 km are likely to exhibit overlap in home ranges and non-zero levels of gene flow among them (although movements of some populations may be on an even greater scale than this; Pillipow and Williamson 2004). Given this approximate dimension, and following the recommendations of Rieman and McIntyre (1993) and Bonar et al. (1997), our guidelines for establishing BC core areas were that they contain or have the potential to contain multiple, interconnected local populations, be typically 100-250 km along their longest dimension unless further restricted by migration barriers (or if they can be estimated more reliably from telemetry/genetic studies), provide all critical habitat elements, and be distributed within the known range of the species in the Province. We delineated core areas using these guidelines and the provincial fish observations and fish obstacles layers in ArcGIS (see section 3.2). They correspond approximately to clusters of geographically adjacent, potentially interconnected stream reaches within a larger basin for which bull trout records exist, and which are separated from other such clusters by a distance requiring exceptional migrations.

Specific details of the bull trout core area assessment methodology are presented in Appendix A of USFWS (2005). Briefly, we distributed a spreadsheet file containing detailed instructions, a putative list of bull trout core areas and tributary streams, and a completed example to a fisheries professional(s) in each British Columbia management region that had the most extensive knowledge of bull trout in his/her area, and was available to participate in the exercise. Biologists who participated in the core area assessment process were, in addition to the authors: D. Jesson (Surrey), R. Bison, A. Caverly, A. Morris (Kamloops), A. Chirico (Nelson), R. Dolighan (Williams Lake), J. Lough, J. DeGisi (Smithers), C. Williamson, R. Pillipow, A. Langston (Prince George), B. Anderson, N. Baccante, T. Euchner (Fort St. John). Where possible, these individuals amended core area boundaries and entered codes corresponding to categorical estimates of distribution (stream km inclusive of all critical habitat elements; IUCN 2001 as cited in USFWS 2005), abundance of mature individuals, trends in abundance, and threats (Appendix 1). Threat categories included 1) habitat threats, including loss of connectivity due to migration barriers, loss of habitat complexity, and human-induced water temperature increases, 2) exploitation threats resulting from inadequate regulations or illegal harvest, and 3) the presence of non-native competitors (see Section 2.2). An overall ‘threats score’ was assigned based on estimated values for severity, scope, and immediacy for each threat category (Appendix 2).

3.5 Assigning conservation status rank to individual core areas and EDUs

As the final step in the core area assessment methodology as presented by USFWS (2005), alphabetical scores corresponding to categorical estimates of abundance, distribution, trend, and threats are converted to numerical values with positive or negative signs (Appendix 3). The numerical values are summed across categories and added to a baseline value developed specifically for bull trout (USFWS 2005). The resulting total is then compared to the range of values corresponding to each of 4 conservation status ranks (C Ranks) in order to assign a rank to the core area. The C Ranks are C1-High Risk, C2-At Risk, C3-Potential Risk, and C4-Low Risk (see Appendix 3 for descriptions). The numeric scoring procedure is compatible with unknown values for the risk factors, and assigns a '0' numeric value for each 'U' (unknown) alphabetic value. In the USFWS (2005) analysis for the contiguous United States, trend was unknown for >50% of core areas, but abundance and distribution were both known for the large majority of them. In order to facilitate meaningful comparison with US and Alberta jurisdictions, we therefore applied the above numerical rank assignment process only to British Columbia core areas for which alphabetical scores for both abundance and distribution existed ('trend' could be unknown). All other core areas received a CU-Unranked status ranking.

The status ranking exercise has not been critically evaluated for use on larger areas such as EDUs (USFWS 2005). However, the approach recommended by the USFWS (2005) for such areas is to utilize the weighted average of the core area numeric sums (across all core areas in the larger area) to determine a C Rank for the larger area, where each core area's numeric sum is weighted by the distribution of bull trout in that core area as a proportion of the total distribution in the larger area. In our analysis, bull trout distribution was not estimated precisely in core areas. As a proxy, we utilized the mid-point of the range of distribution values corresponding to the core area's alphabetic distribution score. For EDUs where C Ranks could only be assigned to a single core area, this C Rank was assigned to the EDU also unless it was deemed unlikely to be representative of other core areas in the EDU.

4.0 DISTRIBUTION

Databases integrated into the Land and Resources Data Warehouse (LRDW) fish observations layer indicate bull trout presence in 26 of 36 EDUs listed for BC (Appendices 3-9; Figure 2), making them one of Province's most widely distributed salmonids (McPhail 2007). Bull trout records extracted from the LRDW suggest they are present in roughly 1,000 watersheds large enough to support local populations, although this should not be considered a reliable estimate of the number of local populations (see below).

The northernmost EDUs of the Yukon and coastal (Nakina, Taku) drainages are noteworthy in that bull trout are present in only a small number of isolated locations (Figure 2; Appendix 4), and are absent from the Alsek EDU (McPhail 2007). While this may be an artefact of sampling intensity (see below), which was not evaluated, the Lewes and Teslin EDUs (Table 1) have a Beringian faunal assemblage (Ciruna et al. 2007), suggesting that post-glacial colonization patterns may also have been a factor limiting current bull trout distribution in these EDUs. In contrast to this notion, bull trout appear to have established numerous populations in the Upper Liard and Lower Liard EDUs, which are also thought to have been colonized post-glacially from the Beringian and Great Plains refugia (Ciruna et al. 2007).

In the rest of the Province, bull trout appear to have a widespread distribution that appears to be associated with mountainous regions, presumably because of the association between these areas and cold water habitats upon which the species depends (see Section 2.2). Bull trout records are notably sparse and isolated in areas of the Great Plains east of the Rocky Mountains in the Lower Liard and Lower Peace EDUs, with the exception of the Liard and Peace River mainstems and reaches of their tributaries within mountainous areas (Figure 2). A similar gap in bull trout records is indicated for broad areas of the Fraser Plateau between the Coast Mountains and the Columbia ranges in the east, and between the Cascades and the Omineca Mountains in the north (Middle Fraser EDU; Figure 2). Bull trout are present in mainstem reaches of larger rivers, but away from the mountains records for tributary reaches and smaller watersheds are relatively isolated (Figure 2). Recent telemetry data, which provides evidence of extremely long migrations (>500 km; R. Pillipow, MNRO Prince George, pers. comm. 2011) between natal streams in the mountainous upper Fraser watershed (Upper Fraser EDU) and adult rearing areas in the Nechako River watershed (Middle Fraser EDU), suggest that some non-mountainous areas do provide critical bull trout rearing habitats for older life stages.

A third major gap in the distribution of bull trout in the interior of BC is the absence of bull trout from three adjacent, warmwater EDUs (Kettle, Okanagan, and Similkameen) in Region 8 in southern BC (Figure 2), which also reflects the dependence of bull trout on coldwater environments.

Bull trout are also absent from most watersheds along the BC coast (Haas and McPhail 1991; Taylor et al. 1999; McPhail 2007). Notable exceptions to this are the presence of the coastal evolutionary lineage (see Section 2.1) in the Lower Fraser, Skagit, and South Coastal (Squamish watershed) EDUs

(Figure 2; Appendix 4), and the presence of the interior lineage in coastal areas of several large rivers that penetrate through the Coast Mountains, including the Homathko-Klinaklini EDU and some watersheds in the Taku, Iskut-Lower Stikine, and Lower Skeena EDUs (Figure 2; Appendix 4).

A key source of uncertainty in the LRDW bull trout distribution records is the relatively broad zone of sympatry for bull trout and Dolly Varden (Haas and McPhail 1991; Redenbach and Taylor 2003). Estimates of bull trout distribution in areas of sympatry based on the known distribution of both species combined will overestimate bull trout distribution. We attempted to mitigate for this potential source of positive bias in our estimates of bull trout distribution for areas of sympatry by excluding records from tributaries that appeared too small to support a migratory population, and those that appeared to come from off-channel areas like wetlands or small lakes (see Section 3.2). However, this information was not present or could not be reviewed for many of the LRDW records. Thus, the estimated number of tributaries for which bull trout records exist (Appendix 4) likely over-represents the actual number of local populations. Likewise, a substantial number of the streams for which bull trout records exist are likely not used by bull trout for spawning and rearing, which also contributes to overestimation of the number of local populations. Regardless, the existence of bull trout records for these streams presumably indicate that they are still important for bull trout seasonally, or for certain life stages.

In contrast, other sources of error likely resulted in underestimation bias with respect to bull trout distribution in the Province. First, the fish sampling data that we used to determine bull trout presence was non-randomly distributed, as it was largely derived from industry-related inventory surveys and environmental impact studies that focused on specific areas of the province. It is highly likely that many watersheds that have received little or no sampling effort contain undetected bull trout populations, especially in remote or pristine areas with low levels of industrial activity. Moreover, the probability of bull trout being detected during a survey is likely to be highly dependent on the goals of the survey. The probability of detecting bull trout at a particular sampling site, even if the species is present in the watershed, is substantially <100%, meaning that, if testing for bull trout presence is goal, studies must be designed appropriately with multiple, randomly- or systematically-distributed sites (USFWS 2008). This issue is mitigated somewhat with respect to determining whether bull trout are presence at the core area- or EDU-level because there was often a relatively large number of sampling sites to draw information from. Another source of negative bias is that bull trout presence would not be documented in the LRDW database for streams that were sampled using a method that did not require a sampling permit (e.g. redd counts, snorkeling surveys, angler surveys), or if the study proponent was not required to upload sampling data, or submit a copy of the report to a resource management agency.

We evaluated LRDW records for their potential to document changes in bull trout distribution over time, but concluded that the LRDW was not useful for this purpose primarily because of the issues mentioned above: non-random sampling, changes in sampling methodology over time, and low and varying detection probability for bull trout depending on the objectives of a particular study.

5.0 ABUNDANCE TRENDS

We compiled 31 datasets that provided two or more years of abundance information for a local population or metapopulation of bull trout (Table 2). The highest number of datasets came from the Columbia drainage (13), followed by the upper Peace and upper Fraser area (6). The Shuswap-Thompson area was represented by a single dataset (i.e. Sugar Lake). Of the 26 EDUs in the Province that have confirmed bull trout populations, only 10 were represented among the 31 abundance datasets. Of a total of 115 core areas identified for the Province, 22 were represented. Twenty-two of the datasets had 5 or more years of data, 15 datasets had seven or more years of data (7 years is likely a reasonable approximation of one generation for bull trout in BC; Westover and Conroy 1997), 11 datasets had 10 or more years of data, 7 datasets had 14 or more years of data (2 generations), and 2 datasets had 21 or more years of data (3 generations). In many cases, surveys did not always occur in consecutive years, so the actual time periods spanned by the datasets ranged from 2-46 years (Table 2).

While most of the datasets represent local populations in individual streams (including tributaries in some cases), three creel survey datasets from lakes (Arrow, Kootenay, Sugar) and redd counts from the Thutade watershed each represent overall abundance for a core area or metapopulation. The Kitwanga River dataset was derived from counts of upstream migrating bull trout at a salmon counting fence during July-October, and enumerated bull trout are probably a combination of mature fish migrating upstream to spawning areas and immature fish (possibly from other spawning populations) moving into the system to feed on salmon eggs and carcasses (J. DeGisi, MNRO, Smithers Region). Similarly, counts of bull trout in the Cheakamus River were obtained during snorkel surveys for returning winter steelhead during February-May, and are not a direct measure of the adult spawning population (bull trout rearing in the Cheakamus River spawn primarily in the upper Squamish River system; Ladell et al. 2010). However the majority of adult bull trout in the Squamish River core area are though to be present in the Cheakamus River during February-May (J. Korman, Ecometric Research Inc., pers. comm.). Finally, the Duncan dataset, which represents annual estimates of the number of bull trout manually transferred through Duncan Dam (Kootenay Lake core area), can be considered an index of aggregate abundance of adfluvial, Kootenay Lake bull trout that utilize upper Duncan River tributaries for spawning and rearing.

We assessed abundance for the 22 datasets with five or more years of data as well as the creel survey dataset for Sugar Lake (Upper Shuswap core area), which contained only four years of data, but spanned a 20-year time period. No trend over time was detected for 13 of the 23 datasets (Table 2; Figures 3-9). Six of the datasets (Sugar Lake, Chowade, Skagit, Damshilgwet, Thutade Lake, Line Creek), representing six different EDUs, exhibited a positive trend in abundance over time. With the exception of Thutade Lake and Damshilgwet Creek[2], which are remote watersheds with negligible angling effort, the positive trend in abundance for these datasets largely reflects population recovery following the implementation of more restrictive angling regulations (including stream closures) to address previous overexploitation (Webster and Wilson 2005; Chapman et al. 2008; Anaka and Scott 2010; Euchner 2011). In addition, there was a positive trend in abundance during a portion of the time series for the Wigwam (1994-2006) and Cheakamus rivers (1996-2004) that was also the result of reduced harvest rates brought about by regulatory changes. The subsequent collapse of the Cheakamus population in latter years was the result of a large-scale caustic soda spill (Ladell et al. 2010), while the negative trend for the Wigwam River population after 2006 likely reflects a shift in angling regulations for Koocanusa Reservoir from strictly catch-and-release during 1994-2003, to a harvest limit of 2 bull trout/person/year during 2004-2010.

The 34-year dataset for Kootenay Lake exhibited a series of positive and negative trends. Catch rates for bull trout increased during the 1960s when nutrient loading from an upstream fertilizer plant led to increased kokanee abundance. Catch rates then declined during the 1970s and 1980s when the kokanee population crashed following the downscaling and closure of the fertilizer plant and the retention of nutrient-laden sediments behind dams on the Duncan and Kootenay Rivers. Finally, after the implementation of a lake fertilization program in the 1990s, bull trout catch rates returned to peak levels, likely in response to both increased kokanee abundance and a shift in angler behaviour towards catch-and-release. However, it should be noted that catch rates are not strictly comparable for the

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[2] The positive trend at the Damshilgwet fence may reflect modification of the structure (narrower spacing between staves) made midway through the monitoring time series (P. Hall, Gitksan Fisheries Authority, pers. comm.).

periods preceding and following 1990 because prior to 1990, a roving creel survey design was employed, whereas from 1990 onward, creel data were limited to a mail-out survey, the reliability of which is uncertain (Andrusak 2007). Moreover, CPUE in recreational fisheries is often insensitive to changes in abundance because angler effort is generally not independent of abundance (e.g., CPUE may remain constant or even increase over time as total effort and catch decline). Only one dataset (Sustut) exhibited a negative trend in abundance. It is uncertain whether the Sustut dataset is a meaningful indication of abundance trend for the Upper Skeena EDU, given the low number of bull trout captured at the counting fence each year (3-70; the fence is primarily operated to enumerate summer steelhead), and the uncertainty concerning what proportion of the upper Sustut bull trout population is intercepted by the fence (adfluvial bull trout are present in the headwater lakes upstream of the fence). However, the possibility that fence operation is partially or primarily responsible for population declines in this portion of the watershed (many mortalities have been observed) should not be discounted.

6.0 CORE AREA ASSESSSMENT

6.1 Provincial overview

Based on bull trout distributions and known migration barriers as indicated by LRDW records, and telemetry and molecular genetic information in some cases, we delineated 115 bull trout core areas for British Columbia. Unfortunately, for the majority of these core areas boundaries are highly uncertain because of limited population structure information. In addition to the lack of more detailed data which would allow us to define core area boundaries, in places where minimal presence/absence sampling has occurred there may be gaps in the sampling which cause the appearance of core areas that are spatially distinct. However, these gaps may be artefactual in that additional sampling could reveal a more continuous distribution of the species[3].

Abundance (categorical estimates based on expert judgment or abundance dataset(s); see Appendix 1) was unknown for 83 of 115 core areas. Of the remaining 32 core areas, four were judged to have 50 or fewer reproductive adults, two to have adult populations of 50-250, 18 to have adult populations of 250-1,000, and eight to have adult populations of >1,000, and one to have an adult population >2,500. A high proportion of the categorical estimates of abundance came from Region 4 (13

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[3] For data-deficient areas of the Province, alternative schemes for delineating bull trout management units, such as EDU sub-units, are being explored and may be preferable until knowledge of population spatial structure is compiled.

of 32 estimates), due to a disproportionately large effort in that region to monitor bull trout populations and assess the impacts of hydroelectric development and other major habitat alterations.

Distribution (categorical estimates derived from expert judgment in most cases; see Appendix 1) was unknown for 44 of 115 core areas. In the remaining 71 core areas, bull trout were judged to utilize less than 4 km of habitat in no core areas, to utilize 4-40 km of habitat in 8 core areas, to utilize 40-200 km in 13 core areas, to utilize 200-1,000 km in 45 core areas, and to utilize greater than 1,000 km in five core areas.

Trend in adult abundance (estimated approximately by expert judgment or utilizing abundance datasets where available) was unknown for 91 of 115 core areas. In the remaining 24 core areas, adult abundance was estimated to be severely declining (>70% within 25 years) in no core areas, very rapidly declining (50-70% decline) in two core areas, rapidly declining (30-50%) in no core areas, declining (10-30%) in six core areas, stable in nine core areas, and increasing in seven core areas.

Threats to bull trout, with respect to habitat, exploitation, and species interactions (competition/hybridization), and considered in terms of their severity, scope, and immediacy, could be identified (by expert judgment) for most (93 of 115) core areas:

- Six core areas were identified as having moderate to severe, imminent threats affecting the majority of the bull trout occurrence in the core area.
- Twenty-two core areas were identified as having moderate to severe, imminent threats affecting 20-60% of the bull trout occurrence in the core area.
- Three core areas were identified as having moderate to severe, non-imminent threats affecting a substantial portion of the bull trout occurrence in the core area.
- Six core areas were identified as having moderate to severe threats affecting a small proportion of the bull trout occurrence in the core area.
- Twenty-six core areas were identified as having low severity threats affecting the majority of the bull trout occurrence in the core area.
- Twenty core areas were identified as having low severity threats affecting a small proportion of the bull trout occurrence in the core area.
- Ten core areas were identified as having no significant threats.

Conservation status ranks (C Ranks; USFWS 2005) could be assigned to 33 core areas for which categorical estimates of distribution and abundance were available (Appendix 4), representing 14 of the 26 British Columbia EDUs known to be inhabited by bull trout (Table 3). C Ranks were C1-High Risk for 4 core areas, C2-At Risk for 11 core areas, C3-Potential Risk for 14 core areas, and C4-Low Risk for 4 core areas (Appendix 4). Conservation status ranks evaluated at the EDU level, based on weighted averages of core area scores within the EDU, were C1-High Risk for no EDUs, C2-At Risk for 4 EDUs, C3-Potential Risk for 8 EDUs, and C4-Low Risk for 2 EDUs (Table 3). It is important to note, however, that in several cases EDU-level assignment of a C rank was based on a ranking from a single core area from within the EDU.

6.2 Synopsis by Ecological Drainage Unit

Puget Sound EDU. The Skagit core area, the sole core area within the Puget Sound EDU in Canada (Appendix 4), comprises the Canadian portion of the Upper Skagit core area that includes Ross Reservoir and additional natal tributaries in Washington State (USFWS 2005). Studies in this core area have included the first ecological study of bull trout and Dolly Varden in sympatry (McPhail and Taylor 1995), meaning that distribution of the two species is relatively well understood compared to other lower mainland EDUs. Snorkel surveys in recent years suggest high (>1,000) and increasing bull trout abundance (Figure 5), related to angling management changes and possibly introduction of redside shiner into Ross Reservoir (Appendix 4). While bull trout distribution in the Canadian portion of the Upper Skagit core area may be <40 km (Appendix 4), the overall distribution is much greater due to connectivity with US portion of the core area (USFWS 2005). Although Canadian anglers are increasingly targeting bull trout in a popular recreational fishery in the upper Skagit River, exploitation threats are not considered significant currently given that adaptive management and population monitoring are in place. Overall, although they require immediate attention, low severity threats from mining, forestry, and increased recreation affect only a relatively small proportion of the core area, as 70% of the upper Skagit watershed is located in parks (Appendix 4). A conservation status rank of C4-Low Risk was assigned to the Skagit core area (Appendix 4) and Puget Sound EDU (Table 3) based on numerical scoring of abundance, distribution, trend, and threats risk factors. An important factor in the perceived C Rank is the perceived low levels of threats.

Management and conservation of bull trout in Provincial management Region 2 warrants unique consideration because the Puget Sound, Lower Fraser, and South Coastal EDUs comprise the entire distribution of the 'coastal' evolutionary lineage in Canada (see Section 2.1). The upper Skagit watershed as a whole (including the US portion) can probably be considered as an important stronghold for bull trout of this lineage.

Lower Fraser EDU. Despite its location in the populated and accessible Lower Mainland area and the fact that it contains the broadest geographic range of coastal lineage bull trout in Canada, relatively little is known of bull trout in the Lower Fraser EDU. A genetic study of bull trout population structure in the Lower Fraser EDU has helped identify the core area structure and therefore has important implications for conservation and management (Taylor and Costello 2006). However, key biological information necessary for assessing bull trout status in core areas of the Lower Fraser EDU (i.e., identification of local populations, critical habitats and important threats, and assessments of abundance) is limited. This probably reflects competing priorities associated with conservation and management of other species, including management of major recreational fisheries and constant threats to habitat associated with rapid urban development in BC's most populous area. A second major factor limiting our assessment of bull trout in the Lower Fraser EDU is the widespread presence of Dolly Varden. Owing to the lack of discrimination between the two species in most LRDW records, our estimates of bull trout distribution and core area structure are less certain for EDUs in the zone of sympatry relative to rest of BC. This issue represents a major source of uncertainty with respect to the distribution and status of both species throughout a large portion of the Province, which probably cannot be resolved without a significant revision of standard protocol for fisheries sampling.

Abundance is unknown for all core areas (Lower Fraser, Lillooet, Lower Fraser Canyon; Appendix 4). Only one time series of abundance data are available for the Lower Fraser EDU: a 5-year data set for a local population in Phelix Creek in the Lillooet core area (Table 2; Figure 5), which is considered to be stable. Based on expert judgment, it is considered likely that bull trout abundance has declined in the highly developed and highly accessible Lower Fraser core area. Further upstream, distribution and trend are unknown for the Lower Fraser Canyon core area. Distribution is probably significantly greater than 200 km for the Lower Fraser and Lillooet core areas, but, as mentioned previously, this is uncertain, as many records do not discriminate between bull trout and Dolly Varden. This uncertainty, coupled with a lack of detailed life history information at the population level, poses a significant challenge in identifying threats, as well, because threats in the Lower Mainland are diverse and location-specific. Currently, moderately severe threats requiring immediate attention are judged to be an issue for much of the EDU, and include illegal harvest, run-of-the-river hydroelectric projects, habitat degradation associated with forestry, agriculture, gravel extraction, and linear developments, and naturalized brook trout populations (Appendix 4). Bull trout are highly vulnerable to angling, and are targeted specifically in Lower Mainland fisheries. Although protective regulations are in place, illegal harvest is thought to be a potential threat to bull trout populations in the Lillooet core area particularly. Bull trout from the Lower Fraser core area (and potentially other core areas) utilize the mainstem Fraser River (Taylor and Costello 2006), where they may be vulnerable to commercial and First Nations fisheries targeting salmon. The degree of temporal overlap of bull trout and migrating salmon, and therefore the threat to bull trout populations, is unknown, suggesting that a study of habitat use for migrating bull trout in the Lower Fraser core area would be valuable (note that such a study would also serve to better define the population spatial structure). Conservation status ranks were CU-Unranked for all core areas (Appendix 4) and the Lower Fraser EDU as a whole (Table 3) because of insufficient distribution and abundance data, but threats indicate that the level of conservation concern should be relatively high.

South Coastal EDU. Within the South Coastal EDU, bull trout distribution is limited to the Squamish River watershed. The Squamish core area forms the northernmost extent of the distribution of coastal lineage of bull trout along the BC coast. Coastal populations of interior lineage bull trout are isolated from the coastal lineage by an extensive area of coastline between the Squamish watershed and the Homathko watershed on the central coast, in between which Dolly Varden are thought to be the only native char species present (McPhail 2007). While abundance for the core area as a whole remains uncertain, snorkeling surveys of the Cheakamus River over the past decade suggest good abundance of individuals of mature size (Table 2; Figure 5), and that abundance exceeds 250 reproductive adults. The sharp decline in abundance during 2007-2009 reflects the recent, severe impact of a chemical spill resulting from a train derailment, but counts during 2010-2011 indicate that the population is recovering (J. Korman, Ecometric Research Inc., pers. comm.). Available information suggests a distribution within the core area of 200 km or less, but this is fairly uncertain. Given the limited geographic extent of the Squamish core area, it is quite possible that total abundance is <1,000 mature individuals, which is the USFWS (2002) minimum threshold for conservation concern for an individual core area; this should be taken into account with respect to future management planning. Moderately severe threats requiring immediate attention and affecting a significant portion of the core area are posed by hydroelectric projects on several systems, continued major transportation system development and increased recreation use along the Sea-to-Sky Corridor, and habitat degradation from past and present forestry activities (Appendix 4). Similar to coastal lineage bull trout in the Lower Fraser and Puget Sound EDUs, bull trout in the Squamish core area inhabit streams subject to high angling pressure and are targeted specifically. However, exploitation threats are not considered significant currently given that protective regulations (no harvest in streams) and population monitoring are in place. Conservation status ranks assigned to the Squamish core area (Appendix 4) and South Coastal EDU (Table 1) are C2-At Risk, with relatively low population size and threats being the most significant factors.

Homathko-Klinaklini EDU. The Homathko-Klinaklini EDU spans the Coast Mountains on south central coast of BC and includes bull trout core areas in both the coastal and interior portions of the Homathko and Klinaklini watersheds. Coastal core areas in the lower Homathko and Klinaklini systems are isolated from upstream core areas by major canyons where each cuts through the spine of the Coast Mountains. Few bull trout records exist for the Lower Klinaklini core area, and distribution, abundance and trend are unknown (Appendix 4). Information is also limited for the Lower Homathko core area, but an abundance of >200 mature individuals is suspected based on verified widespread distribution within the Southgate River watershed (Aquatic Resources 1999), known potential for multiple local populations within the lower Homathko watershed (Appendix 4), and anecdotal angling reports of high catch rates. Distribution is uncertain but may include 200 km or more of critical habitat if distribution in the lower Homathko watershed is comparable to that in the Southgate watershed (Aquatic Resources 1999). Population declines are not expected in the Lower Homathko core area given low assessed threats and insignificant angling pressure (Appendix 4). Habitat is recovering from past logging impacts in both core areas. However, large-scale run-of-the-river hydroelectric proposals are under review for both core areas, and these represent potentially significant threats to bull trout populations requiring immediate attention.

The portion of this EDU within Region 5 contains the upper Homathko River and the upper Klinaklini core areas. (Appendix 4). LRDW data suggests an extensive and fairly contiguous distribution of bull trout in mainstem and colder tributary reaches within these core areas (Figure 2). The area of bull trout occupancy likely exceeds 200 km for both areas. Abundance estimates are unavailable, but it reasonable to suggest that the total number of reproductive adults exceeds 1,000 individuals for each core area. In the absence of major impacts and threats (see below), population trend is probably stable. Although historical logging, agriculture and the recent pine beetle infestation have resulted in the loss of forest cover, the majority of stream reaches occupied by bull trout in these two core areas are downstream of heavily glaciated headwaters that provide a thermal buffer against these impacts and climate change as well (Porter and Nelitz 2009). Anecdotal evidence suggests that local adfluvial populations in several lakes may be depressed by overfishing (R. Dolighan, Consultant, Williams Lake, pers. comm.), but overall, exploitation is limited because the majority of bull trout habitat is not accessible by road. Conservation status ranks for the Upper Klinaklini, Lower Klinaklini, and Upper Homathko core areas were CU-Unranked, and for the Lower Homathko core area C3-Potential Risk (Appendix 4) with the most important risk factor being low threats. The C3-Potential Risk ranking was applied to the Homathko-Klinaklini EDU as a whole with no clear rationale for a more severe rank (Table 3).

Bella Coola-Dean EDU. We delineated two possible core areas for this EDU: the upper Atnarko River and the upper Dean River (Appendix 4). MacPhail (2007) suggests that bull trout are present in both rivers on the east side of the Coast Mountains, whereas regional biologists suggested that only Dolly Varden are present (Appendix 4). Bull trout presence in the upper Dean River is likely given the lack of coastal species, and the minimal geographic separation from adjacent core areas of the Middle Fraser that contain bull trout (Little Chilcotin, West Road). Char observations in the upper Atnarko are limited to the upper portion of the South Atnarko River where anadromous salmon are also present, which argues in favour of Dolly Varden. However, there is a low elevation divide where the South Atnarko River comes within 1 km of a lake in the Klinaklini watershed (Knot Lake) that contains bull trout (Figure 2), and it is quite possible that bull trout have at least a limited presence in the South Atnarko. Collection of voucher specimens for morphological or molecular genetic analysis is needed for these core areas before bull trout status can be meaningfully evaluated.

If the char observed in the upper Dean River are bull trout, the LRDW records indicate that they are broadly distributed in basins draining the east side of the unglaciated Rainbow Mountains, within the section of the Dean River extending from Abuntlet Lake downstream to the Dean River canyon (Figure 2). Guide outfitters operate in this area and may keep catch records that would provide some indication of bull trout abundance. Similar to the situation in the nearby Little Chilcotin core area, the main threats to bull trout in the upper Dean are likely the loss of forest cover due to beetle-kill, and the negative effects of climate change on stream temperatures (Appendix 4). Conservation status ranks for these putative core areas (Appendix 4) and for the Bella Coola-Dean EDU are CU-Unranked due to unknown distribution and abundance (Table 3).

Thompson EDU. The Thompson EDU encompasses the entire Thompson River watershed (Figure 1). Within this EDU, bull trout are broadly distributed in drainages in the Monashee and Cariboo Mountains, but are absent or sporadically distributed in drainages originating from one of the several large mid elevation plateaus that dominate this EDU (Figure 2). Population structure remains uncertain for many parts of the Thompson EDU because, with some exceptions, physical barriers do not restrict movement among putative core areas, and there is little information available from genetic or telemetry studies to aid in defining the geographic extent of core areas or the degree of exchange among core areas. For example, bull trout in tributaries of the North Thompson River could conceivably make extensive migrations to capitalize on more abundant salmon resources in other areas such as the South Thompson River system, similar to the case of fluvial bull trout in the upper Fraser foraging in Fraser tributaries east of Prince George (see Section 4.0). Nevertheless, for most core areas, adequate information (informal surveys and professional knowledge) exists to describe the current area of occupation for bull trout, and the life history types that are present, although formal population assessments are lacking.

We identified seven core areas (Appendix 4); two of the core areas (Upper Shuswap, Middle Shuswap) are isolated by hydroelectric dams, but movement is possible among the five remaining areas, and population structure is less certain. We assumed that the home ranges of adfluvial fish were localized within the immediate basins of Mabel, Shuswap and Adams lakes in delineating these core areas. Seasonally unfavorable thermal regimes in the mainstem rivers connecting these lakes presumably limits movement and rules out fluvial populations. For example, radio-telemetry work on adfluvial bull trout in Adams Lake suggests little interaction with the Shuswap Lake core area downstream, despite minimal geographic separation (O'Brien and Chamberlain 2003).

The area of occupancy (distribution) for bull trout was categorized as 200-1,000 km in three core areas (North Thompson, Shuswap Lake, Mabel Lake; Appendix 4), 40-200 km in two other areas (Adams Lake and Upper Shuswap), and 4-40 km in the remaining two areas (Nicola and Middle Shuswap; Table 1). Population size was categorized as 1,000-2,500 adults for two core areas (North Thompson, Shuswap Lake), 250-1,000 adults for three core areas (Upper Shuswap, Adams Lake, Mabel Lake), <50 or 50-250 adults for the Nicola core area, and <50 adults for the Middle Shuswap core area. Population trend is thought to be increasing for the Upper Shuswap core area based on a limited time series of creel survey data (Section 5.0; Figure 5). In addition, a time-series for angler catch is available for Shuswap Lake spawning 1994-2008. However, effort was not reported and only total catch data is available thus it was not included in trend analyses. However, this data suggests that catches have increased significantly over this time although a recent minor drop was observed from a maximum count of 684 bull trout in 2006 (Andrusak 2011). Trend was categorized as very rapidly declining for the Nicola and Middle Shuswap core areas, and is unknown for the five remaining areas.

The Nicola and Middle Shuswap core area populations appear to be at serious risk of extirpation (Appendix 4). Spawning and rearing habitat for the fluvial population in the Nicola core area is limited to headwater reaches of two tributaries in the Cascade Mountains (Spius Creek and Coldwater River), which are isolated from other suitable habitats by very warm temperature regimes and low summer flows in downstream reaches. The Middle Shuswap fluvial population is isolated from the remainder of the Shuswap River system by two dams[4]. Habitat quality is, at best, marginal in both core areas, as summer water temperatures are at the upper limit of bull trout tolerance, and negative interactions with other salmonids are likely occurring. Comparisons of recent versus past juvenile surveys suggest some degree of range contraction for both core areas (Arc Environmental Ltd. 1999; Decker and Caverly 2007). Redd surveys of spawning reaches in the Nicola core area (Decker and Caverly 2007) and snorkel surveys of the Middle Shuswap area (Chamberlain et al. 2001) suggest adult populations of less than 50 individuals. Given the lack of evidence of juvenile production, it is possible that a self-sustaining population has already been lost from the Middle Shuswap core area, and the few adults remaining are simply strays from the Upper Shuswap core area upstream of the upper dam. Climate change, salvage logging of beetle-kill pine forests, and a proposed all-seasons golf and ski resort in the Coldwater River headwaters threaten the future viability of Nicola core area population. In the Middle Shuswap area, flow regulation has negatively impacted habitat quality in mainstem habitat, while forestry related activities and climate change represent threats to thermal habitat quality in Cherry Creek, the only tributary with the potential to support spawning and rearing.

By contrast, the North Thompson core area is one of the most secure in the southern interior portion of the Province with respect to threats to habitat and population persistence in the long term. Heavily glaciated watersheds in the upper portion of the drainage provide extensive, coldwater spawning and rearing habitat. The fluvial life history type dominates the North Thompson area, but local resident and adfluvial populations are present as well (Appendix 4). Abundance data are unavailable, but abundance is likely > 1,000 reproductive adults at a minimum, based on numerous local populations inhabiting highly suitable tributary habitats in the upper watershed (i.e., upstream of the Mad River), where competition with other species is low (Hagen and Baxter 1992; Wescott and Standen 1993). Wescott and Standen (1993) concluded that available bull trout rearing habitat was near capacity in most streams that they sampled. Future developments in the upper watershed such as run-of-the-river hydroelectric projects and forestry harvesting are likely to be fairly localized and of low severity (Appendix 4). Available data suggests that local populations inhabiting the mainly non-glaciated drainages of the lower North Thompson watershed are less productive (probably due to warmer thermal regimes and competition with other species), and at greater risk from overexploitation and resource development (forestry and mining; Appendix 4). Declines in Pacific salmon escapements to the Thompson EDU relative to historic levels (Irvine and Bradford 2000) also represents a negative impact to

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[4] The level of bull trout production in this core area and whether movement to and from other habitats in the Shuswap River system was possible prior to dam construction are unknown.

bull trout in this and other core areas in the Thompson EDU, as this equates to a reduction in an important food resource.

Populations in the remaining core areas in the Thompson EDU (Upper Shuswap, Shuswap Lake, Mabel Lake, Adams Lake) may be reasonably stable at present, although declines in abundance relative to historic levels have likely occurred as a result of overexploitation and habitat degradation (Appendix 4). Each of these four core areas contains significant amounts of good quality spawning and rearing habitat. The adfluvial life history type is dominant in each area, but local resident populations are present in some cool water streams, either above barriers, or isolated from downstream habitats by warm water reaches. With the exception of the Upper Shuswap drainage, which is isolated above a dam, and the Adams Lake core area, which has been assessed with a radio telemetry study (O'Brien and Chamberlain 2003), the degree of independence among these core areas has not been assessed. Exploitation remains a concern for adfluvial fish, although minimum size restrictions, low quotas and mandatory release in streams during spawning times implemented throughout this EDU have likely resulted in reduced harvest rates in recent years (Bison et al. 2003; Webster and Wilson 2005). The main threats to habitat are forest harvesting and associated road development, and are considered moderate for these areas as a whole. Yellow perch has been introduced into the Adams/Shuswap Lake system but potential impacts to bull trout are unknown. Climate change could lead to losses of suitable habitat in future (Porter and Nelitz 2009), as thermal regimes in many of the streams are less than optimal at present. Available information suggests the possible extirpation of at least one local population in Scotch Creek in in the Shuswap Lake core area (Silvatech Consulting Ltd. 2001).

Conservation status assessments varied widely among the seven core areas of the Thompson EDU. Five core areas in the Thompson EDU were assigned a Potential Risk status, while the remaining two (Middle Shuswap and Nicola) were ranked as High Risk (Appendix 4). The weighted average of these rankings indicated a Potential Risk status for the Thompson EDU as a whole (Table 3). The most important factors affecting EDU status are the high threats and low population sizes in the Nicola and Middle Shuswap core areas.

***Upper Columbia EDU*.** On the whole, bull trout in EDUs of the upper Columbia basin (Upper Columbia, Columbia-Arrow Lakes, Upper Kootenay, Lower Kootenay, Flathead), which make up BC management Region 4, have received more attention from fishery biologists and managers than elsewhere in the Province. Consequently, a high proportion of the core areas in BC for which expert judgments regarding abundance (13 of 32) and trend (13 of 24) were possible are located within these five EDUs. Much of this attention is the direct result of the enormous scope of hydroelectric development in the Region, which has profoundly affected the aquatic ecology of the upper Columbia Basin (Moody et al. 2007; Hagen 2008). Bull trout in the upper Columbia Basin have also been the focus of considerable academic interest. Phylogenetic studies utilizing molecular genetics and other techniques have revealed much about the importance of post-glacial re-colonization, physical geography, and adaptation in determining population spatial structure (O'Brien 2001; Taylor et al. 1999; Latham 2002; Costello et al. 2003).

