A Precautionary Management Strategy for Trout and Char in Streams of the Skeena Region – Risk Assessment and Recommended Management Framework.

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EXECUTIVE SUMMARY

Following a review of existing and historical approaches to managing recreational fisheries for stream-dwelling trout and char, Skeena Region Fisheries Section staff initiated development of a new management strategy in 2013. The guiding principles of this strategy were that it be precautionary in nature, and consistent with Fisheries Program Goals of optimizing recreational fishing opportunities while ensuring conservation. Initial actions were the introduction of more precautionary harvest quotas (non-retention for char, 1 per day between July 1 and October 31 for trout), and the initiation of steps to acquire additional population data (e.g. incidental catches of trout and char at salmon counting facilities). In addition, a conservation status and risk assessment for stream-dwelling trout and char, which is the subject of this report, was initiated in 2014. This report details the results of the risk assessment, and makes recommendations for a management framework.

The study utilized the Core Area Conservation Status and Risk Assessment Methodology, developed by the United States Fish and Wildlife Service for application to Bull Trout in the contiguous U.S., but now also applied to Bull Trout and Arctic Grayling populations in Canada. Conservation status and risk rankings are based on categorical estimates for four indicators: *Distribution*, *Abundance* (of mature individuals), *Trend*, and *Threats*. The *Threats* category was further subdivided in to exploitation threats, which were estimated categorically (in terms of severity and scope) based on indicators *Vulnerability*, *Effort*, and *Mortality* (of captured fish), and habitat threats, which were estimated in the GIS environment from cumulative effects indicators *Road Density*, *Road Density near Streams*, and *Stream Crossing Density*.

A key feature of the risk assessment methodology is that conservation status and risk criteria are applied at the spatial scale of 'Core Areas,' or putative metapopulations within which demographic and genetic connections are expected to exist among local populations. We considered it impractical to delineate separate Core Area structures for Bull Trout, Dolly Varden, Coastal Cutthroat Trout, and Rainbow Trout populations in Skeena Region. Instead, we elected to develop a single spatial layer for all four species, in which Core Areas are termed 'Trout and Char Units' (TCUs). TCUs are based on plausible population structure estimates for Bull Trout in interior areas, and Coastal Cutthroat trout in coastal areas, where each is the stream-dwelling trout/char species of primary conservation concern.

Bull Trout were found to be distributed broadly in 34 of the 52 Skeena Region TCUs, primarily in interior TCUs except where restricted by migration barriers or limited by poor availability of coldwater natal habitats. On the coast, Bull Trout have been confirmed only in TCUs defined by the lower reaches of large, glacial rivers which penetrate the Coast Mountains (Lower Skeena, Lower Nass, Lower Stikine, Lower Taku). Conservation status and risk rankings (C-Ranks) were *C1-High Risk* for no TCUs, *C2-At Risk* for 2 TCUs (6%), *C3-Potential Risk* for 17 TCUs (50%), and *C4-Low Risk* for 12 TCUs (35%). The Cheslatta, Francois-Endako, and Teslin TCUs, for which Bull Trout distribution is highly uncertain, received rankings of *CU-unranked*. Even under a regional regulation of non-retention for char in streams, Bull Trout populations in two TCUs – the Morice River and Bulkley TCUs – were considered to be *At Risk* in our analysis. These two TCUs have had extensive watershed development over a relatively long period of time, are among the most accessible within the Skeena Region, and are subjected to high intensity fisheries targeting steelhead and salmon. Additional factors exacerbating risk in these TCUs are

small Bull Trout population size (Morice River TCU) and a summer bait fishery elevating catch-and-release mortality (Bulkley TCU). The most important factor in *Low Risk* rankings was low estimated levels of threats. *Low Risk* TCUs were primarily located north of the Skeena and Nass basins, with the exception of a small number of TCUs from the remote upper reaches of these watersheds (Upper Nass, Upper Skeena, Upper Sustut).

In contrast to the situation in southern British Columbia, where Dolly Varden have a relatively narrow distribution west of the Coast Mountains (Haas and McPhail 1991), Dolly Varden in the Skeena Region are widely distributed in both coastal and interior drainages. We restricted our risk assessment to 19 coastal or near-coastal TCUs and just one interior TCU, however, based on our assumption that most interior populations of Dolly Varden are not vulnerable to overexploitation, due to small body size resulting from a non-migratory life history. For Dolly Varden, conservation status and risk rankings were *C1-High Risk* for no TCUs, *C2-At Risk* for no TCUs, *C3-Potential Risk* for 7 TCUs (35%), *C4-Low Risk* for 13 TCUs (65%), and *CU-unranked* for no TCUs. The most important factor in *Low Risk* rankings was low estimated levels of both habitat and exploitation threats in these TCUs, which are either relatively inaccessible or located away from major human population centers.

Coastal Cutthroat Trout were found to be present in 32 Skeena Region TCUs. Similar to Dolly Varden, Coastal Cutthroat Trout across most of their range have a relatively narrow distribution within approximately 150 km of the coast. Skeena Region, and in particular the Skeena River watershed, presents a unique situation in that the species distribution extends well inland to headwater reaches of the Babine, Bulkley, and Zymoetz systems. Among 32 Skeena Region TCUs where Coastal Cutthroat Trout were found to be present, conservation status and risk rankings were *C1-High Risk* for no TCUs, *C2-At Risk* for 1 TCU (3%), *C3-Potential Risk* for 18 TCUs (56%), *C4-Low Risk* for 11 TCUs (34%), and *CU-unranked* for 2 TCUs. Coastal Cutthroat Trout of the Kitimat TCU were considered to be *At Risk* in our analysis. While elevated habitat threats and anecdotal suggestions of declining abundance in the Kitimat watershed were significant factors affecting the risk assessment ranking, the most important factor was the estimated level of exploitation threats, which were higher than for any other TCU. With the exception of the pristine Upper Nass TCU, *Low Risk* TCUs were all located on the coast away from human population centers and the transportation corridors traversing the lower Kitimat, lower Nass, and lower Skeena watersheds.

Rainbow Trout are widely distributed in Skeena Region in 45 TCUs, and are absent (or have a negligible distribution) only in 7 far-northern TCUs. In our analysis, we treated Rainbow Trout in TCUs with anadromous steelhead populations as a special case, treating the TCU as a single gene pool exhibiting both anadromous and non-anadromous forms. Because demographic and genetic support between fluvial and anadromous forms of Rainbow Trout/steelhead is the expected norm, we considered the presence of an anadromous steelhead population to be a factor mitigating risk to sympatric Rainbow Trout. Conservation status and risk rankings for Skeena Region Rainbow Trout were *C1-High Risk* for no TCUs, *C2-At Risk* for no TCUs, *C3-Potential Risk* for 26 TCUs (56%), *C4-Low Risk* for 18 TCUs (34%), and *CU-unranked* for 1 TCU (Tatshenshini-Alsek). Within the TCUs receiving a *Potential Risk* ranking, the order of importance for factors driving the ranking was: 1) habitat threats, 2) habitat threats in concert with exploitation threats, 3) exploitation threats, and 4) limited distribution. *Low Risk* TCUs for Rainbow Trout were all located away from human population centers and transportation corridors, i.e., in the northern portion of the region, in inaccessible portions of the Nechako River watershed, and on the coast outside of the lower Nass, lower Skeena, and Kitimat watersheds.

For managing stream-dwelling trout and char populations of the Skeena Region, we have recommended the adoption of a conceptual framework developed by Fisheries and Oceans Canada, which incorporates the Precautionary Approach and the use of two reference points to delineate *Critical*, *Cautious*, and *Healthy* stock status zones, and a set of management rules applying to each of these zones. In our recommended adaptation of this framework, appropriate regulations for the *Critical* management zone would apply to TCUs with conservation status and risk rankings of *C1-High Risk* and *C2-At Risk*, *Cautious* management would apply to TCUs ranked *C3-Potential Risk*, and prescriptions for the *Healthy* zone would apply to TCUs ranked *C4-Low Risk*. We recommend treating Coastal Cutthroat Trout, Rainbow Trout, and Dolly Varden as one group for regional regulations, and Bull Trout as a second to be managed in a more conservative manner consistent with their known susceptibility to overexploitation. To avoid potential overexploitation of Bull Trout misidentified as Dolly Varden, TCUs where both Bull Trout and migratory Dolly Varden greater than 30 cm are present (Lakelse-Kalum, Lower Nass, Lower Stikine, Skeena Coastal, and Lower Taku TCUs) should be classified as 'Bull Trout-designated,' and the corresponding management regulations should be those appropriate for Bull Trout.

For trout and Dolly Varden (outside of Bull Trout-designated TCUs), recommended regulations are:

1. *Critical*: non retention, as well as measures to reduce catch-and-release mortality (e.g. bait ban).
2. *Cautious*: existing regional quota (1 per day), plus minimum size limits designed to protect females spawning for the first time.
3. *Healthy*: pre-2013 quota of 2 per day (alternatively: 1 per day for consistency across the region), plus minimum size limits designed to protect females spawning for the first time.

For Bull Trout (and Dolly Varden in Bull Trout-designated TCUs), recommended regulations are:

1. *Critical*: non retention, as well as measures to reduce catch-and-release mortality (e.g. bait ban).
2. *Cautious*: existing regional regulation (non-retention).
3. *Healthy*: 1 per day, plus minimum size limits designed to protect females spawning for the first time.

We have also recommended five actions meant to increase the availability of trout and char population data, and to facilitate its use in future fishery and habitat management:

1. Develop monitoring plans for stream-dwelling trout and char.
2. Conduct studies of size-at-maturity for stream-dwelling trout and char.
3. Set a timeline for reassessing conservation status and risk.
4. Incorporate models of recreational fishing sustainability into risk assessments.
5. Protect and restore critical habitat.

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1.0 BACKGROUND

In 2012, the Skeena Region Fisheries Section of the British Columbia Ministry of Forests, Lands, and Natural Resource Operations (MFLNRO) conducted a review of the existing and historical approaches to managing trout (Coastal Cutthroat Trout *Oncorhynchus clarki clarki* and Rainbow Trout *Oncorhynchus mykiss*) and char (Bull Trout *Salvelinus confluentus* and Dolly Varden *S. malma*) populations in Skeena Region streams. The review identified that harvest quotas had typically been applied without defined management objectives, documented rationale, or assessments of stock status or risk to the resource. This was largely the result of limited resources and prioritization of other species and fisheries, particularly the highly-valued steelhead fishery. Furthermore, the review identified that the existing regional harvest quota for stream-dwelling (fluvial) trout and char, which was 2 per day with a minimum size limit of 30 cm, potentially posed a risk to fish populations.

The assessment that stream-dwelling trout and char populations may have been at risk was based on compelling evidence that exploitation has been a major factor driving declines of recreational fish populations in British Columbia and elsewhere (e.g. Slaney et al. 1984; Post et al. 2002; Lewin et al. 2006). In addition to negative population growth, long-term effects of overexploitation have included 1) depensatory mechanisms reducing productivity (operating when fish population size declines below a threshold), 2) truncation of age and size structure, 3) loss of genetic variability, and 4) evolutionary changes (Lewin et al. 2006). In British Columbia, the last published management strategy for stream-dwelling trout and char dates from more than 30 years ago. At that time, all accessible populations exposed to creel limits of 4-8 fish per day were found to be depleted or seriously depressed, and the authors recommended quotas of 3 per day or less to maintain fishery quality and stock status (Slaney et al. 1984). While the pre-2013 Skeena Region quota of 2 per day was consistent with this recommendation, more recent information from British Columbia and elsewhere in Canada indicates that even this level is likely to result in overexploitation in accessible streams. Two examples utilizing quantitative stock assessment data from southern B.C.'s Kootenay Region are informative. Westslope Cutthroat Trout and Rainbow Trout populations in the lower St. Mary and Salmo rivers, respectively, were depleted and considered to be of conservation concern under 2 per day harvest quotas, but responded to more restrictive regulations[1] with doubling of population sizes and increases in the proportions of larger fish (Oliver 1990; Hagen and Baxter 2010). The sustainability of recreational stream fisheries under a 2-per-day creel limit may be of even greater concern in relatively unproductive northern watersheds (Post et al. 2002; Post et al. 2003).

In order to address the deficiencies of the traditional management trajectory for trout and char in streams of the Skeena Region, Fisheries Section staff initiated development of a new

[1] Lower St. Mary River: catch and release; Salmo River: mix of catch and release and 1/day harvest >30 cm.

management strategy beginning in 2013. The guiding principles for this strategy are that it: 1) be precautionary in nature, and 2) be consistent with Fisheries Program Goals (MOE 2007).