The core area structure we have outlined for the Upper Columbia, Columbia-Arrow Lakes, Upper Kootenay, and Lower Kootenay EDUs (Appendix 4) can probably be considered more reliable than that for other parts of the Province. This partly because connectivity in the upper Columbia Basin has been severed by 17 dams constructed between 1908 and 1984 (Hagen 2008), which form precise boundaries between core areas. Within core areas delineated by the dams, population structure has been further studied in a number of tagging, radio telemetry, and molecular genetic studies (O'Brien 2001; Oliver 2001; Taylor et al. 1999; Latham 2002; Baxter 2002; Costello et al. 2003; Westover and Heidt 2004). A comprehensive literature review addressing footprint impacts of dam construction on bull trout in the upper Columbia Basin (Hagen 2008) identifies the many references available for bull trout inhabiting these EDUs, which are too numerous to identify here.

The upper Columbia EDU consists of the Columbia River watershed upstream of the Arrow Lakes Reservoir (ALR) (Figure 1). Abundance in each core area of the Columbia mainstem (Revelstoke Reservoir, Kinbasket Reservoir, Upper Columbia) is likely to be 250-1,000 reproductive adults at a minimum (Appendix 4), based on numerous local populations in each core area and adult rearing environments (i.e. pelagic habitat) in reservoirs that have been enhanced by the introduction of kokanee (Hagen 2008), and is likely higher (>1,000 possibly >2,500) for Kinbasket Reservoir, where a major adfluvial population is assumed based on >20 local populations (Fielden et al. 1992; Oliver 2001). Distribution can be estimated reasonably well from sampling that occurred as part of dam impact or forestry-related studies, and is likely in the range of 200-1,000 km for each core area (Appendix 4; Triton 1991, 1992; Fielden et al. 1992, 1993; Hagen 2008). With respect to abundance trends, bull trout populations in these core areas are thought to be stable or increasing (no quantitative abundance data are available). Current threats are primarily from widespread habitat degradation related to forestry, although the recovery potential is high. Hagen (2008) speculated that the major impacts to populations here and throughout the upper Columbia Basin have probably been loss of populations and genetic diversity due to inundation of formerly diverse, aquatic habitats under monomorphic reservoir environments. Genetically-amalgamated populations appear to exist in Revelstoke, Duncan, and Koocanusa reservoirs, supporting this notion (O'Brien 2001; Latham 2002; Costello et al. 2003). The Columbia River basin upstream of Mica Dam can be considered a stronghold for the species in Canada.

The relatively small Spillimacheen core area is located above natural migration barriers on the Spillimacheen River; bull trout are distributed in <40 km of habitat, and abundance and trend are unknown (Appendix 4). A serious potential threat is posed by the presence of brook trout in the system (Triton 1991).

Conservation status ranks are C3-Potential Risk for the Revelstoke Reservoir, Kinbasket Reservoir, and Upper Columbia core areas (Appendix 4) and for the Upper Columbia EDU as a whole (Table 3), with an important factor affecting status being perceived stable or increasing trends. The Spillimacheen core area is ranked CU-unranked because of limited information.

Columbia-Arrow Lakes EDU. Population spatial structure, distribution, and abundance are known in some detail for the Arrow Lakes Reservoir. A genetic study by Latham (2002) indicated that adfluvial sub-populations in the northern (north of MacDonald Creek) and southern portions of the ALR originated from separate post-glacial colonization episodes, and are genetically distinct from one another (Appendix 4). For the ALR-Northern Lineage core area, redd surveys indicate a population of >1,000 adfluvial adults utilizing >200 km of critical habitat (Decker and Hagen 2008), while the ALR-Southern Lineage core area has a smaller population (200-1,000) and more limited distribution (<40 km). A time series of creel survey data indicate a relatively stable population during the last three decades (Table 2; Figure 4). The Whatshan core area is a tributary watershed to the ALR containing a genetically unique adfluvial population isolated above a natural barrier, which is thought to be relatively small and limited to <40 km of suitable habitat (Appendix 4). Considering that this population is lightly exploited, and productive capacity has been enhanced by the successful introduction of kokanee in Whatshan Reservoir, present abundance is likely comparable with historical levels.

The remaining, core areas of the Columbia-Arrow Lakes EDU, Pend d'Oreille and Columbia (Appendix 4), appear to have bull trout populations verging on 50 or less reproductive individuals that are currently in decline, and occupy <40 km of suitable habitat. The productive potential of both core areas has been strongly impacted by hydroelectric development, which has eliminated connectivity to adult foraging areas in large river mainstem habitats downstream. These mainstem habitats have been altered significantly downstream of Hugh Keenleyside Dam with reduced productivity in terms of supporting bull trout populations (H. Andrusak, pers. comm.). Furthermore, increasing temperatures in these habitats and the eradication of Pacific salmon runs that would have provided an important food source also limit bull trout numbers. At present, the Pend d'Oreille and Columbia populations are severely threatened by unfavorably high water temperatures in degraded tributary habitats and also by high brook trout abundance in the Salmo River mainstem (Pend d-Oreille core area; Hagen 2008). These two core areas are likely among BC's most threatened bull trout populations. With the exception of glacial tributaries in the ALR-Northern Lineage core area, spawning and rearing areas in all core areas of the Columbia-Arrow Lakes EDU are marginal with respect to temperature suitability (i.e. maximum temperatures exceeding 15^{o}C), and are highly vulnerable to temperature increases resulting from climate change or watershed development (Decker and Hagen 2007; Hagen 2008).

Conservation status ranks varied widely among core areas of the Columbia-Arrow Lakes EDU, with assigned C Ranks being C4-Low Risk for the ALR-'Northern lineage' core area, C2-At Risk for the Whatshan and ALR-'Southern Lineage' core areas, and C1-High Risk for the Columbia River and Pend d'Oreille core areas (Appendix 4). The weighted average of status ranks for the EDU as a whole was C3-Potential Risk (Table 3), with the opposing factors affecting overall status being low abundance in the C1-High Risk core areas and low threats in the ALR-'Northern Lineage' core area.

Upper Kootenay EDU. The upper Kootenay EDU is located in the Rocky Mountain Trench upstream of the US border. Bull trout management has been particularly active in this EDU, and more knowledge exists about the biology and status of the species here than in any other EDU in the Province. Redd surveys are conducted annually in several streams (Table 2) , providing indices of abundance over the last 10-20 years (Westover and Conroy 1997; Westover and Heidt 2004), and angling effort and harvest is actively managed based on this information.

Genetically unique bull trout in the Elk River and Bull River core areas are isolated above dams built on natural migration barriers. Bull trout are thought to occupy 40-200 km of habitat in each of these two core areas (Appendix 4). Abundance and trend are unknown for the Bull River, but 19 years of redd count data for Line Creek suggest an significant increase in abundance in the Elk River core area following changes to angling regulations c. 1995 (Table 2; Figure 3). Habitat threats related to mining and watershed development are relatively widespread in these two core areas, but are not considered severe at present (Appendix 4).

Based on redd counts in major spawning tributaries (Wigwam, White, and Skookumchuck; Table 2; Figure 3), both the Koocanusa and Upper Kootenay core areas likely contain populations in excess of 1,000 mature bull trout in most years (>2,500 for Koocanusa in some recent years), and numbers appear to have increased substantially since the introduction of more restrictive angling regulations in both core areas in 1995 (Appendix 4). Bull trout distribution is substantially greater than 200 km in each area. Genetic differentiation among local populations in tributaries to Koocanusa Reservoir is low, and may have been influenced by the introduction of a homogenous reservoir environment. Relatively widespread habitat degradation from past forestry activities represents another impact for the Koocanusa and Upper Kootenay core areas. Given that population monitoring and active angling management are in place, for streams in these core areas that are not buffered by glacial inputs, the most significant remaining threat is increased stream temperatures brought about by climate change, forest harvesting or other developments that reduce riparian cover. Overall, threats to bull trout populations in the Upper Kootenay EDU are considered to be of low severity.

Status ranking was possible for the Koocanusa and Upper Kootenay core areas given existing abundance and distribution data, and both were ranked C4-Low Risk (Appendix 4). The weighted average of these C Ranks suggested a Low Risk status assessment for the Upper Kootenay EDU as a whole (Table 3), which is probably reasonable given that low threat levels exist in other areas of the EDU as well, as does a positive trend in abundance in a portion of the Elk core area (Appendix 4). The most important factors affecting EDU status are current high levels of abundance and positive trends, as well as relatively low levels of threats throughout the EDU. Connectivity remains between the Koocanusa and Upper Kootenay core areas, which together represent an international bull trout stronghold that includes the major portion of Koocanusa Reservoir within Montana (Appendix 4).

Lower Kootenay EDU. The Kootenay Lake core area is another bull trout stronghold containing a major, adfluvial population (probably >2,500 reproductive individuals) utilizing much greater than 200 km of habitat in Kootenay Lake and its tributaries, as well as Duncan Reservoir and its tributaries (Appendix 4). Creel survey data suggest that the trend in bull trout abundance in Kootenay Lake has been positive from the early 1990's until present, although the reliability of these data as an index of abundance is uncertain (Table 2; Figure 4; Section 5). This trend is likely associated with increasing kokanee abundance following a population crash in the 1980s (see Section 5). A whole-lake fertilization program has occurred annually in Kootenay Lake since 1993, and is largely responsible for the increase in kokanee abundance. Since current abundance of bull trout in Kootenay Lake is likely dependant to some degree on lake fertilization, uncertainty as to the long-term social and economic viability of the fertilization may be an important factor affecting relative abundance of bull trout in the lake, even though the population would not be threatened *per se* should fertilization be discontinued. A threat to bull trout in this EDU is forestry activities in non-glacial tributaries, which is rated as being widespread, but of low severity with good recovery potential (Appendix 4).

In the Slocan core area, bull trout are distributed in >40 km of habitat in Slocan Lake and its tributaries and tributaries to the Slocan River downstream (Appendix 4). Adult population size is probably >200 individuals based on a relatively widespread distribution in tributaries to Slocan Lake, but significant declines likely occurred following the loss of connectivity with adult rearing habitats in the lower Kootenay and Columbia systems following hydroelectric development in the early 1990s (Hirst 1991). Fluvial populations spawning and rearing in tributaries of the Slocan River are threatened by high summer water temperatures in the mainstem.

Conservation status ranks assigned to the Kootenay Lake and Slocan core areas are C3-Potential Risk and C2-At Risk, respectively (Appendix 4), with the weighted average for the EDU as a whole being C3-Potential Risk. The most influential risk factor was the relatively high threats in the Slocan core area.

Flathead EDU. The Flathead EDU is isolated from the rest of the Canadian portion of the upper Columbia basin by the Border Range of the Rocky Mountains (Ciruna et al. 2007), and consists of the Canadian portion of the international Flathead Lake core area (USFWS 2005). The Upper Flathead core area in BC likely contains >200 reproductive individuals, based on counts of spawners at index sites (Muhlfeld et al. 2008), distributed over >200 km (Appendix 4). Bull trout abundance in Flathead Lake has declined due to negative interactions with lake trout, and during the same time, the proportion of the Flathead Lake population utilizing the BC headwaters has increased (USFWS 2005). Habitat within BC is therefore regarded as critical for the long-term viability of bull trout in this core area (USFWS 2005). The major threat within the core area is the moderately severe threat of lake trout interactions for adfluvial fish (Appendix 4). Habitat threats in the Canadian portion of the core area have been alleviated significantly following a recent decision by the BC Government to ban mining and oil and gas development in the Flathead River watershed. Conservation status for the Upper Flathead core area and Flathead EDU were assessed as C2-At Risk, with the most important factor affecting status being the high level of threat posed by the lake trout incursion.

Middle Fraser EDU. The Middle Fraser is the largest EDU in the province; it spans portions of four management regions (Thompson/Nicola, Cariboo, Omineca, Skeena; Figure 1), and includes 18 putative core areas (Appendix 4). East of the Fraser River, key spawning and rearing areas are closely associated with the Monashee and Cariboo Mountains (Figure 2), while west of the Fraser, bull trout distribution is associated mainly with the Coast, Itcha Ilgachuz and Rainbow Mountains. Bull trout production is concentrated in the Seton/Anderson, Bridge, Chilcotin, and Quesnel watersheds, but smaller populations are present in a number of other watersheds as well (Figure 2). Migratory fluvial adults and sub-adults are also seasonally present in the Fraser River and its larger tributaries (e.g., Chilcotin, Nechako) distant from the aforementioned mountain ranges. With the exception of the Seton/Anderson and Bridge River drainages, there are no major dams limiting connectivity between watersheds in the Middle Fraser EDU, and the mainstems of the larger rivers are mostly free of natural barriers as well. The portion of the Middle Fraser EDU within the Cariboo management region (Region 5) was the subject of a study, unique in the Province, that examined how the distribution of thermally suitable habitat for bull trout may change over the next 70 years under different climate change scenarios (i.e., under varying increases in mean annual temperature; Porter and Nelitz 2009). Porter and Nelitz's results suggest that climate change is potentially the most important factor affecting the long-term persistence of bull trout populations in a number of core areas in this EDU (see below).

Despite the fairly widespread distribution of bull trout in the Middle Fraser EDU, relatively few direct studies of bull trout population structure, life history, movement, distribution, abundance, and exploitation have occurred. Quantitative population monitoring appears to be limited to two years of adult escapement data for Long Valley Creek, a tributary of Chilko Lake (Ladell et al. in prep.; Table 2). Lack of information about life history and population structure, coupled with the absence of physical barriers, required us to delineate core areas based almost exclusively on minimum separation distances between large lakes used by adfluvial bull trout, or between drainages that supported clusters of spawning and rearing reaches (see Section 3.4). As a result, there is potentially significant overlap among a number of the core areas with respect to the home range of fluvial fish. The distribution of bull trout within individual core areas is also quite uncertain in many cases because much of the available LRDW data originates mostly from inventory surveys intended to assess general fish distributions for forest development purposes, rather than to focus specifically on bull trout (Porter and Nelitz 2009). Inferences about current abundance levels and trends are derived mostly from the professional knowledge of regional biologists.

The area of occupancy (distribution) for bull trout was categorized as 1,000-5,000 km in four core areas, 200-1,000 km in six core areas, 40-200 km in four core areas, and unknown for the remaining four core areas (Appendix 4). Population size was categorized as 250-1,000 adults for two core areas (Seton/Anderson/Lower Bridge, Upper Bridge), 250-2,500 adults for one core area (Chilko), and unknown for the remaining 15 core areas (Appendix 4). Trend was categorized as unknown for all 18 core areas in the Middle Fraser EDU. Population size and distribution for the Seton/Anderson/Lower Bridge and Upper Bridge core areas is based on limited redd surveys, observations at a sockeye counting fence, telemetry, juvenile surveys, and reservoir sampling (Griffith 1995; Arc Environmental Lt. 2000; Chamberlain and O'Brien 2000; Chamberlain et al. 2001; Chamberlain 2002; Morris et al. 2003; Appendix 4). For the Chilko Lake core area, current abundance of reproductive adults was categorized as 250-1,000, based on a resistivity counter assessment of one of two known spawning streams that yielded escapement estimates of ≈ 400-700 fish during 2005-2006 (Ladell et al. in prep).

Adfluvial production is dominant in the Seton/Anderson watershed within the Seton/Anderson/Lower Bridge core area, but observations of adult bull trout at a hydro dam at the outlet of Seton Lake and the recapture of one tagged individual in the lower Fraser River downstream of Hell's Gate suggest a fluvial component as well (Chamberlain and O'Brien 2000). Following the construction of Terzaghi and Lajoie dams on the Bridge River, bull trout in the upper river were isolated from the Fraser River, and now persist primarily as an adfluvial population in Carpenter Reservoir (Upper Bridge core area), while those spawning in a tributary downstream of Terzaghi Dam (Yalokom River) continue as a fluvial/resident population with possible connectivity to the Seton/Anderson drainage and other Fraser River tributaries. Within the Fraser Canyon core area, bull trout are absent from east-side tributaries[5], but do occur in several west-side tributaries along the east slope of the Coast Mountains (Appendix 4; Figure 2). Here bull trout occur primarily as local resident populations upstream of barriers, but the fluvial life history is present in tributaries of the Nahatlatch River, and possibly in the lower reaches of the Anderson and Kwoiek drainages as well (Appendix 4).

For the Seton/Anderson/Lower Bridge and Upper Bridge River core areas, the major historical impact was the loss or impairment of connectivity between critical spawning and rearing habitat and salmon-rich foraging habitats downstream resulting from hydroelectric development (Appendix 4). However, losses in the Bridge River were likely offset to some degree by the creation of reservoir habitat

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[5] The Anderson River, which rises in the Cascade Mountains and enters the Fraser River from the east downstream of the Thompson River, is an exception (Appendix 4).

and the establishment of a kokanee population. Other impacts include forest harvesting, unlicensed water diversions in Anderson Lake tributaries and localized overharvest (Chamberlain and O'Brien 2000). For the Fraser Canyon core area, unfavorable thermal regimes, low summer stream flows, and negative interactions with resident rainbow trout populations are likely the main constraints to bull trout production, and may explain the absence of bull trout in many streams. Climate change represents a major threat to bull trout in the Fraser Canyon core area, given the already marginal thermal conditions. Significant amounts of suitable spawning and rearing habitat are available in the Seton/Anderson/Lower Bridge and upper Bridge River core areas to support bull trout, and local populations do not appear susceptible to extirpation in the foreseeable future. This is less certain in the Fraser Canyon core area; the viability of local populations in individual tributaries will likely depend on how well buffered these streams are to climate change. Recent surveys in the Anderson River and Kwoiek Creek suggest that only remnant bull trout populations remain (Griffith 1997; Triton Environmental Consultants Ltd. 1999a).

Feedback provided by the angling community has suggested that more restrictive harvest regulations and public information campaigns have allowed for partial recoveries of formerly depressed populations in core areas of the Middle Fraser EDU within the Cariboo management region (Quesnel Lake and Chilko Lake core areas; R. Dolighan, Consultant, Williams Lake, pers. comm.). This may also apply to the Cariboo, Taseko and Little Chilcotin core areas in the Cariboo Region as well. Relatively high catch rates of fluvial bull trout have also been reported in recent years in a fall steelhead fishery in the mainstem of the Chilcotin River (Peard 2005; MacPherson 2006); these bull trout are likely a mixed stock from the Taseko, Little Chilcotin and Chilko Lake core areas (R. Dolighan, Consultant, Williams Lake, pers. comm.). Although a lack of quantitative abundance and trend data makes any such speculation uncertain, the Quesnel Lake, Cariboo River, Taseko River, and Chilko Lake core area populations appear reasonably healthy based on fairly broadly distributions, substantial amount of suitable spawning and rearing habitat, and a large available prey base (kokanee and/or anadromous salmon), whereas the Little Chilcotin, Big Creek, Churn Creek, Cottonwood River, and West Road River core areas appear vulnerable primarily because suitable habitat and current bull trout distributions are limited (see Figure 2), and, in many areas, bull trout populations are isolated by thermally unfavourable habitats that support high densities of other species. This is particularly true for the Upper Big Creek and Churn Creek core areas which are isolated from the remainder of the Fraser watershed by barriers, and appear to support only scattered pockets of resident bull trout (Triton Environmental Consultants Ltd. 1997b; Ferguson and Bocking 1998; Mossup 1998).

Only a limited number of systems support bull trout in the portion of the Middle Fraser EDU within the Omineca management region (Figures 1,2). Abundance and distribution within the Prince George and Upper Stewart core areas are unknown (Appendix 4), but thought to be limited (Williamson and Zimmerman 2006; Imhof and Sutherland 1996). In the Prince George core area, the Willow River system is considered to have low-to-moderate values for bull trout, while the relatively low elevation watersheds of the Salmon and Chelako rivers are thought to have low values (Williamson and Zimmerman 2006). The remaining systems in the Omineca portion of the EDU can probably be assumed to have low values as well, with the exceptions of larger mainstem reaches in the Fraser and Nechako rivers, which appear to be major seasonal feeding areas for adult fluvial bull trout associated with core areas in the Upper Fraser EDU (see below).

Self-sustaining populations of bull trout may not occur in the Francois and Nechako Reservoir core areas within the Middle Fraser EDU (Skeena management region). Bull trout have not been detected upstream of Kenney Dam on the Nechako River despite extensive sampling, suggesting the isolated LRDW records for Murray Lake and Cheslatta Lake (and the putative Nechako Reservoir core area) are in error (Appendix 4). Bull trout presence in the Francois core area is suggested by only a small number of isolated records, and it is currently thought that the Francois core area does not support spawning or rearing for this species. Dolly Varden populations, however, do appear to exist within the Francois core area (Appendix 4). Migration barriers do not exist between the Francois core area and other core areas in the vicinity of Prince George, and it is conceivable that past records of bull trout within the Francois core area were strays from these other areas.

Other than hydroelectric development, the most significant historical impact on bull trout in the Middle Fraser EDU is likely overexploitation. This has been addressed with the introduction of more stringent angling regulations for both the EDU as a whole, and for specific water bodies. However, limited harvest of bull trout is still permitted in many lakes, and, in contrast to other southern BC EDUs, in some streams as well (e.g., Chilcotin River). Placer mining has also had a significant impact on bull trout habitat in the Cottonwood River and Cariboo River core areas (Chapman Geoscience Ltd. 1997). Forest harvesting has occurred over a very large portion of the EDU, and has presumably resulted in an impact of generally low severity, but broad scope. The negative impacts of forestry on channel morphology and thermal regimes in streams are lessening as improvements in forestry practices are implemented, and logged forests grow back.

The most serious and immediate future threat to bull trout in many portions of the Middle Fraser EDU, particularly in the Caribou and Omineca management regions, is the recent massive loss of mature pine forests to the mountain pine beetle. This could lead to significantly warmer thermal regimes in core areas dominated by pine forests (West Road, Churn Creek, Big Creek, Little Chilcotin, Taseko, Chilko, Prince George), although the Taseko and Chilko areas are buffered by heavily glaciated headwaters. In the long-term, the impact of losses in forest cover will be lessened as forests regenerate. In contrast, climate change will likely exert an increasingly negative influence on thermal regimes for bull trout over the long-term, with a low potential for recovery. Over a range of increases in mean annual temperature, from "best case" to "worst case" scenarios, thermal habitat models developed by Porter and Nelitz (2009) predict substantial losses of viable bull trout habitat in core areas within the Cariboo Region, particularly for "cool water" (as opposed to cold water) core areas (West Road, Churn Creek, Upper Big Creek, Little Chilcotin, Cottonwood, Cariboo, Quesnel) that lack the buffering affect of large glaciers and permanent snowfields in their headwaters. Under the "worst case" scenario, their model predicts the loss of the majority of viable habitat in the above-mentioned core areas.

Distribution and abundance information was sufficient to assign conservation status ranks to the Seton/Anderson/Lower Bridge, Upper Bridge, and Chilko core areas, which were, respectively, C3-Potential Risk, C2-At Risk, and C2-At Risk (Appendix 4). The weighted average of the C Ranks for the Middle Fraser EDU was C3-Potential Risk (Table 3).

Upper Fraser EDU. The boundary between the Upper Fraser and Middle Fraser EDUs corresponds to the limit of distribution for several Middle Fraser species in the Fraser River between Prince George and the Bowron River confluence (McPhail 2007). The upper Fraser River and its major tributaries, with the exception of the Bowron River, are coldwater streams draining glaciated mountains. As expected, bull trout are widely distributed in this coldwater environment (Appendix 4). Importantly, there are no natural or anthropomorphic barriers limiting connectivity between the Upper and Middle Fraser EDUs. Radio-tagged bull trout spawning in the Goat River in the Upper Fraser were also found in mainstem reaches of the Nechako and Fraser River systems hundreds of kilometers distant in the middle Fraser EDU (Pillipow and Williamson 2004; R. Pillipow, MNRO Prince George, pers. comm.), suggesting that non-mountainous areas can provide important rearing habitat for adults and sub-adults, providing that connectivity to suitable, coldwater streams exists. It is unknown if this strategy is utilized by other local populations in the Upper Fraser EDU, but additional work will be conducted in 2011.

Although bull trout abundance monitoring in the Upper Fraser EDU has been identified as a priority in management planning for Region 7 (Clarke and Zimmerman 2005), available quantitative data for assessing abundance and trend are limited at present (Table 2). Systems within the Upper Fraser core area have been previously classified as having high value for bull trout (Williamson and Zimmerman 2006). Distribution is widespread at well over 200 km of habitat (Appendix 4). Abundance in the core area is probably >1,000 mature individuals, with most local populations being <200 individuals, with the exception of a large population in the Goat River system (Pillipow and Williamson 2004). Population trend can only be evaluated over the relatively short-term (5 years) for one system, the Goat River, where abundance appears stable (Table 2; Figure 7). Adequate information does not exist to assess abundance, trend, or distribution for the Robson, McGregor and Bowron core areas. It should be noted, however, that streams in the McGregor core area, along with the mainstem and major tributaries of the Bowron River, have been classified as having high value for bull trout (Williamson and Zimmerman 2006). Habitat threats are insignificant for the Robson core area, but naturalized brook trout may pose a significant threat of high immediacy. Habitat impacts in this EDU consist mainly of locally degraded areas associated with past forestry, but are diminishing as forests regenerate. Potential increases in stream temperatures associated with forest harvesting and climate change remains a threat in the Bowron core area, where streams are generally warmer. Exploitation threats are currently considered low or insignificant.

A conservation status rank of C3-Potential Risk was assigned to the Upper Fraser core area (Appendix 4) and to the Upper Fraser EDU as a whole (Table 3); other core areas were CU-Unranked. The wide distribution of bull trout and relatively low threats were the most important factors supporting the conservation status rank.

Lower Skeena EDU. The presence of bull trout in the Lower Skeena EDU has been confirmed in the Gitnadoix River and Shames Creek (Lower Skeena core area; Appendix 4) by genetic and morphometric analyses (Redenbach and Taylor 2003; Bustard 2004b). Lower Skeena bull trout may be ecologically unique. Not only are they coastal populations of the 'interior' evolutionary lineage (see Section 2.1), they are likely also sympatric with both resident and anadromous Dolly Varden. Sympatry of Dolly Varden and bull trout is widespread in the northwest of the British Columbia and has influenced the ecology of both species (Hagen and Taylor 2001). As a result of complex patterns of ecology, geography, and recent evolutionary history, bull in this part of the Province have been of high scientific interest (Baxter et al. 1997; Hagen and Taylor 2001; Bahr 2002; Redenbach and Taylor 2002; Redenbach and

Taylor 2003), and should be considered an important part of the evolutionary legacy of the species in Canada.

Abundance and trend for bull trout are unknown for the Lower Skeena EDU as is distribution for most watersheds. Widespread presence of Dolly Varden in Region 6 is a major factor affecting the reliability of older LRDW records. Even in modern records, Dolly Varden and bull trout have not been discriminated by genetic samples or morphometry in many cases, and even when they have been discriminated, the methods used were often not recorded. Detailed studies of life history and habitat use are limited to the Gitnadoix River watershed (Bustard 2004b). While the Shames Creek watershed has had extensive forestry development, habitat threats are not currently considered significant (Appendix 4) in the Lower Skeena EDU as a whole. Exploitation threats from intensive guided and non-guided sport fisheries in the lower Skeena EDU are considered to be low-moderate, but regional biologists would like to see this issue examined in the near future. Because of the lack of distribution and abundance data, conservation status ranks assigned to the Lower Skeena core area (Appendix 4) and Lower Skeena EDU (Table 3) were CU-Unranked.

Upper Skeena EDU. The fish fauna of the Upper Skeena EDU shares Great Plains faunal elements with the adjacent Middle Fraser EDU (Ciruna et al. 2007). The Skeena is northern BC's most productive Pacific salmon watershed, and is also a mountainous, coldwater environment in which bull trout are widely distributed. Within Region 6, most of the small number of studies that have focused specifically on bull trout biology have occurred in this EDU (Bustard 1998; Giroux 2001; Bahr 2002; Bustard and Schell 2002) , although work has focused primarily on the Morice core area. Subsequently, this is the only core area in the Skeena Region for which bull trout distribution and can be categorically estimated (trend is unknown; Appendix 4). Redd counts, juvenile abundance surveys, and radio telemetry observations of habitat use and life history suggest a population in excess of 250 mature individuals and a distribution approaching 200 km for the Morice core area.

Bull trout populations in other core areas have received relatively little attention, and population structure is highly uncertain (we delineated 11 putative core areas in addition to the Morice area; Appendix 4). Nevertheless, professional knowledge about bull trout, derived mainly from studies directed at other species, is greater for the Upper Skeena EDU relative to other EDUs in Region 6 (Appendix 4). Despite a lack of formal discrimination of bull trout and Dolly Varden in the LRDW records in many cases, it is suspected that bull trout are widely distributed within the majority of core areas of the Upper Skeena EDU (Appendix 4). The exception is the less mountainous Babine Lake core area, where bull trout appear to be rare in the lake and otherwise limited to a small number of tributaries where suitable habitat is available (Appendix 4). Abundance is unknown outside the Morice core area. However, anecdotal reports exist of population declines in the Upper Babine and Zymoetz core areas (Appendix 4), and trend at the Sustut River counting fence (Upper Sustut core area) is also negative and may indicate an effect of fence operation (mortalities are relatively common) over time. The remote Damshilgwet Creek counting fence in the lower Sustut/Skeena core area suggests a positive trend in abundance although this may be an artefact of a change in methods (see discussion in Section 5), while no trend is evident in counts of bull trout at the Kitwanga fence in the Mid-Skeena core area (Table 2).

Within Region 6, habitat threats to bull trout are of the greatest concern in the Upper Skeena EDU. Past and proposed mining activity and road construction associated with mining development are threats of relatively low severity and scope in the Upper Sustut core area, and proposed coalbed methane development is a threat in the Upper Skeena core area that is of unknown severity but of highest immediacy (temporary moratorium for 2011; Appendix 4). Forestry threats are insignificant in northern core areas (Upper Skeena, Upper Sustut), of low-moderate severity and scope in Babine Lake and Upper and Lower Babine core areas, and of moderate severity and moderate-high scope in the most accessible core areas of the EDU (Bulkley, Morice, Kispiox, Middle Skeena, Zymoetz, Kitsumkalum). Given the known vulnerability of bull trout to overexploitation and the fact that harvest is permitted, exploitation threats are thought to require immediate attention in all core areas of the Upper Skeena EDU. Exploitation threats were not thought to be significant in inaccessible core areas (Upper Skeena, Upper Sustut, Lower Sustut/Skeena, Lower Babine/Skeena). However, in the remaining core areas, where intensive recreational and guided sport fisheries exist for salmon and steelhead, exploitation threats are considered to be more serious, and may be factors affecting the previously mentioned, suspected population declines in the Upper Babine and Zymoetz core areas.

Only the Morice core area was assigned a conservation status rank, C2-At Risk, which was most strongly affected by the level of habitat and exploitation threats. This core area is probably representative of accessible portions of the Upper Skeena EDU with respect to threats levels, so the EDU as a whole also received this C Rank (Table 3).

Upper Nass EDU. With respect to post-glacial colonization, the Upper Nass EDU marks the transition to a primarily Columbian-origin fish fauna relative to more northern EDUs (Ciruna et al. 2007). This EDU drains mountainous terrain and the majority of watersheds have significant glacial inputs. Although abundance and trend are unknown, and the presence of Dolly Varden reduces the reliability of the LRDW records, observations accumulated by MNRO staff suggest bull trout are relatively widespread and abundant within core areas of this EDU between the headwaters and the Meziadin River (Upper Nass, Middle Nass, Bell-Irving, Meziadin core areas; Appendix 4) and in the Cranberry-Kiteen core area upstream of the Cranberry-Kiteen confluence (Appendix 4). Habitat threats include proposed coal bed methane development in the Nass River headwaters (Upper Nass core area), past and proposed mining development (Bell-Irving core area), forestry (Bell-Irving, Middle Nass, Meziadin, Cranberry-Kiteen), and highway and other linear developments (Bell-Irving, Meziadin, Cranberry-Kiteen). While the severity and scope of these threats are mostly unknown, all are considered by Regional staff to require immediate attention. Exploitation threats are low or insignificant for the Upper Nass and Middle Nass core areas. For other core areas in this EDU, exploitation threats are of low-moderate severity and scope, and considered to be of high immediacy. Because of limited distribution and abundance information, the conservation status rank assigned to core areas of the Upper Nass EDU (Appendix 4) and the EDU as a whole (Table 3) was CU-Unranked.

Iskut-Lower Stikine EDU. The presence of bull trout and Dolly Varden/bull trout hybrids in the Iskut-Lower Stikine EDU has been confirmed genetically and morphologically in both the lower Stikine River downstream of the Grand Canyon of the Stikine (Tuya and Tahltan core areas: Schell 1999a; Redenbach and Taylor 2003; Beere 2002) and the middle Iskut River below barrier falls near Natadesleen Lake (Middle Iskut core area; Appendix 4; Schell 1999b). Bull trout have not been positively identified in the lower Iskut River downstream of the anadromous barrier. Bull trout distribution, abundance, trend, and the severity and scope of the threats to individual populations are unknown in these three core areas. However, exploitation in relatively intensive First Nations and recreational fisheries directed at other species on the lower Tahltan River, and on the middle Iskut River, represent potential threats, and warrant attention in the near future, as do active mining projects (Tahltan and Middle Iskut core areas), and the unknown implications of Pacific salmon enhancement (Tuya and Tahltan core areas). Because of limited distribution and abundance information, the conservation status rank assigned to core areas of the Iskut-Lower Stikine EDU (Appendix 4) and the EDU as a whole (Table 3) was CU-Unranked.

Upper Stikine EDU. Post-glacial colonization of the Upper Stikine EDU was of mixed Columbian/Beringian origin, and bull trout are known to be present (Haas and McPhail 1991; Ciruna et al. 2007). Abundance, distribution, and trend are unknown for the four putative core areas that were identified for this EDU (Upper Stikine, Spatsizi, Klappan, Tanzilla; Appendix 4). The severity and scope of threats are also unknown, but a proposed coal mine (Klappan core area) and coal bed methane development (Klappan, Spatsizi, Upper Stikine core areas) are regarded as potential threats in need of immediate attention (Appendix 4). The threat posed by angling exploitation is considered to be of low-moderate severity in all core areas of the upper Stikine EDU at present, but of high immediacy given the known vulnerability of the species to angling. Because of limited distribution and abundance information, the conservation status rank assigned to core areas of the Upper Stikine EDU (Appendix 4) and the EDU as a whole (Table 3) was CU-Unranked.

Nakina and Taku EDUs. Fish fauna of the Nakina and Taku EDUs, along with EDUs south to the Upper Nass EDU (Figure 1), suggest a transition between Beringian and Pacific (Columbian) fauna (Ciruna et al. 2007). The Nakina EDU, which lies within the Taku River watershed, is unique in containing Beringian forms of species also found in the Lewes and Teslin EDUs, including northern pike (*Esox lucius*), that reflect temporary post-glacial drainage patterns (Ciruna et al. 2007). Bull trout are known to be present in the Nakina and Taku EDUs (McPhail 2007), and have been positively identified in mainstem habitats (Appendix 4). However, Region 6 MNRO staff caution that major uncertainty exists with respect to the relative distributions of Dolly Varden and bull trout, and also with respect to bull trout core area boundaries, given the lack of migration barriers between the Inklin, Nahlin, Sheslay, and Nakina core areas. Bull trout abundance is unknown for all of these core areas. Severity and scope of threats are also unknown, although immediacy of threats is thought to be low or insignificant in all cases except for the Inklin core area, where the proposed Tulsequah Mine requires immediate attention. Because of limited distribution and abundance information, the conservation status rank assigned to core areas of the Nakina and Taku EDUs (Appendix 4) and to the EDUs themselves (Table 3) was CU-Unranked.

Lewes and Teslin EDUs. The Lewes and Teslin EDUs consist of the drainages of Atlin and Teslin Lakes, respectively. Fish fauna of these EDUs consists of mostly Beringian species (Ciruna et al. 1997). Few records of bull trout exist for these EDUs. For the Lewes EDU, a single record exists for Atlin Lake (referenced in LRDW as Withler 1956a), but no other observations are known to date for the Yukon River watershed upstream of the city of Whitehorse (J. DeGisi, MNRO, Smithers, pers. comm., L. Jessup, Fisheries Section, Yukon Territory, pers. comm.). It is possible, therefore, that the Atlin Lake record is in error and that neither bull trout or Dolly Varden are present in the Lewes EDU. Reports of bull trout presence in streams in the Teslin EDU (Teslin core area; Appendix 4), however, do appear to be credible. These streams are adjacent to the upper Liard EDU, suggesting the possibility of past headwater capture. Bull trout do not appear to have been captured in lakes in the Teslin EDU, where the only char recorded are lake trout. Based on the lack of information for these EDUs, conservation status ranks are CU-Unranked for both EDUs (Table 3) and for core areas within (Appendix 4), although the estimated low level of threats also suggests a relatively low level of conservation concern.

Upper Peace EDU. The fish community of the Upper Peace EDU is unique in Region 7, containing the Bering species Arctic grayling (Ciruna et al. 2007). It is a mountainous EDU with abundant coldwater habitats, and bull trout appear to be relatively widespread in most core areas (Appendix 4). Bull trout/Dolly Varden sympatry crosses the continental divide in the headwaters of the Upper Peace EDU (Baxter et al. 1997; Hagen and Taylor 2001; Redenbach and Taylor 2002; McPhail 2007 and references therein), but it is of relatively limited geographic scope and not thought to be a significant source of uncertainty in the bull trout distribution. The Thutade watershed is a major area of sympatry between the species, and is perhaps the most intensively studied of any such area in the Province (Hagen 2000; Hagen and Taylor 2001; Redenbach and Taylor 2002; Bustard 2010), with the result that the distribution of each species is known with relatively high precision.

Bull trout abundance monitoring has been identified as a priority in management planning for the Upper Peace EDU (Blackman et al. 1990; Andrusak et al. 2011). Abundance is unknown at the core area level in all cases except the well-studied Thutade core area, in which abundance of mature individuals is thought to be between 500 and 1,000 individuals. With respect to trend, abundance in the Thutade watershed has shown a significant increase over the last 20 years (Table 2; Figure 7), which may be related to angling regulation changes for important staging areas in spawning tributaries (Bustard 2010). Trend in abundance over the past decade in the Davis River in the Finlay Reach core areas appears stable or increasing slightly (Table 2; Figure 7). Trend data for other core areas (Peace Reach, Parsnip Reach) is limited to one stream with five years' data for each area, with no obvious trend indicated (Table 2; Figure 7). Distribution is highly restricted in the Dinosaur Reservoir core area, where only about 5 km of spawning habitat in Gething Creek is accessible to adfluvial fish. Thutade core area is isolated above Cascadero Falls on the Finlay River and distribution is known to be < 200 km, while in the Parsnip Reach core area, distribution probably exceeds 1,000 km (Appendix 4). Bull trout are distributed over >200 km in each of the remaining core areas for which information is available (Upper Finlay, Lower Finlay, Finlay Reach, Omineca, Upper Parsnip, Peach Reach). Habitat threats from forest harvesting and watershed development are low relative to that in EDUs in southern BC (Appendix 4). The W.A.C. Bennett and Peace Canyon dams, which span the Peace River near Hudson's Hope and now delineate the Upper Peace and Lower Peace EDUs, have significantly affected the fisheries ecology of the Upper Peace EDU through creation of Williston Reservoir, the largest body of freshwater in the Province. Increasing abundance of lake trout in Williston Reservoir is a growing but low severity threat at present, while potential overexploitation of bull trout in specific locations in the Peace Reach of Williston Reservoir and in Dinosaur Reservoir may represent a moderately severe threat (Appendix 4).

Estimates of both abundance and distribution existed only for the Thutade core area, which was assigned a C3-Potential Risk conservation status (Appendix 4). The most important factor affecting status was a modest level of threats. Threats may be of a comparable level across most core areas of the EDU, so the C3-Potential Risk conservation status was also assigned to the EDU as a whole (Table 3) despite the lack of abundance information.

Lower Peace EDU. The Lower Peace and Lower Liard EDUs are unique in BC in that faunal assemblages are dominated by species that colonized post-glacially from the Great Plains refugia (Ciruna et al. 2007; McPhail 2007). Bull trout distribution here is closely associated with mountainous areas, similar to other areas of the Province, and, in areas of the Great Plains east of the Rocky Mountains, rarely extends beyond migration/feeding corridors in large river mainstems (Figure 2).

In contrast to the Upper and Lower Liard EDUs in Region 9, development pressure has been intense in the Lower Peace EDU, particularly from the energy and mining sectors, and has resulted in relatively high road densities, localized aquatic habitat degradation, and high recreational angling pressure. The proposed Site C Dam on the Peace River has the potential to profoundly affect bull trout in the Lower Peace EDU. In response to elevated levels of threats to fish populations, Region 9 MOE biologists have focused their research on bull trout population in this EDU. Key steps have included reconnaissance and telemetry studies identifying critical habitats and potential abundance monitoring locations (Burrows et al. 2001; DES 2004, 2006b, 2008; Goddard 2008; Macullo and Goddard 2010), establishment of an abundance monitoring program in the Halfway River watershed, the main spawning and rearing tributary for bull trout rearing in the Peace River mainstem (R.L.&L. 1994; Baxter 1994, 1995, 1997; DES 2006a), and pioneering the use of Wildlife Habitat Area (WHA) provisions in the Forest Practices Code of BC to protect and monitor critical bull trout spawning and rearing areas (Baccante 2007; DES 2008; Goddard 2008; Macullo and Goddard 2010). Further background studies specifically related to the Site C Proposal have included continuation of abundance monitoring on the Halfway system (Mainstream Aquatics and DES 2009, DES 2011a), a molecular genetic study of population spatial structure among potentially affected major tributaries (E. Taylor, UBC Department of Zoology, in prep.), and radio telemetry work to further delineate habitat use and population structure in the major tributaries (AMEC and LGL 2008, 2009, 2010).

Abundance and trend are known for 4 of 9 and 1 of 9 core areas, respectively, in this EDU. Distribution is unknown in all core areas except the Halfway-Peace, but bull trout are thought to occupy >200 km of habitat in each area (Appendix 4). Independence of core areas in the Halfway and Pine River systems is supported by the results of radio telemetry work (Burrows et al. 2001; AMEC and LGL 2010) and molecular genetic studies (E. Taylor, UBC dept. of Zoology, report in prep.), which have also suggested that fish utilizing the mainstem Peace are primarily from natal streams in the Halfway River system. For our assessment, therefore, we associated the Peace River mainstem with the Halfway River in the Halfway-Peace core area. Six years of redd count data over 15 years for the Chowade River in the Halfway system suggests that abundance is significantly >250 mature individuals, and that the population is increasing following angling regulation changes in the 1990s (Table 2; Figure 7). Anecdotal reports suggest a depleted population prior to the regulation changes (Woods Environmental 2001). A moderately severe threat, arising from watershed development and the Site C Proposal, affects most of the Halfway-Peace core area. A small population (<250 mature adults) is thought to inhabit the Moberly core area; this population appears to follow a resident lifestyle in the headwaters upstream of Moberly Lake (Appendix 4). Threats to this core area from watershed development are of relatively low severity and moderate scope. The Moberly core area is also potentially affected by the footprint of the proposed Site C Dam, but it is unknown if any fish from this core area utilize the Peace River mainstem. Moderately severe habitat threats are thought to affect much of the Upper Pine core area, in which abundance and trend are unknown. While a relatively low proportion of the Upper Sukunka core area is thought to be threatened, overall abundance has probably declined (Appendix 4). Total abundance of mature individuals for the core area is likely significantly >250. Abundance is also likely to be significantly >250 mature individuals for the Murray core area, based on redd counts in Fellers Creek and the Wolverine River (Table 2; Macullo and Goddard 2010). Much of the Murray core area is subject to moderately severe threats to bull trout habitat. Additionally, the Murray core area includes a number of naturalized brook trout populations. While there is evidence of bull trout hybridization here, the overall influence of brook trout in this area remains unclear (De Gisi 2003). Little is known about the West Kiskatinaw and Upper Narraway core areas (Appendix 4), although threats are thought to be of low severity. Low severity threats from energy and mining activities affect much of the Upper Wapiti core area, but abundance and trend are unknown. Given the rapid pace of development in the Lower Peace EDU, all threats are considered to be of high immediacy (Appendix 4).

Conservation status ranks could be assigned to 4 of 9 core areas in the Lower Peace EDU. The Halfway/Peace, Moberly, and Lower Murray core areas received C Ranks of C2-At Risk, and the Upper Sukunka core area received a rank of C3-Potential Risk (Appendix 4). The weighted average of the C Ranks indicated an overall C Rank for the Lower Peace EDU of C2-At Risk, with the most important factors affecting the status rank being relatively high threats values.

***Upper Liard EDU*.** Bull trout are widely distributed in the Upper Liard EDU, which is situated upstream of a migration obstacle in the Liard River Canyon, whereas Great Plains species are largely absent (Ciruna et al. 2007). In upstream core areas located within Region 6 (Rancheria, Upper Liard, Lower Dease, Upper Dease), lake trout are the dominant char in lakes, and, to date, bull trout have only been captured in streams and in small lakes in the extreme headwaters of a few drainages in the Upper Dease core area (Appendix 4). Bull trout are known to be common in core areas within the three core areas in Region 9 (Upper Kechika, Turnagain, Kechika-Liard) and are presumed to be distributed in >200 km of habitat in each. Abundance monitoring has not occurred in the EDU and information necessary to assess bull trout populations, even at the metapopulation level, is not available. Much of the Upper Liard EDU is remote and pristine. In Region 6 core areas habitat and exploitation threats along the Highway 37 corridor are of unknown severity and scope, but likely warrant attention in the near future. In Region 9 core areas threats to bull trout are currently considered insignificant at the core area level. Because of limited distribution and abundance information, the conservation status rank assigned to core areas of the Upper Liard EDU (Appendix 4) and the EDU as a whole (Table 3) was CU-Unranked.

***Lower Liard EDU*.** Bull trout abundance and trend are unknown for the five core areas (Lower Liard, Upper Toad, Muskwa, Prophet, Upper Ft. Nelson) of the Lower Liard EDU in Region 9. Distribution is also unknown although thought to be >200 km in each core area (Appendix 4). Little is known about the remote and relatively inaccessible Lower Liard core area, and threats are thought to be insignificant. The Upper Toad core area has been anecdotally described as an excellent bull trout system (Woods Environmental 2001). Although limited to a relatively small portion of the core area, the threat of overexploitation in the Upper Toad core area (focused on Toad River and Moose Lakes) is moderately severe and requires immediate attention (Appendix 4). Exploitation is also considered to be a moderately severe and more widespread threat in the Upper Muskwa core area, where good access has permitted high levels of motorized boat traffic on some systems and prompted reconnaissance and radio telemetry studies (DES 2000a, 2001a, 2002a) to assess the potential impact. Low severity habitat degradation affecting a small portion of the area is considered the most significant threat facing bull trout in the Prophet core area (Appendix 4). Bull trout records for the Upper Fort Nelson core area are widely scattered and may primarily represent foraging adults and sub-adults, in which case it would not be an independent core area. Habitat suitability for bull trout in this relatively low elevation core area is probably marginal in many areas (Appendix 4). Because of limited distribution and abundance information, the conservation status rank assigned to core areas of the Lower Liard EDU (Appendix 4) and the EDU as a whole (Table 3) was CU-Unranked.

7.0 CONCLUSIONS AND RECOMMENDATIONS

It is clear that bull trout are distributed widely in British Columbia and that many hundreds of local populations exist. However, the total distribution of bull trout in the Province, along with the number of occupied streams, cannot be estimated at a very high level of resolution. In particular, the distribution of bull trout in coastal watersheds outside of the Lower Mainland, and in areas of Dolly Varden/bull trout sympatry, is poorly defined. This unsatisfactory situation limits the ability to conserve and manage the species or to identify potential core areas. Significant improvements to the quality of future bull trout monitoring data in British Columbia, particularly estimates of distribution and population spatial structure, will require revisions to standard sampling protocol. The principal methods to achieve this in basic inventory studies include archiving and analysis of tissue samples, voucher specimens for identification by experts, and training of field crews in visual identification. A mandatory requirement that voucher specimens be collected for char whenever sampling occurs within the zone of Dolly Varden/bull trout sympatry would be a useful first step, as this would provide the opportunity for morphological or molecular genetic analysis to be conducted to confirm species. A dedicated study focused on life history, ecology, and population spatial structure of coastal bull trout populations outside of the Lower Mainland, for which little information exists, also appears warranted.

Very limited data are available for evaluating trends in BC bull trout populations. Only seven of the 31 abundance datasets that we compiled met the minimum USFWS (2005) criterion of two generations (14 years) for assessing trend, and only two data sets met the COSEWIC (2010) criterion of three generations (21 years). Moreover, most population monitoring programs for bull trout in BC were initiated in the 1990s or later, following significant management changes initiated across much of the Province to restrict or eliminate harvest. This period also saw a positive change in public attitudes towards conservation of bull trout and other native species. Comments from regional biologists obtained from the core area analysis and anecdotal comments in a number of reports suggest that prior to this period, bull trout populations were depressed in many of the accessible areas of the Province as a result of overexploitation (e.g., Allan 2001; Woods Environmental 2001; DES 2008a). The majority of the abundance trend datasets from the 1980s onward suggest stable or increasing bull trout populations (very rapid population growth was evident in a few systems). Anecdotal information suggests the recovery of a number of other unmonitored populations as well, following reductions in harvest. This reflects the both the vulnerability of bull trout to overharvest, and the ability of the species to recover rapidly once exploitation is reduced, something that has been observed in other jurisdictions as well (Johnston et al. 2007). Exploitation is clearly a major factor/threat affecting bull trout populations in BC, and therefore angling management should be relatively conservative. Opportunities for sustainable harvest likely exist, however, in many of the more productive core areas, particularly those with large lakes or reservoirs containing abundant prey fish populations. The challenge is to ensure harvest rates in open access sport fisheries are limited in accordance to the sustainability of the stock (R. Bison, pers. comm.). Ideally, the sustainability of alternate harvest scenarios should be evaluated through adaptive management, whereby properly designed monitoring programs are in place to identify changes in population status. Some form of population monitoring or, alternatively, fisheries monitoring, is recommended in any system where the potential for overexploitation exists.

Although angling management clearly plays an important role in conserving BC bull trout, it was apparent from the core area analysis that harvest restrictions alone have been insufficient to effect population recoveries, or even halt declines in several core areas in BC where bull trout habitat has been seriously degraded or connectivity between habitats has been lost due to hydroelectric development. Bull trout have highly specific habitat requirements, particularly with respect to water temperature. In addition, the complex life histories of fluvial and adfluvial populations necessitates connectivity between different types of habitats that can be widely separated from one another. Thus, for the more heavily developed southern portions of the Province in particular, the preservation of suitable coldwater habitat and connectivity between suitable habitats should be considered a top priority.

Stream temperature has consistently been shown to be the most important factor affecting the distribution of bull trout within all but the northernmost portion of their range (Haas 2001; Fraley and Shepard 1989; Saffel and Scarnecchia 1995; see Section 2.2). A strong association of bull trout populations with mountainous and glaciated areas of British Columbia was evident in our analysis and reflects this dependence of bull trout on coldwater habitats. We recommend that stream temperature be treated as the primary indicator of habitat suitability for bull trout for all regions of the Province, with maximum stream temperatures >15°C likely to indicate poor or marginal suitability (Haas 2001; Decker and Hagen 2007 and references therein). Moreover, climate change, because of its direct and potentially large effect on stream temperature regimes, should be regarded as the most important future threat to bull trout across the province as a whole, although other threats may be more important locally. The modeling work conducted by Porter and Nelitz (2009) to examine potential losses of bull trout habitat in the Cariboo Region of BC under various climate change scenarios is an important first step (see *Middle Fraser EDU*), and we recommend that this exercise be extended to the remainder of the species' range in the Province. Other factors such as road density, distribution of competitor species, watershed connectivity, habitat "patch size" have also been shown to be important predictors of bull trout distribution in some parts of their range (e.g., Dunham and Reiman 1999), but would likely be less useful relative to temperature for mapping bull trout habitat suitability for the majority of EDUS in BC. Some additional factors cited as predictors of bull trout distribution (e.g., elevation, latitude) are largely surrogates for temperature.

Essentially no quantitative abundance data were collected specifically for BC bull trout populations prior to the 1980s. As a result, we had no means of assessing the current status of population relative to that under pristine conditions. Given the paucity of historic data, the best alternative for evaluating the status of bull trout populations or metapopulations may be through the use of conservation status criteria developed in other jurisdictions for assessing abundance, trend, connectivity, and threats. This approach has been comprehensively applied in the United States (USFWS 2002, USFWS 2005, USFWS 2008), and our own core area assessment suggests this approach has potential in British Columbia as well, especially if more information can be obtained.

Poor and disproportionate geographic representation is the other major deficiency with respect to the currently available collection of bull trout abundance datasets for BC. Only 10 of the 26 EDUs inhabited by bull trout in BC are represented by the abundance datasets that we assembled. Moreover, 13 of the 31 datasets were from a single management region (Region 4 – Kootenay). Abundance data were almost completely lacking for two very large interior EDUs (Thompson and Middle Fraser) that span the Thompson/Nicola, Okanagan, and Cariboo management regions, despite bull trout being fairly widespread in both EDUs, and the fact that each EDU contains core areas where relatively serious conservation concerns have been identified. We also noted that, across all regions, abundance monitoring programs were often focused on the most robust bull trout populations within an area, or those that are relatively well known, rather than smaller or potentially more vulnerable ones. A more systematic approach to selecting populations for monitoring is clearly needed before population and metapopulation status can be evaluated reliably for bull trout at the provincial scale. We strongly recommend that a provincial bull trout monitoring strategy be developed that addresses these imbalances. In the core area assessment, regional biologists were much more likely to be able to identify potential threats to bull trout populations than population distributions, abundance, or trends. This presumably reflects a strong agency emphasis on environmental monitoring and impact assessment, but lower emphasis on stock assessment. This imbalance could be addressed with revisions/supplements to standard protocol for conducting environmental impact studies, such that emphasis is shifted from assessing habitat to directly assessing population status.

The major advantage of conducting a core area assessment, albeit a cursory one, was that it provided systematic and comprehensive coverage for a large area of the Province, particularly for the more heavily populated southern portion (information was very limited for major portions of northern BC), that would have otherwise not been possible. As an example of its utility, the core area assessment allowed for the identification of four highly threatened core areas (Middle Shuswap, Nicola, Pend d'Oreille, Lower Columbia) that would not have been identified based on available abundance and trend data alone. The core area approach also necessitated a comprehensive review of available knowledge, thus providing a good basis for developing future monitoring and management plans for the Province. However, there are a number of important limitations with respect to further application of this approach in BC. As mentioned throughout the report, geographic boundaries are highly uncertain for the large majority of the putative core areas that we have proposed here, owing to a lack of supporting information with respect to bull trout movement, genetic population structure, and definitive migration barriers. A general lack of quantitative abundance data also meant that the core area assessment relied heavily on expert judgment, with associated uncertainty. Our proposed core area structure should therefore be considered a hypothesis, and we caution against using it as a basis for bull trout conservation and management until such time as more information becomes available. However, given that a more precise evaluation of core area structure for the Province may not be feasible over the short to medium-term, the core area structure proposed here may nevertheless be useful for selecting and prioritizing among watersheds and EDUs when allocating resources for new or ongoing population monitoring programs.

8.0 REFERENCES

Allan, J. H. 2001. Increases in the number of bull trout spawning in Line Creek, British Columbia: an update. Pages 229-231 *in* Brewin, M. K., A. J. Paul, and M. Monita, editors. Bull trout II conference proceedings. Trout Unlimited Canada, Calgary, AB.

AMEC Earth and Environmental and LGL Ltd. 2008. Peace River fisheries investigation: Peace River and Pine River radio telemetry study 2007. Consultant report prepared for BC Hydro, Burnaby, BC.

AMEC Earth and Environmental and LGL Ltd. 2009. Peace River fisheries investigation: Peace River and Pine River radio telemetry study 2008. Consultant report prepared for BC Hydro, Burnaby, BC.

AMEC Earth and Environmental and LGL Ltd. 2010. Peace River fisheries investigation: Peace River and Pine River radio telemetry study 2009. Consultant report prepared for BC Hydro, Burnaby, BC.

Andrusak, H. 1987. Kootenay Lake sport fishery 1984-1986. British Columbia Ministry of Environment, Fish and Wildlife Branch, Nelson, BC.

Andrusak, G.F. 2007. Kootenay Lake Rainbow trout survey questionnaire results 2003-2005. Consultant report prepared for the Habitat Conservation Trust Fund, Victoria, BC, by Redfish Consulting, Nelson, BC, March 2007.

Andrusak, G.F. 2011. Shuswap Lake angler survey. 2009 Data Report. Consultant Report prepared for Habitat Conservation Trust Fund. 37 pp.

Andrusak, G.F., H. Andrusak, and A.R. Langston. 2011. Bull trout (*Salvelinus confluentus*) redd count surveys in select Williston Reservoir tributaries (2001-2010) and recommendations for future surveys. Consultant report prepared for Fish and Wildlife Compensation Program, Peace Region, Prince George BC, March 2011.

AquaFor Consulting, Ltd. 1997. 1997 Fish and Fish Habitat Inventory bull trout project TFL 30. Consultant report prepared for Prince George Forest District, BC Ministry of Forests.

Aquatic Resources, Ltd. 1999. Fish sample data for Klinaklini River (alias Kleena Kleene River) in 2009 under MOE Scientific Collection Permit WL09-51561: Klinaklini River Hydroelectric Development.

Arc Environmental Ltd. 1998. Celista Creek Watershed : Overview and Level 1 Fish Habitat Assessment Procedure. Consultant report prepared for Federated Co-operatives Ltd. by Arc Environmental Ltd. and Adams Lake Indian Band, March 1998.

Arc Environmental Ltd. 1999. Reconnaissance (1:20,000) fish and fish habitat inventory of the Cherry Creek watershed. Consultant report prepared for Weyerhauser Canada Ltd., Armstrong, BC, August 1999. 51 pp.

Arc Environmental Ltd. 2000. Reconnaissance (1:20,000) fish and fish habitat inventory of the Fraser River tributaries, Yalakom River, and Tyaughton Creek watersheds. Consultant report prepared for Ainsworth Lumber Company Ltd., Lillooet, BC, May 2000. 97 pp.

Arc Environmental Ltd. 2002. Reconnaissance (1:20,000) fish and fish habitat inventory of selected areas within Units 3 and 4 (Lillooet Forest District). Consultant report prepared for Ainsworth Lumber Company Ltd., Lillooet, BC, April 2002. 82 pp.

Arndt, S. 2004. Arrow Lakes Reservoir Creel Survey 2000-2002. Columbia Basin Fish and Wildlife Compensation Program, Nelson BC.

Arndt, S., and C. Schwarz. 2011. Changes in angling and piscivore condition following 11 years of nutrient additions in Arrow Lakes Reservoir (Arrow Lakes Reservoir creel survey 2003-2009). Fish and Wildlife Compensation Program – Columbia Basin, Nelson, BC.

Baccante, N. 2007. Monitoring effectiveness of bull trout Wildlife Habitat Areas: a proposed approach. BC Ministry of Environment, Ft. St. John, BC.

Bahr, M. A. 2002. Movement Pattterns, Timing of Migration and Genetic Population Structure of Bull Trout (*Salvelinus confluentus*) in the Morice River Watershed, British Columbia. M.Sc. Thesis, University of Northern British Columbia, Prince George, BC.

Baxter, J.S. 1994. Adult bull trout (*Salvelinus confluentus*) surveys and assessment in the Chowade River (1994). Report to Ministry of Environment, Lands and Parks, Fisheries Branch, Ft. St. John, British Columbia.

Baxter, J. S. 1995a. Chowade River bull trout studies 1995: habitat and population assessment. Report to BC Ministry of Environment, Lands, and Parks, Fort St. John, BC.

Baxter, J. S. 1995b. Brook trout impact assessment in the Peace Sub-Region: the problem and possible solutions. Report prepared for BC Fisheries, Ft. St. John, BC.

Baxter, J.S. 1997. Chowade River bull trout studies (1996). Report to Ministry of Environment, Lands and Parks, Fisheries Branch, Ft. St. John, BC.

Baxter, J. S., and J. D. McPhail. 1996. Bull trout spawning and rearing habitat requirements: Summary of the literature. Province of British Columbia Fisheries Technical Circular No. 98, Victoria, BC.

Baxter, J. S., E. B. Taylor, R. H. Devlin, J. D. McPhail, and J. Hagen. 1997. Evidence for natural hybridization between Dolly Varden and bull trout in a northcentral British Columbia watershed. Canadian Journal of Fisheries and Aquatic Sciences 54:421-429.

Baxter, J. S. 2002. Summary of the third year of bull trout (*Salvelinus confluentus*) radio telemetry in the Salmo River watershed. Consultant Report Prepared by Baxter Environmental for Columbia-Kootenay Fisheries Renewal Partnership and BC Hydro, Cranbrook and Castlegar, BC.

Baxter, J.T.A., and S. Decker. 2010. Bull trout spawner escapement in the Salmo River watershed: 2009 update. Consultant report prepared for BC Hydro, Castlegar BC, by Mountain Water Research, Silverton BC, February 2010. 27 pp.

BC Environment. 1994. A Strategic Plan for the Conservation and Management of Char in British Columbia. BC Ministry of Environment, Fisheries Program, Victoria, BC.

Beak International Inc. 1998. 1997 Reconnaissance Fish and Fish Habitat Inventory/Stream Classification: Finlay Forest Industries. Report prepared for Finlay Forest Industries, Inc.

Beere, M. C. 2002. A Reconnaissance of Tuya Lake August 7 to 13 2002 (00373TUYR). BC Ministry of Water, Land, and Air Protection, Smithers, Skeena Fisheries Report #135.

Berry, D.K. 1994. Alberta's bull trout management and recovery plan. Alberta Environmental Protection, Fish and Wildlife Service, Fisheries Management Division, Edmonton, AB. 22 pp.

Bison, R., D. O'Brien, and S.J.D. Martell. 2003. An Analysis of Sustainable Fishing Options for Adams Lake Bull Trout Using Life History and Telemetry Data. BC Ministry of Water, Land and Air Protection, Fisheries Branch, Kamloops, BC, February 2003.

Blackman, B. G., D. A. Jesson, D. Ableson, and T. Down. 1990. Williston Lake fisheries compensation program management plan. Peace/Williston Fish and Wildlife Compensation Program Report No. 58.

Bonar, S. A., M. Divens, and B. Bolding. 1997. Methods for sampling the distribution and abundance of bull trout and Dolly Varden. Washington Department of Fish and Wildlife, Olympia, WA.

Bonneau, J. L., and D. L. Scarnecchia. 1998. Seasonal and diel changes in habitat use by juvenile bull trout (*Salvelinus confluentus*) and cutthroat trout (*Oncorhynchus clarki*) in a mountain stream. Canadian Journal of Zoology 76:783-790.

Burrows, J. T., T. Euchner, and N. Baccante. 2001. Bull trout movement patterns: Halfway River and Peace River progress. Pages 53-55 *in* Brewin, M. K., A. J. Paul, and M. Monita, editors. Bull trout II conference proceedings. Trout Unlimited Canada, Calgary, AB.

Bustard, D. 1998. Aquatic resource baseline studies, Telkwa Coal Project, 1997, Draft 2. Report prepared for Manalta Coal Ltd., Calgary, AB.

Bustard, D., and C. Schell. 2002. Conserving Morice watershed fish populations and their habitat: stage II biophysical profile. Consultant Report by David Bustard and Associates (Smithers BC) for the Habitat Conservation and Stewardship Program of Fisheries and Oceans Canada and Fisheries Renewal BC.

Bustard, D. 2004a. Kemess South project fish monitoring studies 2003. Consultant report prepared by David Bustard and Associates (Smithers BC) for Northgate Minerals Corp., Kemess Mine.

Bustard, D. 2004b. Gitnadoix River char studies. Report prepared for the Habitat Conservation Trust Fund, Victoria, BC.

Bustard, D. 2010. Kemess South project fish monitoring studies 2009. Consultant report prepared by David Bustard and Associates (Smithers BC) for Northgate Minerals Corp., Kemess Mine.

Carswell, R., and D. Philip. 1979. An inventory of the Shuswap Lake tributaries. BC Ministry of Environment, Lands and Parks, Victoria, BC.

Cavender, T.M. 1978. Taxonomy and distribution of the bull trout, *Salvelinus confluentus* (Suckley) from the American Northwest. Calif. Fish. Game 64: 139-174.

Chamberlain, M. W., and D.S. O'Brien. 2000. Lillooet TSA – bull trout distribution survey: Seton/Anderson watershed. Ministry of Environment, Lands and Parks, Fisheries Branch, Southern Interior Region, January 2000. 34pp.

Chamberlain, M.W., A.R. Morris, and A. Caverly. 2001. Middle Shuswap River and Sugar Lake: bull trout (*Salvelinus confluentus*) and kokanee (*Oncorhynchus nerka*) assessment 2000/2001. BC Ministry of Water, Land and Air Protection, Fisheries Branch, Southern Interior Region, August 2001.

Chamberlain, M.W. 2002. Bridge River bull trout (*Salvelinus confluentus*) Investigation 2000. BC Ministry of Water, Land and Air Protection, Fisheries Branch, Thompson Region, June 2002.

Chapman Geoscience Ltd. 1997. An inventory of watershed conditions affecting risks to fish habitat in the Cariboo, Cottonwood, and Horsefly Watersheds. Consultant report prepared for Cariboo Region Interagency Management Committee, Williams Lake, BC, November 1997.

Ciruna, K. A., B. Butterfield, J. D. McPhail, and BC Ministry of Environment. 2007. EAU BC: Ecological Aquatic Units of British Columbia. Nature Conservancy of Canada, Toronto, ON.

Clarke, A. D., and J. T. Zimmerman. 2005. Bull trout management strategy for Region 7a, Omineca. Ministry of Water, Land, and Air Protection, Prince George, BC.

Coombes, D.M.V. 1988. A reconnaissance survey of Bowser Lake. Ministry of Environment, Lands and Parks, Fisheries Branch, Victoria, BC.

Coombes, D.M.V. 1991. A reconnaissance survey of Azure Lake. Ministry of Environment, Lands and Parks, Fisheries Branch, Victoria, BC. 44 pp. + append.

COSEWIC. 2010. COSEWIC's Assessment Process and Criteria. Committee on the Status of Endangered Wildlife in Canada.

Costello, A. B., T. E. Down, S. M. Pollard, C. J. Pacas, and E. B. Taylor. 2003. The influence of history and contemporary stream hydrology on the evolution of genetic diversity with species: an examination of microsatellite DNA variation in bull trout, *Salvelinus confluentus* (Pisces: Salmonidae). Evolution 57(2):328-344.

De Gisi, J. 2003. Brook trout in the upper Murray watershed: issues and approaches. Prepared for the Ministry of Water, Land and Air Protection, Fort St. John, BC. 54 pp.

Decker, A.S. 2008. Sheep Creek nutrient addition study (2001-2007). Report prepared for BC Hydro, Burnaby, BC.

Decker, A. S., and J. Hagen. 2007. Distribution of adfluvial bull trout production in tributaries of the Arrow Lakes Reservoir and the feasibility of monitoring juvenile and adult abundance. Report prepared for the Fish and Wildlife Compensation Program – Columbia Basin, Nelson, BC.

Decker, A. S., and J. Hagen. 2008. Adfluvial bull trout spawner abundance in tributaries to the Arrow Lakes Reservoir (2004-2007). Technical report prepared for the Fish and Wildlife Compensation Program – Columbia Basin, Nelson, BC.

Decker, A.S., and A. Caverly. 2007. Distribution and abundance of anadromous salmonids and migratory bull trout in headwater reaches of Nicola River Watershed in 2006. Consultant report prepared for the Ministry of Environment, Kamloops Region and Living Rivers BC.

Diversified Environmental Services (DES). 2000. An assessment of bull trout habitat used in the Tuchodi River watershed and potential impacts of recreational riverboat use. Report prepared for BC Parks, Ft. St. John, BC.

Diversified Environmental Services (DES). 2001. Overview fish and fish habitat inventory: upper Prophet and Besa river watersheds. Report prepared for BC Ministry of Energy and Mines, Ft. St. John, BC.

Diversified Environmental Services (DES). 2002a. Overview Fish and Fish Habitat Inventory upper Muskwa River watershed group. Report prepared for the Muskwa-Kechika Trust Fund, B.C. Ministry of Sustainable Resource Management.

Diversified Environmental Services (DES). 2002b. Overview Fish and Fish Habitat Inventory Halfway-Graham river watersheds. Prepared for B.C. Ministry of Sustainable Resource Management, Victoria, BC.

Diversified Environmental Services (DES). 2002c. Chowade River bull trout aerial and ground redd counts, distribution and density, snorkel survey data summary. Report prepared for BC Ministry of Water, Land, and Air Protection, Ft. St. John, BC.

Diversified Environmental Services (DES). 2004. Aerial survey of bull trout spawners and redds in Belcourt, Red Deer, Fellers, Tuck and Bullmoose creeks and the Wapiti and Wolverine rivers. Report prepared for BC Ministry of Water, Land, and Air Protection, Ft. St. John, BC.

Diversified Environmental Services (DES). 2006a. Chowade River bull trout population status – 2005. Prepared for the Habitat Conservation Trust Fund, Victoria B.C. HCTF Project No. 7-295.

Diversified Environmental Services (DES). 2006b. Burnt and North Burnt Rivers 2006 spawning assessment. Report prepared for BC Ministry of Environment, Ft. St. John, BC.

Diversified Environmental Services (DES). 2008. Bull trout Wildlife Habitat Area effectiveness monitoring. Report prepared for BC Ministry of Environment, Ft. St. John, BC.

Diversified Environmental Services (DES). 2010. Burnt River data summary 1992-2006. Report prepared for BC Ministry of Environment, Ft. St. John, BC.

Diversified Environmental Services (DES). 2011a. 2010 Upper Halfway River watershed bull trout spawning survey (draft). Report prepared for BC Hydro, Vancouver, BC.

Diversified Environmental Services (DES). 2011b. Sukunka River data summary 1987-1992 (draft). Report prepared for BC Ministry of Environment, Ecosystems Protection and Sustainability Branch, Victoria, BC.

Diversified Environmental Services (DES). 2011c. 2010 Gordon Creek bull trout population monitoring. Report prepared for Golder Associates, Burnaby, BC.

Dolighan. R.B. 1985. Fisheries inventory of the West Road River with reference to the Alexander Mackenzie Grease Trail. BC Ministry of Environment, Habitat Management Section, Williams Lake, BC, November 1985. 65 pp.

Dolighan. R.B., and M.G. Lirette. 1993. Preliminary fisheries assessment of the Cariboo Mountains deferral area. BC Ministry of Environment, Fisheries Branch, Williams Lake, BC. Regional Fisheries Report No. CA 934.

Donald, D.B., and D.J. Alger. 1993. Geographic distribution, species displacement, and niche overlap for lake trout and bull trout in mountain lakes. Canadian Journal of Zoology 71:238-247.

Downs, C., D. Horan, E. Morgan-Harris, and R. Jakubowski. 2006. Spawning demographics and juvenile dispersal of an adfluvial bull trout population in Trestle Creek, Idaho. North American Journal of Fisheries Management 26:190-200.

Dunham, J., and B. Rieman. 1999. Metapopulation structure of bull trout: influences of physical, biotic, and geometrical landscape characteristics. Ecological Applications 9:642-65

Dunham, J., B. Rieman, and K. Davis. 2001. Sources and magnitude of sampling error in redd counts for bull trout. North American Journal of Fisheries Management 21:343-352.

ECL Envirowest Consultants Ltd. 1998. Fish and Fish Habitat Inventory of the Mesilinka River and Tributaries – 1997. Report prepared for BC Ministry of Environment, Lands, and Parks, Prince George, BC.

Environmental Dynamics Inc. (EDI). 2001. Overview Fish and Fish Habitat Inventory Within the Vents and Upper Toad Watersheds. Report prepared for the Muskwa-Kechika Trust Fund, B.C. Ministry of Sustainable Resource Management.

Environmental Dynamics, Inc. (EDI). 2002. Upper and Lower Torpy Watershed Units Results of 2001 Field Reconnaissance and FRBC funded WRP Assessments Conducted in the Upper Torpy/Pass Lake and Lower Torpy South Sub-basins. Report prepared for Canfor Forest Products, Prince George, BC.

Ferguson, J., and R. Bocking. 1998. Big, Gaspard and West Churn Creek watersheds level 1 fish habitat assessments. Consultant report prepared for Ministry of Environment, Lands and Parks, Willaims Lake, BC by LGL Limited, March 1998.

Fielden, R. J., T. L. Slaney, and A. W. Wood. 1992. Survey of tributaries to Kinbasket Reservoir. Report prepared by Aquatic Resources Ltd, Vancouver, BC, for Mica Compensation Program, Nelson, BC. Fraley, J. J., and B. B. Shepard. 1989. Life history, ecology, and population status of migratory bull trout (*Salvelinus confluentus*) in the Flathead Lake and River system, Montana. Northwest Science 63:133-143.

Fielden, R. J., A. W. Wood, and T. L. Slaney. 1993. Fisheries Survey of Dutch, Toby and Horsethief Creeks. Report prepared by Aquatic Resources Ltd, Vancouver, BC, for Mica Compensation Program, Nelson, BC. Fraley, J. J., and P. J. Graham. 1981. Physical habitat, geologic bedrock types, and trout densities in tributaries of the Flathead River drainage, Montana. Pages 178-185 *in* N. B. Armantrout, editor. Acquisition and Utilization of Aquatic Habitat Inventory Information. Symposium proceedings, American Fisheries Society, Portland OR.

Giroux, P. A. 2001. Aspects of the life history of Shelagyote River adult bull trout (*Salvelinus confluentus*). BC Ministry of Water, Land and Air Protection, Fish & Wildlife Science and Allocation Branch, Smithers, BC.

Goddard, A. D. 2008. Bull trout (*Salvelinus confluentus*) Wildlife Habitat Area Assessment Dawson Creek TSA: Annual Report 2007. BC Ministry of Environment, Ft. St. John, BC.

Goetz, F. 1989. Biology of the bull trout, *Salvelinus confluentus*: a literature review. U.S.D.A., Willamette National Forest, Eugene, Oregon.

Graham, P. J., B. B. Shepard, and J. J. Fraley. 1981. Use of stream habitat classifications to identify bull trout spawning areas in streams. . Pages 186-190 *in* N. B. Armantrout, editor. Acquisition and Utilization of Aquatic Habitat Inventory Information. Symposium proceedings, American Fisheries Society, Portland OR.

Griffith, R. P. 1995. Yalakom River assessment of juvenile fish production, preliminary report: summary of results and conclusions. Prepared for the Department of Fisheries and Oceans, Vancouver, BC, and Ministry of Environment, Lands and Parks, Kamloops, BC, by R. P. Griffith and Associates, Sidney, BC. 66 pp.

Griffith, R.P. 1997. Kwoiek Creek drainage assessment of fish habitat and production 1995. Consultant report prepared for Ministry of Environment, Fisheries Branch, Kamloops, BC, and the BC Conservation Foundation, Kamloops, BC, by R. P. Griffith and Associates, Sidney, BC.

Haas, G.R. and J.D. McPhail. 1991. The systematics, zoogeography, and evolution of Dolly Varden and bull trout in North America. Canadian Journal of Fisheries and Aquatic Sciences 48: 2191-2211.

Haas, G. 2001. The mediated associations and preferences of native bull trout and rainbow trout with respect to maximum water temperature, its measurement standards, and habitat. Pages 53-55 *in* Brewin, M. K., A. J. Paul, and M. Monita, editors. Bull trout II conference proceedings. Trout Unlimited Canada, Calgary, AB.

Haas, G.R. and J.D. McPhail. 2001. The post-Wisconsinan biogeography of bull trout (Salvelinus confluentus): a multivariate morphometric approach for conservation biology and management. Canadian Journal of Fisheries and Aquatic Sciences 58: 2189-2203.

Hagen, J., and E. B. Taylor. 2001. Resource partitioning as a factor limiting gene flow in hybridizing populations of Dolly Varden char (*Salvelinus malma*) and bull trout (*S. confluentus*). Canadian Journal of Fisheries and Aquatic Sciences 58:2037-2047.

Hagen, J., and J. Baxter. 1992. Bull trout populations of the North Thompson River basin, British Columbia: initial assessment of a biological wilderness. Prepared for Ministry of Environment, Lands and Parks, Fisheries Branch, Kamloops Region, BC.

Hagen, J. 2000. Reproductive isolation between Dolly Varden (*Salvelinus malma*) and bull trout (*S. confluentus*) in sympatry: the role of ecological factors. M.Sc. thesis, University of British Columbia, Vancouver BC.