Since the 1990s, the Precautionary Approach has been recommended widely as a strategy for risk management in Earth's fisheries, in recognition of serious uncertainties in fisheries science and the difficulties of implementing management measures (reviewed in Hilborn et al. 2001). It implies being cautious when scientific information is uncertain, unreliable or inadequate, and has been described succinctly for application in Canada by the Federal Government:

> The application of "precaution", "the precautionary principle" or "the precautionary approach" recognizes that the absence of full scientific certainty shall not be used as a reason for postponing decisions where there is a risk of serious or irreversible harm.

Importantly, it is further identified that "sound scientific information and its evaluation must be the basis for applying precaution," and "mechanisms should exist for re-evaluating the basis for decisions and for providing a transparent process for further consideration" (Government of Canada 2003).

Under the Freshwater Fisheries Program Plan (MOE 2007), program goals are:

1. *Establish governance approaches that are strategic, effective and efficient*. This goal implies the need for science-based management and partnerships between MFLNRO fisheries managers, First Nations, and stakeholders that are strategic, effective, and efficient.
2. *Conserve wild fish and their habitats*. This goal recognizes that robust wild fish populations, as a key component of healthy watersheds and ecosystems, are the foundation of a sustainable freshwater fisheries program.
3. *Optimize recreational opportunities based on the fishery resource*. This goal identifies that fisheries should be managed sustainably to provide social, economic and recreational benefits to all British Columbians. It also identifies that management approaches should take into account the preferences and interests of resource users (where this does not conflict with the primary program goal of conservation).

Three key objectives were identified for the Skeena Region fluvial trout and char management strategy: The first was to implement more precautionary regional regulations. As of April 1, 2013, regional harvest quotas in streams were reduced to:

1. Trout (i.e. Coastal Cutthroat Trout and Rainbow Trout): 1 per day between July 1 and October 31, with a minimum size limit of 30 cm.
2. Char (i.e. Bull Trout and Dolly Varden): 0 per day

The second objective of the management strategy was to initiate the acquisition of additional trout and char population data to assist with future evaluations of the sustainability of recreational fishing. This initiative is underway, and involves: 1) Compilation and synthesis of raw trout and/or char data from existing MFLNRO files, 2) requests for potentially valuable population data acquired through fisheries monitoring activities of Canada's Department of Fisheries and Oceans (DFO) and First Nations of the Skeena Region, and 3) initiation of MFLNRO-led monitoring studies for priority conservation and management situations for fluvial trout and char. Synthesis and reporting of these population data will be a future task and is not part of this report.

The third objective was to design and implement a systematic and transparent risk assessment mechanism for further evaluation of regional regulations, and to utilize the results to make recommendations for a precautionary management framework for fluvial trout and char in the Skeena Region. The risk assessment was initiated in 2014 with the assistance of consultant John Hagen, and its results are the subject of this report.

2.0 STUDY METHODS

2.1 Stream-dwelling trout and char species and their life histories

The trout and char species exposed to potential exploitation in streams of the Skeena Region are Coastal Cutthroat Trout, Rainbow Trout, Bull Trout, and Dolly Varden. Detailed life history reviews for these species, emphasizing British Columbia populations, are presented in McPhail (2007). Generalized life histories for these four species are similar in some important regards. However, key differences among species also exist which affect the level of risk that individual populations face. Varying levels of risk related to life history are a feature of this analysis, so these differences are highlighted below.

In British Columbia watersheds that are accessible from the sea, stream-dwelling trout and char are found in four general life history forms: stream resident (non-migratory), fluvial, adfluvial, and anadromous.

Stream resident trout and char spend their entire life cycle within a relatively restricted area in individual streams or stream reaches, have maximum body sizes of 200-300 mm, and rarely exceed 5-8 years of age (McPhail 2007). Stream resident populations may be isolated from migratory populations by physical (e.g. waterfalls, dams) or physiological (e.g. unfavourably high water temperatures) barriers, or be excluded from a potentially migratory life history by ecological factors affecting growth and survival such as the presence of competitor or predator species (Werner and Gilliam 1984; Paul and Post 2001; Costello et al. 2003).

Because of their small body size, stream resident trout and char are protected from harvest by the regional regulation (30 cm minimum size limit) and rarely targeted. Therefore, stream resident populations are a special case and are not the focus of this risk assessment. The species most affected by this prioritization is the Dolly Varden. The Dolly Varden populations are located close to the Coast in other locations in British Columbia (Haas and McPhail 1991), but in

Skeena Region extend well into the interior to the headwaters of major North Coast drainages, and beyond into the headwaters of the Liard, Peace, and Nechako watersheds which the species appears to have colonized via headwater capture. Dolly Varden are sympatric with the closely-related Bull Trout in interior areas of Skeena Region, forming a bimodal hybrid zone where distinct gene pools are maintained through a remarkable interactive segregation (Haas and McPhail 1991; Redenbach and Taylor 2002, 2003). In these areas, Dolly Varden populations express a stream resident life history, while Bull Trout populations are almost exclusively migratory (adfluvial or fluvial; McPhail and Taylor 1995; Hagen 2000; Hagen and Taylor 2001; D. Bustard, Smithers, pers. comm. 1995-2015). In coastal areas, where Bull Trout are absent, Dolly Varden occupy both stream resident and migratory (fluvial, adfluvial, anadromous) niches. The only known exceptions to this pattern are the glacial-fed lower Skeena, lower Nass, lower Stikine, and lower Taku rivers, where migratory individuals of both species have been captured.[2] Therefore, it appears that the current practice of treating Dolly Varden and Bull Trout jointly in the regulations synopsis is unnecessary outside of the lower reaches of the four major systems mentioned above. In smaller coastal watersheds, managers can assume that char captured by anglers in streams are Dolly Varden, and in interior reaches char >30 cm will be Bull Trout. This is the approach taken in this analysis, with three designations 'Dolly Varden-designated,' 'Bull Trout-designated,' and 'Bull Trout/Dolly Varden-designated' applying to coastal streams, interior streams (>100 km approximately from the coast) and to the lower Skeena, lower Nass, lower Stikine, and lower Taku rivers, respectively.

Similar to the Dolly Varden, across most of its range the Coastal Cutthroat Trout has a distribution that extends roughly 150 km inland. The Skeena River watershed is the major exception to this generalization, and interior populations exist exhibiting stream resident, fluvial, and adfluvial life histories.[3] Life histories for coastal populations of Coastal Cutthroat Trout and Dolly Varden are characteristically complex – several life history patterns may be in evidence within a single population (Morrow 1980; Saiget et al. 2007; Bond and Quinn 2013). Fluvial fish may be vulnerable to exploitation throughout the angling season, while anadromous and adfluvial fish become vulnerable to stream anglers when they make migrations into streams for spawning and/or feeding. For adfluvial and anadromous populations, therefore, lake and marine environments, respectively, may provide a refuge of reduced vulnerability. This is a factor we consider in our risk assessment where adequate life history information is available.

In British Columbia and across its geographic range, the spatial distribution of the Bull Trout is closely associated with the mountains, reflecting the species' critical requirement for cold water habitats (Hagen and Decker 2011). Bull Trout are widely distributed within interior watersheds of the Skeena Region, many of which drain mountainous areas, and as mentioned are

[2] Self-sustaining Bull Trout populations are known from the lower Skeena, with juveniles captured in the Shames Creek and Gitnadoix River systems (Hagen and Decker 2011).

[3] We assume that anadromous life histories are unlikely in interior populations, but this has not been determined.

also present in the lower Skeena, Lower Nass, Lower Stikine, and lower Taku rivers. Bull Trout are generally migratory in Skeena Region, unless isolated in headwater areas that have not been colonized by Dolly Varden, and are ecologically specialized as piscivores in lake and stream environments (Hagen 2000). Fluvial Bull Trout may be vulnerable in streams throughout their subadult and adult life stages, while adfluvial fish are present during feeding forays into streams and migrations to spawning areas, which may be of lengthy duration, and during which they may spend up to a month or more in highly vulnerable aggregations (Hagen and Decker 2011). No evidence of anadromy exists for Bull Trout populations within the Skeena Region, although credible reports exist of Bull Trout captured close to tidewater in the lower Skeena River.

Rainbow Trout in the Skeena Region are frequently found in ecologically-specialized populations, which have been termed 'ecotypes'[4] and include adaptations to distinct environments ranging from small stream residents, to anadromy in coastal (winter and summer steelhead) and interior (summer steelhead) watersheds, to adfluvial piscivory in large lakes. Ecotypes are considered to be important components of *O. mykiss* diversity in British Columbia (e.g. De Gisi 2002; Keeley et al. 2005). Similar to other stream-dwelling trout and char in Skeena Region, fluvial fish may be vulnerable throughout the angling season, while adfluvial fish are present during feeding forays into streams and during migrations to spawning areas.

A second special case in our analysis (in addition to the special case for stream-resident Dolly Varden populations) is comprised of fluvial Rainbow Trout in anadromous steelhead rivers. Partial anadromy refers to a situation of life history polymorphism in which a single gene pool exhibits both anadromous and non-anadromous forms (Jonsson and Jonsson 1993). Although reproductive isolation between sympatric steelhead and fluvial Rainbow Trout does occur, partial anadromy with obvious anadromous and resident components may be the norm in *O. mykiss* (Busby et al. 1996; Docker and Heath 2003; Olsen et al. 2006; McPhee et al. 2007; Araki et al. 2007). In British Columbia, partial anadromy has been demonstrated for sympatric populations of fluvial rainbow trout and steelhead in the Babine and Thompson rivers, using otolith microchemistry analysis to indicate maternal origin (Zimmerman and Reeves 2000; Hagen et al. 2011). Gene flow between sympatric life history forms has also been inferred from molecular genetic analyses indicating relatively little differentiation between them (Docker and Heath 2003). When resident rainbow trout are sympatric with steelhead, partial anadromy should probably be assumed until evidence of reproductive isolation is available (McPhee et al. 2007). In this risk assessment, therefore, we consider the presence of a sympatric steelhead population to be a factor mitigating risk for fluvial Rainbow Trout, even though this situation may imply increased potential for high angler effort. This is because demographic and genetic support, in the forms of gene flow and life history polymorphism (some progeny of steelhead will become

[4] Ecotype: populations or population assemblages adapted to specific environmental conditions. Typically among animal and plant species, ecotypes exhibit genetically-based phenotypic differences stemming from environmental heterogeneity, but are still capable of interbreeding with other geographically adjacent ecotypes without loss of fertility or vigor (Turesson 1992; Mager 2012).

fluvial trout and vice versa; Araki et al. 2007), are likely to exist between the steelhead and trout, and steelhead are protected by a provincial non-retention regulation.[5]

2.2 Spatial scale for risk assessment – Trout and Char Units (TCUs)

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) identifies 'Designatable Units' (DUs) as the primary scale for assessing conservation status nationally, and defines the DU as *infraspecific units that are distinguishable and have different extinction probabilities from the species as a whole* (COSEWIC 2010). Information to be considered in assigning DUs includes taxonomic assessments, phylogenetic evidence, range disjunctions, and biogeographic history (McPhail 2007; COSEWIC 2010). In practice, DUs have been assigned at relatively large spatial scales. For example, just four DUs are identified for the entire geographic range of the Bull Trout in British Columbia: South Coast British Columbia populations, Western Arctic populations, Upper Yukon populations, and Pacific populations (COSEWIC 2012). Government of British Columbia biologists have recognized that assessments at this scale may not provide adequate guidance for managers wishing to preserve the full evolutionary potential and productive capacity of B.C. fish populations.

In Skeena Region (for steelhead: Tautz et al. 2011) and elsewhere in British Columbia (for Bull Trout: Hagen and Decker 2011; for Arctic Grayling: Stamford et al. 2016), the 'Conservation Unit' concept of the Government of Canada's Wild Salmon Policy (FOC 2005) has been preferred. With reference to Pacific salmon, the Conservation Unit is defined as a *group of wild salmon, sufficiently isolated, that if extirpated, is unlikely to re-establish itself within a human lifetime or in a specified number of salmon generations*. The definition implies higher levels of demographic and genetic support among partially-isolated local populations within the Conservation Unit, but not among Conservation Units, and therefore the Conservation Unit can be considered a proxy for the metapopulation structure (Dunham and Rieman 1999). This is the scale at which migratory populations may complete their life cycle, and at which threats and demographic and genetic factors affecting population viability operate (Neville et al. 2006). Therefore, this is the scale that we considered appropriate for our assessments of risk to stream-dwelling trout and char.

Unfortunately, for virtually all fish species in British Columbia, conservation management at the scale of metapopulations is hampered by a lack of knowledge about population structure, i.e., what unique conservation units should be delineated, within which population status can be monitored and precautionary management undertaken so that significant biodiversity and productivity is maintained across the species' provincial range.