Hagen, J. 2008. Impacts of dam construction in the upper Columbia Basin, British Columbia, on bull trout (*Salvelinus confluentus*) production, fisheries, and conservation status. Report prepared for the Fish and Wildlife Compensation Program – Columbia Basin, Nelson, BC.

Hagen, J., and A. S. Decker. 2009. Bull trout monitoring plan for Kootenay Lake. Report prepared for the Fish and Wildlife Compensation Program – Columbia Basin, Nelson, BC.

Henderson Environmental Consulting. 2002. Summer/fall stream temperature in the Nicola River Watershed 1999-2001. Unpublished Consultant Report prepared by Henderson Environmental Consulting, Kelowna, BC.

Hirst, S. M. 1991. Impacts of the operations of existing hydroelectric developments on fishery resources in British Columbia, Volume II: inland fisheries. 91. Canada. Department of Fisheries and Oceans. Canadian Manuscript Report of Fisheries and Aquatic Sciences.

Holmes, R., and G. Smith. 2006. Consultant report prepared for Xeni Gwet'in First Nations Government, Nemiah Valley, BC, November 2006. 40 pp.

Holtby, L. B. 1988. Effects of logging on stream temperatures in Carnation Creek, British Columbia, and associated impacts on coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 45(3):502-515.

Imhof, D. and D. R. Sutherland. 1996a. Fish Habitat Inventory of the Willow River Watershed 1995. BC Ministry of Environment, Fisheries Branch, Prince George, BC.

Imhof, D., and D.R. Sutherland. 1996b. Fish habitat inventory of the Swift River watershed 1995. BC Environment, Fisheries Branch, Williams Lake, BC. Regional Fisheries Report No. CA 964.

Irvine, J.R., and M. Bradford. 2000. Declines in the abundance of Thompson River coho salmon in the interior of southern British Columbia, and Canada's coho recovery plan. L.M. Darling [ed.] Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, BC, February 15-19, 1999. Volume 2. BC Ministry of Environment, Lands and Parks, Victoria, BC, and University College of the Cariboo, Kamloops, BC. 520 pp.

Jakober, M. J., T. E. McMahon, R. F. Thurow, and C. G. Clancy. 1998. Role of stream ice on fall and winter movements and habitat use by bull trout and cutthroat trout in Montana headwater streams. Transactions of the American Fisheries Society 127(2):223-235.

Jesson, D. 2003. Birkenhead Lake bull trout conservation spawner assessment 2001& 2002. BC Ministry of Environment, Surrey, BC.

Jesson, D., and Juteau, C. 2005. Birkenhead Lake Bull Trout Conservation Spawner Assessment-Year 3 (2004). BC Ministry of Environment, Surrey, BC.

Johnson, S. L., and J. A. Jones. 2000. Stream temperature responses to forest harvest and debris flows in western Cascades, Oregon. Canadian Journal of Fisheries and Aquatic Sciences 57(Suppl. 2):30-39.

Johnston, F. D., J. R. Post, C. J. Mushens, J. D. Stelfox, A. J. Paul and B. Lajeunesse. 2007. The demography of recovery of an overexploited bull trout, Salvelinus confluentus, population. Canadian Journal of Fisheries and Aquatic Sciences 64:113-126.

Juteau, C., and D. Jesson. 2010. Birkenhead Lake bull trout conservation spawner assessment – year 5 (2009). Ministry of Environment, Fish and Wildlife, Surrey BC, January 2010. 35 pp.

Kossman, R. 2010. Bull trout habitat in the Babine watershed: An estimation of the extent of habitat and the amount of habitat protected in the various Management Zones (Project 2008–3). Report prepared for the Babine Watershed Monitoring Trust, Smithers, BC, by McElhanney Consulting Services, Smithers, BC.

Ladell, J., J. Korman, and D.J.F. McCubbing. 2010. Cheakamus River bull trout telemetry and enumeration program 2007-2009. Consultant report prepared for Canadian National Railway Company by Instream Fisheries Research Inc., July 2010. 88 pp. + appendices.

Ladell, J., R. Dolighan, and D.J.F. McCubbing. In prep. Chilko resistivity fish counter bull trout enumeration report: 2005 and 2006. Draft report prepared for BC Ministry of Environment, Fisheries Branch, Williams Lake by Instream Fisheries Research Inc., Vancouver BC.

Langston, A. R. 2008. Gething Creek Bull Trout Translocation Project. Peace/Williston Fish and Wildlife Compensation Program Report No. 333.

Langston, A. R., and B. G. Blackman. 1993. Fisheries resources and enhancement potentials of selected tributaries of the Williston Reservoir. Volume II. Peace/Williston Fish and Wildlife Compensation Program Report No. 70.

Langston, A. R., and J. C. Cubberley. 2008. Assessing the Origin of Bull Trout Spawners in the Misinchinka River and River's Potential as a Redd Count Index System. Peace/Williston Fish and Wildlife Compensation Program Report No. 317.

Latham, S. J. 2002. Historical and anthropogenic influences on genetic variation in bull trout (*Salvelinus confluentus*) in the Arrow Lakes, British Columbia. M.Sc. thesis, University of British Columbia, Vancouver BC.

Leggett, J. W. 1980. Reproductive ecology and behaviour of Dolly Varden charr in British Columbia. Pages 721-737 *in* Balon, E. K. editor. Charrs, salmonid fishes of the genus *Salvelinus*. W. Junk, The Hague, Netherlands.

Lheidli Tenneh Band. 2000. 1997 Reconnaissance Level (1:20,000) Fish and Fish Habitat Inventory in the Herrick Creek Watershed WSC:190-2651-000 And Sub-Basins Framstead Creek WSC:190-2651-449-000 Muller Creek WSC:190-2651-449-088-000. Report prepared for Northwood Pulp and Timber, Ltd., Prince George, BC.

Lohr, S., T. Cummings, W. Fredenberg, and S. Duke. 2000. Listing and recovery planning for bull trout. Pages 80-87 *in* Schill, D., S. P. Moore, P. Byorthe, and B. Hamre, editors. Wild Trout VII, Management in the new millennium: are we ready? Prodeedings of the Wild Trout VII Symposium, 1-4 October 2000, Yellowstone National Park , WY. Trout Unlimited, Arlington, VA.

MacPherson, C. 2006. Chilcotin River creel survey 2005. Ministry of Environment, Fisheries Branch, Williams Lake, BC, March 2006. 7 pp.

Macullo, M. A. and A. D. Goddard. 2010. Bull trout (*Salvelinus confluentus*) Wildlife Habitat Area Assessment: Dawson Creek TSA 41 & TFL 48. BC Ministry of Environment, Ft. St. John, BC.

Mainstream Aquatics and Diversified Environmental Services. 2009. Site C fisheries study: upper Halfway River watershed spawning survey 2008. Report prepared for BC Hydro, Vancouver, BC.

McElhany, P., M.H. Ruckelhaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42.

McPhail, J. D., and C. B. Murray. 1979. The early life history and ecology of Dolly Varden (*Salvelinus malma*) in the upper Arrow Lakes. Report to BC Hydro and British Columbia Ministry of Environment, Fisheries Branch, Nelson.

McPhail., J. D., and E. B. Taylor. 1995. Final Report to Skagit Environmental Endowment Commission: Skagit Char Project (Project 94-1).

McPhail, J. D., and J. S. Baxter. 1996. A review of bull trout (*Salvelinus confluentus*) life-history and habitat use in relation to compensation and improvement opportunities. Province of British Columbia Fisheries Management Report No. 104.

McPhail, J.D. 2007. The freshwater fishes of British Columbia. The University of Alberta Press, Edmonton, Alberta.

Moody, A., P. Slaney, and J. Stockner. 2007. Footprint impact of BC Hydro dams on aquatic and wetland productivity in the Columbia Basin. Report prepared by AIM Ecological Consultants Ltd. In association with Eco-Logic Ltd. and PSlaney Aquatic Science Ltd. for Fish and Wildlife Compensation Program, Nelson, BC.

Morris, A.R., A. Caverly, and E. Braumandl. 2003. Seton and Anderson Lakes kokanee and char assessment. Report prepared for BC Hydro Bridge Coastal Restoration Program, Burnaby, BC, and Ministry of Water, Land and Air Protection, Kamloops BC, February 2003. 23 pp.

Morris, A.R., and A. Wilson. 2005. 2003 and 2004 upper Shuswap River bull trout assessment. BC Ministry of Water, Land and Air Protection, Fisheries Branch, Penticton, BC.

Mossup, B. 1998. Southern Chilcotin overview (1:50,000) fish and fish habitat inventory (Beece, Owell and upper Big Creeks). BC Environment, Fisheries Branch, Williams Lake, BC, September 1998. 22 pp. + append.

Muhlfeld, C., M. Deleray, and A. Steed. 2008. Canadian energy development threats and native fish research and monitoring in the transboundary Flathead River system, Montana (USA) and British Columbia (Canada). USGS-Northern Rocky Mountain Science Center, Glacier National Park, MT, and Montana Fish, Wildlife, and Parks, Kalispell, MT.

Nelson, M. L., T. E. McMahon, and R. F. Thurow. 2002. Decline of the migratory form in bull charr, *Salvelinus confluentus*, and implications for conservation. Environmental Biology of Fishes 64:321-332.

Nunney, L., and K. A. Campbell. 1993. Assessing minimum viable population size: demography meets population genetics. Trends in Ecology and Evolution 8:234-239.

O’Brien, D. S. 2001. Bull trout spawning migrations in the Duncan River: insights from telemetry and DNA. Report prepared for Columbia Basin Fish and Wildlife Compensation Program, Nelson, BC.

O’Brien, D. S., and J. T. Zimmerman. 2001. Davis River bull trout radio telemetry studies, 1999 final report. Peace/Williston Fish and Wildlife Compensation Program Report No. 236.

O'Brien, D.S., and M.C. Chamberlain. 2003. Adams bull trout telemetry project final report. Report prepared for the BC Ministry of Water, Land and Air Protection, Southern Interior Region by the BC Conservation Foundation.

Oliver, G. G. 1979. A final report on the present fisheries use of the Wigwam River with an emphasis on the migration, life history, and spawning behaviour of Dolly Varden char. BC Fish and Wildlife Branch, Cranbrook, BC.

Oliver, G. G. 2001. Kinbasket Reservoir bull trout radio telemetry study; 2000 tributary use summary. Report prepared by G. G. Oliver and Associates for Columbia-Kootenay Fisheries Renewal Partnership, Cranbrook, BC.

Parkinson, E., and G. Haas. 1996. The role of macrohabitat variables and temperature in defining the range of bull trout. Province of British Columbia Fisheries Project Report 51.

Paul, A. J., and J. R. Post. 2001. Spatial distribution of native and nonnative salmonids in streams of the eastern slopes of the Canadian Rocky Mountains. Transactions of the American Fisheries Society 130:417-430.

Peard, D. 2005. Chilko/Chilcotin River Guardian Program summary report 2002. Ministry of Water, Land and Air Protection, Fish and Wildlife Science and Allocation Branch, Williams Lake, BC. Regional Fisheries Report No. Ca-02-02.

Peterson, J. T., R. F. Thurow, and J. W. Guzevich. 2004. An evaluation of multi-pass electrofishing for estimating the abundance of stream-dwelling salmonids. Transactions of the American Fisheries Society 133:462-475.

Pillipow, R. and C. Williamson. 2004. Goat River bull trout (*Salvelinus confluentus*) biotelemetry and spawning assessments 2002-03. BC Journal of Ecosystems and Management 4(2):1-9.

Porter, M., and M. Nelitz. 2009. A future outlook on the effects of climate change on bull trout (*Salvelinus confluentus*) habitats in the Cariboo-Chilcotin. Consultant report prepared for Fraser Salmon and Watersheds Program, B.C. Ministry of Environment, and Pacific Fisheries Resource Conservation Council by ESSA Technologies Ltd., Vancouver, BC.

Post, J. R. and F. D. Johnston. 2002. The status of bull trout (*Salvelinus confluentus*) in Alberta. Alberta Environment, Fisheries and Wildlife Management Division, and Alberta Conservation Association, Wildlife Status Report No. 39, Edmonton, AB.

Post, J. R., C. Mushens, A. Paul, and M. Sullivan. 2003. Assessment of alternative harvest regulations for sustaining recreational fisheries: model development and application for bull trout. North American Journal of Fisheries Management 23:22-34.

Pratt, K. L. 1992. A review of bull trout life history. Pages 5-9 *in* P. J. Howell and D. V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

R.L. & L. Environmental Services Ltd. 1994. Fish migrations in the Chowade River, B.C. - Fall 1994. Prepared for B.C. Ministry of Environment, Lands and Parks, Fish and Wildlife Branch, Fort St. John, BC.

Ratliff, D. E., and P. J. Howell. 1992. The status of bull trout populations in Oregon. Pages 10-17 *in* P. J. Howell and D. V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon.

Redenbach, Z. and E. B. Taylor. 2002. Evidence for historical introgression along a contact zone between two species of char (Pisces: Salmonidae) in northwestern North America. Evolution 56:1021-1035.

Redenbach, Z. and E. B. Taylor. 2003. Evidence for bimodal hybridization between two species of char (Pisces: *Salvelinus*) in northwestern North America. Journal of Evolutionary Biology 16:1135-1148.

Rich, C. F., T. E. McMahon, B. E. Rieman, and W. L. Thompson. 2003. Local-habitat, watershed, and biotic features associated with bull trout occurrence in Montana streams. Transactions of the American Fisheries Society 132:1053-1064.

Rieman, B. E., and J. D. McIntyre. 1993. Demographic and habitat requirements for the conservation of bull trout *Salvelinus confluentus*. USDA, Forest Service, Intermountain Research Station, General Technical Report INT-302, Ogden, UT.

Rieman, B. E., D. C. Lee, and R. R. Thurow. 1997. Distribution, status, and likely future trends of bull trout within the Columbia River and Klamath basins. North American Journal of Fisheries Management 17:1111-1125.

Saffel, P. D., and D. L. Scarnecchia. 1995. Habitat use by juvenile bull trout in belt-series geology watersheds of northern Idaho. Northwest Science 69(4):304-317.

Schell, C. 1999a. Overview (1:50,000) fish and fish habitat inventory of the Chutine River watershed. Report prepared for Ministry of Environment, Lands, and Parks, Fisheries Branch, Smithers, BC.

Schell, C. 1999b. Overview (1:50,000) fish and fish habitat inventory of the Middle Iskut River watershed atlas group. Report prepared for Ministry of Environment, Lands, and Parks, Fisheries Branch, Smithers, BC.

Sebastian, D., H. Andrusak, G. Scholten, and L. Brescia. 2000. Arrow Reservoir fish summary. Stock Management Report. BC Ministry of Environment, Lands, and Parks.

Silvatech Consulting Ltd. 2001. Reconnaissance (1:20,000) fish and fish habitat inventory of the Scotch Creek watershed. Consultant report prepared for Federated Co-operatives Ltd., Canoe, BC, September 2001. 77 pp. + append.

Simberloff, D. S. 1988. The contribution of population and community biology to conservation science. Annual Reviews in Ecology and Systematics 19:473-511.

SKR Consultants. 1997. A Reconnaissance Inventory of Unnamed Lake (alias Upper Tootsee Lake) (219-479500-70600) (00354LRAN). Report prepared for BC Ministry of Environment, Skeena Region.

SKR Consultants. 1998. Reconnaissance Level Stream Inventory of the Bell-Irving/Bowser Watershed. Report prepared for Ministry of Environment, Lands and Parks, Fisheries Branch, Skeena Region, Smithers, BC.

Swanberg, T. R. 1997. Movements of and habitat use by fluvial bull trout in the Blackfoot River, Montana. Transactions of the American Fisheries Society 126(5):735-746.

Taylor, E. B., S. Pollard, and D. Louie. 1999. Mitochondrial DNA variation in bull trout (*Salvelinus confluentus*) from northwestern North America: implications for zoogeography and conservation. Molecular Ecology 8:1155-1170.

Taylor, E. B., and A. B. Costello. 2006. Microsatellite DNA analysis of coastal populations of bull trout (*Salvelinus confluentus*) in British Columbia: zoogeographic implications and its application to recreational fishery management. Canadian Journal of Fisheries and Aquatic Sciences 63:1157-1171.

Taylor, E. B., and A. D. Clarke. 2007. Microsatellite DNA and otolith microchemistry analysis of populations of bull trout (*Salvelinus confluentus*) in tributaries of the upper Fraser River, British Columbia. Prepared for Habitat Conservation Trust Fund of British Columbia, Victoria, BC, and BC Ministry of Transportation, Victoria, BC.

Thurow, R. F. 1997. Habitat utilization and diel behavior of juvenile bull trout (*Salvelinus confluentus*) at the onset of winter. Ecology of Freshwater Fish. 6(1):1-7.

Tisdale, A.E. 2006. 2002 Downton Lake Reservoir rainbow trout (*Oncorhynchus mykiss*) spawning assessment. Consultant report prepared for BC Hydro, Bridge Coastal Division, Burnaby, BC, by Tisdale Environmental Consulting Inc., March 2006. 61 pp. + append.

Tredger, C.D. 1981. Evaluation of the Little Chilcotin River and Elkin Creek with reference to Chilcotin steelhead enhancement. BC Ministry of Environment, Fish and Wildlife Branch, Fish Habitat Improvement Section, Victoria, BC, July 1981. 116 pp.

Tredger, C.D. 1982. Assessment of steelhead carrying capacity in the Chilko River with reference to Chilcotin River steelhead enhancement opportunities. BC Ministry of Environment, Fish and Wildlife Branch, Fish Habitat Improvement Section, Victoria, BC, January 1982. 61 pp.

Triton Environmental Consultants Ltd. 1991. Preliminary evaluation of enhancement opportunities on six Columbia River tributaries. Report prepared by Triton Environmental Consultants Ltd., Vancouver, B.C, for Mica Fish and Wildlife Compensation Program, Nelson, BC.

Triton Environmental Consultants Ltd. 1992. Biophysical surveys and enhancement opportunities for tributaries of the Upper Columbia River. Report prepared by Triton Environmental Consultants Ltd., Richmond, BC, for Mica Fish and Wildlife Compensation Program, Nelson, BC.

Triton Environmental Consultants Ltd. 1997a. Cariboo fish stream inventory: Little River watershed. Consultant report prepared for BC Environment, Fisheries Branch, Williams Lake, BC, September 1997. 47 pp. + append.

Triton Environmental Consultants Ltd. 1997b. Cariboo fish stream inventory: Big Creek watershed. Consultant report prepared for BC Environment, Fisheries Branch, Williams Lake, BC, September 1997. 56 pp. + append.

Triton Environmental Consultants Ltd. 1998. Charlotte Alplands Stream Inventory. Consultant report prepared for BC Environment, Fisheries Branch, Williams Lake, BC, March 1998. 20 pp. + append.

Triton Environmental Consultants Ltd. 1999a. Reconnaissance (1:20,000) fish and fish habitat inventory of Anderson River watershed. Consultant report prepared for Cattermole Timber Ltd., Chilliwack, BC, March 1999. 85 pp. + append.

Triton Environmental Consultants Ltd. 1999b. Reconnaissance (1:20,000) fish and fish habitat inventory of the TFL 5 planning area WSCs: 100- (Fraser River) 170- (Blackwater River). Consultant report prepared for Slocan Group, Tolko Industries and Weldwood of Canada by Triton Environmental Consultants Ltd., Prince George, BC, August 1999.

Triton Environmental Consultants Ltd. 2006. Pine River snorkel surveys 2005: year 1 data report. Prepared for BC Ministry of Environment, Ft. St. John, BC.

United States Fish and Wildlife Service (USFWS). 1999. Determination of threatened status for bull trout in the coterminous United States. Final Rule Federal Register 64:58909-58933.

United States Fish and Wildlife Service (USFWS). 2002. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. USFWS, Portland, OR.

United States Fish and Wildlife Service (USFWS). 2005. Draft Bull Trout Core Area Conservation Status Assessment. USFWS, Portland, OR.

United States Fish and Wildlife Service (USFWS). 2008. Bull Trout Recovery: Monitoring and Evaluation Guidelines. USFWS, Vancouver, WA.

Van Schubert, R. M. 2002. Table River Watershed 2001 Instream Restoration Summary Report. Consultant report prepared for Canfor Forest Products, Prince George, BC.

Walter, A., and K. Scott. 2001. Birkenhead Lake stock assessment 2000. Prepared for BC Ministry of Environment, Surrey, BC.

Walthers, L.C., and J.C. Nener. 2000. Water temperature monitoring in selected Thompson River tributaries, B.C., 1996: implications of measured temperatures for anadromous salmonids. Canadian Technical Report of Fisheries and Aquatic Sciences 2306.

Webster, J., and A. Wilson. 2005. Okanagan Region large lake creek census 2004: Sugar Lake. BC Ministry of Water, Land and Air Protection, Fisheries, Branch, Penticton, BC.

Westcott, B., and J. Standen. 2002. Distribution, abundance and growth of bull trout (*Salvelinus confluentus*) within North Thompson River tributaries above the Clearwater River. BC Ministry of Environment, Fish and Wildlide Branch, Kamloops, BC, November 1993.

Westover, W. T., and D. Conroy. 1997. Wigwam River bull trout: Habitat Conservation Trust Fund progress report (1996). Fisheries Project Report KO 51, BC Ministry of Environment, Cranbrook.

Westover, W. T., and K. D. Heidt. 2004. Upper Kootenay River bull trout radio telemetry project (2000-2003). BC Ministry of Water, Land, and Air Protection, Kootenay Region, Cranbrook, BC.

Williamson, S., and T. Zimmerman. 2006. Bull trout watershed sensitivity classification within selected watersheds in the Omineca Region 7a. BC Ministry of Environment, Environmental Stewardship Division, Fish and Wildlife Science and Allocation, Prince George, BC.

Withler, I. L. 1956a. A Limnological survey of Atlin and Southern Tagish Lakes: with special reference to their proposed use as hydro-electric storage reservoirs. British Columbia Game Commission, Management Publication No. 5.

Zemlak, R. J., and A. R. Langston. 1994. Finlay River lake trout spawning investigation. Peace/Williston Fish and Wildlife Compensation Program Report No. 80.

Table 1. Summary of Ecological Drainage Units for British Columbia (Ciruna et al. 2007).

	EDU	Description
North Pacific Coastal Freshwater Ecoregion		
1	Taku	Taku watershed
2	Iskut-Lower Stikine	not defined - assume below Grand Canyon
3	Lower Nass	not defined - assume upstream of Ksi Sii Aks R.
4	North Coastal	high gradient, independent rivers north of Portland Canal
5	Lower Skeena	boundary not defined - assume Kitsumkalum R. and Skeena downstream
6	Haida Gwaii	All watersheds
7	Bella Coola-Dean	Bella Coola and Dean river watersheds
8	Homathko-Klinaklini	Homathko and Klinaklini watersheds
9	Central Coastal	small, independent rivers north of Cape Caution and south of Portland Canal
10	Vancouver Island	All watersheds
11	South Coastal	relatively small systems draining the Coast Mountains north of the Fraser
12	Puget Sound	headwaters of Skagit R.
13	Lower Fraser	mouth to Boston Bar
Interior Freshwater Ecoregion		
14	Middle Fraser	Boston Bar to Bowron/Fraser confluence
15	Upper Fraser	upstream of Bowron/Fraser confluence
16	Thompson	Thompson watershed
17	Upper Skeena	not defined - assume above Terrace?
18	Upper Nass	not defined - assume above lava flows?
Columbia Glaciated Freshwater Ecoregion		
19	Upper Columbia	above Arrow Lakes Reservoir
20	Columbia-Arrow Lakes	US border to Arrow Lakes
21	Upper Kootenay	above Kootenai Falls, MT
22	Lower Kootenay	Kootenai Falls to Columbia confluence - includes Kootenay Lake
23	Kettle	along with Okanagan and Similkameen, do not contain bull trout
24	Okanagan	Okanagan watershed
25	Similkameen	Similkameen watershed
26	Flathead	BC portion of Flathead watershed
McKenzie Freshwater Ecoregion		
27	Lower Liard	downstream of Liard Canyon
28	Upper Liard	upstream of Liard Canyon
29	Lower Peace	downstream of location of Peace Canyon
30	Upper Peace	upstream of Peace Canyon
31	Hay	BC portion of Hay watershed
Yukon Freshwater Ecoregion		
32	Lewes	Atlin and Tagish Lakes and tributaries
33	Teslin	Teslin Lake and tributaries
34	Alsek	Alsek R. and tributaries
35	Nakina	Nakina R. and tributaries
36	Upper Stikine	Upstream of Grand Canyon of the Stikine

Table 2. Description of 31 adult abundance datasets complied for bull trout populations in British Columbia. For datasets with more than five years of data, simple regression was used to test for positive or negative trends in abundance over time (see Section 3.3). Datasets that exhibited both positive and negative trends over time are indicated as having 'multiple trends' detected (see Section 5).

Region	EDU	Core area	Stream or lake	Sampling method / data type	No. years data	Time span	Range in abundance values	Detectable trend in abundance over time	Source
2	Lower Fraser	Lillooet	Phelix	fence count	5	2001-2009	27-185	no	Juteau and Jesson 2010
2	Puget Sound	Skagit	Skagit	snorkel count	5	1998-2010	159-1650	positive (P =0.03)	Nelson et al. 2002; Anaka and Scott 2010
2	South Coastal	Squamish	Cheakamus	snorkel count	13	1996-2009	75-316	multiple trends	Ladell et al. 2010
4	Columbia-Arrow	Pend d'Oreille	Salmo	redd count	12	1998-2009	38-109	no	Baxter and Decker 2010
4	Columbia-Arrow	ALR (all)	Arrow Lakes	angler catch/hour	23	1987-2009	0.02-0.13	no	Arndt and Schwarz 2011
4	Columbia-Arrow	ALR southern	Arrow tribs	redd count	2	2006-2007	198-260	na	Decker and Hagen 2008
4	Columbia-Arrow	ALR northern	Arrow tribs	redd count	2	2006-2007	755-586	na	Decker and Hagen 2008
4	Lower Kootenay	Kootenay Lake	Irishman	redd count	8	2000-2010	13-32	no	P. Corbett, consultant, data on file
4	Lower Kootenay	Kootenay Lake	Duncan	dam transfers	9	1995-2009	202-725	no	BC Hydro, Castlegar, data on file
4	Lower Kootenay	Kootenay Lake	Kaslo	resistivity counter	5	2006-2010	716-1219	no	Andrusak 2010
4	Lower Kootenay	Kootenay Lake	Crawford	resistivity counter	3	2008-2010	336-486	na	Andrusak 2010
4	Lower Kootenay	Kootenay Lake	Kootenay Lake	angler catch/hour	34	1962-2008	0.02-0.15	multiple trends	Andrusak 1987, 2007; Region 4, data on file
4	Upper Kootenay	Elk	Line	redd count	19	1986-2007	28-184	positive (P =0.001)	Chapman et al. 2008
4	Upper Kootenay	Upper Kootenay R	Skookumchuck	redd count	14	1997-2010	64-189	no	MOE, Region 4, data on file
4	Upper Kootenay	Upper Kootenay R	White	redd count	10	2001-2010	93-193	no	MOE, Region 4, data on file
4	Upper Kootenay	Koocanusa	Wigwam	redd count	17	1994-2010	105-2298	multiple trends	MOE, Region 4, data on file
5	Middle Fraser	Chilko lake	Long Valley	resistivity counter	2	2005-2006	433-693	na	Ladell et al. in prep.
6	Upper Skeena	Upper Sustut	Sustut	fence count	19	1992-2010	3-70	negative (P =0.04)	MOE, Region 6, data on file
6	Upper Skeena	Mid-Skeena	Kitwanga	fence count	7	2004-2010	31-495	no	Gitskan Watershed Authority, data on file
6	Upper Skeena	Lower Sustut/Skeen	Damshilgwet	fence count	11	2000-2010	22-302	positive (P =0.01)	Gitskan Watershed Authority, data on file
7	Upper Fraser	Upper Fraser	Goat	redd count	5	2003-2008	55-163	no	MOE, Region 7a, data on file
7	Upper Peace	Finlay Reach	Davis	redd count	9	2001-2010	37-85	no	Andrusak et al. 2011
7	Upper Peace	Parsnip Reach	Misinchinka	redd count	5	2006-2010	35-58	no	Andrusak et al. 2011
7	Upper Peace	Parsnip Reach	Scott	redd count	2	2009-2010	58-106	na	Andrusak et al. 2011
7	Upper Peace	Peace Reach	Point	redd count	5	2006-2010	5-39	no	Andrusak et al. 2011
7	Upper Peace	Thutade	Thutade Lake	redd count	16	1994-2009	122-288	positive (P =0.01)	Bustard 2011
9	Lower Peace	Halfway-Peace	Chowade	redd count	6	1995-2010	55-864	positive (P =0.01)	Euchner 2006, 2011
9	Lower Peace	Halfway-Peace	Needham	redd count	3	2007-10	52-103	na	Euchner 2011
9	Lower Peace	Halfway-Peace	Cypress	redd count	3	2007-10	18-120	na	Euchner 2011
9	Lower Peace	Murray	Wolverine	redd count	3	2007-09	25-67	na	Macullo and Goddard 2010
8	Middle Fraser	Upper Shuswap	Sugar Lake	angler catch/hour	4	1985-2004	0.01-0.26	positive (P =0.02)	derived fom Webster and Wilson 2005

Table 3. Summary of bull trout conservation status ranks for 26 Ecological Drainage Units (EDUs) known to support bull trout in British Columbia. Conservation status for each EDU is the weighted average of status ranks for all bull trout core areas within (See *Section 3.5* and *Appendix 3*).

			# core areas by category						-
Ecological *Drainage* Unit (EDU)	**Abundance data sets (#)**	**Core areas (#)**	**C1-High Risk**	**C2-At Risk**	**C3-Potential Risk**	**C4-Low Risk**	**CU-Unranked**	**EDU Status Ranking**	**Primary factor(s) affecting status**
South Coastal	1	1		1				C2-At Risk	Population size, threats
Lower Fraser	1	3					3	CU-Unranked	Concern over threats
Puget Sound	1	1				1		C4-Low Risk	Low threats, positive trend
Homathko-Klinaklini	0	4			1		3	C3-Potential Risk	Threats, expected stable trend
Bella Coola-Dean	0	2					2	CU-Unranked	Distribution in question
Thompson	1	7	2		5			C3-Potential Risk	Population size, threats
Upper Columbia	0	4			3		1	C3-Potential Risk	Stable/increasing trends
Columbia-Arrow	4	5	2	2		1		C3-Potential Risk	Abundance, threats
Upper Kootenay	4	4				2	2	C4-Low Risk	High abundance, low threats
Lower Kootenay	5	2		1	1			C3-Potential Risk	High threats in Slocan
Flathead	0	1		1				C2-At Risk	Threats (non-native lake trout)
Middle Fraser	1	18		2	1		15	C3-Potential Risk	Population size, threats
Upper Fraser	1	4			1		3	C3-Potential Risk	Low threats, wide distribution
Lower Skeena	0	1					1	CU-Unranked	Limited information
Upper Skeena	3	12		1			11	C2-At Risk	Habitat, exploitation threats
Upper Nass	0	5					5	CU-Unranked	Limited information
Iskut-Lower Stikine	0	3					3	CU-Unranked	Limited information
Upper Stikine	0	4					4	CU-Unranked	Limited information
Nakina	0	1					1	CU-Unranked	Limited information
Taku	0	3					3	CU-Unranked	Limited information
Lewes	0	1					1	CU-Unranked	Distribution in question
Teslin	0	1					1	CU-Unranked	Low conservation concern
Upper Peace	5	9			1		8	C3-Potential Risk	Low-moderate threats values
Lower Peace	4	9		3	1		5	C2-At Risk	High threats values
Upper Liard	0	7					7	CU-Unranked	Limited information
Lower Liard	0	5					5	CU-Unranked	Limited information

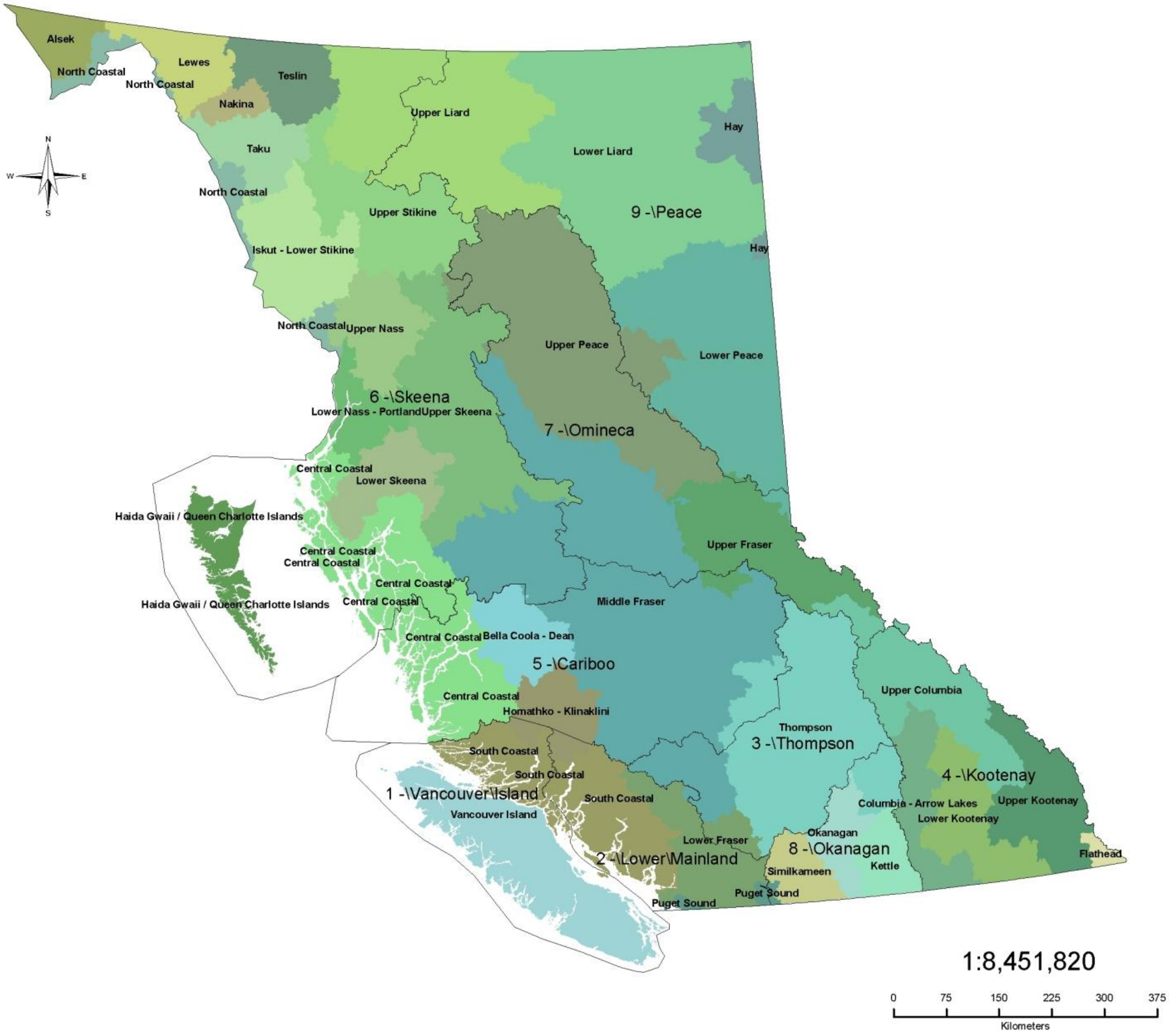

Figure 1. Map of management regions (black outlined areas) and Ecological Drainage Units (coloured areas; Ciruna et al. 2007) in British Columbia.

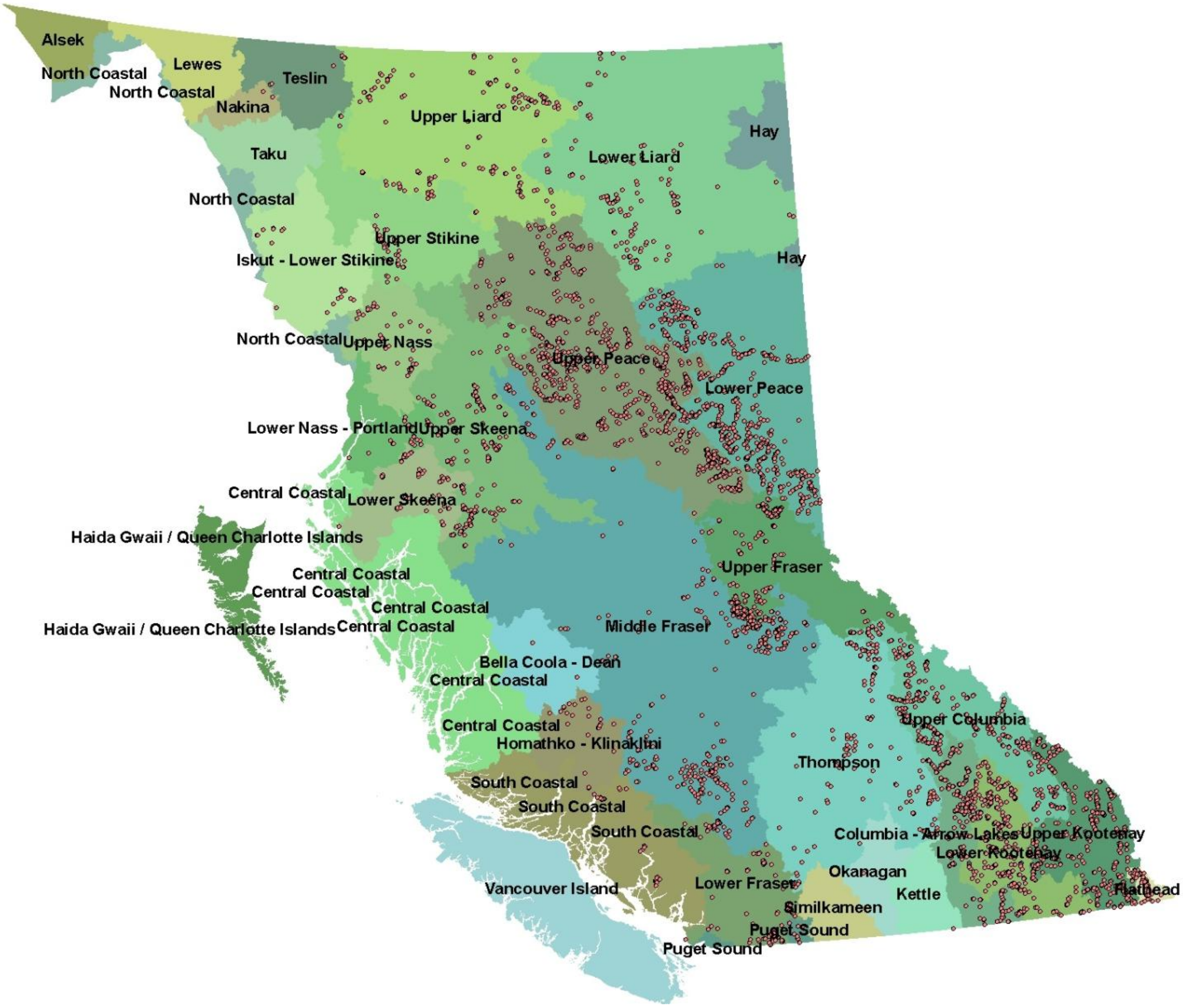

Figure 2. Map showing showing distribution of all recorded bull trout observations for British Columbia and for individual Ecological Drainage Units (Land and Resources Data Warehouse).

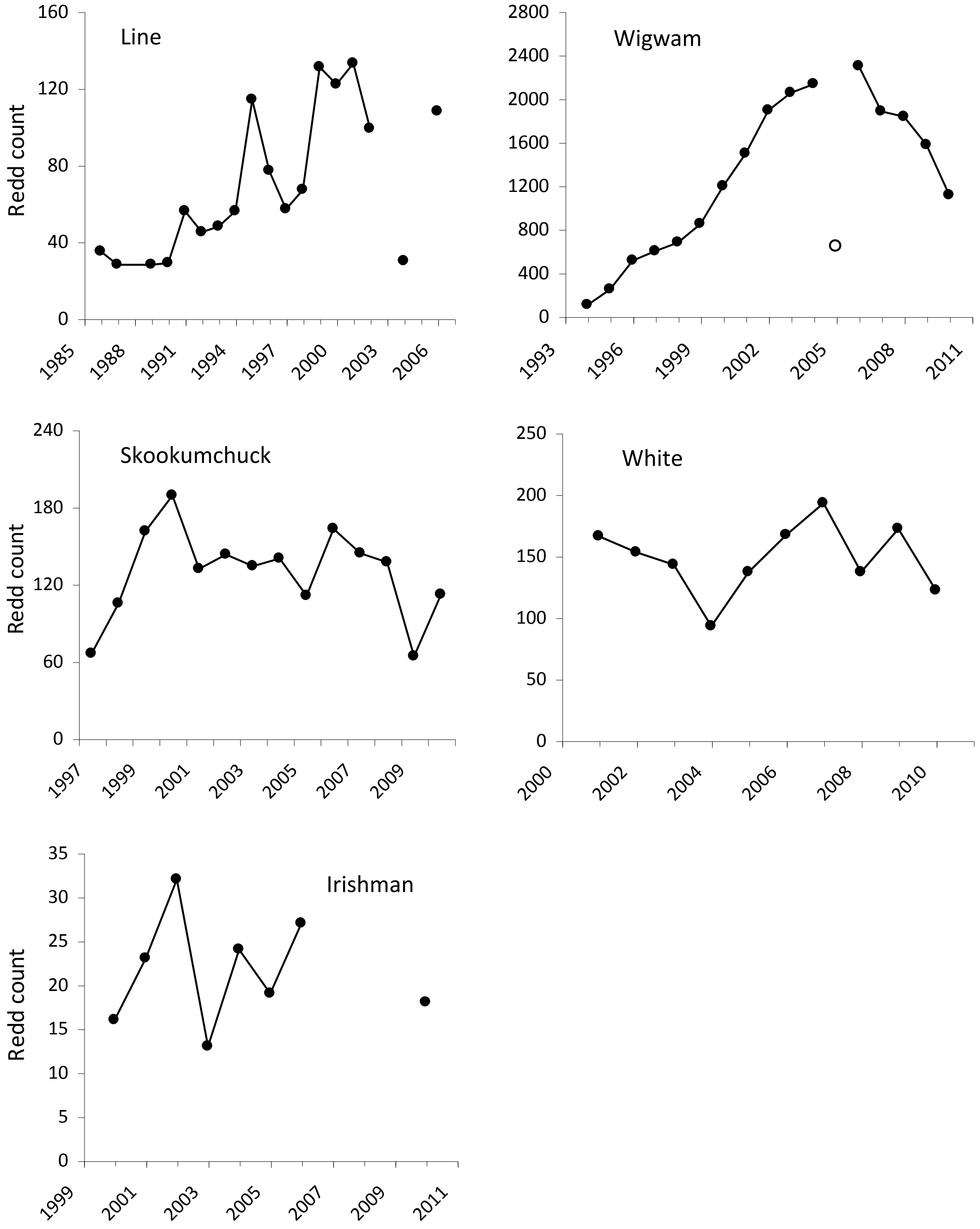

Figure 3. Annual bull trout redd counts for four streams (Line, Wigwam, Skookumchuck, White) in the Upper Kootenay Ecological Drainage Unit, and for Irishman Creek in the Lower Kootenay EDU (see Section 5 for details).

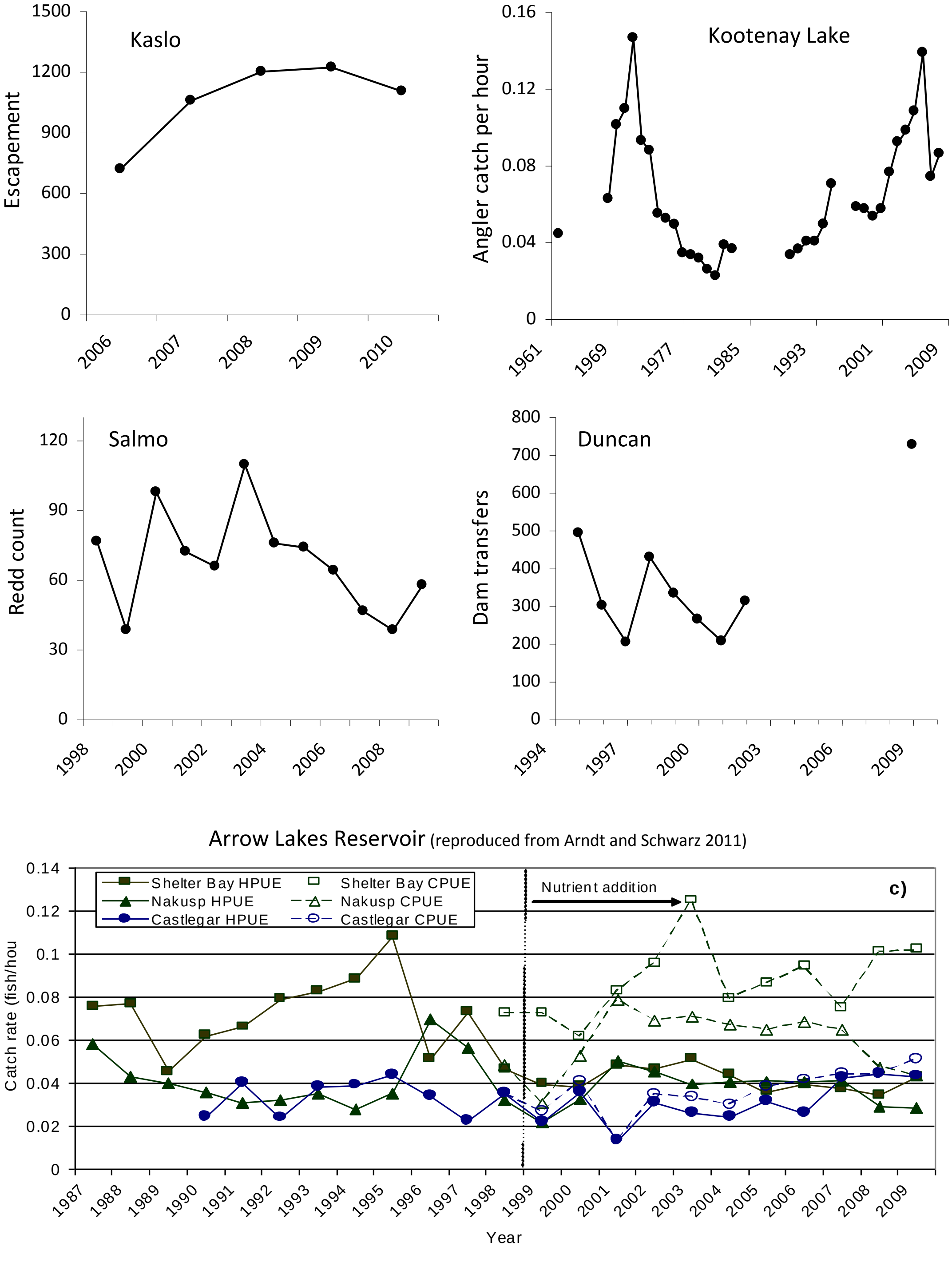

Figure 4. Annual indices of adult bull trout abundance for the Kootenay Lake core area in the Lower Kootenay EDU, including spawner escapement to the Kaslo River and the Duncan River system upstream of Duncan Dam, and angler catch rates in Kootenay Lake; and for the Salmo River watershed (redd counts) and the Arrow Lakes Reservoir (angler catch rates in the reservoir; Arndt and Schwarz 2011) in the Columbia-Arrow Lakes EDU (see Section 5 for details).

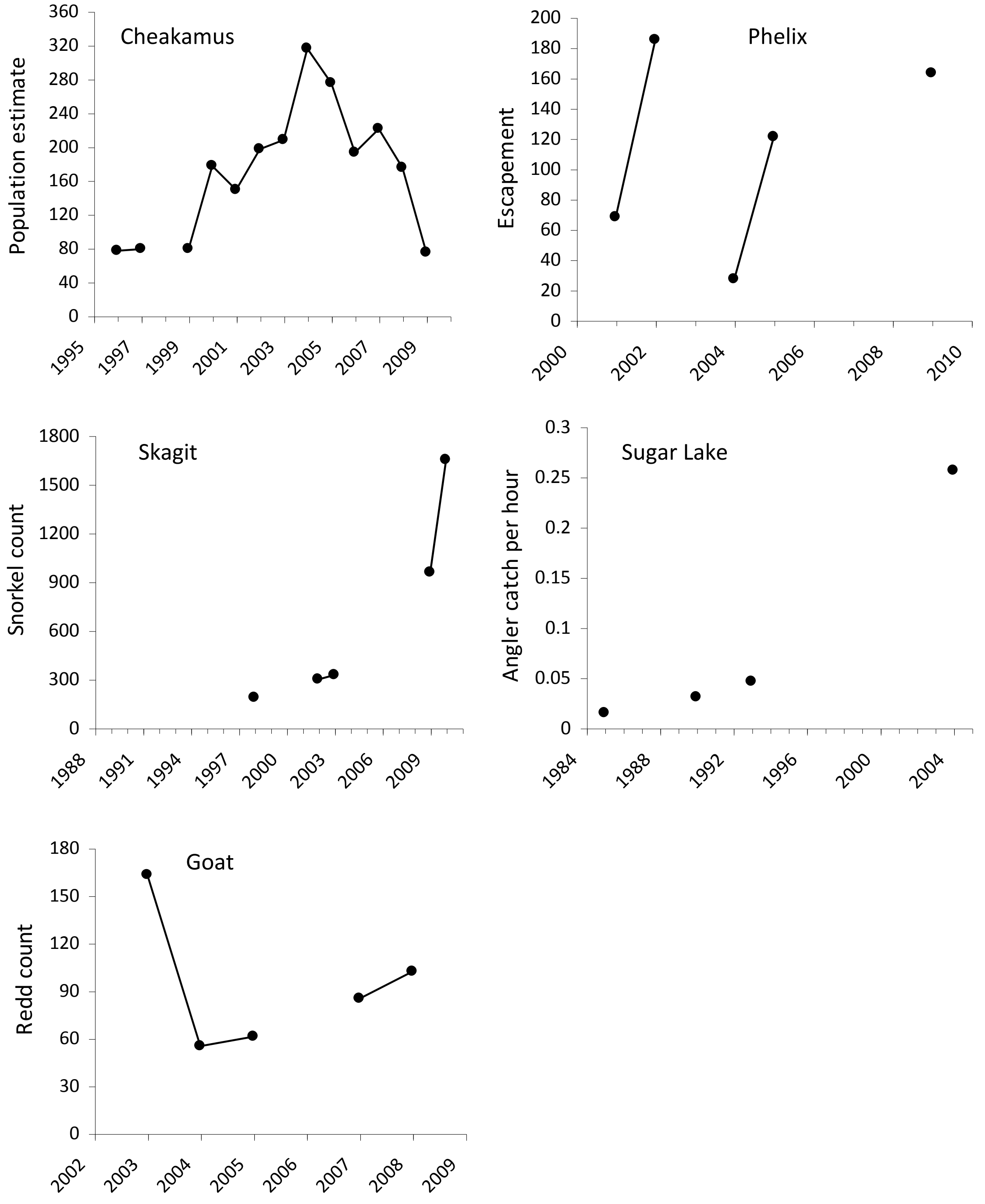

Figure 5. Time series of adult bull trout abundance including population estimates for the Cheakamus River and Phelix Creek in the South Coastal and Lower Fraser EDUs, respectively; snorkel counts for the Skagit River (Puget Sound EDU); angler catch rates for Sugar Lake (Upper Shuswap core area in the Thompson EDU); and redd counts for the Goat River in the Upper Fraser EDU (see Section 5 for details).

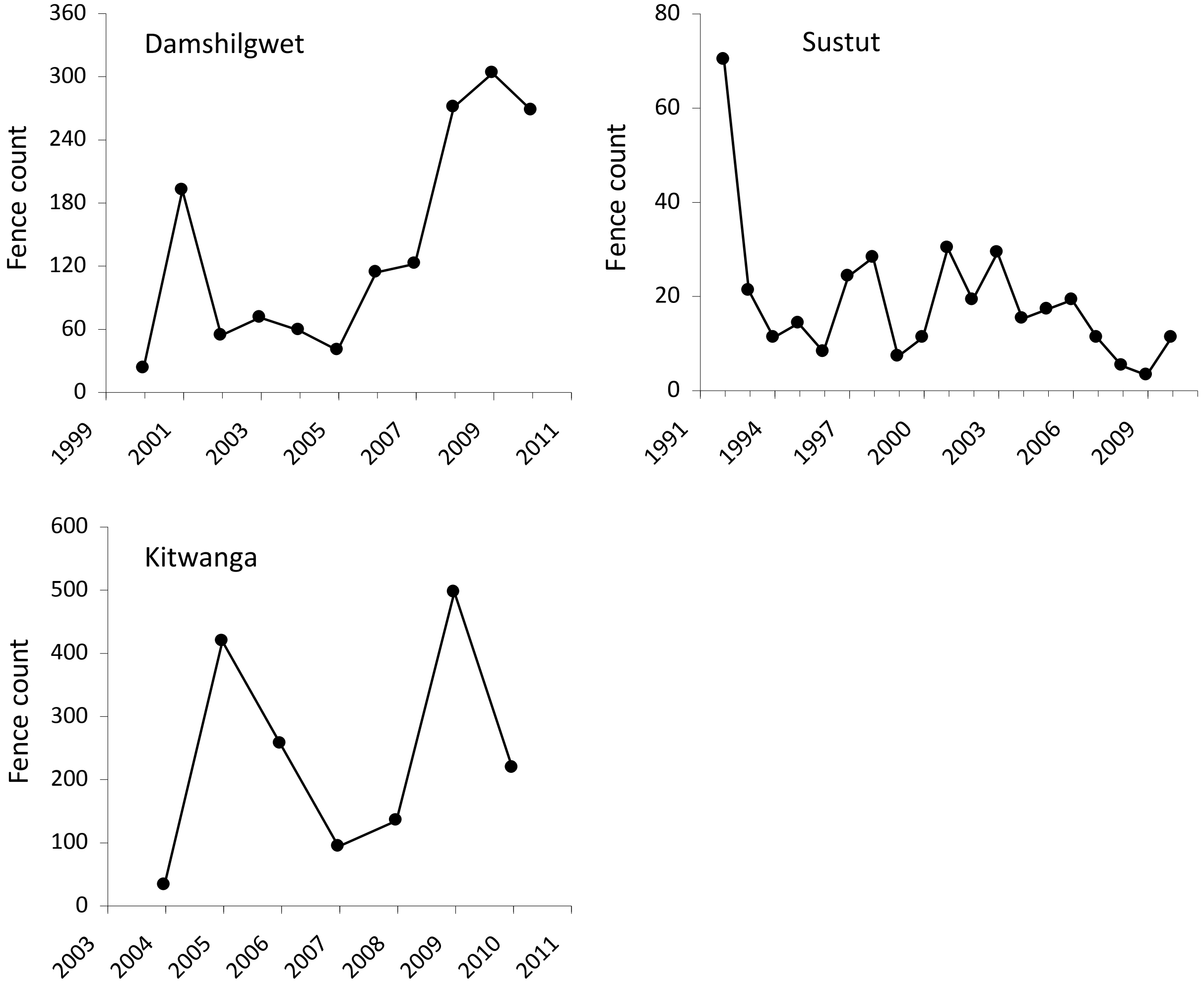

Figure 6. Annual counts of upstream migrating adult bull trout at full-span enumeration fences in Damshilgwet Creek (Slamgeesh River watershed), the upper Sustut River, and the Kitwanga River in the Upper Skeena EDU.

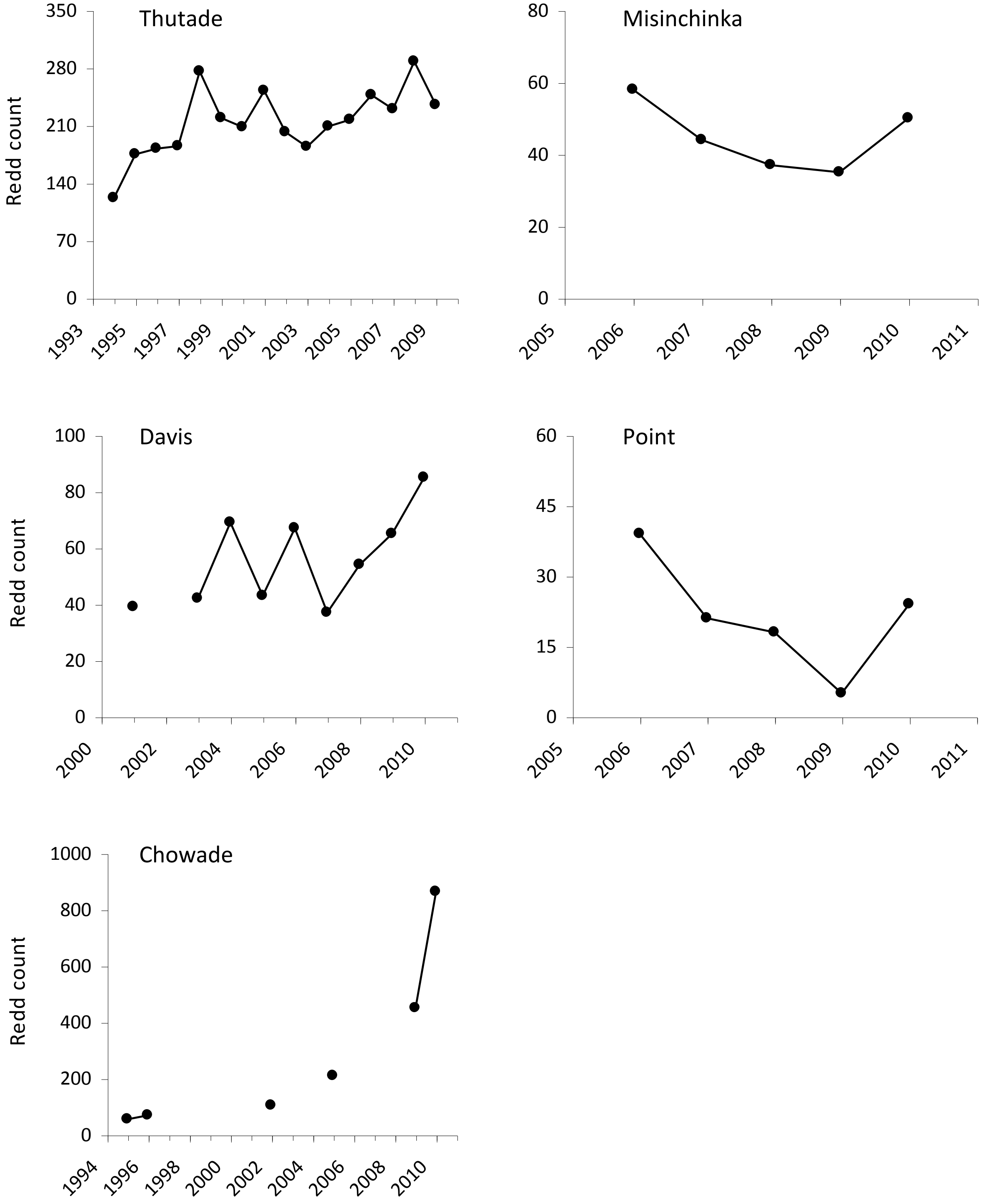

Figure 7. Annual bull trout redd counts for the Thutade Lake core area, and three tributaries of Williston Reservoir (Misinchinka, Davis, Point) in the Upper Peace EDU; and for the Chowade River in the Lower Peace EDU (see Section 5 for details).

Appendix 1. Instructions and categorical codes provided to regional biologists to solicit their qualitative expert judgments regarding the status of bull trout populations in core areas within each Ecological Drainage Unit occupied by bull trout in British Columbia (derived from USFWS 2005; see Section 3.4).

1. EDU	• delineated based on zoogeographic patterns of fish re-colonization, climatic patterns, and existing physical geography. • potential conservation units for assessing population 'health'
2. 'Core Area'	• population or groups of populations potentially interconnected by migration/straying, but acting approximately independently from other core areas • intended to approximate meta-population structure • examples: Squamish system, Lower Fraser, Morice system, Upper Kootenay, Upper Fraser, upper North Thompson, Upper Klinaklini • approximate scale: watersheds within larger EDU's • Fill in population size, distribution, and threats values for core area as a whole
3. 'Tributary'	• Tribs for which bull trout presence confirmed
4. 'Population size'	A 1-50 adults B 50-250 adults C 250-1,000 adults D 1,000-2,500 adults E 2,500-10,000 adults F 10,000-100,000 adults; not relevant U Unknown
5. 'Distribution' (area of occupancy within core area)	A <4 km B 4-40 km C 40-200 km D 200-1,000 km E 1,000-5,000 km U Unknown
6. 'Trend' (within 25 years)	A Severely declining. Decline of >70% in population, distribution, or number of occurrences B Very rapidly declining. Decline of 50-70% in " " " C Rapidly declining. Decline of 30-50% in " " " D Declining. Decline of 10-30% in " " " E Stable. Population, distribution, or number of occurrences unchanged or remaining within +/- 10% fluctuation F Increasing. Increase of >10% in population, distribution, or number of occurrences U Unknown
7. Threats ('Severity', Scope,' and 'Immediacy')	• The degree to which bull trout in the core area are observed, inferred, or suspected to be directly or indirectly threatened • Habitat threats include loss of connectivity due to migration barriers, loss of habitat complexity, human-induced water temperature increases (extensive forestry, etc.) • Exploitation threats should consider high vulnerability of bull trout to angling, current regulations, and monitoring • Competitors: Brook trout can displace bull trout or hybridize - their presence in a core area is a significant threat to long-term bull trout persistence. Introduced Lake Trout are likely to displace bull trout from lacustrine environments. • For all threats (habitat, exploitation, and competitors) considered as a whole, estimate levels of severity, scope, and immediacy
Severity	**High:** Loss of population or destruction of species' habitat in area affected, with effects irreversible or requiring long-term recovery (>100 yrs) **Moderate:** Major reduction of species population or long-term degradation or reduction of habitat in the core area, requiring 50-100 yrs for recovery **Low:** Low but significant reduction of species population or reversible degradation or reduction of habitat in area affected, with recovery expected in 10-50 yrs **Insignificant:** Essentially no reduction of population or degradation of habitat or ecological community due to threats, or recovery from minor temporary loss possible within 10 yrs (Note that effects of locally sustainable levels of fishing are generally considered insignificant as defined here).
Scope	**High:** >60% of total population or area affected **Moderate:** 20-60% of total population or area affected **Low:** 5-20% of total population or area affected **Insignificant:** <5% of total population or area affected
Immediacy	**High:** Threat is happening now or imminent **Moderate:** Threat is likely to be operational within 2-5 yrs **Low:** Threat is likely to be operational within 5-20 years **Insignificant:** Threat is not likely to be operational within 20 yrs
8. Recovery potential	**Low:** Irreversible losses or requiring long-term recovery (>50 yrs) **Moderate:** Significant losses but recovery possible within 10-50 yrs **High:** minor temporary losses or recovery possible within 10 yrs
9. Comments	• Opportunity to qualify rankings, describe populations or information sources, etc.

Appendix 2. Table used to calculate threat values for individual bull trout core areas within each Ecological Drainage Unit in British Columbia (see Appendices 3-9) based on categorical ratings provided by regional biologists for different types of threats (habitat, exploitation, competitiors) and different threat attributes (severity, scope, and immediacy (derived from USFWS 2005; see Appendix 1 and Section 3.4 for details).

SEVERITY	*SCOPE*	*IMMEDIACY*	*VALUE*	*DESCRIPTION*
High	High	High	A	Moderate to severe, imminent threat for most (>60%) of population, occurrences, or area
High	High	Moderate		
Moderate	High	High		
Moderate	High	Moderate		
High	Moderate	High	B	Moderate to severe imminent threat for a significant proportion (20-60%) of population, occurrences, or area
High	Moderate	Moderate		
Moderate	Moderate	High		
Moderate	Moderate	Moderate		
High	High	Low	C	Moderate to severe, nonimminent threat for significant proportion of population, occurrences, or area
Moderate	High	Low		
High	Moderate	Low	D	Moderate to severe, nonimminent threat for a significant proportion of population, occurrences, or area
Moderate	Moderate	Low		
High	Low	High	E	Moderate to severe threat for small proportion of population, occurrences, or area
High	Low	Moderate		
High	Low	Low		
Moderate	Low	High		
Moderate	Low	Moderate		
Moderate	Low	Low		
Low	High	High	F	Low severity threat for most or significant proportion of population, occurrences, or area
Low	High	Moderate		
Low	High	Low		
Low	Moderate	High		
Low	Moderate	Moderate		
Low	Moderate	Low		
Low	Low	High	G	Low severity threat for a small proportion of population, occurrences, or area
Low	Low	Moderate		
Low	Low	Low		
Two of three insignificant			H	Unthreatened. Threats are minimal or very localized
Two of three unknown or not assessed			U	Unknown. The available information is not sufficient to assign a degree of threat

Appendix 3. Numeric scoring procedure for assigning core area conservation status ranks to core areas for which categorical estimates of abundance and distribution information exist (see Section 3.5), and description of conservation status ranks.

Core Area Numeric Scoring (USFWS 2005, Appendix A)

(Starting value = 3.5)

Categorical value	Population Size	Distribution*	Trend	Threats
U	0	0	0	0
A	-1	-1	-1	-1
B	-0.75	-0.75	-0.75	-0.75
C	-0.5	-0.5	-0.5	-0.5
D	-0.25	-0.25	-0.25	-0.25
E	-0.25	0	0	0
F	0	-	+0.25	0
G	-	-	-	+0.75
H	-	-	-	+1.0

* lower score by one rank (i.e. reduce risk) if anadromous or adfluvial

Points (P)	C Rank	Description
P≤1.5	C1	**HIGH RISK** - Core area at high risk because of extremely limited and/or rapidly declining numbers, range, and/or habitat, making the bull trout in this core area highly vulnerable to extirpation
1.5<P≤2.5	C2	**AT RISK** - Core area at risk because of very limited and/or declining numbers, range, and/or habitat, making the bull trout in this core area vulnerable to extirpation
2.5<P≤3.5	C3	**POTENTIAL RISK** - Core area potentially at risk because of limited and/or declining numbers, range, and/or habitat even though bull trout may be locally abundant in some areas of the core area.
3.5<P≤4.5	C4	**LOW RISK** - Bull trout common or uncommon, but not rare, and usually widespread throughout the core area. Apparently not vulnerable at this time, but may be cause for long-term concern.
N/A	CU	**UNRANKED** - Core area currently unranked due to lack of information or due to substantially conflicting information about status and trends.
N/A	CX	**EXTIRPATED** - Core population extirpated; not a viable core area.

Appendix 4. Summary of expert judgment information for bull trout core areas in 26 EDUS known to support bull trout in British Columbia. Definitions for classification codes are provided in Appendices 1 and 2 (see Section 3.4 for more details).

<table>
<tr><th colspan="4">Geographic information</th><th>Life history</th><th colspan="4">Adult population (see Table 2 for codes)</th><th colspan="13">Threat (high-H, moderate-M, low-L, insignificant-I)</th><th>Status</th></tr>
<tr><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th colspan="4">Severity</th><th colspan="4">Scope</th><th colspan="4">Immediacy</th><th></th><th></th></tr>
<tr><th>Region (1-9)</th><th>Ecological Drainage Unit</th><th>Core Area</th><th>Tributary (sub-tributary)</th><th>(res, adfluv, fluv, anad)</th><th>Pop. size</th><th>Distribution</th><th>Trend</th><th>Reference</th><th>Habitat</th><th>Exploitation</th><th>Competitors</th><th>Overall</th><th>Habitat</th><th>Exploitation</th><th>Competitors</th><th>Overall</th><th>Habitat</th><th>Exploitation</th><th>Competitors</th><th>Overall</th><th>Overall threat value</th><th></th></tr>
<tr><td>2</td><td>South Coastal</td><td>Squamish</td><td>Squamish, Mamquam, Cheakamus (Cheekye, Culliton, Brohm, Daisy L, Upper Cheakamus (Brandywine, Callaghan), Pillchuck, Ashlu, Shovelnose, upper Squamish, Elaho</td><td>adfluv, fluv, anad, (res?)</td><td>C?</td><td>C</td><td>D</td><td>Ladell et al. 2010</td><td>H</td><td>M</td><td>L</td><td>M</td><td>M</td><td>M</td><td>I</td><td>M</td><td>H</td><td>M</td><td>H</td><td>H</td><td>B</td><td>at risk</td></tr>
<tr><td colspan="23"><i>Comment: Abundance data (snorkel counts) available for Cheakamus R. Area of Dolly Varden, bull trout sympatry; distribution of each not defined; popular angling area of region; Cheakamus R railway spill impacted BT but recovering; possible isolated BT population in upper Mamquam; Angling Guides report stable BT populations; snorkeling-based population estimate for Cheakamus indicates adult population for core area >200 (see text); significant DFO stocking programs may contribute to BT food source; IPP development is in place on a number of char systems (Furry C, Ashlu R, Mamquam R); logging past and present is a threat; transportation/communications corridor - Sea to Sky Highway, hydro lines and railway confine systems; small population of brook trout from previous lake stocking (Lucille Lake) now in Chance Cr trib to Cheakamus R, but not a big threat.</i></td></tr>
<tr><td>2</td><td>Lower Fraser</td><td>Lower Fraser</td><td>Pitt (Pitt L, Upper Pitt, Corbould, Boise), Alouette Reservoir, Stave Reservoir, Upper Stave, Harrison, Harrison L (Talc, Big Silver, Stokke, Trethaway, Sloquet), Chehalis (Chehalis L), Chilliwack (Cultus, Cultus L, Liumchen, Tamihi, Borden, Slesse, Chipmunk, Foley, Nesakwatch, Center, Post, Chilliwack L, Depot, Paleface, upper Chilliwack)</td><td>adfluv, fluv, anad</td><td>U</td><td>D</td><td>D</td><td>Taylor and Costello 2006</td><td>M</td><td>L</td><td>I</td><td>L</td><td>M</td><td>M</td><td>I</td><td>M</td><td>H</td><td>M</td><td>I</td><td>M</td><td>F</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment: Bull trout core areas limited to watersheds with known bull trout presence; Dolly Varden may dominate distribution in small streams without glacial influence; portion of Pitt R in provincial park; Chilliwack L and Cultus L in Provincial Park; Chilliwack L population is transboundary with Washington State; impact of Chehalis Lake slide on BT is unknown; BT migration from upper Pitt River to Fraser River at Pattulo Bridge is documented; BT knowledge limited in this area; older angler survey available for Chilliwack Lake BT by LGL; BT also present in Alouette and Stave Reservoirs (BC Hydro impoundments); IPPs developments in area but require review for BT; area of stream recovery from past logging; Little known regarding BT in Pitt L and Harrison L; all-season resort proposed for west Harrison area .</i></td></tr>
<tr><td>2</td><td>Lower Fraser</td><td>Lillooet</td><td>Lillooet, Gowan, Snowcap, Tuwasus, Billygoat, Little Lillooet L, Lillooet L, Kakila, Lizzie, Green (Rutherford), Birkenhead (Spetch, Poole, Taillefer, Birkenhead L, Phelix), Miller, Ryan, Wolverine, Railroad, North, Meagher, Green (Alta, Alta L, Fitzsimmons/Blackcomb, Green L), upper Lillooet,</td><td>res, adfluv, fluv, (anad?)</td><td>U</td><td>D</td><td>E</td><td>Taylor and Costello 2006; Walter and Scott 2001; Jesson 2003; Jesson and Juteau 2005</td><td>H</td><td>M</td><td>I</td><td>M</td><td>M</td><td>M</td><td>I</td><td>M</td><td>H</td><td>H</td><td>I</td><td>H</td><td>B</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment: Adult fence on East Phelix Cr. indicates small stable population for Birkenhead Lake system (150 - 200 BT). Agricultural disturbances in Phelix Cr. Poaching occurrences on Lillooet system; Birkenhead L in provincial park; BT spawners in Ryan R from Lillooet L?. Isolated populations of stunted BT above barriers on Birkenhead R and Sockeye C (trib to Birkenhead L); Green Lake (near Whistler) population threatened by gravel removal activities in lower Firzsimmons C; IPP on Miller C; IPP on Fitzsimmons C (upstream of BT migration); IPPs proposed for Ryan C (BT in diversion reach) and other systems.</i></td></tr>
<tr><td>2</td><td>Lower Fraser</td><td>Lower Fraser Canyon</td><td>Silverhope (upper Silverhope, Silver Lake), Coqhihalla (Sowaqua, Dewdney, Ladner, Boston Bar, upper Coquihalla)</td><td>fluv, adfluv, (res?)</td><td>U</td><td>U</td><td>U</td><td></td><td>L</td><td>L</td><td>I</td><td>L</td><td>M</td><td>L</td><td>I</td><td>L</td><td>H</td><td>L</td><td>I</td><td>L</td><td>G</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment: Bull trout core areas limited to watersheds with known bull trout presence; Dolly Varden may dominate distribution in small streams without glacial influence; resident bull trout present above falls on Dewdney C, Boston Bar C?; Little known regarding BT populations in this area; BT population thought to be small; linear developments in Coquihalla R (pipeline); past logging recovery.</i></td></tr>
<tr><td>2</td><td>Puget Sound</td><td>Skagit</td><td>Ross L, Skagit, McNaught, Shawatum, St. Alice, Klesilkwa, Sumallo (Potter), Skaist, upper Skagit</td><td>adfluv, fluv, res</td><td>D</td><td>B/C</td><td>F</td><td>McPhail and Taylor 1995; USFWS 2005</td><td>H</td><td>L</td><td>I</td><td>L</td><td>M</td><td>L</td><td>I</td><td>L</td><td>H</td><td>H</td><td>H</td><td>H</td><td>G</td><td>low risk</td></tr>
<tr><td colspan="23"><i>Comment: Abundance data (snorkel counts) available for Skagit R. Transboundary population with Washington State; Significant portion of watershed in provincial or US parks; increasing BT population in Ross-Skagit system; Upper Skagit recreational fishery moving from RB to BT; Ross Reservoir impacts connectivity with Lower Skagit in Washington State; Some brook trout in small high elevation lakes on US side but removal program in place; redside shiner introduction into Ross plus restrictive regulation resulting in increasing BT abundance?; approx. 70% of upper Skagit located in park; some mining, forestry and recreational expansion (Sumallo) in non-park areas; DV-BT hybridization of scientific interest;</i></td></tr>
</table>

Appendix 4 continued.