To address major data deficiencies with respect to population structure among fish species, the B.C. Government has developed the Ecological Aquatic Units (EAU) hierarchical classification system (Ciruna et al. 2007). The EAU system recognizes that a key factor

[5] However, the degree of the polymorphism is unknown and likely variable from population to population.

governing fish species distribution and sub-specific biodiversity is the historical sequence of drainage connections that occurred during deglaciation (McPhail 2007), and that commonalities in patterns of distribution and diversity among species can be utilized to identify geographic units for conservation that are potentially applicable to multiple species. Five 'Freshwater Ecoregions' (North Pacific Coastal, Interior, Columbia Glaciated, Mackenzie) have been proposed based on patterns of fish recolonization following deglaciation, and are the primary classification level. The second level of classification is comprised of 36 'Ecological Drainage Units,' or EDUs (Figure 1), which account for zoogeographic, climatic, and physiographic patterns nested within the primary classification, and which can be considered major adaptive zones for freshwater fauna.

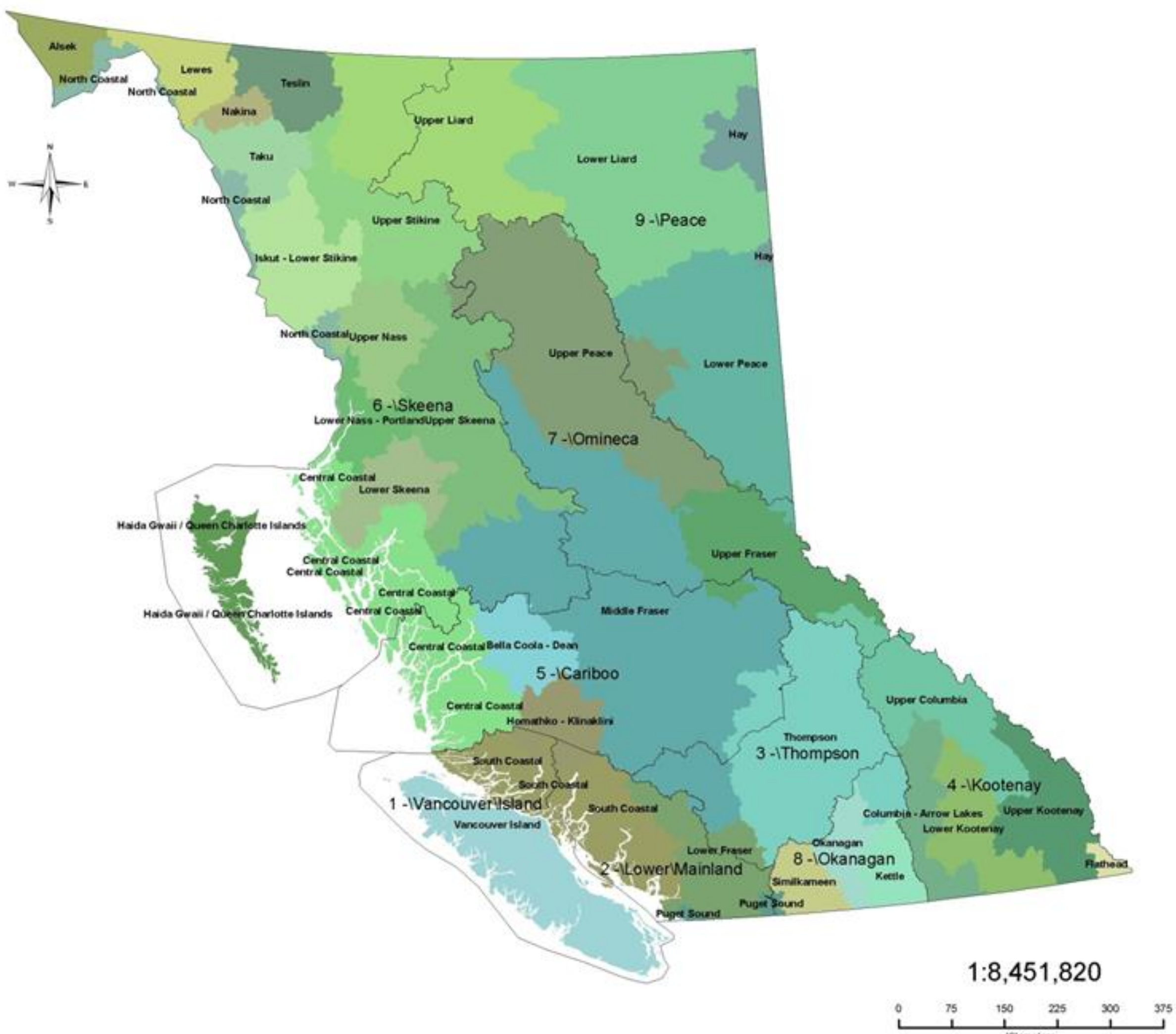

Figure 1. Map of fisheries management regions (black outlined areas) and Ecological Drainage Units (coloured areas; Ciruna et al. 2007) in British Columbia.

The finest classification level in the EAU system are Ecological Drainage Sub-Units (EDSUs), which correspond approximately to major tributary watersheds (or a significant section of a major tributary watershed) making up the EDUs (Hubregtse 2014).

In applications of the EAU system to conservation status and risk assessments for British Columbia Bull Trout (Hagen and Decker 2011) and Arctic grayling (Stamford et al. 2016), further subdivision of EDSUs has been required to account for known barriers to gene flow and/or existing data indicating population structure (e.g. molecular genetics, movement studies). These population units have been termed 'core areas,' and are defined approximately 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, Hagen and Decker 2011; Stamford et al. 2016). The core area is therefore approximately equivalent to the 'conservation unit' of the Wild Salmon Policy.

We considered it impractical to delineate separate core area structures for Bull Trout, Dolly Varden, Coastal Cutthroat Trout, and Rainbow Trout populations in Skeena Region. Instead, we elected to develop a single spatial layer for all four species, in which core areas are termed 'Trout and Char Units' (TCUs). Development of the spatial layer was facilitated by prioritizing two species of high conservation concern in Skeena Region: Bull Trout and Coastal Cutthroat Trout, both of which are Blue-Listed as Species of Special Concern by British Columbia's Conservation Data Centre.[6] TCUs are based on plausible population structure estimates for Bull Trout in interior areas, and Coastal Cutthroat trout in coastal areas, where each is the stream-dwelling trout/char species of primary conservation concern (Figure 2).

[6] Status rank is S3S4 Provincially for both species, which implies they are of special concern and vulnerable to extirpation in part of their British Columbia range. Populations in some areas, particularly those of southern British Columbia, are at risk of extirpation due to angling exploitation and habitat degradation threats (Slaney and Roberts 2005; Costello 2008; Hagen and Decker 2011). Both species are susceptible to overexploitation due to their aggressive feeding behaviour (i.e. easy to catch), and their tendency to form highly vulnerable aggregations during spawning and feeding migrations. Coastal Cutthroat Trout are highly vulnerable to habitat degradation due to their dependence on small, valley bottom streams for spawning and rearing, which are easily degraded and frequently overlooked in planning residential, agricultural, and forestry developments (Slaney and Roberts 2005; Costello 2008). Bull Trout are also highly sensitive to habitat degradation (Hagen and Decker 2011), and their distribution and abundance is strongly limited by stream temperature regimes – even small shifts to warmer temperatures (a typical result of watershed development) may be highly significant with respect to habitat suitability for bull trout (Parkinson and Haas 1996; Haas 2001; Porter and Nelitz 2009).

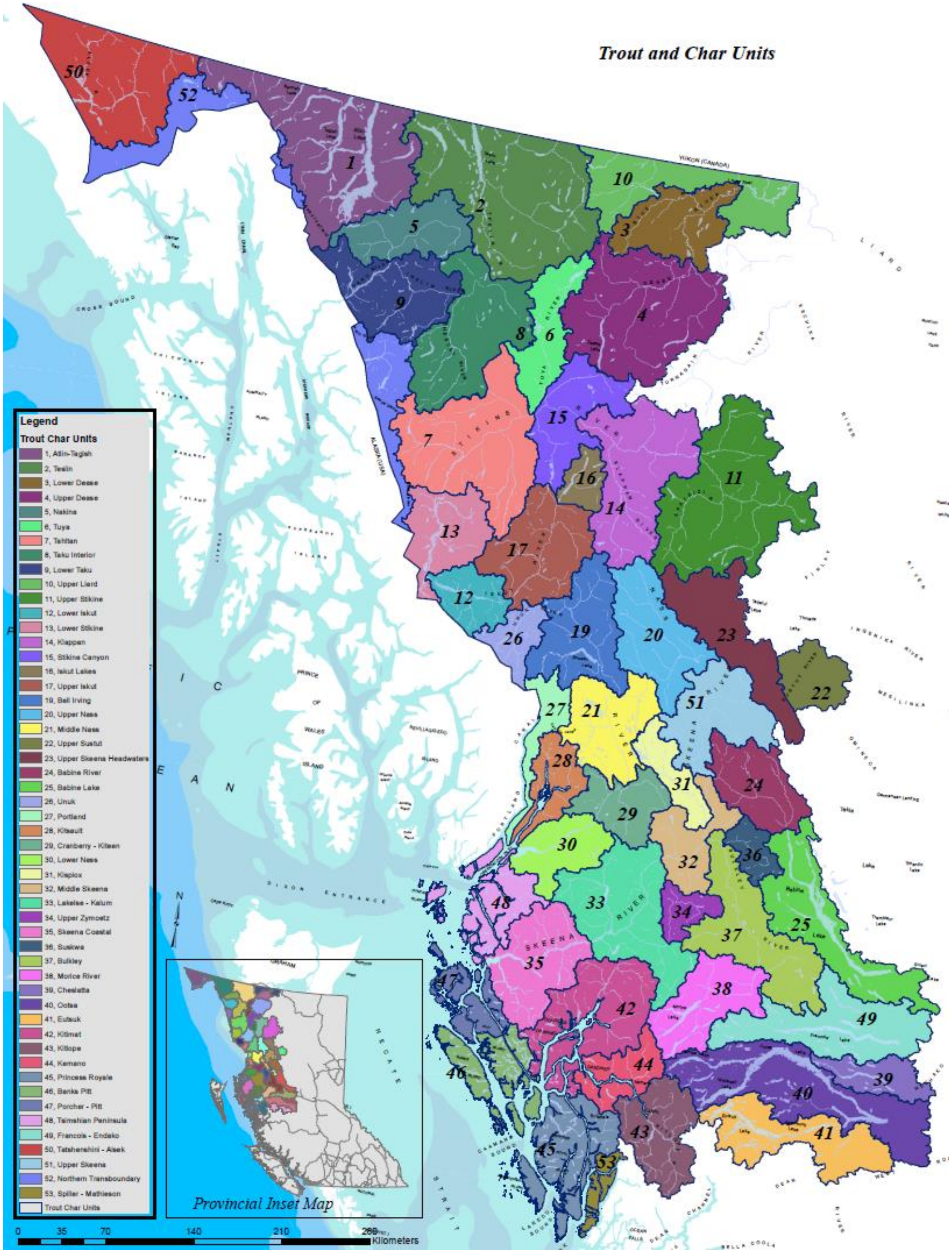

Figure 2. 52 Trout and Char Units delineated for conservation management of trout and char in streams of the Skeena Region.

Population structure at the level of Conservation Units may be estimated from molecular genetic data indicating spatial patterns of gene flow (e.g. Costello et al. 2003), movement data from radio telemetry or otolith microchemistry studies (e.g. Giroux 2001; Bahr 2002; Clarke et al. 2005), or known barriers to dispersal such as waterfalls and dams (e.g. Costello et al. 2003; Hagen 2008). For stream-dwelling trout and char populations of the Skeena Region, however, direct evidence of dispersal potential and/or gene flow is often limited. We found it necessary, therefore, to extrapolate to the Skeena Region based on patterns of Bull Trout and Coastal Cutthroat Trout population structure observed elsewhere.

For Bull Trout, the 2011 British Columbia Core Area Conservation Status and Risk Assessment (Hagen and Decker 2011) provided an existing estimate of the core area structure, which we reviewed and adjusted in order to delineate TCUs for interior areas of the Skeena Region (generally >100 km from the coast; Figure 1).[7] Our updates to these conservation units were in many cases modifications to ensure the TCU spatial layer nested within the existing EDSU structure updated in 2014 (Hubregtse 2014), and will be incorporated into the spatial layer for Bull Trout Core Areas as soon as possible (Susanne Williamson, BC Ministry of Environment Prince George, pers. comm.).