Geographic information				Life history	Adult population (see Table 2 for codes)				Threat (high-H, moderate-M, low-L, insignificant-I)													Status
									Severity				Scope				Immediacy					
Region (1-9)	Ecological Drainage Unit	Core Area	Tributary (sub-tributary)	(res, adfluv, fluv, anad)	Pop. size	Distribution	Trend	Reference	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	**Overall threat value**	
1	Homathko-Klinaklini	Lower Klinaklini	Klinaklini, Devereux (Devereux L, Laura L), Canyon L	fluv	U	U	U	Taylor and Costello 2006	M	I	I	**M**	L	I	I	**L**	L	I	I	**L**	E	unranked
Comment: Area of Dolly Varden, bull trout sympatry; distribution of each not defined; limited records in LRDW; hydroelectric development proposed; fluvial bull trout adults present in the lower Kliniklini.																						
5	Homathko-Klinaklini	Upper Klinaklini	Klinaklini, North Kliniklini (Knot L), Bussel, McClinchy (McClinchy L), One Eye L, Miner L, upper Klinaklini	fluv, adlfluv, resid?	D?	D	E	Triton Environmental Consultants Ltd. 1998	L	L	I	**L**	M	L	I	**L**	L	L	I	**L**	G	unranked
Comment : No formal assessments completed other than limited species inventory/distribution surveys. Kliniklini population as a whole likely stable and healthy; anecdotal evidence of decline in One Eye Lake adfluvial population. Large portion of watershed in Tweedsmuir Park; little development. Watershed less vulnerable to climate change due to heavily glaciated headwaters. (see Region 2 for lower Klinaklini).																						
2	Homathko-Klinaklini	Lower Homathko	Homathko (Cumsack, Smith, Heakamie, Jewakwa, Brew, Scar, Klattasine), Teaquahan (Galleon), Southgate (Elliot, Icewall, Raleigh, Sisyphus, Bishop)	fluv, anad	C?	C/D	E	Redenbach and Taylor 2003; Taylor and Costello 2006; Aquatic Resources 1999	L	I	I	**I**	L	I	I	**I**	L	L	I	**L**	H	potential risk
Comment: Area of DV/BT sympatry; distribution of each not defined; Scar Creek is important system; bull trout common in lower Southgate and tribs; main threat will be future IPP development if approved and eventually future global warming; historic past logging practices likely an issue but improving; little angling pressure, mainly by Vancouver Island based angling guides in spring.																						
5	Homathko-Klinaklini	Upper Homathko	Homathko, Doran, Mosley (Scimitar, Five Finger, Crazy, Middle L, Horn L, Bluff L, Sapeye L, Little Sapeye L), Notstetuko, Ottarasko, Tatlayoko L, Upper Homathko	fluv, adlfluv, resid?	D?	D	E		L	L	I	**L**	M	L	I	**L**	L	L	I	**L**	G	unranked
Comment : No formal assessments completed other than limited species inventory/distribution surveys. Homathko population as a whole likely stable and healthy; suspected declines in Bluff L and Sapeye L adfluvail pops due to overharvest and loss of stream habitat/access. Watershed less vulnerable to climate change due to heavily glaciated headwaters. (see Region 2 for lower Homathko)																						
5	Bella Coola-Dean	Upper Dean	Upper Dean, Nimpo L, Lessard, Tusulko, Hump, Beef Trail, Far, Obsidian, Tanswanket	adfluv, flu, resid	U	C	U	MacPhail 2007	L	L	L	**L**	H	L	M	**M**	H	L	L	**L**	F	unranked
Comment : MacPhail (2007) indicates that BT are present in the upper Dean River east of the Coast Mts, whereas BC MOE regional staff indicate that only Dolly Varden are present . The occurence of BT seems likely, given minimal geographic separation with other BT systems (Little Chilcotin, West Road). Only Dolly Varden reported for lower Dean. BT/DV are well distributed in tributaries of the upper Dean R downstream of Abuntlet L. Habitat degradation likely in core reaches (increased temperatures) as beetle-killed pine forest now dominates.																						
5	Bella Coola-Dean	Upper Atnarko	South Atnarko?	resid	U	B	U	MacPhail 2007														unranked
Comment : MacPhail (2007) indicates that BT are present in the upper portion of the Atnarko River east of the Coast Mts, whereas BC MOE regional staff indicate that only Dolly Varden are present. The occurence of BT seems likely, given minimal geogrphical separation with the Klinaklini system at several points (e.g, Knot Lake). Several bull trout have been captured in the lower Atnarko, which could represent drop-downs from the upper river or perhaps a local population (MacPhail 2007).																						
8	Thompson	Upper Shuswap	Sugar L, Upper Shuswap (Sitkum, Star, Vigue, Gates, Vanwyk, Lindmark, Greenbush L)	adfluv, resid?	C	C	F	Morris and Wilson 2005; Webster and Wilson 2005	L	M	U	**L**	L	M	U	**M**	U	L	U	**L**	F	potential risk
Comment : Abundance data (creel survey) available for Sugar L. ; Adfluvial population in Sugar Lake with spawning and rearing occurring in tributaries of the upper Shuswap River. Isolated from remainder of Shuswap R. by dam at outlet of Sugar L. Sporadic creel surveys spanning 1974-2004 indicate several-fold increase in catch rate and larger average body size in recent years following the introduction of a 50 cm minimum size limit. Kokanee present in Sugar Lake. Tributary habitat in in good condition, but the extent of which is currently used by bull trout is unclear.																						
8	Thompson	Middle Shuswap	Cherry (Monashee, Severide)	fluvial, resid?	A	B	B	Chamberlain et al. 2001; Arc Environmental Ltd. 1999	H	M	H	**H**	H	M	H	**H**	H	L	M	**H**	A	high risk
Comment : Isolated from upstream and downstream habitats by two dams. Available habitat is both limited and marginal habitat due to unfavorable thermal regime and dam-related habitat degradation ith other popualtions. No access to anadromous salmon or kokanee food sources. Not clear where spawning and juvenile production occurs in Cherry Creek drainage (if at all). High risk of extirpation in near future.																						

Appendix 4 continued.

Geographic information				Life history	Adult population (see Table 2 for codes)				Threat (high-H, moderate-M, low-L, insignificant-I)													Status
									Severity				**Scope**				**Immediacy**					
Region (1-9)	Ecological Drainage Unit	Core Area	Tributary (sub-tributary)	(res, adfluv, fluv, anad)	Pop. size	Distribution	Trend	Reference	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	**Overall threat value**	
3	Thompson	Adams Lake	Adams L (Sinmax, Momich, Momich L, Cayenne, upper Adams River, Tumtum L, Oliver),	adfluv	C	C	U	Obrien and Chamberlain 2003; Bison et al. 2003	M	L	I	**L**	M	H	I	**M**	U	L	I	**L**	F	potential risk
Comment : Local adfluvial populations present in both Adams L. and smaller lakes within tributaries. Recent introduction of a 80 cm minimum size limit in Adams L. has likely reduced exploitation. Moderate impacts to tributaries from forest harvesting and associated road development, but tributary spawning and rearing habitat remains in relatively good condition.																						
3	Thompson	Shuswap Lake	S. Thompson, Chase, Shuswap L, Scotch (Kwikoit), Seymour (McNomee), Ross, Celista, Hunakwa (Hunakwa L.), Humamilt L, Anstey, Shuswap (Mara L), Eagle (Perry, upper Eagle, Three Valley Gap Lakes)	adfluv, resid	D	D	U	Carswell and Philip 1979; Arc Environmental Ltd. 1998; Silvatech Consulting Ltd. 2001	L	L	I	**L**	U	H	I	**H**	U	U	I	**U**	F	potential risk
Comment : Local adfluvial populations present in both Shuswap L. and smaller lakes within tributaries. Adfluvial bull trout populations occur in sympatry with endemic lake trout populations in the Three Valley Gap lakes in the Eagle River system (R. Bison, MOE Kamloops Region, pers. comm.), which is atypical, as bull trout are often restricted to a resident life history form in tributary habitat when naturally co-occurring with lake trout in low elevation lakes (Donald and Alger 1993). Introduction of a 60 cm minimum size limit and one char per day in Shuswap L. may have reduced exploitation. Extensive lake-shore residential development on Shuswap L. Impacts to tributaries from forest harvesting and associated road development, but most tributary spawning and rearing habitat remains in relatively good condition. Local resident populations above barriers in Perry and Seymour rivers. Some tributaries (e.g., Celista, Hunakwa, Ross, Scotch) vulnerable to climate change. Possible extirpation of bull trout, (both the resident and adfluvial life history forms) from Scotch Creek (present in 1979 survey, but not detected in extensive 1999 survey).																						
8	Thompson	Mabel Lake	Lower Shuswap, Ashton, Trinity, Cooke, Kingfisher, Mabel L, Wap (Cavanaugh, Derry, Devil), Latewhos	adfluv, resid	C	D	U	Morris and Wilson 2004; Chamberlain et al. 2001	M	M	L	**M**	M	M	L	**M**	L	M	L	**L**	D	potential risk
Comment : Recent introduction of a 50 cm minimum size limit and one char per day in Mabel L. has likely reduced exploitation. Impacts from hydroelectric development in middle Shuswap River including; 1) blocked access to historic habitats, 2) loss of habitat, 3) reduced habitat capability. Impacts to tributaries from forest harvesting and associated road development, but spawning and rearing habitat remains in relatively good condition. Local resident populations occur in several tributaries to lower Shuswap River (Kingfisher, Cooke, Trinity, Ashton). All tributaries have moderate elevation drainages and are likely vulnerable to climate change.																						
3	Thompson	Nicola	Nicola (upper Coldwater/upper Spius)	fluv, resid	A/B	B	B	Decker and Caverly 2007; Henderson 2002	H	M	H	**H**	H	H	H	**H**	M	L	I	**M**	A	high risk
Comment : Core area is limited to upper headwater reaches of the Coldwater River and Spius Creek. Core area habitat marginal owing to warmer than optimum summer water temperatures and competition with other salmonids. Primarily a fluvial population, but may be shifting to a resident life history due to poor access to adult foraging habitats downstream. Low densities of redds and juveniles observed in core area reaches. Connectivity with other habitats and populations is limited by high water temperatures and low flows in downstream stream reaches. Some evidence of range contraction over time in Coldwater River. Substantial threats include linear corridor developments and ski/golf resort proposal in Coldwater River, pine beetle salvage logging in Spius Creek, and climate change.																						
3	Thompson	North Thompson	Canvas, N. Thompson, Bone, Serpentine (inc. headwaters), Finn, Blue (White, N. Blue), Mud (Mud L), Cook, Bone, Thunder, Miledge, Chappell, Albreda (Dominion, Allan, Clemina), Canvas, Adolph, Gum, Stormking, McAndrew, Barriere (Harper, Saskum, Birk), Clearwater (Moul, Hemp), Dunn (Dunn Lake)	fluv, adfluv	D	D	U	Hagen and Baxter 1992; Wescott and Standen 1993; Coombes 1991	L	L	I	**L**	U	H	I	**M**	U	U	I	**L**	F	potential risk
Comment : Fluvial populations dominate but local resident populations are present, as well as local adfluvial populations (Mud, Dunn, Saskum, North and East Barriere lakes). Extensive tributary habitat in in good to excellent condition is available. Very large and old (maximum 24 years) bull trout have been recorded from the North Thompson River, suggesting that exploitation rates are relatively low compared to other southern BC stocks. Local populations are likely less healthy in the lower portion of the North Thompson drainage versus those in the upper watershed due to higher exploitation, less favorable thermal regimes and greater competition threats from other species. . Hydroelectric projects have been proposed for most of the larger tributaries in the upper North Thompson drainage, and have been approved for three (Bone, Clemina, Serpentine). Proposal for large open pit mine in Harper Creek drainage may impact bull trout. Adfluvial bull trout populations occur in sympatry with endemic lake trout populations in North Barrier and Saskum lake.																						
4	Columbia-Arrow Lakes	Columbia River	Blueberry; Casino	fluv	A	B	D	Hagen 2008	H	L	U	**H**	M	L	L	**M**	H	L	L	**H**	B	high risk
Comment: connectivity remains only with Blueberry C, which has numerous obstacles previously thought to be migration barriers; numbers have probably declined drastically since dam construction.																						

Appendix 4 continued.

<table>
<tr><th colspan="4">Geographic information</th><th>Life history</th><th colspan="4">Adult population (see Table 2 for codes)</th><th colspan="13">Threat (high-H, moderate-M, low-L, insignificant-I)</th><th>Status</th></tr>
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<tr><th>Habitat</th><th>Exploitation</th><th>Competitors</th><th>Overall</th><th>Habitat</th><th>Exploitation</th><th>Competitors</th><th>Overall</th><th>Habitat</th><th>Exploitation</th><th>Competitors</th><th>Overall</th></tr>
<tr><td>4</td><td>Columbia-Arrow Lakes</td><td>Pend d'Oreille</td><td>Salmo R; South Salmo; Sheep; upper Salmo; Clearwater</td><td>fluv</td><td>A/B</td><td>B</td><td>D</td><td>Baxter 2008; Hagen 2008</td><td>H</td><td>L</td><td>M</td><td>H</td><td>H</td><td>L</td><td>M</td><td>H/M</td><td>H</td><td>L</td><td>M</td><td>H</td><td>A/B</td><td>high risk</td></tr>
<tr><td colspan="23"><i>Comment: Abundance data (redd counts) available for Salmo R. spawning tribs.; connectivity with all other populations and Columbia mainstem cut off; Salmo mainstem of marginal suitability because of recent high summer temperature and lack of a prey fish base; low and declining abundance (approaching 50) and distribution; brook trout relatively abundant.</i></td></tr>
<tr><td>4</td><td>Columbia-Arrow Lakes</td><td>ALR - 'Southern' lineage</td><td>McDonald C; Cariboo, Snow, Burton C complex; Woden; Mosquito; Taite</td><td>adfluv/res</td><td>C</td><td>B</td><td>E</td><td>Latham 2002; Arndt 2004; Decker and Hagen 2008</td><td>M</td><td>L</td><td>L</td><td>L</td><td>H</td><td>L</td><td>L</td><td>M</td><td>M</td><td>L</td><td>L</td><td>M</td><td>F</td><td>at risk</td></tr>
<tr><td colspan="23"><i>Comment: Total spawner population estimates available from redd counts in 2006-2007 (Decker and Hagen 2007) Angler effort and success relatively stable since 1970s (Arndt 2004); rearing habitats on margin of temperature suitability - highly vulnerable (Decker and Hagen 2007). Genetically unique above-barrier population in Woden C.</i></td></tr>
<tr><td>4</td><td>Columbia-Arrow Lakes</td><td>ALR - 'Northern' lineage</td><td>Illecillewaet (and tribs); Incomappleaux (and tribs); Halfway; Kuskanax; St. Leon; minor populations in Hill; Blanket; Begbie; Mulvehill; Jordan; Crawford;</td><td>adfluv/res</td><td>D</td><td>C</td><td>E</td><td>Arndt 2004; Decker and Hagen 2008; Latham 2002</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>G</td><td>low risk</td></tr>
<tr><td colspan="23"><i>Comment: Total spawner population estimates available from redd counts in 2006-2007 (Decker and Hagen 2007); angler effort and success relatively stable since 1970s (Arndt 2004), and improved in the period immediately following experimental fertilization; habitat losses from Revelstoke Dam construction (est. 1,950 spawners) partially mitigated by barrier removal on Illecillewaet and Halfway Rivers (est. 1,200 spawners); glacial inputs to Illecillewaet and Incomappleaux provide cold water stronghold; genetically unique population above barrier in St. Leon C (Latham 2002); residents also present in upper Halfway, upper Jordan; upper Wallis.</i></td></tr>
<tr><td>4</td><td>Columbia-Arrow Lakes</td><td>Whatshan</td><td>Whatshan; Whatshan L; Fife</td><td>fluv/adfluv</td><td>B?</td><td>B</td><td>E</td><td>Hagen 2008</td><td>L</td><td>L</td><td>L</td><td>L</td><td>M</td><td>M</td><td>L</td><td>M</td><td>L</td><td>L</td><td>L</td><td>L</td><td>F</td><td>at risk</td></tr>
<tr><td colspan="23"><i>Comment: genetically unique above barrier population (Latham 2002); no connectivity; lightly exploited; reservoir enhanced by naturalization of kokanee; potentially vulnerable to water temperature issues; no monitoring.</i></td></tr>
<tr><td>4</td><td>Upper Columbia</td><td>Revelstoke Reservoir</td><td>La Forme; Carnes; Mars, Big Eddy; Park; Downie (and tribs); Kirbyville; Hoskins; Ruddock; Nichols; Scrip; Bigmouth (and tribs); Mica</td><td>adfluv/res</td><td>C/D</td><td>D</td><td>E/F</td><td>Hagen 2008 and references therein</td><td>L</td><td>L</td><td>I</td><td>L</td><td>M</td><td>L</td><td>I</td><td>M</td><td>H</td><td>L</td><td>I</td><td>H</td><td>F</td><td>potential risk</td></tr>
<tr><td colspan="23"><i>Comment: genetically amalgamated population (Latham 2002) may be related to loss of fluvial habitats/populations and homogenous reservoir environment; 125 km of tributary rearing habitat in total estimated to be accessible to adfluvial populations; Glacial/coldwater tributaries somewhat buffered against temperature increases; widespread forestry impacts but recovering. Naturalization of kokanee has enhanced reservoir for bull trout production.</i></td></tr>
<tr><td>4</td><td>Upper Columbia</td><td>Kinbasket Reservoir</td><td>Beaver, Blackman, Bush, Camp, Canoe, Chatter, Cummins, Dave Henry, Dawson, Encampment, Grouse, Harvey, Horse, Howard, Hugh Allen, Molson, Packsaddle, Ptarmigan, Prattle, Quartz; Sullivan, Wood,</td><td>fluv/adfluv/res</td><td>D/E</td><td>D</td><td>E/F</td><td>Fielden et al. 1992; Oliver 2001; Hagen 2008</td><td>L</td><td>L</td><td>I</td><td>L</td><td>M</td><td>L</td><td>I</td><td>M</td><td>M</td><td>L</td><td>I</td><td>M</td><td>F</td><td>potential risk</td></tr>
<tr><td colspan="23"><i>Comment: inundation of 140 km of bull trout rearing by reservoir estimated (Hagen 2008); more than 20 sub-populations remain with good connectivity with upper Columbia; bull trout have been highly successful utilizing Kinbasket Reservoir - large, adfluvial population; trends may be increasing as a result of kokanee naturalization (Hagen 2008); abundant glacial/coldwater tributary environments; widespread forestry impacts noted previously (Fielden et al. 1992) but recovering; bull trout stronghold in combination with upper Columbia; residents present above barriers in Gold C.</i></td></tr>
<tr><td>4</td><td>Upper Columbia</td><td>Upper Columbia</td><td>Dutch (Brewer), Toby (Delphine), Horsethief (Bruce), Blaeberry (Redburn), Kicking Horse (Beaverfoot, Ice, Moose); Pinnacle; Shuswap; Windermere C; Columbia mainstem, Windermere Lake</td><td>fluv</td><td>C/D?</td><td>D</td><td>U</td><td>Triton 1991; Fielden et al. 1993; Hagen 2008</td><td>L</td><td>L</td><td>I</td><td>L</td><td>M</td><td>L</td><td>I</td><td>M</td><td>M</td><td>L</td><td>I</td><td>M</td><td>F</td><td>potential risk</td></tr>
<tr><td colspan="23"><i>Comment: a number of tributaries supporting migratory BT identified (Triton 1991; Fielden et al. 1993) and no barriers to connectivity with Kinbasket Reservoir; distribution, abundance, trend, and connectivity criteria likely being met; forestry-related habitat impacts identified (Triton 1992), but recovering; no monitoring.</i></td></tr>
<tr><td>4</td><td>Upper Columbia</td><td>Spillimacheen</td><td>Spillimacheen R and several tribs.</td><td>res</td><td>U</td><td>B</td><td>U</td><td>Triton 1991; Hagen 2008</td><td>L</td><td>I</td><td>M</td><td>M</td><td>L</td><td>I</td><td>L</td><td>L</td><td>L</td><td>I</td><td>M</td><td>M</td><td>E</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment: more than one resident BT pop. identified; little known about this small core area; coldwater system; eastern brook trout present in the watershed are principal threat; no monitoring</i></td></tr>
</table>

Appendix 4 continued.

Geographic information				Life history	Adult population (see Table 2 for codes)				Threat (high-H, moderate-M, low-L, insignificant-I)													Status
									Severity				Scope				Immediacy					
Region (1-9)	Ecological Drainage Unit	Core Area	Tributary (sub-tributary)	(res, adfluv, fluv, anad)	Pop. size	Distribution	Trend	Reference	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	**Overall threat value**	
4	Lower Kootenay	Kootenay Lake	Yahk (Gilnockie, West Yahk, Freeman); Moyie (Little Moyie, Irishman, Moyie L); Summit; Cultus; Midge (Conway, Seeman, Kutetl); Lockhart; Crawford; Coffee; Woodbury; Kaslo (Keen); Bernard; Fry (Carney, Gillis, Pinnacle); Duncan tribs: Cooper (McKian, S. Cooper); Meadow (John, Mat); Hamill; Glacier; Howser; East; Giegerich; Stevens; Westfall; Hume; Houston; upper Duncan; Lardeau tribs (Lake; Poplar; Healy; Tenderfoot; Mobbs); Trout L; (Asher; Wilkie)	adfluv, res	E	D	E	O'Brien 2001; Hagen 2003; Hagen and Decker 2009; Hagen 2008 and references therein.	L	L	L	**L**	M	H	L	**M**	L	L	L	**L**	F	potential risk
Comment: Annual escapement monitoring at Duncan Dam, Kaslo River; Crawford Cr.; Long-term creel survey data for Kootenay L..; potential genetic diversity losses resulting from homogenous Duncan Reservoir environment - low genetic population subdivision among tributaries to reservoir; residents above barriers in Fry Creek Canyon, Howser C; confirmed adfluvial populations: upper Duncan tribs; Hamill; Cooper; Poplar; Cascade; Mobbs; Tenderfoot; Healy; Crawford; Kaslo; Coffee; Woodbury; Midge; Seeman; Conway; Summit; Cultus; forestry degradation a significant threat in tributaries without glacial inputs.																						
4	Lower Kootenay	Slocan	Slocan; Little Slocan (Koch, Hoder); Lemon (Monument); Slocan L; Evans; Silverton; Carpenter; Wilson (Dennis; Fitzstubbs); Wragge; Shannon; Bonanza	fluv, adfluv	C	C	D	Hirst 1991; Hagen 2008	H	L	L	**M**	M	L	L	**M**	H	L	L	**M**	B	at risk
Comment: Connectivity with Columbia and Kootenay mainstems severed; low suitability of mainstem Slocan because of high summer temperatures; declines inferred relative to historical conditions but unknown recently. Potentially low population size, at risk; residents above falls on Hoder C, Wilson C.																						
4	Upper Kootenay	Upper Kootenay River	Vermillion; upper Kootenay; Verdant C; Daer; Palliser R; White R (Blackfoot, Thunder, East White, North White, Mayuk); Findlay C; Skookumchuck C (Bradford, Sandown); Lussier R (Diorite); Ta Ta, Lewis, Mather, Wild Horse, St. Mary R (Joseph, Perry, Matthew, St. Mary L, Meachen, Redding, White, Dewar, upper St. Mary)	fluv/adfluv	D	D	F	Westover and Heidt 2004; Hagen 2008; MOE monitoring data on file.	L	I	L	**L**	M	I	L	**L**	L	I	L	**L**	G	low risk
Comment: Abundance data (redd counts) available for Skookumchuck, White. At least 7 potentially interconnected fluvial populations; adult abundance probably >1000 individuals; increasing trend; residents above falls on Findla																						
4	Upper Kootenay	Koocanusa	Sand (Little Sand); Plumbob; Wigwam R (Lodgepole, Bighorn, Rabbit, Desolation); Gold C (Bloom, Caven, Tepee); Linklater	adfluv	D/E	D	F	Westover and Heidt 2004; Westover and Conroy 1997; Hagen 2008; MOE data on file.	L	I	L	**L**	M	I	L	**L**	L	I	L	**L**	G	low risk
Comment: Abundance data (redd counts) available for Wigwam, Lodgepole, Gold. Potential genetic diversity losses resulting from homogenous reservoir environment. Low genetic population subdivision among tributaries to reservoir; major adfluvial population of >1,000 individuals utilizes Wigwam River; population increasing following naturalization of kokanee and angling regulation changes c. 1995; bull trout stronghold along with upper Kootenay core area; international core area; forestry-related habitat degradation but recovering.																						
4	Upper Kootenay	Bull	Bull; upper Bull	fluv	U	C	U		L	L	I	**L**	M	L	I	**L**	L	L	I	**L**	G	unranked
Comment: Genetically unique above-barrier population; dams built on natural migration barriers; little information; no monitoring data; forestry-related habitat degradation but recovering.																						
4	Upper Kootenay	Elk	Elk; Morissey; Lizzard; Coal; Hartley; Lladnar; Michel (Erickson, Leach); Cummings; Grave; Brule; Line (South Line); Fording; Bingay; Forsyth; Aldridge; Beasdell; upper Elk L	fluv	U	C	F	Allan 2001;	L	L	I	**L**	M	L	I	**L**	L	L	I	**L**	G	unranked
Comment: Abundance data (redd counts) available for Line Cr. Genetically unique above-barrier population; Line Cr. monitoring data suggests significant increases following c.1995 angling management changes; habitat threats																						

Appendix 4 continued.

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<tr><td>4</td><td>Flathead</td><td>Upper Flathead</td><td>Kishinena, Sage, Flathead, Couldrey, Howell (Cabin), Middlepass, Cate, Harvey, Shepp, Pollock, McLatchie, Foisey, McEvoy, Squaw</td><td>res, fluv, adfluv</td><td>C</td><td>C/D</td><td>D</td><td>USFWS 2005;</td><td>L</td><td>I</td><td>H</td><td>M</td><td>M</td><td>I</td><td>M</td><td>M</td><td>L</td><td>I</td><td>M</td><td>M</td><td>B</td><td>at risk</td></tr>
<tr><td colspan="23"><i>Comment: Declines due to lake trout introduction in Flathead L.; BC headwaters supporting an increasing proportion of total spawning, key to long-term protection of international core area; Mining and oil and gas development threats now alleviated following Premier's announcement of Feb. 15, 2011.</i></td></tr>
<tr><td>3</td><td>Middle Fraser</td><td>Fraser Canyon</td><td>Lower Nahatlatch (Log, Kookapi), Texas, Anderson, Kwoiek, Stein</td><td>fluv, resid</td><td>U</td><td>C</td><td>U</td><td>Griffiths 1997; Arc Environmental Ltd. 2002; Triton 1999</td><td>M</td><td>L</td><td>L</td><td>M</td><td>H</td><td>L</td><td>L</td><td>M</td><td>M</td><td>L</td><td>L</td><td>M</td><td>B</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment : Most tributaries have barriers near their confluence with the Fraser River; some have local resident populations, but most do not; unfavorable thermal regimes, low summer stream flows, and negative interactions with resident rainbow trout likely factor in this. Surveys suggest bull trout productivity/abundance is low in tributaries where they are present; Stein River may be more productive. Fluvial life history type is present in two sub-tributaries of the lower Nahatlatch River (Log, Kookapi). Hydroelectric projects proposed for both Log and Kookapi, and approved for Kwoiek Creek. Historical and ongoing impacts from forestry activities. Climate change is a threat in this core area, given the already marginal thermal conditions in most cases.</i></td></tr>
<tr><td>3</td><td>Middle Fraser</td><td>Seton/ Anderson/ Lower Bridge</td><td>Fraser, Anderson L. (Whitecap, Spyder, McConnell, Lost Valley, Gates, Haylmore), Seton (Portage), Bridge (Yalokom), Leon, French Bar Cr.(Schraeder L.), Lone Cabin Cr.</td><td>adfluv, fluv, resid</td><td>C</td><td>D</td><td>U</td><td>Haas and McPhail 1991; Chamberlain and O'Brien 2000; Arc Environmental Ltd. 2000; Chamberlain 2002; Morris et. al. 2003; Harry O'Donaghey, Darcy Indian Band, pers. comm.</td><td>M</td><td>M</td><td>I</td><td>M</td><td>M</td><td>M</td><td>I</td><td>M</td><td>L</td><td>L</td><td>L</td><td>L</td><td>D</td><td>potential risk</td></tr>
<tr><td colspan="23"><i>Comment : Fluvial bull trout in Yalakom R.; adfluvial and probably fluvial BT in Seton/Anderson drainage; local resident pops. in upper Yalakom R. and Lone Cabin, Leon, and French Bar creeks Local adfluvial pops. present in Schrader L. above barrier in French Bar Cr. Verified specimens of Dolly Varden collected from Anderson/Seton drainage. Five tribs. to Anderson L. provide majority (30 km) of spawning and rearing habitat in Seton/Anderson drainage. Habitat degradation and reduced connectivity to Fraser R. from Seton/Anderson and upper Bridge drainages as a resulted of hydro development. Substantial numbers of BT have been captured and tagged in the vicinity of Seton Dam suggesting some degree of movement still occurs between Seton/Anderson and Fraser River (one BT tagged at Seton Dam was recovered in Fraser R. downstream of Hell's Gate near Mission. Access for Anderson L. adfluvials to critical spawning habitat in Gates R. impeded by counting fence used to divert sockeye salmon into spawning channel (up to 200 BT captured at fence in some years). Proposed Chinook enhancement in Yalokom R. Other impacts include forest harvesting, unlicensed water diversions in Anderson L. tribs., and heavy angling pressure in vicinity of local communities.</i></td></tr>
<tr><td>3</td><td>Middle Fraser</td><td>Upper Bridge</td><td>Tyaughton, Gun, Hurley, Fergusson</td><td>adfluv, resid</td><td>C</td><td>C</td><td>U</td><td>Arc Environmental Ltd. 2000; Chamberlain et. al., 2001; Tisdale 2006</td><td>L</td><td>M</td><td>I</td><td>L</td><td>M</td><td>M</td><td>I</td><td>M</td><td>L</td><td>U</td><td>I</td><td>L</td><td>D</td><td>at risk</td></tr>
<tr><td colspan="23"><i>Comment : Adfluvial bull trout associated with Carpenter Reservoir dominate this core area, but resident life history form is also present in tributaries (e.g., Tyaughton, Gun). 164 bull trout were angled in 62 hours during a tagging study in Carpenter Reservoir in 2000, suggesting a reasonably abundant population. Extensive loss of fluvial habitat and the loss of connectivity among habitats following construction of Terzaghi and Lajoie dams. Bull trout probably no longer present upstream of LaJoie Dam. The loss of fluvial habitat and salmon runs has been offset to some degree by the creation of adfluvial habitat in Carpenter Reservoir and the establishment of a kokanee population. Additional run-of-the-river hydroelectric projects proposed in tributaries. Other impacts/threats include forest harvesting, angler harvest, negative interactions with rainbow trout and Eastern brook trout (extensive stocking of rainbow trout has occurred in lakes tributary to Carpenter Reservoir, and a recent large forest fire in the Tyaughton Creek drainage.</i></td></tr>
<tr><td>5</td><td>Middle Fraser</td><td>Quesnel Lake</td><td>Quesnel L, Grain, Long, Isaiah, Mitchell (Mitchell L., upper Mitchell, "Betty Cr", Penfold), Blue Lead</td><td>adfluv, resid?</td><td>U</td><td>C</td><td>E</td><td>Dolighan and Lirette 1993; Porter and Nelitz 2009</td><td>L</td><td>L</td><td>L</td><td>L</td><td>M</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>L</td><td>G</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment : Implementation of catch-and-release for BT in Quesnel Lake in 1990s has aided in pop recovery from previous low levels. BT stocked above barrier in Penfold Creek in an atttempt to establish resident population. Mitchell River system (Penfold, Betty, upper Mitchell) is most important producer of BT in Quesnel L and lies with a provincial park. There is concern that smallmouth bass from the Beaver Creek watershed will eventually invade the Quesnel and Cariboo Rivers. Thermally suitable habitat for BT in the Quesnel drainage could decline drastically during the next 70 years, depending on the severity of climate change.</i></td></tr>
</table>

Appendix 4 continued.

Geographic information				Life history	Adult population (see Table 2 for codes)				Threat (high-H, moderate-M, low-L, insignificant-I)													Status
									Severity				Scope				Immediacy					
Region (1-9)	Ecological Drainage Unit	Core Area	Tributary (sub-tributary)	(res, adfluv, fluv, anad)	Pop. size	Distribution	Trend	Reference	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	**Overall threat value**	
5	Middle Fraser	Cariboo	Cariboo R., Spanish, Spanish L., Seller, Cariboo L, Little (Ishkloo), Cunningham, Matthew, Harold, Babcock, Babcock L., Betty Wendle, Lanezi L., Quesnel R. mainstem	fluv, adlfluv, resid	U	D	U	Dolighan and Lirette 1993; Chapman Geoscience Ltd. 1997; Triton Environmental Consultants Ltd. 1997a; Porter and Nelitz 2009	M	L	L	**L**	M	L	L	**L**	M	L	L	**L**	G	unranked
Comment : Bull trout are fairly widely distributed in lakes and streams of this core area; resident populations are present above waterfalls. Extensive placer mining throughout drainage has impacted BT habitat. Extensive logging activity. Watershed is dominated by highly erodible soils, and road development delivers large amounts of sediments to streams. There is concern that small mouth bass from the Beaver Creek watershed will eventually invade the Quesnel and Cariboo Rivers. Thermally suitable habitat for BT in the Cariboo R drainage could decline substantially during the next 70 years, depending on the severity of climate change.																						
5	Middle Fraser	Cottonwood	Cottonwood, John Boyd, Lightning (Wormwold, Peters, Jawbone, Houseman, Milk Ranch Pass, Beaver Pass, upper Lightning), Swift (Little Swift (Foster, Agnes), Bendixon, Victoria, McMartin, Aster, upper Swift)	fluv, resid	U	D	U	Imhof and Sutherland 1996b; Chapman Geoscience Ltd. 1997; Porter and Nelitz 2009	M	I	I	**M**	M	I	I	**M**	M	I	I	**H**	B	unranked
Comment : Watershed has been heavily logged. Resident populations likely occur above barriers in several sub-basins. Extensive placer mining in Lighting Cr. Drainage has impacted BT habitat. Core spawning/rearing reaches not well defined. Distribution limited to higher elevation portions of watershed in Cariboo Mts. Thermally suitable habitat for BT inthe Cottonwood drainage could decline drastically during the next 70 years, depending on the severity of climate change.																						
5	Middle Fraser	West Road	Batnuni L, Baezaeko (Coglistiko, Coglistiko L), upper West Road (Euchiniko Ls, Tsacha L, Eliguk L, Ulgako C)	fluv, adlfluv	U	D	U	Dolighan 1985; Triton Environmental Consultants Ltd. 1999b; Porter and Nelitz 2009	H	I	I	**M**	H	I	I	**M**	H	L	I	**H**	B	unranked
Comment : Informal surveys suggest BT abundance is very low relative to rainbow trout and other species. Extensive beetle-kill in wateshed (threat of habitat loss due to increased temperatures and migration obstructions). Extensive salvage logging has occurred. Majority of BT habitat occurs in 'cool' as opposed to 'coldwater' streams (i.e, nonglaciated mts), and thermally suitable habitat for BT in the watershed could decline drastically during the next 70 years, depending on the severity of climate change.																						
5	Middle Fraser	Churn	Churn (Dash, Lone Valley, Fairless)	resid (fluv?)	U	C	U	Ferguson and Bocking 1998; Porter and Nelitz 2009	L	I	M	**L**	H	I	M	**M**	H	I	M	**M**	F	unranked
Comment : FISS records suggest BT are distributed fairly extensively in the upper watershed. Not certain whether falls near mouth are a barrier and whether a fluvial life history form is present. Extensive beetle-kill in upper wateshed. Thermally suitable habitat for BT in Churn Cr. could decline substantially during the next 70 years, depending on the severity of climate change.																						
5	Middle Fraser	Upper Big Creek	Big (Tosh, Grant)	resid	U	C	U	Triton Environmental Consultants Ltd. 1997b; Mossup 1998; Ferguson and Bocking 1998	M	L	M	**M**	H	L	M	**M**	H	L	M	**M**	B	unranked
Comment : Barrier falls near mouth. BT restricted to upper watershed, which lies mostly within a prov. park. Habitat degradation in core reaches (increased temperatures) likely as beetle-killed pine forest now dominates the upper watershed. Electrofishing surveys suggest very low densities and limited distribution of BT (5 individauls captured in total during 4 separate surveys).																						
5	Middle Fraser	Little Chilcotin	Chilcotin, Punkutlaenkut, Moore, Downton	fluv	U	C	U	Peard 2005; MacPherson 2006	M	M	I	**M**	M	L	I	**M**	H	M	I	**M**	B	unranked
Comment : Large-bodied fluvial BT are presumably part of the mainstem Chilcotin metapopulation; some degree of overlap with Taseko and Chilko Lake fluvial populations likely (telemetry work needed). Habitat degradation has likely ocurred as beetle-killed pine forest now dominates the watershed (increased temperatures and potential access problems as trees fall and create barriers). Creel survey estimates of 300-600 BT caught annually duing fall/spring steelhead fishery in mainstem Chilcotin. One BT/day retention allowed, concern about possible overharvest. Thermally suitable habitat for BT could decline substantially during the next 70 years, depending on the severity of climate change.																						

Appendix 4 continued.

Geographic information				Life history	Adult population (see Table 2 for codes)				Threat (high-H, moderate-M, low-L, insignificant-I)													Status
									Severity				Scope				Immediacy					
Region (1-9)	Ecological Drainage Unit	Core Area	Tributary (sub-tributary)	(res, adfluv, fluv, anad)	Pop. size	Distribution	Trend	Reference	Habitat	Exploitation	Competitors	Overall	Habitat	Exploitation	Competitors	Overall	Habitat	Exploitation	Competitors	Overall	Overall threat value	
5	Middle Fraser	Chilko	Chilko, Lingfield, Chilko L (Long Valley, Gridwood, Nine Mile, Edmond, Nehamia (Klukon, Konni L, Robertson, Tatlow, unnnamed lake at Tatlow headwaters)	fluv, adlfluv	C	C	E	Tredger 1982; Ladell et al. in prep; Holmes and Smith 2006; Porter and Nelitz 2009	M	L	I	**L**	H	L	I	**M**	H	L	I	**M**	F	at risk
Comment : Two years' abundance data (resistivity counter) for Long Valley Cr. suggest escapements of 400-700 fish. Chilko pop. likely increasing over last 25 years due to more restictive angling regulations. First Nations harvest still occurs. Long Valley and Nemiah are the only documented Chilko L spawing tribs. Ancedotal information suggests that sizable spawning population occurred historically in Klokon Creek in the Nemiah system. Beaver dams and cluverts impede passage of adfluvial spawners in the Neiah system (some remedial work has been undertaken). A fluvial life history form may also be present in Chilko core area, with a home range that includes the mainstem Chilcotin, where overlap with Taseko and Little Chilcotin fluvial populations is likely (telemetry work needed). Chilko watershed is less vulnerable to climate change due to heavily glaciated headwaters. Large portion of spawning/rearing reaches dominated by beetle-kill pine forest (threat of habitat loss due to increased temperatures and potential access problems).																						
5	Middle Fraser	Taseko	Taseko, Elkin, Elkin L., Vedan L., Taseko Lakes, Big Onion Lake, Beece, Yohetta (Lastman L, Fishem L, Tuzcha L), upper Taseko	fluv, adlfluv	U	D	U	Tredger 1981; Mossup 1998; Porter and Nelitz 2009	M	L	I	**L**	H	L	I	**M**	H	L	I	**M**	F	unranked
Comment : Home range of fluvial BT may include Chilcotin mainstem, thus some degree of overlap with Chilko Lake and Little Chilcotin fluvial populations (telemetry work needed). Beece Cr. appears to be major spawning area. Watershed less vulnerable to climate change due to heavily glaciated headwaters. Large portion of core spawning/rearing reaches dominated by beetle-kill pine forest. Major mine still expected to be operational within the next five years.																						
7	Middle Fraser	Prince George	Willow (Wansa, Pitoney, Narrow Lake, Stony L, Big Valley, Pundata, Archer, Tregillus, Upper Willow), Eaglet L, Aleza L, Olsson, Salmon (Chief L, Muskeg, Great Beaver L, upper Salmon), Stone, Hixon	fluv, adfluv, res	U	U	U	Imhof and Sutherland 1996; Williamson and Zimmerman 2006	L	L	I	**L**	M	I	I	**M**	L	L	I	**L**	F	unranked
Comment : Willow and tributaries classified as having low to moderate values for bull trout during previous literature review and sensitivity analysis (Williamson and Zimmerman 2006), low values for lower Salmon and Chilako; Willow and assoicated tributaries in low elevation areas are considered marginal bull trout habitat due to temperatures; therefore vulnerable to temperature increases associated with forest harvesting; pockets of resident populations in cold tribs within core area; BT present at only 3 of 35 sampling sites during 1995 fish habitat inventory (Imhof and Sutherland 1996); salmon and bull trout are able to ascend the Willow canyon below the highway.																						
7	Middle Fraser	Upper Stuart	Trembleur L (Paula), O'Ne'ell, Van Decar, Unnamed (Takla Narrows), Sakeniche, Sinta, Dust, Lovell, Unnamed (Takla east shore), Sitilika, Driftwood, Kotsine		U	U	U		L	L	I	**L**	M	L	I	**M**	L	I	I	**L**	F	unranked
Comment : Fraser L to be included with Region 6; upper Fraser fish known to utilize Nechako mainstem - subject of future study; little known of bull trout use of this core area.																						
6	Middle Fraser	Francois	Peter Alleck, Nadina, Tagetochlain, Nadina L and unnamed tributaries, Henkel	U	U	U	U	Fielden 1995 (Endako and Nadina rivers biophysical and fishery survey, 1994; ref. not available)													U	unranked
Comment: It appears that only one report of BT to date in this CA specifically refers to BT (a single 'adult' BT reported in the Nadina River by Fielden 1995) and neither the method of ID for that observation nor the body length of the individual fish is provided in the reference. Other observations coded as DV are a mix of historical observations before BT were recognized as distinct from DV, and more recent observations many of which appear credibly to be DV (forest inventory by relatively experienced consultants). It is thus unclear whether BT are present in this CA, and if they are then we know nothing at all about them although the Nadina River is certainly a plausible location for mainstem feeding by larger BT. Tagetochlain L, and Francois L (Nadina R is tributary to the latter), both support S. namaycush and no catches of BT/DV have been reported by recreational anglers or in survey netting on either lake. Henkel C, tributary to north shore of Francois L, also has a 1988 record of DV (Bustard 1988) but otherwise Francois L and its other tribs are not believed to support either DV or BT.																						
6	Middle Fraser	Nechako Reservoir	Tahtsa L, Murray L, Cheslatta L	U	U	U	U		U	U	U	**U**	U	U	U	**U**	U	U	U	**U**	U	unranked
Comment: Limited sampling in Coast Mountains? Credible evidence is lacking for the presence of any char upstream of Kenney Dam (i.e., Nechako Reservoir drainage). There are no char records for the upper Nechako despite considerable reconnaissance-level sampling in Tweedsmuir Park, and extensive forest inventory sampling in streams and lakes in the portion of the watershed outside of the park and north of Ootsa Lake, including Whitesail and Tahtsa areas. The Cheslatta system now receives outflow of the Nechako Reservoir via Skins spillway, but was historically only connected to the remainder of the upper Nechako watershed downstream of the Nechako Canyon after passing over Cheslatta Falls, and is presently downstream-accessible-only from the reservoir as no fish ladder exists at the Skins spillway. The Cheslatta watershed historically did and presently does support lake char in Cheslatta Lake, Murray Lake, and Knapp Lake and there is some suggestion that BT&orDV may be present in that watershed (i.e. upstream of Cheslatta Falls and downstream of Skins), although it is not clear whether any of this information is derived from field sampling. If BT are present in this CA, they are almost certainly only present in the Cheslatta portion.																						

Appendix 4 continued.

Geographic information				Life history	Adult population (see Table 2 for codes)				Threat (high-H, moderate-M, low-L, insignificant-I)													Status
									Severity				Scope				Immediacy					
Region (1-9)	Ecological Drainage Unit	Core Area	Tributary (sub-tributary)	(res, adfluv, fluv, anad)	Pop. size	Distribution	Trend	Reference	Habitat	Exploitation	Competitors	Overall	Habitat	Exploitation	Competitors	Overall	Habitat	Exploitation	Competitors	Overall	Overall threat value	
7	Upper Fraser	Robson	Moose L, Moose, Grant, upper Fraser	fluv, adfluv, res	U	U	U		I	I	H	**M**	I	I	H	**M**	I	I	H	**M**	B	unranked
Comment : Above Overlander Falls BT restricted to tributaries due to lake trout in Moose and Yellowhead lakes; direct competition with naturalized EBT in streams; upper Fraser unknown.																						
7	Upper Fraser	Upper Fraser	Holmes (Chalco), Goat (McCleod), Morkill, Torpy (Humbug, Walker, West Torpy), Slim, Hungary, Kenneth, McKale, Castle, Rausch, Mainstem Fraser, mainstem Nechako.	fluv	D	D	E?	EDI 2002; Taylor and Clarke 2007; Williamson and Zimmerman 2006; Pillipow and Williamson 2004	L	L	I	**L**	M	M	I	**M**	M	H	L	**H**	F	potential risk
Comment : Abundance data (redd counts) available for Goat, McKale, Chalco. Systems classified as high value for bull trout during previous literature review and sensitivity analysis (Williamson and Zimmerman 2006); Chalco appears to be of conservation concern (very low numbers of large fish), others unknown; exploitation moderate on Goat, moderate to high on the Holmes, unknown but previously high on McKale, rest cannot comment on; numbers per trib would be B (Goat system: C); Goat trend stable, rest unknown; large fluvial fish from Goat utilize mainstem Fraser and Nechako 100s of km distant; unknown habitat use for other populations - some may be upper Fraser residents; locally degraded channel and fish habitat conditions following extensive forest harvesting in the Torpy watershed (EDI 2002); Population subdivision evident genetically but metapopulation status appropriate within core area, with approx. 1-10 individuals exchanged between populations per generation (Taylor and Clarke 2007).																						
7	Upper Fraser	McGregor	Seebach, Huble, Otter, Captain, Bad/James, Cargill, Fontoniko, Herrick (Spakwaniko, Muller, Framstead, upper Herrick), Gleason, Hedrick, Jarvis, Bastille, Buchanan	res, fluv	U	U	U	Williamson and Zimmerman 2006; Lheidli Tenneh Band 2000;	L	L	I	**L**	M	L	I	**M**	M	L	I	**M**	F	unranked
Comment : Systems classified as high value for bull trout during previous literature review and sensitivity analysis (Williamson and Zimmerman 2006); Isolated populations above Herrick River falls; Jarvis bull trout abundance unknown but habitat capability appears high; recent forestry impacts focused around lower Framstead, Muller, and Muller/Herrick confluence (Lheidli Tenneh Band 2000);																						
7	Upper Fraser	Bowron	Hah, Grizzly Bear, Indianpoint, Pinkerton, Summit, Haggen	fluv, adfluv, res	U	U	U	Williamson and Zimmerman 2006	L	I	I	**L**	M	I	I	**M**	L	I	I	**L**	F	unranked
Comment : Bowron and major tributaries classified as high value for bull trout during previous literature review and sensitivity analysis (Williamson and Zimmerman 2006); Indian Point likely too warm to support year round bull trout; tributaries are used for spawning (small fish) up here; other tribs no information; Haggen River appears to be the most significant bull trout system the upper Bowron; Grizzly Bear, Hah and most small tributaries to Indian Point have forest harvest impacts that are at various stages of recovery.																						
6	Lower Skeena	Lower Skeena	Shames, Gitnadoix (Magar), Skeena	adfluv?, fluv?, res?	U	U	U	Haas and McPhail 1991; Taylor and Costello 2006, Bustard 2004b	I	L/M	I	**L**	I	L/M	I	**L**	H	H	I	**M**	G	unranked
Comment: BT confirmed only from Shames, Gitnadoix; DV expected to dominate records. Inferred use of Skeena in this CA due to otolith microchemistry indication of possibly anadromy by BT (Bustard 2003 if I recall correctly - JD). The Gitnadoix is a pristine park-enclosed watershed, while Shames has received extensive forestry development. BT are reportedly captured in the upper Gitnadoix below Alastair L (Rob Dams per comm via Bustard 2003), as well as in in the lower Gitnadoix sport fisheries for coho and winter steelhead, where BT vulnerability is high due to use of bait. Gillnetting of Alastair Lake in 1944 yielded "DV" of small body size in relatively low numbers.																						
6	Upper Skeena	Upper Skeena	Upper Skeena, Beirnes, Courier, Kluatantan (upper Kluatantan, Kluayaz, Kluayaz L), Duti, Chipmunk, Mosque	adfluv?, fluv?	U	U	U		U	I	I	**U**	U	I	I	**U**	H	H	I	**M**	U	unranked
Comment: Basis for differentiation of CA's in the Skeena drainage is unknown. BT &or DV have been sampled widely in this putative CA but it appears that formal morphometric or genetic data have not been used to discriminate between the two species. MoE staff captured BT (ID by informal morphological obs - head size) by angling downstream of Kluayaz Lake (Atagi, pers. comm.). Anadromous fish use the mainstem Skeena for access as least as far upstream as the Kluatantan watershed, and it is hypothesized that DV which are present in the Thutade L watershed may have historically transferred via the headwaters of the Mosque system, so it is not implausible that both DV and BT are widespread in this CA. Coalbed methane development at/near the headwaters of the Skeena poses a potential threat to habitat. Angling activity in this CA is presently believed relatively low, but expanding guiding opportunities (mainly SST) in this CA has been recommended during the QWS process (2010) with potential attendant impacts to BT.																						

Appendix 4 continued.

Geographic information				Life history	Adult population (see Table 2 for codes)				Threat (high-H, moderate-M, low-L, insignificant-I)													Status
									Severity				**Scope**				**Immediacy**					
Region (1-9)	**Ecological Drainage Unit**	**Core Area**	**Tributary (sub-tributary)**	**(res, adfluv, fluv, anad)**	**Pop. size**	**Distribution**	**Trend**	**Reference**	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	**Overall threat value**	
7	Upper Fraser	Robson	Moose L, Moose, Grant, upper Fraser	fluv, adfluv, res	U	U	U		I	I	H	**M**	I	I	H	**M**	I	I	H	**M**	B	unranked
6	Upper Skeena	Upper Sustut	Sustut, Saiya, Asitka, Red, Two Lake, Willow, Moosevale, Johanson, Sustut L, Johanson L	fluv?	U	U	U	Upper Sustut RST trap and adult counting fence (MNRO, data on file)	L	U	I	**U**	L	U	I	**U**	H	H	I	**M**	G	unranked
Comment: Basis for differentiation of CA's in the Sustut drainage is unknown. BT &or DV have been sampled widely in this putative CA but it appears that formal morphometric or genetic data have not been used to discriminate between the two species. Informal morphological observations (head size etc) by MoE staff/contractor suggest BT are captured annually at the Sustut weir and these are enumerated; large char (to 60 cm) captured during reconn inventory of Sustut and Johanson lakes appear likely to be BT also. Anadromous fish use the Sustut system into the lakes and their tributaries, so the presence of DV in the watershed is also very plausible. The mining access road along Johanson C, upper Sustut R and Moosevale C does not appear to create passage issues but is a sediment source (J Lough pers. comm). The Sustut watershed upstream of the Bear R confluence is closed to recreational angling, but First Nations harvest of fish does occur in this portion of the watershed and is facilitated by roading. Protected areas (Sustut Park and Protected Area) provide some protection of habitat.																						
6	Upper Skeena	Lower Sustut/ Skeena	Skeena, Sustut (Bear, Bear L, Birdflat), Squingula (Motase L), Slamgeesh (Damshilgwet, Shilahou),	adfluv?, fluv?	U	U	U	Slamgeesh (Damshilgwet) fence counts (Gitskan Fisheries Authority, data on file; see Section 5 in text)	L/M	I	I	**U**	U	I	I	**U**	H	H	I	**M**	G	unranked
Comment: Gitksan Fisheries Authority operates a fish enumeration weir on Damshilgwet Cr. upstream of Slamgeesh L where BT (ID'ed by formal morphometrics: Peter Hall, pers. comm.) are enumerated annually -- however the origin, stock status and life history of these fish are as yet unknown. BT &/or DV have been sampled widely in this putative CA but it appears that formal morphometric or genetic data have not been used to discriminate between the two species. Bear L supports SK and lake char (S. namaycush) and recorded sampling in the lake to date has not yielded BT or DV; Motase L supports SK (but not S. namaycush) and the largest "DV" captured during 1975 lake survey was 48 cm suggesting potential BT. Snorkel swim of the Bear R downstream of the lake revealed large char (among spawning SST) which by informal morphological observation appeared to be BT (J Lough pers comm). Sustut Park provides some protection of habitat in Bear L trib headwaters; Damdochax Protected Area appears to protect some of the habitat in the Slamgeesh watershed. Extensive forestry development has occurred in the lower Sustut watershed. SST angling guiding and non-guided ST angling occur on the lower Sustut R with likely minimal impact to BT.																						
6	Upper Skeena	Lower Babine/ Skeena	Skeena, Canyon C, Sicintine (Sicintine L), Kuldo, Larkworthy, Babine (Shegisic, Sam Green, Shedin)	adfluv?, fluv?, res?	U	U	U	Kossman 2010	I	I	I	**U**	I	I	I	**I**	H	H	I	**M**	H	unranked
Comment: Uncertain basis for differentiation of CA's in the Skeena/Babine drainage. BT &/or DV have been sampled widely in this putative CA but it appears that formal morphometric or genetic data have not been used to discriminate between the two species. Sicintine L supports SK (no S. namaycush) and the largest "DV" captured during lake survey was 60 cm suggesting probable BT. No confirmed fish sampling in Canyon C watershed including Canyon L but anecdotal report of large char (B Domonkos, angling guide, pers. comm.) which may be BT. There are few lakes in this putative CA and some are confirmed fishless (Damsumlo, Smokee). Uppermost Kuldo sampling appears to show "DV" above several barriers and may be a headwater resident population of either BT or DV. Extensive forestry development has occurred in this CA. SST angling guiding and non-guided ST angling occur on the lower Babine and Skeena mainstem with potential (probably insignificant) impact to BT. FN salmon fishery on lower Babine River (Kisgegas) may be a data source for BT.																						
6	Upper Skeena	Upper Babine	Babine, Shenismike, Shelagyote (Cayuse Jack, various unnamed), Hannawald, Nichyeskwa (various unnamed), Nilkitkwa (Watson, Charleston, West Nilkitkwa, Barbeau, Tsezakwa, Nilkitkwa L west trib, Boucher	adfluv, fluv?, res?	U	U	D?	Giroux 2001	L/M	L /M	U	**U**	I	U	I	**U**	H	H	H	**H**	E	unranked
Comment: Uncertain basis for boundaries of this CA . BT &/or DV have been sampled widely in this putative CA, but formal morphometric or genetic data have not often been used to discriminate, or the method of descrimination has not been documented. BT sampled in Shelagyote R (n=38, ID'ed possibly by genetics, photos suggest BT morphometry), floy tagged, bio data collected (sex, mat, age; Giroux 2001); one of these was recaptured as a kelt by an angler in Babine R. Most surveyed lakes in the Shelagyote and Hannawald drainages have not yielded BT (or DV, - Beta L an exception). Onerka L at top of Nilkitkwa R supports SK and the "DV" captured in 1975 were 12 cm FL. SK enhancement in Babine L tribs may impact downstream BT status (positively or negatively). The middle and upper Babine R reaches are heavily angled for SST; guides (anecdotally) report fewer and/or smaller char over time. BT or DV are not often reported (at present) in Rainbow Alley (incl Nilkitkwa L) fishery which is dominated by non-anadromous rainbow. Forestry development has been most intensive adjacent to Nilkitkwa L, in Nilkitkwa R watershed, and less so in Nichyeskwa. Babine R corridor park may protect some BT habitat.																						

Appendix 4 continued.

<table>
<tr><th colspan="4">Geographic information</th><th>Life history</th><th colspan="4">Adult population (see Table 2 for codes)</th><th colspan="13">Threat (high-H, moderate-M, low-L, insignificant-I)</th><th>Status</th></tr>
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<tr><td>6</td><td>Upper Skeena</td><td>Babine Lake</td><td>Heal, Five Mile (Williams), Fulton (Fulton L, Byron, Brystow, Cronin, Nata, upper Fulton)</td><td>adfluv, fluv?, res?</td><td>U</td><td>U</td><td>U</td><td></td><td>L/M</td><td>L</td><td>U</td><td>U</td><td>M</td><td>L</td><td>I</td><td>L</td><td>H</td><td>H</td><td>I</td><td>M</td><td>F</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment: DV may dominate records from small, non-glacial tribs. Basis for boundaries of this CA is unknown. Formal morphometric or genetic data have not often been used to discriminate between DV and BT in this CA. Waterfalls (and 50-yr-old dam) a few km upstream of the mouth of Fulton R isolates the BT/DV population(s) upstream from bi-directional exchange with any downstream population(s). BT are extremely uncommon in Babine L sport catch or research fish sampling. One anecdotal report of capture of BT in Fulton Reservoir soon after iceoff; S. namaycush are also present in the reservoir and in several other lakes in the watershed including Chapman, Doris and Tanglechain. Neither BT nor DV are apparently reported from Babine Lake tributaries other than those listed, despite extensive sampling. Extensive forestry development in this CA, with roading and associated angling access.</i></td></tr>
<tr><td>6</td><td>Upper Skeena</td><td>Kispiox</td><td>Skeena (Shegunia, Sediesh, Sterritt), Kispiox, Date, Hevenor, McCully, Murder, Cullon, Ironside, Steep Canyon, Sweetin, Nangeese, Stephens (Swan L, Club L, Stephens L)</td><td>adfluv, fluv?, res?</td><td>U</td><td>U</td><td>U</td><td></td><td>M?</td><td>L/M</td><td>U</td><td>U</td><td>M/H</td><td>L/M</td><td>U</td><td>L</td><td>H</td><td>H</td><td>H</td><td>H</td><td>B</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment: DV may dominate records from small, non-glacial tribs. Basis for boundaries of this CA is unknown. BT &/or DV have been sampled widely in this putative CA but formal morphometric or genetic data have not often been used to discriminate between the two species, and sometimes the method of discrimination has not been documented. Notwithstanding, considerable anecdotal evidence (with morph obs) suggests BT to 4kg or larger annually aggregate after ice off at the outlet end of Swan L (and into Club L and downstream) to feed on SK smolts and are subjected to a sport fishery including harvest. BT are also present in Swan Lake in the summer (Withler 1955; Falls 1974 which includes smaller sized BT of unknown age). The spawning location of these Swan/Stephens BT is unknown, as the tribs to Swan Lake do not appear suitable, but nearby mountainous Kispiox tribs (i.e, Sweetin or Nangeese) are a possibility. Swan/Stephens sytem is non-motorized and semi-remote (canoe and portage access). Large-sized probable BT are captured in the road-accessible recreational salmon fishery on the Kispiox R, though bait is not allowed. Extensive forestry development in this CA.</i></td></tr>
<tr><td>6</td><td>Upper Skeena</td><td>Bulkley</td><td>Upper Bulkley (Maxan, Buck), Bulkley, Emerson, Dockrill, Thompson, Deep, Coffin, Telkwa (Goathorn, Tenas, Pine, Cumming, Howson, Jonas, Sinclair, Milk), Canyon, Driftwood, Toboggan, Corya, Porphyry, Luno, Boulder, Suskwa (Natlan, Harold Price)</td><td>adfluv?, fluv?, res?</td><td>U</td><td>U</td><td>U</td><td>Bustard 1998</td><td>M?</td><td>M</td><td>U</td><td>U</td><td>M/H</td><td>M</td><td>U</td><td>M</td><td>H</td><td>H</td><td>H</td><td>H</td><td>B</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment: DV may dominate records from small, non-glacial tribs. Basis for boundaries of this CA is unknown. BT &/or DV have been sampled widely in this putative CA. BT juvenile abundance estimates and spawner/redd counts were made in Goathorn and Tenas Creeks in 1997 (Bustard 1998). BT are bycatch in the ST and salmon sport fisheries, particularly in the mainstem Bulkley R when bait is allowed (CH fishery during last half of June and all of July), and in the mainstem Telkwa, and are often harvested. Extensive forestry development in this CA. Mining in Telkwa watershed and in Babine Mtns.</i></td></tr>
<tr><td>6</td><td>Upper Skeena</td><td>Morice</td><td>Nanika, Morice, Morice L, Gosnell (Shea), Thautil (Denys, Starr), Houston Tommy, Gold</td><td>adfluv, fluv?, res?</td><td>C</td><td>C</td><td>U</td><td>Bahr 2002</td><td>J (M</td><td>M</td><td>U</td><td>U</td><td>M</td><td>M</td><td>U</td><td>M</td><td>H</td><td>H</td><td>U</td><td>H</td><td>B</td><td>at risk</td></tr>
<tr><td colspan="23"><i>Comment: DV may dominate records from small, non-glacial tribs (e.g. Lamprey, Owen). Morice BT have been intensively studied by D. Bustard, and M. Bahr, using juvenile surveys, redd counts, radio telemetry and genetic methods. Redd counts could be used to estimate population size but Bahr's work also suggests many mature BT do not spawn every year. Bull trout are primarily angled in the Morice mainstem and in the Nanika, often below Nanika Falls; they are also angled in the Bulkley although Barr's work suggests that Morice BT don't go down into the Bulkley very often. Bait is prohibitied in the entire Morice drainage. Closure of the Morice River mainstem to non-salmon angling between Gosnell and Lamprey from Jan thru end of Aug is intended to protect staging BT. Extensive forestry development in this CA; the proposed Northern Gateway pipeline route traverses the watershed.</i></td></tr>
</table>

Appendix 4 continued.

Geographic information				Life history	Adult population (see Table 2 for codes)				Threat (high-H, moderate-M, low-L, insignificant-I)													Status
									Severity				Scope				Immediacy					
Region (1-9)	Ecological Drainage Unit	Core Area	Tributary (sub-tributary)	(res, adfluv, fluv, anad)	**Pop. size**	**Distribution**	**Trend**	Reference	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	**Overall threat value**	
6	Upper Skeena	Mid-Skeena	Kitseguecla (Juniper, Kitsuns), Boulder, Kitwanga (Deuce, Kitwancool, Moonlit, Kitwancool L), Skeena (Mill, Sedan, Wilson, Lorne, Fiddler, Oliver, Little Oliver, Legate, Carpenter, Hardscrabble, Shannon, Chimdemash, Kleanza	adfluv?, fluv	U	U	U		M?	M	U	**U**	M	M	U	**M**	H	H	U	**H**	B	unranked
Comment: Gitksan Fisheries Authority operates a fish enumeration weir on lower Kitwanga R. where BT are enumerated annually -- however the origin, stock status and life history of these fish are as yet unknown. DV may dominate records from small, non-glacial tribs; Basis for boundaries of this CA is unknown. BT &/or DV have been sampled widely in this putative CA but formal morphometric or genetic data have not often been used to discriminate between the two species, and sometimes the method of descrimination has not been documented. Extensive forestry development in this CA.																						
6	Upper Skeena	Zymoetz	Zymoetz, Eight Mile, Salmon Run, Clore (Trapline, upper Clore, Burnie), Kitnayakwa, Limonite, Many Bear, Treasure, Red Canyon, Mulwain, Coal, Serb, Hankin	adfluv?, fluv?, res?	U	U	U		M?	M	U	**U**	M	M	U	**M**	H	H	U	**H**	B	unranked
Comment: DV may dominate records from small, non-glacial tribs; upper Clore, Burnie isolated above migration barriers? Basis for boundaries of this CA is unknown. BT &/or DV have been sampled widely in this putative CA but formal morphometric or genetic data have not often been used to discriminate between the two species, and sometimes the method of descrimination has not been documented. Extensive forestry development in this CA; the proposed Northern Gateway pipeline route traverses the watershed. . BT&orDV are angled in Zymoetz R mainstem salmon and steelhead sport and fisheries (no bait) and anecdotally have declined in abundance; regional stakeholder advisory committee has proposed non-retention.																						
6	Upper Skeena	Kitsumkalum	Kitsumkalum, Deep, Lean-to, Erlandson, Nelson, Maroon, Wesach, Douglas, Clear, Kitsumkalum L, upper Kitsumkalum (Cedar, Hadenschild, Little Cedar, Mayo, Bohler)	adfluv?, fluv?, res?	U	U	U		M?	M	U	**U**	M	M	U	**M**	H	H	U	**H**	B	unranked
Comment: DV may dominate records from small, non-glacial tribs. BT &/or DV have been sampled widely in this putative CA but formal morphometric or genetic data have not often been used to discriminate between the two species, and sometimes the method of descrimination has not been documented. Extensive forestry development in this CA.																						
6	Upper Nass	Upper Nass	Upper Nass, Muskaboo, Damdochax, *Kotsinta* , Taylor (West Taylor)	fluv?, res?, adfluv?	U	U	U	EDI 1998; reconnaissance inventory of upper Taylor and upper Nass watersheds (reference not available)	U	I	I	**L**	U	L	I	**U**	H	I	I	**L**	U	unranked
Comment: To Taylor River; Basis for differentiation of CA's in the Nass drainage is unknown. Unknown from where Kotsinta BT information is derived as it does not show in FISS or FLNRO Region 6 files; BT were sampled (morphometric ID only) during inventory of upper Nass, Taylor and Muskaboo drainages (EDI 1998) whereas a single DV and one BT/DV hybrid were morphometrically ID'ed in the Nass mainstem and Taylor/Nass confluence (EDI 1998); BT are captured in Damdochax Creek during ST sampling (morphometric ID); it appears likely that BT are widely distributed in this putative CA but sampling intensity has been low, mostly predates wide knowledge of BT/DV differentiation and genetic ID methods have not been applied to our knowledge. Angling guiding of significant magnitude occurs in the Damdochax and upper Nass and "BT" are captured but generally not harvested. Spawning locations are not known, nor are the population/stock structure or fluvial/adfluvial status; Damdochax/Wiminasik lakes support BT or DV but their origin and life history has not been documented. Coalbed methane development proposed at Sacred Headwaters area could affect water quality in Nass mainstem if implemented (temporary moratorium in 2011) -- this is a big unknown in terms of likelihood, and extent of impacts.																						

Appendix 4 continued.

Geographic information				Life history	Adult population (see Table 2 for codes)				Threat (high-H, moderate-M, low-L, insignificant-I)													Status
									Severity				Scope				Immediacy					
Region (1-9)	Ecological Drainage Unit	Core Area	Tributary (sub-tributary)	(res, adfluv, fluv, anad)	**Pop. size**	**Distribution**	**Trend**	Reference	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	**Overall threat value**	
	Upper Nass	Middle Nass	Nass, Sanskisoot, Kwinageese (Shanalope),	fluv?, res?, adfluv?	U	U	U	AEM 2001; reconnaissance 1:20K inventory of Nass tributaries project area (references not available)	U	I	I	**U**	U	U	I	**U**	H	H	I	**H**	U	unranked
Comment: Basis for differentiation of CA's in the Nass drainage is unknown. The Meziadin system was moved into its own CA as the basis of grouping the Meziadin with the Nass, Sanskisoot, Kwinageese but not Bell-Irving seems to be arbitrary. Sanskisoot BT were morphometrically ID'ed using Haas-McPhail DFA (AEM 2001) and one DV was identified in this watershed (AEM 2001). Shanalope BT were morphometrically ID'ed using Haas-McPhail DFA (AEM 2001) but no DV were identified. Kwinageese R mainstem is known to support BT from below Fred Wright Lake downstream to Nass (morphometric ID by MoE staff during ST fieldwork) and are likely present upstream into Fred Wright and Kwinageese lakes, but presence of DV is unknown. Road access to the Kwinageese watershed was created by timber harvest especially in the middle portion of the watershed and the effects of the access and habitat degradation are unknown.																						
6	Upper Nass	Meziadin	Meziadin (Tintina, Hanna, Surprise, Strohn),	adfluv, fluv?, res?	U	U	U	Withler 1956b; Harding and Sebastian 1975	U	L	I	**U**	U	M	I	**M**	H	H	I	**H**	U	unranked
Comment: Several Nass tributaries between Meziadin and Cranberry rivers appear to lack BT (e.g., Paw, Brown Bear, White, and Moore); barriers occur near the mouth of many of these, with only RB present upstream. Meziadin L anecdotally supports adfluvial BT, which are exploited by fishery in lake; char thought to be BT are also sampled in Meziadin R at DFO weir/fishway; not clear if these BT are associated with Meziadin L. pop; fishway could have changed BT pop. structure by allowing increased movement in both directions, but this is unknown. Withler (1956) reports numerous large char caught during gillnetting surveys in lake during July. Char described as DV (2-8 lbs) were noted in upper Hanna Cr. d/s of falls. Spawning char described as'DV' also noted in upper Tintina Cr., 7-8 miles u/s of Meziadin L.. Strohn and Surprise creeks are thought to used by Meziadin L. pop. (S. Kingshott, LGL, pers. comm.). BT are captured in recreational salmon fisheries in Meziadin R. at Nass confluence; their origin is unknown. BT passage is impeded at some hwy 37 and 37A stream crossings. Northern Transmission Line development (underway in 2011) may create impacts. Extensive logging east and north of Meziadin L.																						
6	Upper Nass	Cranberry-Kiteen	Cranberry (Ginmiltkun, Weber, Kiteen)	fluv, res?	U	U	U		L/M	L	I	**U**	M/H	L	I	**M**	H	H	I	**H**	F	unranked
Comment: No record of BT presence in the Cranberry mainstem below Kiteen R. Uncertain basis for differentiation of CA's in Nass drainage. There are very few naturally fish-bearing lakes in the Cranberry watershed (exceptions: Derrick, McKnight, Borden) and DV or BT have not been reported from any of these although sampling has been minimal. It appears likely that BT are widely distributed in this putative CA, including to near the headwaters of the Kiteen and tributaries, Cranberry, and Weber mainstems. DV were reported present in some portions of the Kiteen watershed, ID'ed by Haas-McPhail LDF (SKR 1999) including in at least one stream where BT were also present. BT angling cpue during MoE ST tagging programs in 1980s/90s was high (Lough, pers. comm). No information (anecdotal or otherwise) is known about the movements or life history of BT in this watershed. Easy access for angling is created by Highway 37 and logging roads along the Cranberry and Kiteen valleys; use of bait is allowed in CH fishery but prohibited during late summer and fall. Forest harvest has been extensive in this watershed since the 1970s.																						
6	Upper Nass	Bell-Irving	Bell-Irving (Scott, Treaty, Oweegee, Hodder, Teigen, Owl, Rochester)	adfluv, fluv?, res?	U	U	U	Coombes 1988; SKR 1998	L/M	L	I	**U**	U	L	I	**U**	H	H	I	**H**	F	unranked
Comment: Many of Bell-Irving tribs between Rochester L. and Nass confluence support both BT and DV (ID'ed by Haas-McPhail LDF; SKR 1999), but BT are probably widespread. BT angling CPUE during MOE ST tagging programs in 90s/00s was high in the B-I between and including Teigen to Taft/B-I confluence (ID by informal morph obs, J. Lough, MNRO, pers. comm). Sampling of lakes in watershed has mostly pre-dated widespread knowledge of the DV-BT distinction, so fish ID'ed as DV in past may be either . Bowser L is highly silty but is a SK lake; gillnetting captured BT &/or DV from 65mm to 426mm at low/mod abundance. Oweegee L ice fishery anecdotally yields large-bodied char which appear to be BT. Hwy 37 traverses watershed and creates angling access and fish passage issues. Three angling guide camps on the B-I, mostly ST focus but BT are also captured; bait ban probably incidentally benefits BT. Extensive forest harvest and attendant roading has occurred in the NE central portion of the watershed (north of Bowser and south of Bell II). Mining activity occurs in the watershed and may expand as NTL is implemented - egs include historic Granduc mine in Bowser and Seabridge gold development in Teigen.																						

Appendix 4 continued.

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<tr><td></td><td>Iskut-Lower Stikine</td><td>Tuya</td><td>Tuya L, Tuya R, Butte L</td><td>res adfluv; fluv?, res?</td><td>U</td><td>U</td><td>U</td><td>Beere 2002</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>U</td><td>H</td><td>H</td><td>H</td><td>H</td><td>U</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment: Confirmed BT presence in Butte L., Tuya L. and an unnamed inlet tributary west of Butte Cr. The BT were id'ed based on morphometry (Beere, 2002). DV and LT were previously reported in Tuya L, but not found to be present in the 2002 reconnaissance survey. There two complete obstructions to upstream passage of fish in the Tuya River 3 km u/s of the confluence with the Stikine. These areas have been assessed as to the possibility of creating upstream passage for salmon (by modifying the barriers and/or building a fishway) which remains a possibility in the future. Tuya Lake receives sockeye fry outplants annually (Snettisham hatchery) and the returning adult sockeye are harvested at the barriers previously mentioned and the outplants may impact BT status (positively or negatively) . The barriers isolate the BT in this watershed from other Stikine BT populations, hence it is logical to consider the Tuya a distinct CA. Some BT gillnetted in July 2002 in Tuya Lake were immature, hence adfluvial designation. Unknown whether separate fluvial population(s) exist in Tuya drainage.</i></td></tr>
<tr><td>6</td><td>Iskut-Lower Stikine</td><td>Tahltan</td><td>Stikine (d/s Canyon), Tahltan (Middle, Beatty, Little Tahltan, Tahltan L), Chutine (Dirst, Ugly, Cave, Pendant)</td><td>adfluv; fluv?</td><td>U</td><td>U</td><td>U</td><td>Redenbach and Taylor 2003; Schell 1999a</td><td>U</td><td>U</td><td>I</td><td>U</td><td>U</td><td>U</td><td>I</td><td>U</td><td>H</td><td>H</td><td>H</td><td>H</td><td>U</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment: Genetic corroboration of BT in Tahltan (Redenbach and Taylor 2003); hybrid BT-DV also present . Tahltan enters Stikine R. d/s of Grand Canyon; anadromous fish can access as far as Tahltan L ; unknown whether headwater resident BT and/or DV exist above barriers. Sockeye enhancement at Tahltan Lake at present primarily involves an annual egg take which might reduce the food supply for BT, which have been seined in the lake during the egg take and may be an adfluvial population. There are significant FN and recreational fisheries on the lower Tahltan River (for steelhead, chinook, and possibly other species). The (gated?) access road for Golden Bear Mine traverses the Tahltan watershed. In addition, both BT and DV are present in the Chutine watershed (Schell 1999) which enters the Stikine River a considerable distance downstream of the Tahltan confluence. Other Stikine tributaries between the Chutine and Tahltan (Mess, Yehiniko etc) have not been demonstrated to support BT but the sampling to date is not definitive. Grouping of Chutine in the same CA as Tahltan is arbitrary. Mining exploration and active placer mining occur in the Chutine watershed, and may create impacts to bull trout habitat.</i></td></tr>
<tr><td>6</td><td>Iskut-Lower Stikine</td><td>Middle Iskut</td><td>Iskut, Thomas, Devil, More, Ningunsaw (Ogilvie, Alger, Liz)</td><td>fluv?, res?, adfluv?</td><td>U</td><td>U</td><td>U</td><td>Redenbach and Taylor 2003; Schell 1999b</td><td>U</td><td>U</td><td>I</td><td>U</td><td>U</td><td>U</td><td>I</td><td>U</td><td>H</td><td>I</td><td>I</td><td>L</td><td>U</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment: Genetic corroboration of BT in the Iskut (Redenbach and Taylor 2003) and elsewhere (Schell 1999b); a BT/DV hybrid was captured in Devil Creek system (Schell 1999). DV are present in Ningunsaw and tribs. along with BT; char sampled from Bob Quinn L. may have been either species; both are likely widespread in this CA, though BT tended to be found in the large mainstem systems; whereas DV appear widespread in upper reaches of glacially-influenced systems (Schell 1999). The upstream extent of char distribution in the Iskut mainstem is probably the falls downstream of Natadesleen L.; only RB present upstream. The lower Iskut R. (downstream of the impassable canyon has not been demonstrated to support BT , but the amount/timing of sampling might not be definitive. Hwy. 37 traverses the Ningunsaw and Iskut valleys in this CA and may create or exacerbate fish passage difficulties as well as allowing angling access. Hydroelectric development in the Iskut Canyon at the downstream end of the CA and elsewhere may impact bull trout habitat. Mineral extraction activities in the Iskut watershed are primarily downstream but future development is possible within the CA; road develpment related to mining might create additional angling access, sediment inputs and/or passage issues.</i></td></tr>
<tr><td>6</td><td>Upper Stikine</td><td>Upper Stikine</td><td>Stikine, Hotlesklwa, Chukachida (Geese)</td><td>adfluv?, fluv?</td><td>U</td><td>U</td><td>U</td><td></td><td>U</td><td>U</td><td>I</td><td>U</td><td>U</td><td>U</td><td>I</td><td>U</td><td>H</td><td>H</td><td>I</td><td>M</td><td>U</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment: Above Spatsizi confluence. Basis for differentiation of CA's in the Stikine drainage is unknown. To the best of our knowledge, neither morphometric analyses (LDF per Haas and McPhail 1991) nor genetic methods have been used for credible species identification (BT versus DV) anywhere in this CA; either or both species may be present though large reported body size of some captures suggests BT presence. Coalbed methane development at/near the headwaters of the Stikine poses a potential threat to habitat. Remoteness and park status provide substantial (but incomplete) protection from other industrial development and increased access (exploitation). Boat traffic on the Stikine and Chuckachida rivers is likely the main vector for angling exploitation which is believed low/moderate in intensity.</i></td></tr>
<tr><td>6</td><td>Upper Stikine</td><td>Spatsizi</td><td>Stikine, Spatsizi, Mink (Gladys), Grizzley</td><td>adfluv?, fluv?</td><td>U</td><td>U</td><td>U</td><td></td><td>U</td><td>U</td><td>I</td><td>U</td><td>U</td><td>U</td><td>I</td><td>U</td><td>H</td><td>H</td><td>I</td><td>M</td><td>U</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment: Basis for differentiation of CA's in the Stikine drainage is unknown. To the best of our knowledge, neither morphometric analyses (per Haas 2001) nor genetic methods have been used for credible species identification (BT versus DV) anywhere in this CA; either or both species may be present though large reported body size of some captures suggests BT presence. Coalbed methane development at/near the headwaters of the Spatsizi poses a potential threat to habitat. Remoteness and park status provide substantial (but incomplete) protection from other industrial development and increased access (exploitation). Boat traffic on the Stikine and Spatsizi rivers is likely the main vector for angling exploitation which is believed low/moderate in intensity.</i></td></tr>
<tr><td>6</td><td>Upper Stikine</td><td>Klappan</td><td>Stikine (Tees, Pitman), Klappan, McEwan, Eaglenest, Little Klappan (Tsetia), Sweeney</td><td>fluv?</td><td>U</td><td>U</td><td>U</td><td></td><td>U</td><td>U</td><td>I</td><td>U</td><td>U</td><td>U</td><td>I</td><td>U</td><td>H</td><td>H</td><td>I</td><td>M</td><td>U</td><td>unranked</td></tr>
<tr><td colspan="23"><i>Comment: Stikine mainstem from Pitman to Canyon; anecdotal reports from Pitman of large (> 7kg) spawners captured by hunters in autumn. Basis for differentiation of CA's in the Stikine drainage is unknown. All char specimens collected in the Klappan during an overview inventory (Schell 1999) were genetically ID'ed as BT. Boat traffic on the Stikine and Pitman rivers is likely the main vector for angling exploitation which is believed low/moderate in intensity. Proposed mining development in the Klappan drainage (coal at Klappan/Groundhog, coal bed methane at Sacred Headwaters) is extensive and could include habitat impacts in addition to increased access allowing angling exploitation.</i></td></tr>
</table>

Appendix 4 continued.