In coastal areas, it was difficult to delineate a putative Coastal Cutthroat Trout population structure due to geographic complexity of inlets and islands, a general lack of movement or other data indicating potential gene flow, and incomplete sampling across the landscape. Our guidelines for identifying coastal TCUs were therefore comprised of generalizations extrapolated mostly from Coastal Cutthroat Trout population structure and movement studies in other jurisdictions, which are themselves relatively few in number. TCUs were delineated assuming that 1) significant changes in population structure would occur at the scale of 90-150 km (Currens et al. 2003); 2) populations within 30 km shoreline distance would have significant genetic exchange (Campton and Utter 1987; Currens et al. 2003); 3) most individuals do not undertake migrations across large bodies of open water or distances of greater than 70-100 km (Jones 1976; Campton and Utter 1987); and 4) populations are structured at the scale of watersheds (Griswold 2009). With these guidelines in mind, we delineated coastal TCUs

[7] The putative Bull Trout Core Area structure for B.C. was estimated in a two-part process in 2011. 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. Based on this review, guidelines for establishing B.C. Bull Trout 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. Core Areas were then delineated using these guidelines and the provincial fish observations and fish obstacles layers in ArcGIS. 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 (Hagen and Decker 2011).

centered on putative source watersheds using ArcGIS and the Provincial fish observations and fish obstacles layers populated from the BC Geographic Warehouse (BCGW).[8]

2.3 Risk assessment

2.3.1 Risk assessment methodology

Following a review of existing protocols for evaluating conservation status within the context of viability assessments for the United States Forest Service, Andelman et al. (2004) suggested that conservation status ranking protocol developed by NatureServe and the Natural Heritage Network[9] may be the most suitable because of flexibility of scale, potential for use of a variety of existing information, and ability to integrate threats analyses. NatureServe does not identify specific criteria for assigning conservation status and risk to stream-dwelling trout and char species (NatureServe 2015), and instead advocates a more general approach (Hammerson et al. 2008). In preference, we elected to employ the Core Area Conservation Status and Risk Assessment Methodology utilized by the United States Fish and Wildlife Service to assess Bull Trout across their range in the contiguous U.S. (USFWS 2005). This methodology is based on the generalized ranking methodology for animal species developed by the Montana Natural Heritage Program (MNHP 2005), but applies criteria at the spatial scale of putative metapopulations (core areas), and describes status and risk according to a system of four C-ranks rather than NatureServe's five subnational S-ranks[10]. The principal attractions of the USFWS (2005) approach over the generic approach developed by NatureServe (Hammerson et al. 2008) were: 1) the rule- and point-based process for assigning risk was less subjective and therefore was felt to be more standardized and repeatable; and 2) the methodology has been previously selected for national and subnational application to Bull Trout in the United States and Canada (USFWS 2005; Rodtka 2009; Hagen and Decker 2011); and 3) the abundance criteria associated with elevated conservation concern are consistent with those derived from studies of effective population size in Bull Trout (Rieman and Allendorf 2001).

A key feature of the USFWS (2005) methodology is that conservation status and risk are assessed at the spatial scale of putative metapopulations, which we term Trout and Char Units in this report (see Section *2.2*). We use the 52 putative TCUs for the Skeena Region (Figure 2) as the geographic units for summarizing population data and assessing threats in Sections *3.1-3.5*.

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[8] The BCGW 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.

[9] A network of 82 member organizations (as of 2013), known as natural heritage programs or conservation data centers (CDCs), of which the British Columbia CDC is one (online at: www.env.gov.bc/cdc/).

[10] Bull Trout status and risk was described by 4 C-ranks, rather than NatureServe's 5 subnational S-ranks, with C1-High Risk=S1, C2-At Risk=S2, C3-Potential Risk=S3, and C4-Low Risk=S4 or S5.

Conservation status and risk rankings are based on categorical estimates for four indicators. These include three categories of population data, 1) *Distribution* 2) *Abundance* (of mature individuals), and 3) *Trend*, as well as 4) the cumulative effects of angling exploitation and habitat *Threats* (Tables 1, 2). Methods for deriving these categorical estimates are described in the following sections *2.3.2 Population data*, *2.3.3 Exploitation threats*, and *2.3.4 Habitat threats*.

As the final step in the Core Area assessment methodology, alphabetical scores corresponding to categorical estimates of *Abundance*, *Distribution*, *Trend*, and *Threats* are converted to numerical values with positive or negative signs (Table 3). The numerical values are summed across categories[11] and added to a baseline value (USFWS 2005). The resulting total is then compared to the range of values corresponding to each of four conservation status/risk 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* (Table 3). The numeric scoring procedure is compatible with unknown values for the conservation status indicators (although this weakens the sensitivity of the analysis for detecting risk), and assigns a numeric value of zero for each 'U' (unknown) alphabetic value.

It is important to note that the methodology and criteria have yet to be evaluated quantitatively against British Columbia population viability data, simulated or empirical – this remains an important step to undertake if they are to be applied more frequently in the province in future.

[11] The numerical value entered for threats overall was calculated as the average of numerical values calculated for each of exploitation threats and habitat threats.

Table 1. Codes and associated definitions for categorical estimates of *Abundance* (mature adults), *Distribution*, *Trend*, and *Threats* for use in the USFWS (2005) Core Area Conservation Status and Risk Assessment Methodology.

1. 'Population Size' codes

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
U Unknown

2. 'Distribution' (area of occupancy within core area expressed as stream length) codes

A <4 km
B 4-40 km
C 40-200 km
D 200-1,000 km
E 1,000-5,000 km
U Unknown

3. 'Trend' (within 25 years) codes

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

4. 'Threats'

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 (effects of locally sustainable levels of fishing are 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

Table 2. Calculation of overall threats values from values for severity, scope, and immediacy sub-factors (USFWS 2005).

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

Table 3. Numeric scoring procedure for assessing risk to trout and char populations in Trout and Char Units based on categorical estimates of population data and threats, and descriptions of levels of assessed risk (adapted from USFWS 2005).

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 population 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 population 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 the species may be locally abundant in some areas of the Core Area.
3.5<P≤4.5	C4	**LOW RISK** - The species is 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.

2.3.2 Population data

Among population data categories *Distribution*, *Abundance*, and *Trend*, only distribution estimates could be reasonably made for the four stream-dwelling trout and char species in most TCUs.

Distribution is a key indicator of conservation status and risk because a broadly distributed population consisting of multiple, connected sub-populations is generally thought to be more robust to extinction forces than is a single group (Simberloff 1988). Distribution within TCUs and individual watersheds was assessed primarily using ArcGIS software and the provincial fish observation and fish obstacles layers populated from the BC Geographic Warehouse (BCGW). Older distribution information from outside the BCGW was also evaluated during our review of files maintained at the Smithers Office of MFLNRO, which are organized by major watershed or coastal area.[12] As the first step in the method for estimating distribution, stream segment lengths occupied by the four species in 14 TCUs were measured in the GIS environment. The 43 resulting distribution estimates were then compared to categorical (see Table 1 for categories) visual estimates of the same distributions. The correct categorical estimate was made in 41 of 43 cases, which was deemed to be an acceptable rate of error (<5%). For efficiency, the remainder of the TCUs were then evaluated using the visual estimation method.

Abundance, expressed as the estimated number of mature individuals, is an important indicator of extinction risk because the deleterious effects of population dynamics and genetic processes, including demographic stochasticity, environmental stochasticity, loss of genetic diversity, and inbreeding depression, are magnified at small population sizes (Simberloff 1988; Nunney and Campbell 1993; Franklin 1980). A serious lack of abundance monitoring data for fluvial trout and char populations in Skeena Region restricted our ability to assess total population abundance and trend. This situation is typical for most regions of the province. Where possible, categorical estimates of total abundance were made based on abundance data from mark-recapture studies (Shepard 1953, as cited in Bilton 1954; Bilton and Shepard 1955; Bustard 1990; Lough 1990b; DeLeeuw 1991; Slaney et al. 2006), fence counts (Lough and Bustard 1990; Hatlevik 1990; Hagen and Decker 2011), snorkeling surveys (MFLNRO Smithers and MFLNRO Prince George, data on file), distribution studies (Bustard 1989; Koehler 2010), and redd counts (Bahr 2002; Bustard and Schell 2002; Lough 2016 *in prep*.).[13]

Trend is obviously an important indicator of extinction risk. When a sustained negative trend in abundance is observed, extinction is likely unless the agents forcing population decline are identified and mitigated (Caughley 1994). Estimates of trend require observations over time, however, which were extremely limited for stream-dwelling trout and char populations in the Skeena Region. Pre-2011 time series of count data for Bull Trout (available from Hagen and

[12] Morphological, genetic, and radio telemetry studies of population structure, life history, and distribution were also reviewed to evaluate Bull Trout versus Dolly Varden distributions, which are sympatric in many Skeena Region TCUs (e.g.; Taylor et al. 1999), 2) morphological and genetic studies of the distributions and life histories of Bull Trout versus Dolly Varden (e.g. Haas and McPhail 1991; Bustard 1998, 2004; Bustard and Schell 2002; Schell 1999a, 1999b; Taylor et al. 1999; Giroux 2001; Bahr 2002).

[13] Because we assume in this analysis that fluvial Rainbow Trout and steelhead populations are likely to be demographically and genetically linked in most systems, we also made use of abundance estimates for the anadromous life history component where available to assess abundance and trend for the fluvial component (MFLNRO Smithers data on file).

Decker 2011) from fences in the Upper Sustut (Sustut River; 19 yrs), Upper Skeena (Damshilgwet Creek; 11 yrs), and Middle Skeena (Kitwanga River; 7 yrs), along with multiple mark-recapture studies for Coastal Cutthroat Trout in the Lakelse River system, provided the only quantitative trend data at the time of writing.[14] In addition to these data, a small number of anecdotal reports of trend were deemed reliable, and were also incorporated into the analysis.

2.3.3 Exploitation threats

A model developed for evaluating the sustainability of recreational fisheries (Post et al. 2003) provided important background information for evaluating exploitation threats in TCUs of the Skeena Region. Quantitative estimates for model parameters were not possible for Skeena Region populations, or would have been uninformed guesses, so the model itself could not be utilized to assess threats. Instead, general findings of the Post et al. (2003) simulation modeling, conducted using Bull Trout as an example, were utilized to identify three putative indicators of overexploitation risk:

1. ***Vulnerability***. Vulnerability was defined in our analysis as the estimated proportion of the population or area that was exposed to the exploitation threat.
2. ***Effort***. Effort level was either estimated based on professional judgment and personal knowledge, and/or based on considerations of i) targeting of trout/char (especially vulnerable aggregations), ii) presence of fisheries targeting salmon and steelhead (implying high effort even at low abundance of trout/char), iii) distance from human population centers, iv) access (i.e. roads), and v) seasonal closures (or lack thereof).
3. ***Fishing Mortality***. The potential mortality rate for captured fish was assumed to be strongly influenced by the existing regional regulation, by the presence of a First Nations fishery(s), and by variance in catch-and-release mortality. Catch-and-release mortality was assumed to be positively related to hook size and, particularly, the use of bait, and negatively related to angler experience.[15]

Categorical estimates of exploitation threats were made by considering *Vulnerability* to be equivalent to the scope of the threat (Table 1), and by estimating the severity of the threat by considering *Effort* and *Fishing Mortality* factored together. Scenarios representing the Skeena Regional regulations were not modeled in Post et al. (2003). Therefore, our guidelines were extrapolated from their general findings, and can be illustrated through hypothetical examples:[16]

[14] Incidental captures of trout and char at salmon and steelhead counting facilities is a potentially important source of trend information. These data are in the process of being requested and compiled by MFLNRO.

[15] E.g. relatively lower catch-and-release mortality might be expected from a fishery comprised mostly of experienced fly anglers targeting steelhead, versus one comprised of anglers with a mix of experience levels using bait and/or large hooks targeting salmon.

[16] Bull Trout populations were assumed to be of lower population productivity relative to Coastal Cutthroat Trout, Rainbow Trout, and Dolly Varden populations due to our expectation for low intrinsic rates of population

1. High severity: e.g. high level of constant effort (even at low trout/char abundance), plus harvest with no minimum size limit, plus elevated catch-and-release mortality from widespread use of bait and large hooks in fisheries targeting Pacific salmon.
2. Moderate severity: e.g. the same fishery as above, but with a catch-and-release regulation eliminating legal harvest (alternatively: same fishery, but with 1/day harvest (trout) and minimum size restriction greater than the size of first maturity, plus a year-round bait ban to reduce mortality).
3. Low severity: e.g. low effort, plus various combinations of angling regulations including legal harvest.