Geographic information				Life history	Adult population (see Table 2 for codes)				Threat (high-H, moderate-M, low-L, insignificant-I)													Status
									Severity				Scope				Immediacy					
Region (1-9)	Ecological Drainage Unit	Core Area	Tributary (sub-tributary)	(res, adfluv, fluv, anad)	Pop. size	Distribution	Trend	Reference	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	**Overall threat value**	
6	Upper Stikine	Tanzilla	Tanzilla, Hluey	adfluv?, fluv?	U	U	U		U	U	I	**U**	U	U	I	**U**	H	H	I	**M**	U	unranked
Comment: Basis for differentiation of CA's in the Stikine drainage is unknown. The Tanzilla joins the Stikine River upstream of the Grand Canyon of the Stikine. None of the char reported from this CA have been credibly positively identified as BT (characters used for ID were not recorded). Hydro development has occurred at Hluey Lakes with an expansion proposed. Highway 37 and Telegraph Creek Road parallel much of the length of the mainstem Tanzilla Creek, allowing access for angling exploitation.																						
6	Nakina	Nakina	Nakina, Silver Salmon, Sloko (Nakonake)	fluv?	U	U	U		U	U	I	**U**	U	U	I	**U**	I	I	I	**I**	U	unranked
Comment: Fluvial char angled in 1990 in the Nakina mainstem near Sloko confluence as well as 10km upstream were genetically ID'ed to show BT markers (memo to Beere from E. Taylor); this is well downstream of the impassable barrier to upstream movement on the Nakina mainstem which is near the Taysen C confluence and neither DV nor BT have been captured during sampling upstream of this barrier. Dolly Varden occur in the lower Taku watershed but the location of the zones of overlap with bull trout are unknown. A plausible route for colonization of the lower Nakina watershed by bull trout could be via the Inklin system. Unknown whether this CA is distinct from the Inklin CA.																						
6	Taku	Inklin	Inklin, Yeth, King Salmon, Sutlahine, Kowatua, Trapper L, Tulsequah?	adfluv?, fluv?, res?	U	U	U		U	U	I	**U**	U	U	I	**U**	H	I	I	**L**	U	unranked
Comment: Unknown whether fish in this CA identified as BT or DV are BT or DV or both. Unknown whether this CA is distinct from the Nakina and/or Sheslay and/or Nahlin CAs (i.e. there is potential migrational conectivity between some portion of each of these CA's). Tunjony Lake (Kowatua system) is above a 10m falls and may be a distinct headwater population of DV or BT. Would other mainstem Taku tributaries (besides King Salmon) also be included in this CA if BT were present? Tulsequah fish may be DV or BT or (more likely) both, and if they are BT it is unknown whether they would group in this CA, but a mine site in the central watershed (Tulsequah - proposed for further development) might impact habitat; other mine development is likely in this watershed in the future. Salmon enhancement activities have been proposed for this watershed and might impact BT status if implemented (positively or negatively).																						
6	Taku	Sheslay	Sheslay, Tatsatua C, Tatsatua L, Samotua, Egnell, Hackett	adfluv?, fluv?	U	U	U		U	U	I	**U**	U	U	I	**U**	I	I	I	**I**	U	unranked
Comment: Unknown whether fish in this CA identified as BT or DV are BT or DV or both. Unknown whether this CA is distinct from the Inklin and/or Nahlin and/or Nakina CAs (i.e. there is conectivity between some portion of each of these CA's). Fluvial char angled in 1990 in Tatsatua watershed were genetically ID'ed to show BT markers (memo to Beere from E. Taylor). In Tatsatua Lake gillnetting in 1985, S. namaycush was the dominant char (only one BT or DV captured); S. namaycush was the only char captured in gillnetting of Tatsamenie Lake in 1985 and 2001, but BT are reported in the Tatsamenie R. downstream. Salmon enhancement activities have been implemented in this watershed and might impact BT status (positively or negatively).																						
6	Taku	Nahlin	Nahlin, Dudidontu (Matsatu, Kakuchuya), Tseta	adfluv?, fluv?	U	U	U		U	U	I	**U**	U	U	I	**U**	I	I	I	**I**	U	unranked
Comment: Unknown whether fish in this CA identified as BT or DV are BT or DV or both. Unknown whether this CA is distinct from the Inklin and/or Sheslay and/or Nakina CAs (i.e. there is conectivity between some portion of each of these CA's). Gillnet sampling of Victoria Lake (headwater to Tseta Cr in the upper Nahlin) by Taku River Tlingit Fisheries in 2004 captured "DV" but identification method is not documented.																						
6	Lewes	Atlin Lake	Atlin Lake	adfluv?	U	U	U	Withler 1956	U	I	I	**U**	U	I	I	**U**	H	I	I	**L**	U	unranked
Comment: One LRDW record for Atlin Lake only (referenced in LRDW as Withler 1955). Withler (1956) reports on extensive fish sampling of Atlin Lake related to hydroelectric storage and does not mention Dolly Varden at all. If BT or DV are present in Atlin Lake or its tributaries, they are extremely uncommon. A query was sent to Yukon Territory Fisheries section as to the presence of BT in the Yukon mainstem system upstream of Whitehorse; no observations are known to date (L. Jessup, pers. com.) Key areas (if any) of production are completely unknown. The major known potential habitat impacts in this area would be placer mining, which is significant in some areas of this EDU but we cannot assess the overlap of development with BT habitat given unknown location of the latter. No known reports of angling capture of BT in this EDU. It is implausible that either BT or DV are present in this CA.																						
6	Teslin	Teslin	Swift (Swift, McNaughton, Plate), Teslin (Hayes)	fluv?	U	U	U		I	I	I	**I**	I	I	I	**I**	H	I	I	**L**	H	unranked
Comment: BT are reportedly present in some streams in this drainage, and the reports are credible; reported locations are generally adjacent to the Upper Liard and headwater transfer appears plausible. However, none have been captured in sampling of the lakes, where the dominant char present is S. namaycush. Very minimal road access occurs in this watershed except along the Alaska Highway corridor (Swift River mainstem). There is some (historical) mining activity in this Core Area but not extensive, future unknown.																						

Appendix 4 continued.

<table>
<tr><th colspan="4">Geographic information</th><th>Life history</th><th colspan="4">Adult population (see Table 2 for codes)</th><th colspan="13">Threat (high-H, moderate-M, low-L, insignificant-I)</th><th>Status</th></tr>
<tr><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th colspan="4">Severity</th><th colspan="4">Scope</th><th colspan="4">Immediacy</th><th></th><th></th></tr>
<tr><th>Region (1-9)</th><th>Ecological Drainage Unit</th><th>Core Area</th><th>Tributary (sub-tributary)</th><th>(res, adfluv, fluv, anad)</th><th>Pop. size</th><th>Distribution</th><th>Trend</th><th>Reference</th><th>Habitat</th><th>Exploitation</th><th>Competitors</th><th>Overall</th><th>Habitat</th><th>Exploitation</th><th>Competitors</th><th>Overall</th><th>Habitat</th><th>Exploitation</th><th>Competitors</th><th>Overall</th><th>Overall threat value</th><th></th></tr>
<tr><td>7</td><td>Upper Peace</td><td>Thutade</td><td>Known adfluvial populations: Kemess, Attichika, Attycelley, Niven, Trib 4, South Pass.</td><td>res, adfluv</td><td>C</td><td>C</td><td>F</td><td>Bustard 2010; Hagen 2000; Hagen and Taylor 2001; Redenbach and Taylor 2003</td><td>M</td><td>I</td><td>I</td><td>**L**</td><td>L</td><td>I</td><td>I</td><td>**L**</td><td>M</td><td>I</td><td>I</td><td>**M**</td><td>G</td><td>potential risk</td></tr>
<tr><td colspan="23">*Comment : Areas of Dolly Varden/Bull trout sympatry have been of high scientific interest; habitat use patterns for DV and BT in sympatry known from studies conducted here; high value, 17-year time series of juvenile and adult population size estimates; populations increasing gradually probably due to angling regulation changes (c. mid-90s); relatively pristine habitat throughout core area; mine-related habitat loss successfully compensated to date, but water temperature increases following shutdown (drainage from wetland flooding tailings) a threat.*</td></tr>
<tr><td>7</td><td>Upper Peace</td><td>Upper Finlay</td><td>Sturdee, Upper Finlay, Todoggone (Moosehorn, McClair, Jack Lee), Delta C, Firesteel, Fishing Lakes, Thudaka R, Obo R, Spinel R, Spinel Lake.</td><td>fluv, adfluv?</td><td>U</td><td>D</td><td>U</td><td>Zemlak and Langston 1994</td><td>I</td><td>I</td><td>I</td><td>**I**</td><td>I</td><td>I</td><td>I</td><td>**I**</td><td>I</td><td>I</td><td>I</td><td>**I**</td><td>H</td><td>unranked</td></tr>
<tr><td colspan="23">*Comment : Given bull trout round trip spawning migrations can exceed 400 km (McPhail 2007) I suspect large adfluvial Williston bull trout might be present. FDIS records (including electrofishing data in early 2000's by FWCP-P), and FWCP-P reports document bull trout in identified locations. Barriers to upstream movement occur at Cascadero falls and on other tribs in Firesteel. Large bull trout captured in Finlay River fall of 1994 near fishing lakes large bodied and likely adfluvial from Williston Reservoir (not known for a fact though). Studies in 2009 (data on file with Brendan Anderson) on Spinel Lake captured bull trout. Golder and Assocaites 2002 report identifies locations of bull trout, Dolly Varden and possible hybrids, report also identifies barriers and to fish movement. Extremely remote location and limited road access to only a few points reduce angler access to near zero level.*</td></tr>
<tr><td>7</td><td>Upper Peace</td><td>Lower Finlay</td><td>Fox (Carcajou, McCook, Poole, Weissener) Kwadacha (Warneford, Chesterfield, North Kwadacha, upper Kwadacha), Russel, Paul, Foot, Del, Tsaydiz, Estella, Pesika, Akie R., Jack Lake, Stelkuz Lake, Truncate C, Truncate Lake #3.</td><td>res, fluv, adfluv</td><td>U</td><td>D</td><td>U</td><td>Langston and Blackman 1993; Trition 2006</td><td>L</td><td>I</td><td>I</td><td>**L**</td><td>M</td><td>I</td><td>I</td><td>**M**</td><td>H</td><td>I</td><td>I</td><td>**H**</td><td>F</td><td>unranked</td></tr>
<tr><td colspan="23">*Comment : BT widespread at >60% of sampling sites in Fox, Wiessener, Kwadacha, and Warneford systems (Triton 2006); Upper Kwadacha resident/fluvial pop. located above 10 m falls; FDIS records show BT in Foot and Quentin lakes; Jack L. has BT therefore Stelkuz L. must also have BT. BT likely in McGraw, Bower and Cutoff Creeks as well. M value for habitat because lower Finlay has seen a lot of logging and forest fires and now beetle kill, and cumulatively, these factors have the potential to raise stream temperatures and lower summer base flows. I placed the recovery at high because the forest in that area historically has had many burns (natural and First Nations Cultural) and with little angling pressure coupled with large adfluvial bull trout apparently doing quite well in Williston, any down turn should be offset quickly. Road access generally limited to a few points in the lower rivers (usually one road crossing at lower points limiting habitat disturbances and angler access. However as noted above the lower Finlay River valley from Kwadach to the reservoir is extermely heavily impacted by beetle kill pine and resource (log) extraction. Also mining activity increasing in Akie drainage.*</td></tr>
<tr><td>7</td><td>Upper Peace</td><td>Finlay Reach</td><td>Ingenika (Cutbank, Pelly, Swannell), Chowika, Factor Ross, Davis, Bruin, Collins, Ospika, Lafferty C, Pelly Lake, Wrede C, Tucha Lake, and others (see comments section)</td><td>res, adfluv</td><td>U</td><td>D</td><td>E</td><td>Andrusak et al. 2011; O'Brien and Zimmerman 2001</td><td>I</td><td>I</td><td>I</td><td>**I**</td><td>I</td><td>I</td><td>I</td><td>**I**</td><td>I</td><td>I</td><td>I</td><td>**I**</td><td>H</td><td>unranked</td></tr>
<tr><td colspan="23">*Comment : Upper Chowika, Ospika BT present above putative migration barriers. I suspect (hopefully FDIS has records) that Ingenika tribs Tucha C, Pelly Lake have bull trout (I have been told Tucha Lake has bull trout). Lafferty Creek has bull trout, have seen adfluvial adults milling at mouth in September, and electrofished a 55mm bull trout in 1989 (PWFWCP report 70). Graham River (trib to Davis has bull trout adfluvial and possible fluvial residents in Graham Lake). Aerial surveys (Sept 2003 notes on file): BT redds observed in Wrede Creek, nice spawning habitat noted at 9.322162.6343224 (upper Pelly trib). I believe Ted Zimmerman (Prince George MNRO) identified Dolly Varden in upper Ingenika watershed (in McConnell and possibly Flammeau Creeks). Not as much Pine here. Redd counts in Davis C stable or slightly increasing (not significant; Andrusak et al. 2011).*</td></tr>
</table>

Appendix 4 continued.

Geographic information				Life history	Adult population (see Table 2 for codes)				Threat (high-H, moderate-M, low-L, insignificant-I)													Status
									Severity				Scope				Immediacy					
Region (1-9)	Ecological Drainage Unit	Core Area	Tributary (sub-tributary)	(res, adfluv, fluv, anad)	Pop. size	Distribution	Trend	Reference	Habitat	Exploitation	Competitors	Overall	Habitat	Exploitation	Competitors	Overall	Habitat	Exploitation	Competitors	Overall	Overall threat value	
7	Upper Peace	Omineca	Mesilinka (upper Lay C, Abraham, Tutizika, Chase?), Osilinka (Unnamed, Flegel, Wasi, Tenakihi, Vega, Thane, Haha, Unnamed, Uslika Lake), Omineca (Porter, Nina, Germanson, Twenty-mile, Discovery, Duckling, Fall, Ogden, Ominicetla, Genlid, Carruthers, upper Omineca)	res, fluv, adfluv	U	D	U	ECL Envirowest 1998; Beak International 1998;	I	I	I	**I**	I	I	I	**I**	I	I	I	**I**	H	unranked

Comment : BT from upper Lay C, Abraham C, upper Omineca R present above putative migration barriers. Lower areas of Mesilinka, and Osilinka River logged with frequent road access. Area is remote with likely low angler effort and little or no boat anglers at river mouths. Pine beetle has affected the area, but steep mountainous headwaters likely mitigates any solar affects on water temperature. Very large schools (some 300+) of adfluvial bull trout observed in mainstem (especially around Germansen River area) feeding on large kokanee spawner runs in mid September. Bull trout widespread in watersheds during 1997 Fish and Fish Habitat Inventory (Beak International 1998).

7	Upper Peace	Parsnip Reach	Manson (Munro, Gaffney, Carmella), Nation (Phillip, Suschona, Klawli, Ahdatay, Kwanika, Rottacker, Sylvester, Fish), Weston, Scott, Six Mile, Blackwater, Cut Thumb, Tony, Tsedeka, Mugaha, Chichouyenily, Mischinsinlika, Pack (McCleod, Crooked), Misinchinka, Colbourne	adfluv, fluv	U	E	U	Langston and Cubberley 2008; Andrusak et al. 2011; Williamson and Zimmerman 2006	L	L	I	**L**	M	L	I	**M**	I	H	I	**H**	F	unranked

Comment : M value for habitat because area (especially Manson and Nation rivers) has had heavy logging and beetle kill, which has the potential to raise stream temps and potentially lower summer flows. High for immediacy because it has happened; pine beetle is ongoing. Manson and Nation systems are warmer than most rivers their size in Williston watershed because they are headed by large lakes and meander through a lot of open benchland as opposed to steep mountains. There are likely less BT in these streams due to the warmer water temps. Many road crossings due to logging, and poor or failing culverts likely impede fish access in some cases. Lots of road access and angling pressure for BT and little enforcement presence, therefore regulation compliance low, catch and release, bait bans, etc. not followed (especially along hwy beside Misinchinka R). Heavy angling pressure at mouths of Cutthumb, Mugaha, and Nation rivers and uncertain compliance rate. Threat of overexploitation at these sites and Mackenzie causeway is high. Angler retention of BT is likely occuring, but undocumented; BT values rated high during literature review and sensitivity analysis (Williamson and Zimmerman 2006).

7	Upper Peace	Upper Parsnip	Reynolds, Anzac, Fern, Tacheeda, Table, Missinka, Hominka, upper Parsnip	fluv, adfluvial	U	D	U	Table, Anzac, Hominca and Missinka rivers (see PWFWCP reports on their website); Van Schubert 2002; Williamson and Zimmerman 2006	L	I	I	**L**	M	I	I	**M**	I	I	I	**I**	F	unranked

Comment : I placed a M value on habitat as about 40% of the area has seen logging and now beetle kill pine issue is extensive, which has the potential to raise stream temperatures and potentially lower stream summer base flows, increase tubidity due to run-off and failing banks. I placed High in the immediacy box because it has happened, the pine beetle kill is ongoing up there. Table River has a small (approx, 3 m waterfall) approx. 46 km upstream of the mouth. The falls stops most bull trout but once in a while a few get up as I captured juveniles in the approx 10 km upper length of the stream. I beleive they are simply juveniles and not a stream resident dwarf group, (but I can't prove it). Curiously there is also a population of sculpins that somehow got into this little bit of stream above the falls. Information documented in Table River Inventory type reports on our website. Low angelr access to most locations in this section; 30% mainstem Table River logged; locally degraded habitats (Van Schubert 2002); Systems classified as high value bull trout habitats in previous literature review and analysis (Williamson and Zimmerman 2006).

Appendix 4 continued.

Geographic information				Life history	Adult population (see Table 2 for codes)				Threat (high-H, moderate-M, low-L, insignificant-I)													Status
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Region (1-9)	Ecological Drainage Unit	Core Area	Tributary (sub-tributary)	(res, adfluv, fluv, anad)	**Pop. size**	**Distribution**	**Trend**	Reference	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	**Overall threat value**	
9	Upper Peace	Peace Reach	Nabesche, Upper Nabesche, West Nabesche, Selwyn, Bernard, Point, Clearwater, Clearwater lake, Carbon, Ducette, Schooler, Adams, Dresser, Dunlevy,	adfluv, res	U	D	U	Langston and Blackman 1993; reconnaissance of Clearwater Lake (PWFWCP data on file)	I	M	L	**M**	I	L	L	**L**	I	H	M	**H**	E	unranked
Comment : No barrier on Clearwater R. Large adfluvial bull trout ascend Clearwater at least to Clearwater L.; Large adfluvial bull trout captured in Clearwater L. in 1991. Barrier to bull trout identified in Nabesche River (approx 20 km?) from the mouth. Documented in reports and photos on file (guessing 7m vertical waterfall). Bull trout (strream resident) documented above the falls and far upstream as Nabesche R. and Emerslund Cr. and Emerslund Lakes (PWFCP report on on file). Angling pressure may be extremely important. Jet boats anglers target BT at mouths of Clearwater, Nabesche, Carbon and Wicked rivers. If anglers were more aware of the concentration of bull trout feeding on kokanee in mid-Sept, Bt would be even more vulnerable. Lake torut numbers appear to be increasing in the Peace Reach especially. Trophy size lake trout (30+ pounds) are being captured with lots of kokanee in their stomachs. Williston Res. stays cold late into July with the thermocline weak and not far down thereby allowing lake trout to forage near the surface and stream mouths. BT redd counts in Point Creek provide abudance index for Peace Reach.																						
9	Upper Peace	Dinosaur Reservoir	Gething, upper Gething, Dowling, Gaylard, Johnson	adfluv, res	U	B	U	Langston 2008 (PWFWCP no. 333)	M	M	M	**M**	L	L	M	**L**	H	M	M	**H**	E	unranked
Comment : A BT tagged in Dunlevy Cr (Williston Res.) was captured in Gething Cr (Dinosaur Res.) indicating some get through turbines and some exchange occurs between these core areas. Gething is the main if not the only spawning trib in Dinosaur Res.; barrier 5 km from the mouth. We translocated adults above falls on Gething to Gaylard and Dowling tribs and upper Gething. Offspring appeared to have mostly left the system, but some were observed in headwater lake (Wright L.). Johnson Cr surveyed in 2006 at same time redds were seen in Gething, but no redds seen in Johnson Cr suggesting Gething might be the only spawning location in Dinosaur. Lake trout #,s increasing in Dinosaur, and competitive pressure on bull trout may increase in future. Very hard to pin down categories because it is now a reservoir and there is more habitat for large BT , but spawning habitat is now very limited and very low quality, so habitat is affected. Catch and release regulations, and effort is apparently low. Compliance with regulations is poor; anglers sometimes can't differentiate BT and perch, nevermind BT and lake trout. Majority of Dinosaur res. spawners stage at waterfall barrier in Gething Cr. where they are highly vulnerable to poaching.																						
9	Lower Peace	Halfway-Peace	Halfway, Ground Birch, Cameron (Cameron, Deadhorse), Kobes, Graham (Graham, Needham, Colt), Blue Grave, Horseshoe, Chowade (and unnamed tribs), Cypress (Cypress, Robertson, Geesdale), Headstone, Turnoff, Fiddes, Calnan	fluv, adfluv, res	C?	D?	F?	Burrows et al. 2001; Baxter 1994, 1995a, 1997; RL&L 1994; DES 2002b, 2002c, 2006a, 2011; Mainstream Aquatics and DES 2009	M	L	I	**M**	H	L	I	**H**	H	H	I	**H**	A	at risk
Comment : Trend code may be 'F' for fluvial component if trend of increasing redd abundance in Halfway tribs is an indicator for the whole watershed. Isolated resident in upper Graham above Christina Falls (originated from transplanted BT from below Christina Falls); no spawning habitat in Kobes, Groundbirch & Cameron (warm, high TSS) - occurences in these tribs limited to sub-adults rearing/foraging; spawning in Bluegrave & Horseshoe also unlikely - similar issues & extensive beaver activity. Resident BT above Halfway Falls in Halfway mainstem and Calnan Creek. Possible adfluvial population using outlet of Robb Lake for spawning as evidenced by presence of high densities of YOY BT.																						
9	Lower Peace	Moberly	Moberly L, Dokie, upper Moberly	res, adfluv	B?	D?	U	Goddard 2008	L	I	I	**L**	M	I	I	**M**	H	I	I	**H**	F	at risk
Comment : scattered occurrences in upper watershed, did Brendan rule out adfluv BT from Moberly Lake? Resident life history for upper Moberley suggested by Goddard (2008)																						
7b	Lower Peace	Pine/Sukunka	Pine, Lower Sukunka (Dickebusch, Martin), Burnt (Brazion, North Burnt), Centurion, Wildmare, Hasler, Crassier, Falling, Willow, Beaudette, Le Moray, Mountain, Silver Sands, Upper Pine, John Bennett, Callazon	fluv	U	D?	U	AMEC and LGL 2008, 2009, 2010; DES 2006b, 2008, 2010; Macullo and Goddard 2010	M	L	I	**M**	M	L	I	**M**	H	H	I	**H**	B	unranked
Comment : MELP/DES snorkel surveys conducted in Burnt between 1992-2006;density of RB in Burnt R. watershed increasing																						

Appendix 4 continued.

Geographic information				Life history	Adult population (see Table 2 for codes)				Threat (high-H, moderate-M, low-L, insignificant-I)													Status
									Severity				Scope				Immediacy					
Region (1-9)	Ecological Drainage Unit	Core Area	Tributary (sub-tributary)	(res, adfluv, fluv, anad)	**Pop. size**	**Distribution**	**Trend**	**Reference**	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	**Overall threat value**	
9	Lower Peace	Upper Sukunka	Upper Sukunka, Boulder, Rocky, Chamberlain, Windfall, Baker, McClean, Twidwell	fluv, res	C?	D?	U	Upper Sukunka BT snorkel counts 1989 & 1990 (DES 2011b)	L/M	L	I	**L**	L	L	I	**L**	H	H	I	**H**	G	unranked
Comment : Isolated fluvial population above Sukunka Falls, also residents in upper Chamberlain Cr.; congregations of spawning BT observed by Brian Pate (West Fraser) in west fork of upper Sukunka; windfall believed to be important spawning area for upper Sukunka BT; snorkel surveys conducted in upper Sukunka (above falls) in 1989 & 1990;																						
9	Lower Peace	Lower Murray	Murray, Wartenbe, Gwillim (Trapper, Gwillim L, Meikle, Suprenant), Bullmoose, Wolverine (Mesa), Mesa, Flatbed (Hambrook, Babcock, Gordon), Kinuseo, Fellers	fluv, adfluv, res	C	D?	U	Baxter 1995b; DES 2004; Goddard 2008; Macullo and Goddard 2010; 2010 redd counts in Gordon Creek (DES 2011c); spawning adults sampled in Fellers Cr. in 2010 (DES in progress)	M	L	L	**M**	M	M	L	**M**	H	H	H	**H**	B	at risk
Comment : fluvial/adfluvial/resident populations above Kinuseo Falls, brook trout documented in Murray mainstem and tribs in vicinity of Kinuseo Falls to Quality Creek (Baxter 1995b); Wolverine and Fellers important spawning tributaries for lower Murray; redd counts for Wolverine/Fellers indicate core area population > 250 (Macullo and Goddard 2010); spawning adults sampled by DES in Fellers in 2010 - write-up in progress; redd surveys of resident population in Gordon (DES pers. comm., report in prep.) C afor upper Murray 2010; isolated resident population in Bullmoose (DES 2004)																						
9	Lower Peace	Upper Murray	Upper Murray (above Kinuseo Falls), Hook, Hook L, Monkman	fluv, adfluv, res	U	D?	U		L/M	L/U	I	**L**	L/M	L/U	I	**L**	H	H	I	**H**	G	unranked
Comment : fluvial/adfluvial/resident populations above Kinuseo Falls																						
9	Lower Peace	West Kiskatinaw	West Kiskatinaw	fluv	U	D?	U		L	I	I	**L**	M	I	I	**M**	H	I	I	**H**	F	unranked
Comment : Two isolated mainstem records from 1987 - subsequent sampling has failed to capture more.																						
9	Lower Peace	Upper Wapiti	Wapiti, Huguenot (Belcourt, Belcourt L, Winfrey), Red Deer, Calliou, Fearless, Dokken, Bekker, Fellers L,	fluv, adfluv, res	U	D?	U	DES 2004	L/M	L/U	I	**L**	L/M	L/U	I	**L**	H	H	I	**H**	G	unranked
Comment : Resident fish above putative barrier falls on Huguenot; redds documented in Belcourt Cr. in 2002; threats include extensive oil & gas development, proposed coal mines, possible wind energy projects																						
9	Lower Peace	Upper Narraway	Upper Narraway	fluv	U	D?	U		L/M	L	I	**L**	L/M	L	I	**L**	H	H	I	**H**	G	unranked
Comment :																						
6	Upper Liard	Lower Dease	Dease, Blue (Little Blue, Chromite, Upper Blue), Charlie Chief	fluv?	U	U	U		U	U	I	**U**	U	U	I	**U**	H	H	I	**M**	U	unranked
Comment: It is unclear where the geographic division between Upper Dease and Lower Dease core areas should be located (see below). Fish passage issues exist at Highway 37 crossings (including Blue River mainstem) but it is unknown whether/how these may affect BT. Some angling access occurs along the Highway 37 corridor but it is unknown whether BT staging areas or other points of concentrated abundance are thus made accessible to anglers.																						

Appendix 4 continued.

<table>
<tr><th colspan="4">Geographic information</th><th>Life history</th><th colspan="4">Adult population (see Table 2 for codes)</th><th colspan="13">Threat (high-H, moderate-M, low-L, insignificant-I)</th><th>Status</th></tr>
<tr><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th colspan="4">Severity</th><th colspan="4">Scope</th><th colspan="4">Immediacy</th><th></th><th></th></tr>
<tr><th>Region (1-9)</th><th>Ecological Drainage Unit</th><th>Core Area</th><th>Tributary (sub-tributary)</th><th>(res, adfluv, fluv, anad)</th><th>Pop. size</th><th>Distribution</th><th>Trend</th><th>Reference</th><th>Habitat</th><th>Exploitation</th><th>Competitors</th><th>Overall</th><th>Habitat</th><th>Exploitation</th><th>Competitors</th><th>Overall</th><th>Habitat</th><th>Exploitation</th><th>Competitors</th><th>Overall</th><th>Overall threat value</th><th></th></tr>
<tr><td>6</td><td>Upper Liard</td><td>Upper Dease</td><td>Little Dease L, Eagle R, Little Dease C, upper Dease R, Moose Ls, Hotel C</td><td>adfluv?, fluv?</td><td>U</td><td>U</td><td>U</td><td>Redenbach and Taylor 2002</td><td>U</td><td>U</td><td>I</td><td>U</td><td>U</td><td>U</td><td>I</td><td>U</td><td>H</td><td>U</td><td>I</td><td>U</td><td>U</td><td>unranked</td></tr>
<tr><td colspan="23">Comment: Hot Lake in McDame Creek watershed is also known to support BT or DV (Janice Joseph, BC Parks, pers. comm.); connectivity to Dease River is unknown. It is unclear where the geographic division between Upper Dease and Lower Dease core areas should be located, and in which core area the McDame watershed should be located. Connectivity of extreme headwater populations where BT/DV have been sampled (Moose Lakes, Little Dease Lake) to the rest of the Upper Dease CA is unknown. Moose Lakes char were dominated by S. namaycush with only a single BT/DV captured; Dease Lake itself is dominated by S. namaycush with no known reports of BT from anglers though Redenbach and Taylor (2002) reported a BT from Hotel Creek (trib to lake). Little Dease Lake survey report not available in Smithers. Fish passage issues may exist at Highway 37 crossings, but it is unknown whether/how these may affect BT. Some angling access occurs along the Highway 37 corridor and via mining access roads, and the community of Dease Lake lies within this CA which increases angling activity, but it is unknown whether BT staging areas or other points of concentrated abundance are accessible to anglers. Proximity of mining to areas of importance to BT is also unknown.</td></tr>
<tr><td>6</td><td>Upper Liard</td><td>Rancheria</td><td>Toozaza, Tootsee</td><td>fluv?</td><td>U</td><td>U</td><td>U</td><td>SKR Consultants 1997; B. Lancaster, guide outfitter, pers. com.</td><td>U</td><td>I</td><td>I</td><td>U</td><td>U</td><td>I</td><td>I</td><td>U</td><td>I</td><td>I</td><td>I</td><td>I</td><td>U</td><td>unranked</td></tr>
<tr><td colspan="23">Comment: This CA might be considered to be included in the Upper Liard CA, but because the confluence of the Rancheria River with the Liard is a considerable distance upstream of the Dease River confluence, and all other Upper Liard CA streams are downstream of the Dease confluence, it appears potentially logical that the Rancheria be considered a distinct CA. Information about BT in the Toozaza watershed is by personal communication (Bart Lancaster, guide outfitter). Again, S. namaycush is the dominant lake-dwelling char in this watershed while BT have been sampled only in streams to date. Most of the Rancheria watershed is in the Yukon Territory. Alaska Highway traverses the watershed (mostly in YT) and any passage issues are unknown.</td></tr>
<tr><td>6</td><td>Upper Liard</td><td>Upper Liard</td><td>Liard, Irons, Tatisno, Hyland</td><td>fluv?</td><td>U</td><td>U</td><td>U</td><td></td><td>U</td><td>I</td><td>I</td><td>U</td><td>U</td><td>I</td><td>I</td><td>U</td><td>I</td><td>I</td><td>I</td><td>I</td><td>U</td><td>unranked</td></tr>
<tr><td colspan="23">Comment: See above, as to whether Rancheria system should be included in this CA or remain separate. Nearly all of the stream length of Hyland and Irons watersheds is in the Yukon Territory. Alaska Highway traverses the portion of the CA that is within BC, and any passage issues are unknown. The LRDW references concerning BT sampling in this CA are not available in the Smithers stream files.</td></tr>
<tr><td>9</td><td>Upper Liard</td><td>Upper Kechika</td><td>Gataga (Through, S Gataga, Unnamed, Bluff), Denetiah, Unnamed (u/s of Denetiah, same side), Moodie</td><td>fluv, adfluv</td><td>U</td><td>D?</td><td>U</td><td></td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>H</td><td>#N/A</td></tr>
<tr><td colspan="23">Comment : Much of this core area is remote and pristine; bull trout likely widespread but abundance unknown</td></tr>
<tr><td>9</td><td>Upper Liard</td><td>Turnagain</td><td>Turnagain, Dall, Kutcho, Hard, Ferry, Snowdrift, Settea</td><td>fluv</td><td>U</td><td>D?</td><td>U</td><td></td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>H</td><td>unranked</td></tr>
<tr><td colspan="23">Comment : Mostly remote and pristine; bull trout likely widespread but abundance unknown</td></tr>
<tr><td>9</td><td>Upper Liard</td><td>Ketchika/Liard</td><td>Sandin, Tatzille, Lower Kechika, Rabbit, Coal, Geddes, upper Smith, Vents (Berg, Lapie, Long Mountain, Sick Wife), Mould, Trout, Deer, Canyon, Moule, Unnamed (N bank opposite Sulphur)</td><td>fluv</td><td>U</td><td>D?</td><td>U</td><td>Vents-Upper Toad overview (EDI 2001)</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>H</td><td>unranked</td></tr>
<tr><td colspan="23">Comment : Grand Canyon of Liard to Region 6 boundary; upper Smith isolated above putative barrier falls; insignificant threats</td></tr>
<tr><td>9</td><td>Lower Liard</td><td>Lower Liard</td><td>Grayling, lower Toad, Scatter, Beaver, La Biche</td><td>fluv</td><td>U</td><td>D?</td><td>U</td><td></td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>H</td><td>unranked</td></tr>
<tr><td colspan="23">Comment : Little known about abundance and trends for this core area</td></tr>
<tr><td>9</td><td>Lower Liard</td><td>Upper Toad</td><td>Toad, Racing, Moose Lakes</td><td>fluv</td><td>U</td><td>D?</td><td>U</td><td></td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>I</td><td>H</td><td>I</td><td>H</td><td>H</td><td>unranked</td></tr>
<tr><td colspan="23">Comment : Moose Lakes targetted heavily by locals; anecdotally Toad R considered an excellent BT system (Woods Environmental 2001)</td></tr>
</table>

Appendix 4 continued.

Geographic information				Life history	Adult population (see Table 2 for codes)				Threat (high-H, moderate-M, low-L, insignificant-I)													Status
									Severity				Scope				Immediacy					
Region (1-9)	Ecological Drainage Unit	Core Area	Tributary (sub-tributary)	(res, adfluv, fluv, anad)	**Pop. size**	**Distribution**	**Trend**	Reference	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	Habitat	Exploitation	Competitors	**Overall**	**Overall threat value**	
9	Lower Liard	Muskwa	Muskwa,Tetsa (North Tetsa), Gathto, Kluachesi, Crehan, Upper Muskwa, Tuchodi (Dead Dog, Joplin)	fluv	U	D?	U	DES 2000, 2002a	I	L	I	**L**	I	M	I	**M**	I	H	I	**H**	F	unranked
<u>Comment</u> : redds documented in Dead Dog, Crehan, Gathto, Dead Dog BT major spawning tributary for Tuchodi (Upper Muskwa bull trout spawning assessment-DES 2002; Tuchodi BT/riverboats DES 2000); Joplin and Dead Dog spawners overwinter in Muskwa mainstem ~130km downstream (DES 2000)																						
9	Lower Liard	Prophet	Prophet, Cheves, Adsett, Minaker (Impa, Pocketknife), Besa (Petrie, Keily), Richards, Hewer	fluv	U	D?	U	DES 2001	L	I	I	**L**	L	I	I	**L**	H	L	I	**H**	G	unranked
<u>Comment</u> : Scattered BT occurrences in upper watershed; YOY captured in Petrie, Duffield and Upper Richards creeks, mature males captured in Upper Richards Cr, mature precocious males caught in Petrie Ck- assumed to be spawning tributaries; lower suitability in Minaker, Pockeknife, Adsett																						
9	Lower Liard	Upper Fort Nelson	Sikanni Chief, Teklo, Foulwater	fluv	U	D?	U		M	I	I	**M**	H	I	I	**H**	H	I	I	**H**	A	unranked
<u>Comment</u> : Occurence of BT in the Sikanni appears limited to adult & sub-adult foraging BT; access to mainstem Sikanni limited by impassable falls. Downstream of Sikanni Falls, the Sikanni transects the Taiga Plains to the east of the foothills, and tributaries tend to be originate from low gradient, warm muskeg peatlands, and are tannic and carry high sediment loads in spring and following heavy rainfall. I've changed the habitat ratings because impacts from development decrease the already limited suitability of the lower Sikanni for BT																						