Immediacy of exploitation threats was not estimated for TCUs individually. However, immediacy is an important factor affecting the risk assessment when threats are of moderate-to-high severity and moderate-to-high scope (Table 2). For example, the definition of a high severity threat of high immediacy (Table 1) indicates an extremely severe scenario[17] which does not appear to be occurring at the TCU scale anywhere in Skeena Region for stream-dwelling trout and char. Instead, all threats of moderate-to-high scope and moderate-to-high severity were assumed to have components that were operating both now (or in the near term) and at the decadal scale, and therefore received numeric scores intermediate between the values assigned for moderate-to-high immediacy and low immediacy threats (Tables 2, 3).[18]

2.3.4 Habitat threats

In spawning and rearing streams for Bull Trout, Coastal Cutthroat Trout, Dolly Varden, and Rainbow Trout, mechanisms of habitat degradation include: 1) loss of riparian vegetation, 2) loss of stream habitat complexity, 3) lost access to critical habitats, 4) increased water temperature beyond threshold values, 5) increased sediment transport and associated channel destabilization, 6) increased risk of channel widening with associated reduction of bed material size and stream depth, and 7) risk of accidental release of hazardous materials. Bull Trout populations in watersheds lacking glaciers or permanent snowfields are particularly vulnerable to stream temperature increases (Porter and Nelitz 2009). These threats mechanisms can stem from multiple sources, including forestry activities, urbanization, agriculture, mines, and linear developments including roads (Hatfield and Long 2010).

We considered it impractical to rate specific threats sources and mechanisms for all 52 TCUs. Furthermore, if threats were to be estimated strictly using professional judgment, we

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increase (Post et al. 2003), and therefore severity ratings were typically higher for the same levels of the exploitation risk indicators.

[17] Loss of population or destruction of species' habitat in area affected, with effects irreversible or requiring long-term recovery >100 years.

[18] E.g. a threat of moderate or high severity and moderate scope would receive the hybrid code BD, associated with an intermediate numeric value of -0.5 (Tables 2, 3). The unique hybrid code BDEF is associated with a numeric score of -0.25 intermediate between BD and E or F, and indicates a threat of low-to-moderate scope and moderate severity, or moderate scope and low-to-moderate severity.

thought that mistakes or omissions due to lack of knowledge would be likely. Instead, we opted to assess aquatic ecosystem health in a systematic manner in the GIS environment, utilizing remotely-sensed 'cumulative effects' indicators.[19] Road density is a good example of one such indicator. The density of roads within an area has long been known to be a good general indicator of the cumulative effects on natural ecosystems associated with land use and human access (Eaglin and Hubert 1993; Rieman et al. 1997; Foreman and Alexander 1998; Baxter et al. 1999; Dunham and Rieman 1999; Trombulak and Frissel 2000).

In advance of the analysis, we utilized our own professional knowledge of potential threats mechanisms and threats sources to prioritize four cumulative effects indicators: *Road Density*, *Road Density near Streams*, *Stream Crossing Density*, and *Riparian Disturbance*. These were selected because of known correlations or obvious causal linkages with stream habitat degradation, because of their feasibility of measurement in the GIS environment for Skeena Region TCUs, and because threshold values were available that facilitated ranking of threats severity within the Core Area Risk Assessment Methodology (Section *2.3.1*). Three of these four indicators were utilized to assess habitat threats in this report (Table 4) – estimates for the *Riparian Disturbance* indicator were not feasible at the time of writing. Within TCUs, *Road Density*, *Road Density near Streams*, and *Stream Crossing Density* were assessed at the scale of Freshwater Assessment Units[20], which are watershed polygons of 2,000-10,000 Ha, and were also summarized at the scale of the TCU as a whole. The GIS-based habitat threats assessment procedure is provided in greater detail in Appendix 1.

In order to express the GIS-based habitat threats assessment in terms of severity and scope, for integration into the Core Area Risk Assessment methodology, we utilized a two-part procedure. First, for Freshwater Assessment Units (FWAs) within TCUs, cumulative indicator rankings were estimated by combining rankings for the three indicators into one of five categories (Table 5). From these five categories, three levels of severity were derived, which were based on average values of the three indicators across the area affected (Table 5). As the final step in developing the habitat threats estimate for TCUs, severity and scope were visually estimated from the map of FWAs and their associated cumulative indicator rankings, utilizing the guidelines of Table 5 for estimating severity. Similar to exploitation threats, all habitat threats of moderate-to-high scope and moderate-to-high severity were assumed to have components that were operating both now and at the decadal scale, and therefore received numeric scores intermediate between values for high immediacy and low immediacy threats (Tables 2, 3).

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[19] In order to help implement the BC Cumulative Effects Framework, the BC Government is developing a procedure for broad-scale cumulative effects assessment for aquatic ecosystems (Aquatic Ecosystems Working Group 2015). While the Aquatic Ecosystems assessment procedure was in draft form at the time of writing, we nonetheless elected to utilize its GIS-based indicators for our own purposes of estimating the severity and scope of habitat threats to stream-dwelling trout and char of the Skeena Region.

[20] FWA layer in the BC Government GIS.

Table 4. Three GIS-based indicators of aquatic habitat condition within Freshwater Assessment Units, and associated reference points (see Appendix 1).

Indicator	Measurement	Levels
Road density	Road length (km)/ watershed area (km^2)	1) Lower risk – density < 0.6 km/km^2 2) Moderate risk – density 0.6-1.2 km/km^2 3) Higher risk – density > 1.2 km/km^2
Road density near streams	Road length <100 m from a stream (km)/ watershed area (km^2)	1) Lower risk – density < 0.08 km/km^2 2) Moderate risk – density 0.08-0.16 km/km^2 3) Higher risk – density > 0.16 km/km^2
Stream crossing density (Interior watersheds)	# of stream crossings/ watershed area (km^2)	1) Lower risk – density < 0.16/km^2 2) Moderate risk – density 0.16-0.32/km^2 3) Higher risk – density > 0.32/km^2
Stream crossing density (Coastal watersheds)	# of stream crossings/ watershed area (km^2)	1) Lower risk – density < 0.40/km^2 2) Moderate risk – density 0.40-0.80/km^2 3) Higher risk – density > 0.80/km^2

Table 5. Cumulative indicator ranks within Freshwater Assessment Units and equivalent severity rankings for application in the risk assessment methodology (See Table 4 for indicators).

Cumulative ranking	Severity ranking for risk assessment
Nil	*Insignificant*
Low	*Low*
Moderate	*Moderate*
High (1 of 3 indicators 'High')	*Moderate*
Higher (2 of 3 indicators 'High')	*High*
Highest (All 3 indicators 'High')	*High*

3.0 RISK ASSESSMENT RESULTS

3.1 Habitat threats synopsis

Aquatic habitat condition was assessed in two ways. First, average values for the cumulative effects indicators *Road Density*, *Road Density near Streams*, and *Stream Crossing Density* were computed at the scale of entire TCUs. As expected, average values for the three indicators were highly correlated with each other (r = 0.96-0.98), and were at their highest levels in southern

TCUs of the interior Skeena and Fraser River watersheds (Bulkley, Babine Lake, Francois-Endako, Cheslatta; Table 6) where watershed development has been most extensive. Second, severity and scope of aquatic habitat threats (required for application of the risk assessment methodology – see Section *2.3.1*) within TCUs was estimated based on spatial patterns for the cumulative indicator ranks, which were assessed at the scale of Freshwater Assessment Units (Figure 3) and based on all three indicators (see Section *2.3.4*).

Among the 52 Skeena Region TCUs, 4 (8%) were estimated to have insignificant habitat threats (Category *H*: Kitlope, Lower Taku, Tuya, Upper Nass; Table 6, Figure 3), based on estimates of scope and severity for the cumulative indicator ranks. These TCUs are thought to currently be unthreatened by habitat degradation, or else current habitat threats are minimal or highly localized.

Thirteen TCUs (25%) were categorically estimated to currently have low severity habitat threats for a small proportion of the population(s) or area (Catgory *G*: Banks-Pitt, Kitsault, Klappan, Lower Iskut, Lower Stikine, Porcher-Pitt, Princess Royal, Spiller-Mathieson, Tahltan, Taku Upper, Tatshenshini-Alsek, Unuk, Upper Stikine; Table 6, Figure 3). Similar to the unthreatened TCUs above, these TCUs are located in coastal and northern portions of the Skeena Region outside of the Skeena and interior Fraser watersheds.

Three TCUs (6%) were categorically estimated to currently have threats of slightly elevated, low-to-moderate severity but limited to a small proportion of the population(s) or area (Hybrid category *EG*: Atlin-Tagish, Teslin, Upper Skeena; Table 6).

12 TCUs (23%) were estimated to currently have low severity threats affecting most or a significant proportion of the TCU (Category *F*: Iskut Lakes, Portland, Tsimshian Peninsula, Upper Iskut; Table 6, Figure 3), low-to-moderate severity threats affecting a low-to-moderate proportion of the TCU (Hybrid category *EF*: Lower Dease, Skeena Coastal, Stikine Canyon, Upper Dease, Upper Liard, Upper Skeena Headwaters), or a moderate-to-severe threat limited to a small proportion of the TCU (Category *E*: Bell-Irving, Upper Sustut).

Four TCUs (8%) were currently estimated to have moderate-to-severe habitat threats affecting a low-to-moderate proportion of the TCU, or low-to-moderate severity threats affecting a moderate proportion of the TCU (Hybrid category *BDEF*: Eutsuk, Kemano, Kitimat, Lower Nass; Table 6, Figure 3).

It was of significant concern that our analysis indicated that 9 TCUs (18%) were exposed to moderate-to-severe habitat threats estimated to be affecting a significant proportion (20-60%) of the population(s) or TCU area. These threats were assumed to contain elements affecting populations both now and at longer time scales, and therefore received hybrid categorical estimates (Hybrid category *BD*: Babine Lake, Babine River, Cranberry-Kiteen, Kispiox, Lakelse-Kalum, Middle Nass, Morice River, Ootsa, Upper Zymoetz; Table 6, Figure 3). The 4 TCUs (8%) of highest concern were those where most (>60%) of the assessment units indicated moderate-to-severe habitat threats levels. (Hybrid category *AC*: Bulkley, Cheslatta, Francois-Endako, Middle Skeena, Suskwa; Table 6, Figure 3). Trout and Char units in these latter two categories of elevated concern, which account for roughly one quarter of the Skeena Region, lie within the southern portion of the region in relatively close proximity to human population centers and major transportation corridors.

Table 6. Aquatic habitat threats summary for Skeena Region Trout and Char Units. Severity and scope estimates were based on spatial patterns for the cumulative indicator ranks, which were assessed at the scale of Freshwater Assessment Units and based on all three indicators (Figure 3).

	Average values across TCU				Severity and scope within TCU		
Trout and Char Unit (TCU)	***TCU Area*** **(km²)**	***Mean Road Density*** **(km/km²)**	***Mean Road Density Near Streams*** **(km/km²)**	***Mean Stream Crossing Density*** **(#/km²)**	**Severity**	**Scope**	**Value**
Atlin-Tagish	11,719	0.1226	0.0191	0.1025	LM	L	EG
Babine Lake	6,555	1.1418	0.0765	0.5682	H	M	BD
Babine River	3,895	0.4062	0.0305	0.2730	M	M	BD
Banks-Pitt	3,058	0.0234	0.0020	0.0110	L	L	G
Bell-Irving	5,333	0.1769	0.0216	0.1342	M	L	E
Bulkley	6,425	1.3011	0.0987	0.6940	MH	H	AC
Cheslatta	2,140	1.4325	0.0827	0.4778	H	H	AC
Cranberry-Kiteen	3,060	0.5753	0.0392	0.2618	M	M	BD
Eutsuk	5,200	0.2239	0.0097	0.0692	M	LM	BDEF
Francois-Endako	6,575	1.7931	0.1398	0.8899	H	H	AC
Iskut Lakes	1,405	0.1557	0.0145	0.1217	L	M	F
Kemano	2,444	0.1188	0.0287	0.1984	M	LM	BDEF
Kispiox	2,101	0.6878	0.0523	0.4514	H	M	BD
Kitimat	6,189	0.4051	0.0445	0.3164	H	LM	BDEF
Kitlope	4,063	0.0092	0.0025	0.0155	I	I	H
Kitsault	2,307	0.0355	0.0092	0.0317	L	L	G
Klappan	7,815	0.0334	0.0038	0.0423	L	L	G
Lakelse-Kalum	7,387	0.6474	0.0676	0.4824	MH	M	BD
Lower Dease	4,366	0.1072	0.0133	0.0666	LM	LM	EF
Lower Iskut	2,425	0.0203	0.0045	0.0000	L	L	G
Lower Nass	3,187	0.3093	0.0371	0.1689	M	LM	BDEF
Lower Stikine	4,021	0.0220	0.0040	0.0079	L	L	G
Lower Taku	5,445	0.0049	0.0009	0.0009	I	I	H
Middle Nass	4,575	0.5224	0.0560	0.3843	M	M	BD
Middle Skeena	3,112	0.8495	0.0684	0.5310	MH	H	AC
Morice River	4,379	0.5920	0.0416	0.2962	MH	M	BD
Nakina	4,026	0.0244	0.0054	0.0076	L	L	G
Northern Transboundary	6,432	0.0415	0.0062	0.0301	L	L	G
Ootsa	8,871	0.7785	0.0528	0.3853	MH	M	BD

Table 6, continued.

Trout and Char Unit (TCU)	*TCU Area* (km²)	*Mean Road Density* (km/km²)	*Mean Road Density Near Streams* (km/km²)	*Mean Stream Crossing Density* (#/km²)	Severity	Scope	Value
	Average values across TCU				Severity and scope within TCU		
Porcher-Pitt	1,964	0.0997	0.0135	0.1203	L	L	G
Portland	1,790	0.1024	0.0304	0.1195	L	M	F
Princess Royal	4,434	0.0337	0.0043	0.0450	L	L	G
Skeena Coastal	5,198	0.1375	0.0326	0.1810	LM	LM	EF
Spiller-Mathieson	825	0.1019	0.0137	0.0350	L	L	G
Stikine Canyon	4,380	0.1215	0.0158	0.0899	LM	LM	EF
Suskwa	1,338	0.6836	0.0450	0.3976	M	H	AC
Tahltan	9,435	0.0465	0.0064	0.0407	L	L	G
Taku Interior	7,187	0.0191	0.0020	0.0061	L	L	G
Tatshenshini-Alsek	8,016	0.0218	0.0043	0.0231	L	L	G
Teslin	13,287	0.0205	0.0022	0.0170	LM	L	EG
Tsimshian Penninsula	3,282	0.1704	0.0228	0.1711	L	M	F
Tuya	3,575	0.0051	0.0007	0.0044	I	I	H
Unuk	1,822	0.0270	0.0055	0.0040	L	L	G
Upper Dease	10,277	0.0974	0.0116	0.0770	LM	LM	EF
Upper Iskut	5,586	0.1075	0.0133	0.0817	L	M	F
Upper Liard	5,892	0.1121	0.0123	0.0710	LM	LM	EF
Upper Nass	5,327	0.0000	0.0000	0.0045	I	I	H
Upper Skeena	4,842	0.0760	0.0084	0.0905	LM	L	EG
Upper Skeena Headwaters	5,379	0.1216	0.0132	0.0901	LM	LM	EF
Upper Stikine	10,993	0.0089	0.0008	0.0082	I	I	G
Upper Sustut	2,374	0.0765	0.0107	0.0889	M	L	E
Upper Zymoetz	1,420	0.3663	0.0402	0.3229	M	M	BD

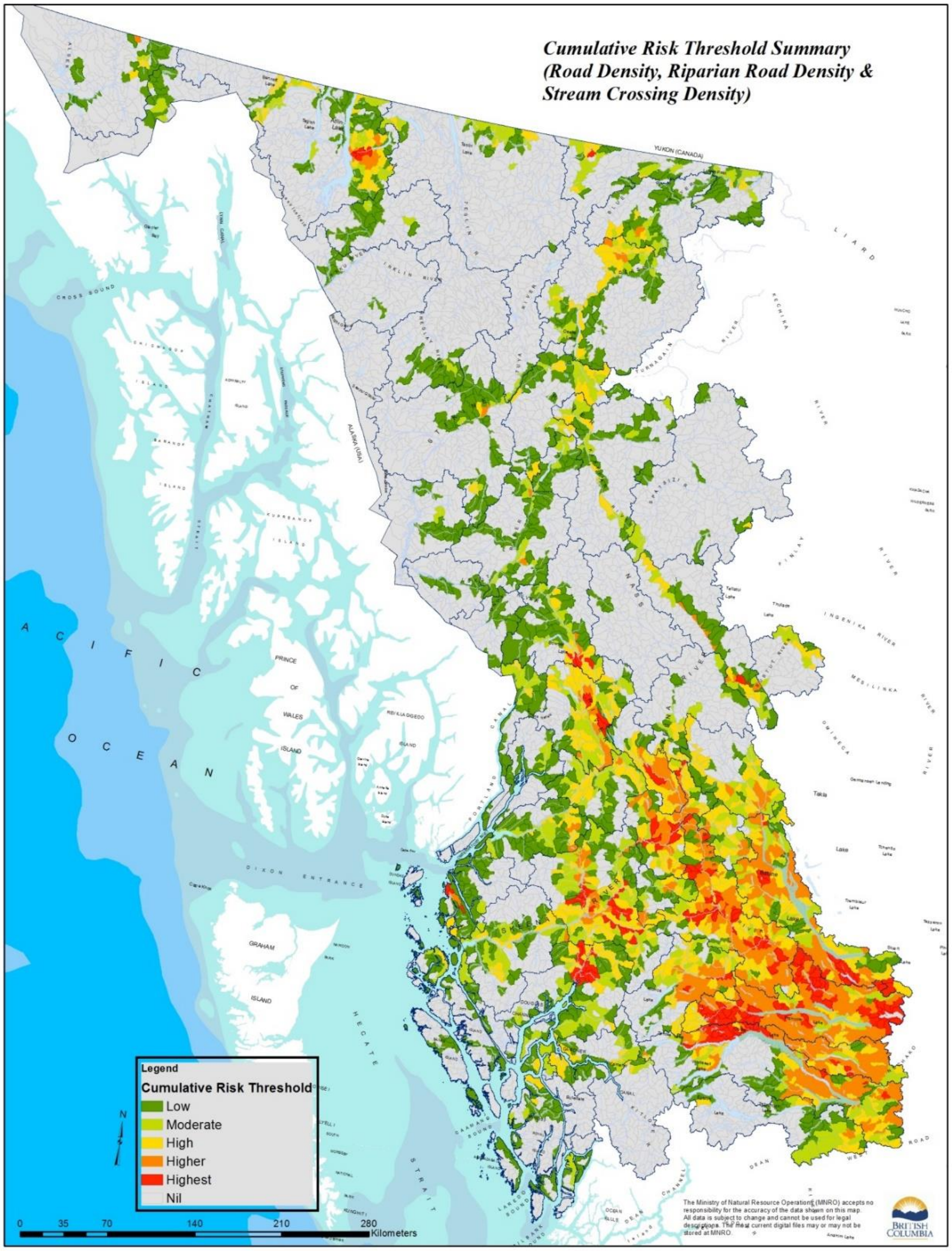

Figure 3. Cumulative indicator ranks within Freshwater Assessment Units in 52 TCUs of the Skeena Region (see Figure 2 for TCUs). Cumulative habitat threat indicator ranks range from grey (nil) to red (highest), and are associated with severity ranks ranging from 'insignificant' to 'high' as detailed in Table 5.

3.2 Bull Trout

The risk assessments for Skeena Region TCUs were based on the four conservation status indicators *Distribution*, *Abundance*, *Trend*, and *Threats*. Estimates for these indicators are described in the following sections, but are tabulated together in a single location at the end of Section *3.2* (Table 7) for efficiency.

3.2.1 Distribution

Records identified within the BCGW as Bull Trout, and other char records deemed likely to be Bull Trout, indicate Bull Trout presence in 34 of 52 TCUs (65%), making the species one of the region's most widely distributed salmonids. Bull Trout are widely distributed in interior TCUs of Skeena Region (>100 km from the coast) except where restricted by migration barriers (e.g. Iskut Lakes TCU, Eutsuk TCU) or limited to low abundance by poor availability of coldwater natal habitats (e.g. Francois-Endako TCU). Bull Trout are absent from coastal TCUs, with the exception of those defined by the lower reaches of the large, glacial rivers which penetrate the Coast Mountains (Lower Skeena, Lower Nass, Lower Stikine, Lower Taku TCUs). The wide distribution of the species in mountainous, interior parts of the region is likely related to its dependence on cold water natal habitats (see Section *2.1*).

Among indicators of conservation status and risk based on population data (i.e. distribution, abundance, trend – see Section *2.3.2*), distribution was the critical indicator as it was the only one for which categorical estimates could be made for most TCUs. Distribution was considered unknown for just 3 of the 34 TCUs in which Bull Trout are present (Cheslatta, Francois-Endako, Teslin; Table 7). In the remaining 31 TCUs, Bull Trout were judged to utilize less than 4 km of habitat in no TCUs, to utilize 4-40 km of habitat in no TCUs (possibly Babine Lake TCU), to utilize 40-200 km in 8 TCUs, and to utilize >200 km in the remaining 23 TCUs. In several cases where a significant adfluvial population(s) was known to exist within the TCU, the distribution estimate was boosted one category (i.e. to a lower level of risk) following risk assessment protocol (see Table 3).

Several important sources of error potentially affect Bull Trout distribution estimates in TCUs of the Skeena Region. A key source of uncertainty in the BCGW 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. Fortunately, identification of these two char species by fisheries professionals has become increasingly reliable since the mid-1990s, following the introduction of reliable guidelines for species identification based on morphological characteristics (particularly branchiostegal ray counts; Haas and McPhail 1991). Furthermore, for older or unvalidated records, we were frequently able to infer species identity based on life history or body size (see Section *2.1*).

In contrast, other sources of error likely resulted in underestimates of Bull Trout distribution within TCUs of the Skeena Region, particularly non-random sampling[21] and low and varying detection probability for Bull Trout depending on the objectives of a particular study.[22] 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 TCUs with low levels of industrial activity.

3.2.2 Abundance and Trend

Total estimates of adult Bull Trout abundance were not possible in TCUs of the Skeena Region, with one exception. In the Morice TCU, Bull Trout-focused studies, which have included juvenile abundance surveys and radio telemetry observations to identify natal streams, and redd count surveys to quantify abundance, have suggested a population likely in excess of 250 mature individuals (Bahr 2002; Bustard and Schell 2002; Hagen and Decker 2011)(Table 7). Estimating total abundance of mature individuals will continue to be a challenge within Skeena Region TCUs, because of the necessity of identifying and surveying multiple spawning tributaries. Total abundance is a key indicator of conservation status and risk (see Section *2.3.2*), however, so efforts to acquire this data may be warranted in circumstances of serious conservation concern (i.e. *High Risk* and *At Risk* TCUs).

Trend in adult abundance (estimated approximately by expert judgment or utilizing time series data where available) was also highly uncertain for Bull Trout in Skeena Region, and considered unknown for 28 of 34 TCUs (Table 7). Among the remaining 6 TCUs, Bull Trout abundance was estimated to be declining in 4 TCUs (Babine River, Bulkley, Upper Sustut; Figure 4, Upper Zymoetz), stable in 1 TCU (Middle Skeena; Figure 4), and increasing in one TCU (Upper Skeena; Figure 4). In all TCUs in which Bull Trout are thought to be declining, populations are exposed to intensive sport and/or First Nations fisheries, while Bull Trout in the relatively remote Upper Skeena TCU are thought to be exposed to relatively low fishing effort (see Section 3.2.3 *Threats*).

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[21] Fish sampling data may be derived from industry-related inventory surveys and environmental impact studies that focus only on specific areas of the TCU.

[22] 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 a primary objective, studies must be designed appropriately with multiple, randomly- or systematically-distributed sites (USFWS 2008).

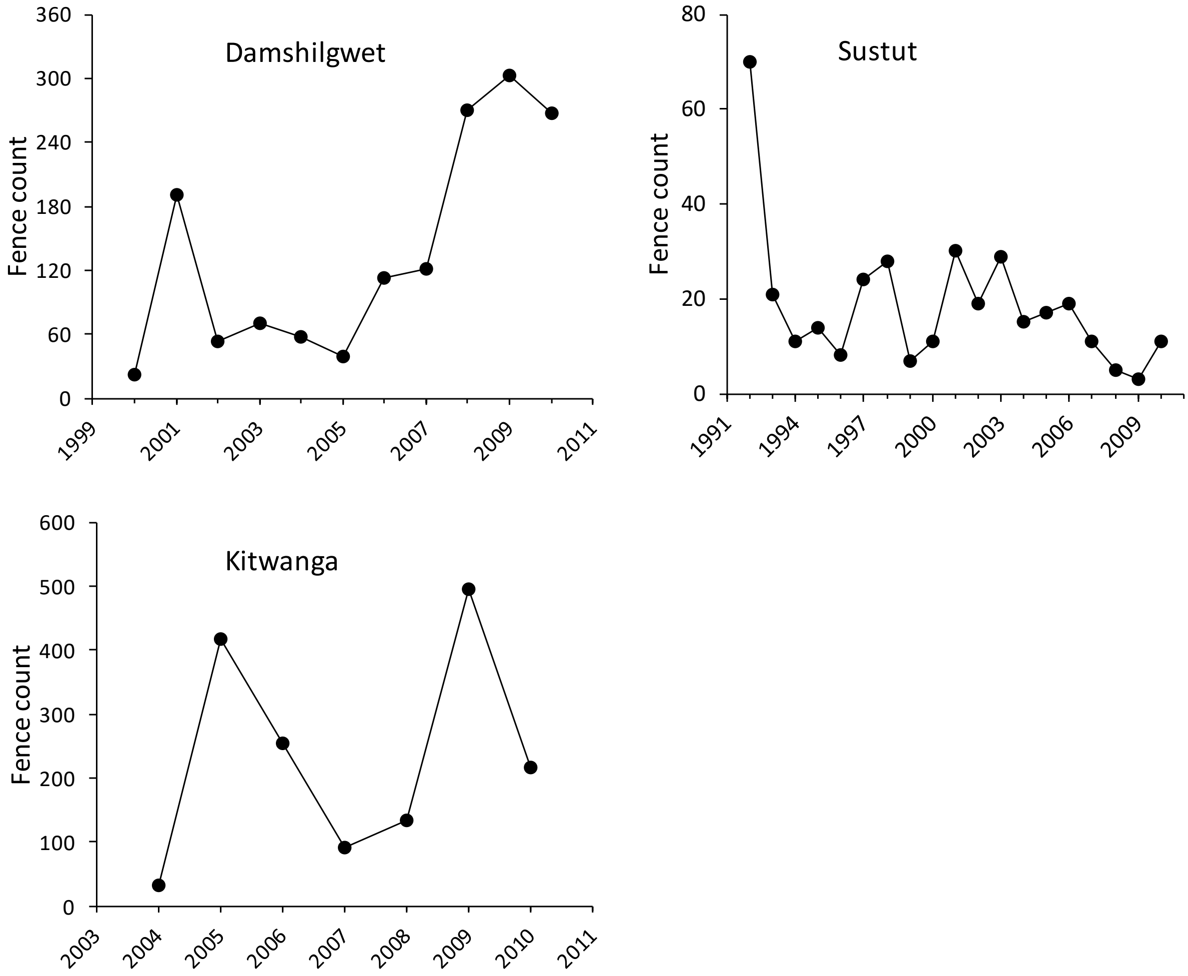


Figure 4. Pre-2011 time series of abundance data for Bull Trout enumerated at counting fences on Damshilgwet Creek in the Upper Skeena TCU (positive: $P = 0.01$), Sustut River in the Upper Sustut TCU (negative: $P = 0.04$), and Kitwanga River in the Middle Skeena TCU (no significant trend). Data are reprinted from Hagen and Decker (2011).

As mentioned previously (see Section *1.0*), efforts are underway to update these time series and acquire additional population data, through: 1) requests for relevant population data acquired through fisheries monitoring activities of Canada's Department of Fisheries and Oceans (DFO) and First Nations of the Skeena Region, and 2) initiation of MFLNRO-led monitoring studies for key conservation and management situations for stream-dwelling trout and char. Synthesis and reporting of these population data is a future task.

3.2.3 Exploitation threats summary

In our analysis, the two key indicators of overall threats to stream-dwelling trout and char populations are generalized aquatic habitat threats, and species-specific exploitation threats.

Habitat threats were not treated as species-specific and were summarized in Section *3.1* (Table 6) to avoid redundancy.

As described in Section *2.3.3*, scope and severity of exploitation threats were estimated by considering three indicators of potential overexploitation risk, under the existing regional regulation: 1) *Vulnerability* (indicator of 'scope'), 2) *Effort*, and 3) potential *Fishing Mortality* for captured fish. Exploitation threats were estimated (by expert judgment) for all 34 TCUs that have been documented to have Bull Trout. Five general levels of exploitation threats for Bull Trout were discerned (Figure 5), in order of increasing conservation concern:

1. <u>Low</u>: 16 TCUs (47%) were categorically estimated to have low severity exploitation threats for a low or low-to-moderate proportion of the population(s) or area, or low-to-moderate severity threats for a low proportion of the population(s) or area (Category *G*: Babine Lake, Cheslatta, Francois-Endako, Klappan, Lower Dease, Lower Stikine, Lower Taku, Taku Upper, Teslin, Tuya, upper Iskut, Upper Liard, Upper Sustut, Upper Zymoetz; Category *FG*: Upper Skeena; Category *EG*: Lower Nass; Figure 5, Table 7).

2. <u>Low-to-moderate</u>: 6 TCUs (18%) were estimated to have low severity exploitation threats for a moderate-to-high proportion of the TCU (Category *F*: Babine River, Suskwa, Upper Nass, Upper Skeena Headwaters; Figure 5, Table 7), low-to-moderate severity exploitation threats for a low-to-moderate proportion of the TCU (Category *EF*: Stikine Canyon, Upper Dease), or moderate-to-high severity exploitation threats for a low proportion of the population(s) or area (Category *E*: no TCUs).

3. <u>Moderate</u>: 4 TCUs (12%) were estimated to have low-to-moderate severity exploitation threats for a moderate proportion of the TCU, or moderate severity threats for low-to-moderate proportion of the TCU (Category *BDEF*: Babine River, Suskwa, Upper Nass, Upper Skeena Headwaters; Figure 5, Table 7).

4. <u>Moderate-to-high</u>: 8 TCUs (24%) were estimated to have moderate-to-severe exploitation threats for a moderate proportion of the population(s) or area (Category *BD*: Babine River, Suskwa, Upper Nass, Upper Skeena Headwaters; Figure 5, Table 7).

5. <u>High</u>: No TCUs were estimated to have moderate-to-severe exploitation threats for a high proportion of the population(s) or area (Category *AC*).

The key result of our analysis was that almost one quarter of Skeena Region TCUs were estimated to have elevated exploitation threats (category *BD* above), despite the regional non-retention regulation. In each case this was the direct result of our assumption of significantly elevated catch-and-release mortality during summer bait fisheries, combined with incidental catch in the intensive sport and First Nations fisheries targeting salmon during the summer period. The use of bait, therefore, in high-use fisheries appears to be one of the most significant fishery management factors threatening Bull Trout populations in the Skeena Region.

Consequently, Bull Trout population monitoring and mortality studies are recommended to further assess the sustainability of populations under these regulations.

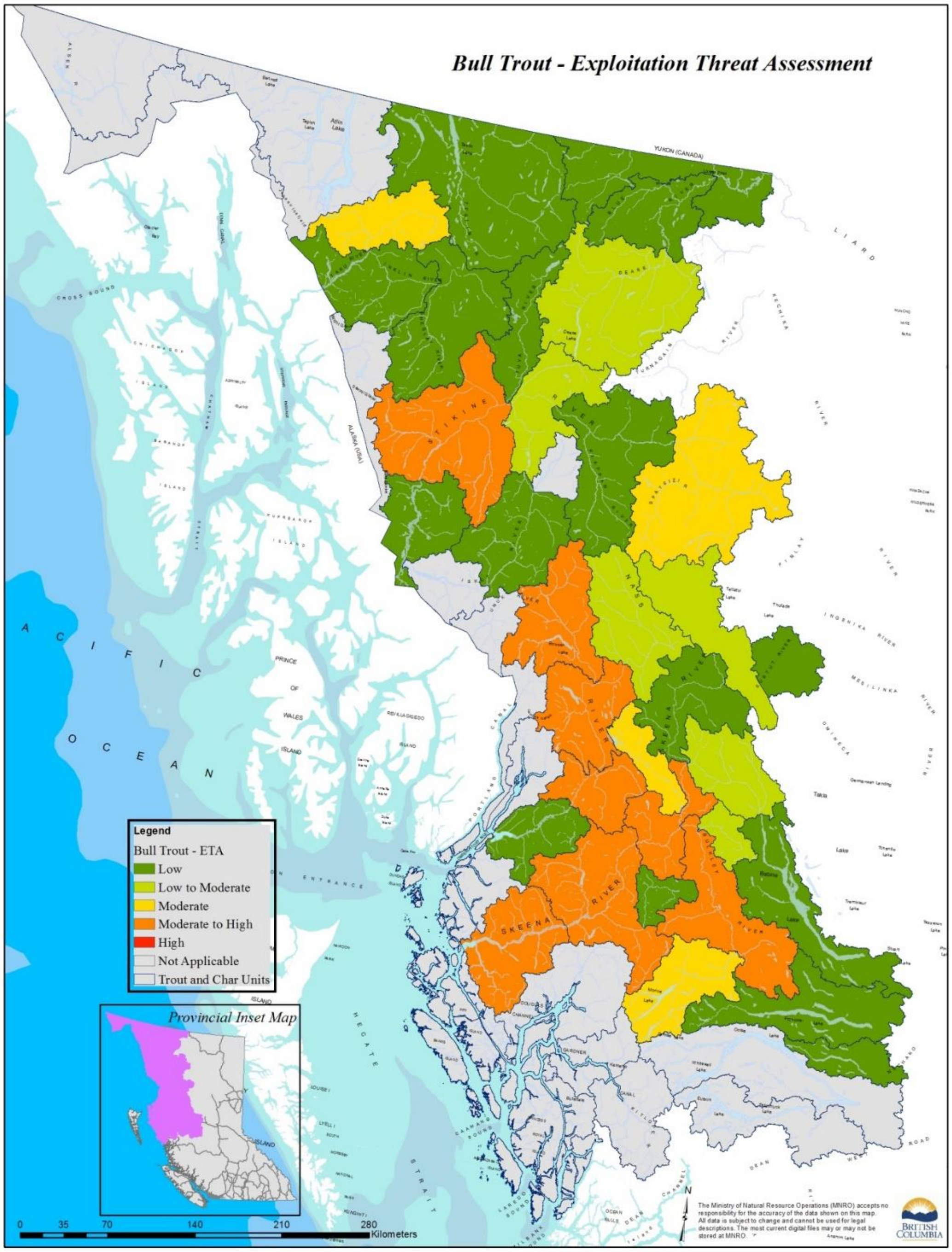


Figure 5. Exploitation threats estimates, in five categories of increasing risk, for 34 TCUs of the Skeena Region (see Figure 2 for TCU identification) in which Bull Trout are present.

The distribution of exploitation threats estimates for Bull Trout did not exactly mirror the distribution of habitat threats estimates. Therefore, in some TCUs lower estimated levels of exploitation threats was a factor mitigating elevated habitat threats (e.g. Babine Lake, Babine River, Cheslatta, Francois-Endako, Upper Zymoetz, Suskwa; Table 7), and vice-versa (e.g. Nakina, Upper Stikine, Tahltan). In the case of the former, low exploitation threats were a result of a lack of intensive summer fisheries in which bait use is permitted. In the case of the latter, pristine aquatic habitat is associated with remote or northern locations with limited watershed development. However, within the geographic range of Bull Trout, TCUs with lowest levels of habitat threats generally also had the lowest levels of exploitation threats. These TCUs are generally located in the northern portion of the region away from population centers and major transportation corridors. Similarly, TCUs with the highest levels of both habitat and exploitation threats were located in the southern portion of the range in accessible portions of the Skeena River and Nass River watersheds (Table 7).

3.2.4 Risk assessment

Conservation status and risk rankings (C-Ranks; USFWS 2005), which were computed from the numerical scores associated with codes for *Distribution*, *Abundance*, *Trend*, *Habitat Threats*, and *Exploitation Threats* (see Section *2.3.1*), were assigned to Bull Trout in 31 TCUs (91%) for which distribution and threats scores, at a minimum, were available (Table 7; Figure 6). C-Ranks were *C1-High Risk* for no TCUs, *C2-At Risk* for 2 TCUs (6%), *C3-Potential Risk* for 17 TCUs (50%), and *C4-Low Risk* for 12 TCUs (35%). The Cheslatta, Francois-Endako, and Teslin TCUs, for which Bull Trout distribution is highly uncertain, received rankings of *CU-unranked*.

A ranking of *C1-High Risk* implies the extremely serious situation where the metapopulation is highly vulnerable to extirpation, because of extremely limited and/or rapidly declining numbers, range, and/or habitat (Table 3). At this point in time, our assessment has not indicated this circumstance anywhere within the Skeena Region for Bull Trout.

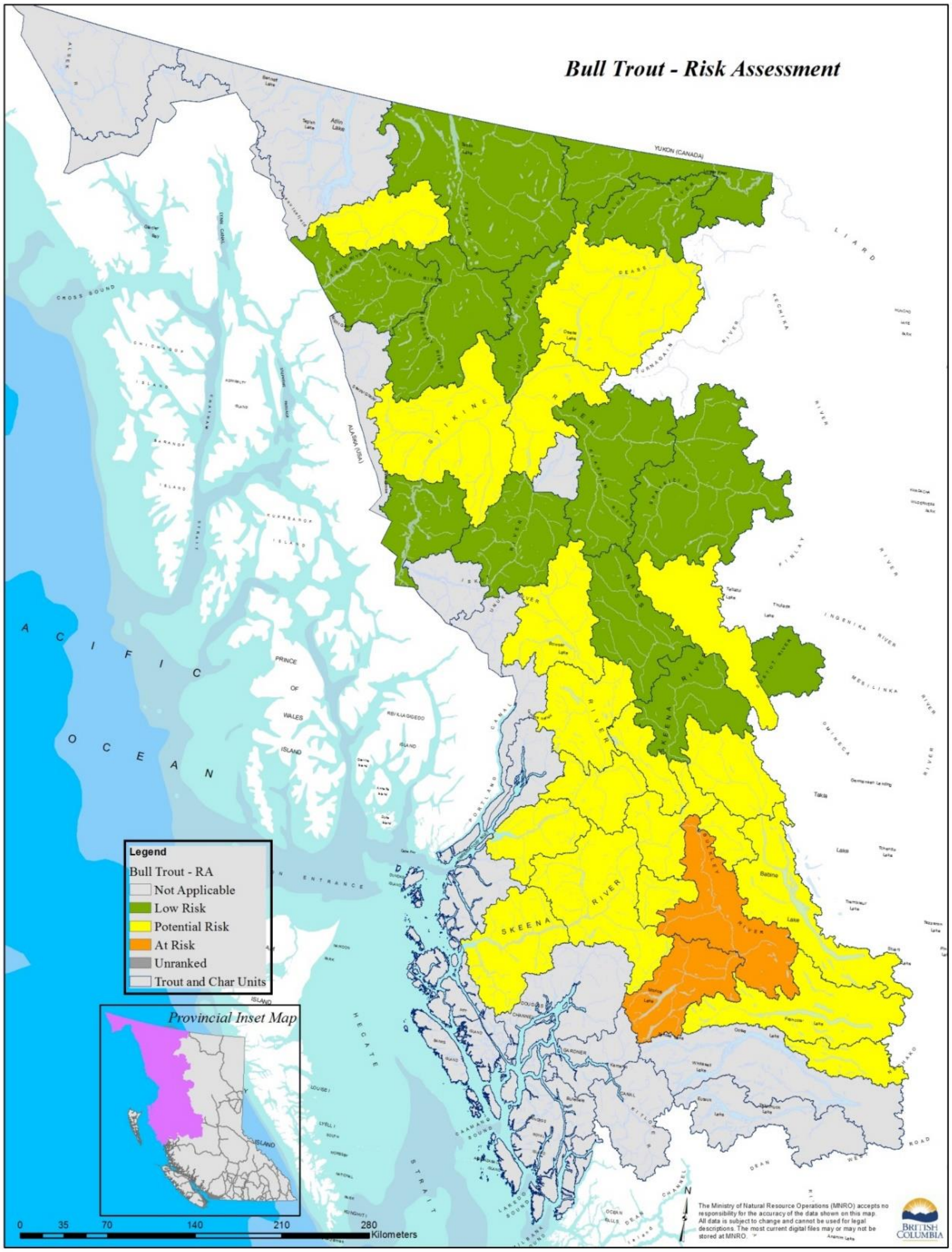
A ranking of *C2-At Risk* also implies a situation of serious conservation concern, where the population in a TCU may be vulnerable to extirpation because of very limited and/or declining numbers, range, and/or habitat (Table 3). Even under a regional regulation of non-retention for char in streams, Bull Trout populations in two TCUs – the Morice River and Bulkley TCUs – were considered to be at risk in our analysis (Table 7, Figure 6). These two TCUs have had extensive watershed development over a relatively long period of time, are among the most accessible within the Skeena Region, and are subjected to high intensity fisheries targeting steelhead and salmon. Additional factor exacerbating risk in these TCUs are small Bull Trout population size (Morice River TCU) and a summer bait fishery elevating catch-and-release mortality (Bulkley TCU).

Bull Trout populations in TCUs ranked *C3-Potential Risk* may potentially be at risk because of limited and/or declining numbers, range, and/or habitat, even though the species may be locally abundant in some areas of the TCU (Table 3). Two factors in particular had strong influence on risk assessments in these TCUs. The first was elevated exploitation threats as a consequence of intensive summer fisheries targeting salmon, in which the use of bait is permitted. The second was elevated habitat threats resulting from watershed development (Table 7). TCUs in the *Potential Risk* category form the majority of the Skeena River and Nass River watersheds, but a small number of northern TCUs away from major population centers are also included in this list because of potentially elevated habitat and exploitation threats in accessible areas.

Bull Trout in TCUs ranked *C4-Low Risk* are in most cases widespread throughout the TCU. They do not appear to be vulnerable at this time, but may still be cause for long-term concern. The most important factor in *Low Risk* rankings was low estimated levels of threats (Table 7). *Low Risk* TCUs were primarily located north of the Skeena and Nass basins, with the exception of a small number of TCUs from the remote upper reaches of these watersheds (Upper Nass, Upper Skeena, Upper Sustut; Table 7).

Table 7. Categorical estimates for conservation status and risk indicators for Bull Trout within 34 Skeena Region Trout and Char Units, resulting cumulative numeric scores, and associated conservation status and risk assessments (C-Ranks; see Section *2.3.1*).

Trout-Char Unit	Distribution	Population size	Trend	Exploitation threats	Habitat threats	*Numeric score*	C-rank for occurrence
Babine Lake	BC	U	U	G	BD	3.00	C3-Potential Risk
Babine River	D	U	D	F	BD	2.75	C3-Potential Risk
Bell-Irving	E	U	U	BD	E	3.25	C3-Potential Risk
Bulkley	D	U	D	BD	AC	2.38	***C2-At Risk***
Cheslatta	U	U	U	G	AC	3.50	CU-Unranked
Cranberry-Kiteen	D	U	U	BD	BD	2.75	C3-Potential Risk
Francois-Endako	U	U	U	G	AC	3.50	CU-Unranked
Kispiox	D	U	U	BDEF	BD	2.88	C3-Potential Risk
Klappan	D	U	U	G	G	4.00	C4-Low Risk
Lakelse-Kalum	D	U	U	BD	BD	2.75	C3-Potential Risk
Lower Dease	D	U	U	G	EF	3.63	C4-Low Risk
Lower Nass	C	U	U	EG	BDEF	3.06	C3-Potential Risk
Lower Stikine	C	U	U	G	G	3.75	C4-Low Risk
Lower Taku	C	U	U	G	H	3.88	C4-Low Risk
Middle Nass	E	U	U	BD	BD	3.00	C3-Potential Risk
Middle Skeena	D	U	U	BD	AC	2.63	C3-Potential Risk
Morice River	D	C	U	BDEF	BD	2.38	***C2-At Risk***
Nakina	C	U	U	BDEF	G	3.25	C3-Potential Risk
Skeena Coastal	C	U	U	BD	EF	2.75	C3-Potential Risk
Stikine Canyon	C	U	U	EF	EF	3.00	C3-Potential Risk
Suskwa	C	U	U	F	AC	2.63	C3-Potential Risk
Tahltan	CD	U	U	BD	G	3.25	C3-Potential Risk
Taku Upper	E	U	U	G	G	4.25	C4-Low Risk
Teslin	U	U	U	G	EG	4.06	CU-Unranked
Tuya	D	U	U	G	H	4.13	C4-Low Risk
Upper Dease	E	U	U	EF	EF	3.50	C3-Potential Risk
Upper Iskut	D	U	U	G	F	3.63	C4-Low Risk
Upper Liard	D	U	U	G	EF	3.63	C4-Low Risk
Upper Nass	D	U	U	F	H	3.75	C4-Low Risk
Upper Skeena	D	U	U	FG	EG	3.63	C4-Low Risk
Upper Skeena Headwaters	D	U	U	F	EF	3.25	C3-Potential Risk
Upper Stikine	E	U	U	BDEF	G	3.75	C4-Low Risk
Upper Sustut	E	U	D	G	E	3.63	C4-Low Risk
Upper Zymoetz	D	U	D	G	BD	3.13	C3-Potential Risk


Bull Trout - Risk Assessment
Legend
Bull Trout - RA
Not Applicable
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Trout and Char Units
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The Ministry of Natural Resource Operations (MNRO) accepts no responsibility for the accuracy of the data shown on this map. All data is subject to change and cannot be used for legal descriptions. The most current digital files may or may not be stored at MNRO.
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Figure 6. Conservation status and risk assessment rankings for 34 TCUs of the Skeena Region (see Figure 2 for TCU identification) in which Bull Trout are present.

3.3 Dolly Varden

For Dolly Varden in TCUs of Skeena Region, categorical estimates for conservation status indicators *Distribution*, *Abundance*, *Trend*, and *Threats* are described in sections *3.3.1* to *3.3.4* below, and are tabulated together in one location at the end of Section *3.3* (Table 8).

3.3.1 Distribution

In contrast to the situation in southern British Columbia, where Dolly Varden have a relatively narrow distribution west of the Coast Mountains (Haas and McPhail 1991), Dolly Varden in the Skeena Region are widely distributed in both coastal and interior drainages. As described previously, however (Section *2.1*), interactive segregation between the Dolly Varden and closely-related Bull Trout has resulted in the restriction of the former to a stream-resident, non-migratory life history. In our analysis, we assume that non-migratory, interior populations of Dolly Varden are not vulnerable to overexploitation, and the risk assessment is limited to coastal TCUs in which the migratory form is known or assumed to be present. The only exception to this division is the unique situation (of scientific interest) of the Francois-Endako TCU, where Bull Trout presence in the TCU is thought to be negligible and adfluvial Dolly Varden appear to be present.

Records identified within the BCGW as Dolly Varden indicate the species' presence in 19 coastal and near-coastal (within 100 km) TCUs (Table 8), in addition to the Francois-Endako TCU where migratory Dolly Varden may also be present (unconfirmed). Distribution was categorically estimated for all 20 of these TCUs. Dolly Varden were judged to utilize less than 4 km of stream habitat in no TCUs, to utilize 4-40 km of habitat in one TCU, to utilize 40-200 km in 12 TCUs, and to utilize >200 km in the remaining 7 TCUs. In all cases anadromous life histories (adfluvial in the case of Francois-Endako TCU) were assumed to be present, so the distribution estimate for each TCU was boosted one category (i.e. to a lower level of risk) following risk assessment protocol (see Table 3).

Similar to the situation for the other stream-dwelling trout and char species in the Skeena Region, it is highly likely that many watersheds that have received little or no sampling effort contain undetected Dolly Varden populations, especially in remote or pristine TCUs with low levels of industrial activity.

3.3.2 Abundance and Trend

Anecdotal information and observations by Skeena Region fisheries professionals indicate that Dolly Varden are widespread and relatively abundant in coastal watersheds, but almost no quantitative data exists with which to estimate total abundance and trend. Total abundance was estimated only for the Lakelse-Kalum TCU, where a large population of migratory DV appears to be present. Seine hauls made during a study of Coastal Cutthroat Trout abundance in the 1980s captured 7,900 Dolly Varden in the Lakelse River alone, suggesting that a population in excess of 2,500 mature individuals is likely for the TCU (Table 8). This estimated level of abundance suggests a significant difference in productivity for Dolly Varden relative to the closely-related Bull Trout, for which local populations of mature fish typically number in the 10s to 100s.

Unfortunately, trend in Dolly Varden abundance was considered unknown for all 20 TCUs. Trend in abundance is a key indicator of conservation status and risk, so efforts to acquire population data from index streams in future are recommended. A limited amount of Dolly Varden population data are available in the form of incidental captures at salmon and steelhead counting facilities, and may potentially be important sources of trend information. As mentioned, these data are in the process of being requested and compiled by MFLNRO.

3.3.3 Exploitation threats summary

Similar to Bull Trout, the regional regulation for Dolly Varden is now non-retention in streams. Under this regulation, exploitation threats for migratory Dolly Varden were estimated to be lower in the 20 TCUs they inhabit, relative to other species of stream-dwelling trout and char in their respective ranges. In order of increasing conservation concern:

1. <u>Low</u>: 14 TCUs (70%) were categorically estimated to have low or low-to-moderate severity exploitation threats for a low proportion of the population(s) or area (Category *G*: Banks-Pitt, Francois-Endako, Kemano, Kitlope, Lower Iskut, Lower Stikine, Lower Taku, Northern Transboundary, Porcher-Pitt, Portland, Princess Royal, Spiller Mathieson, Tatshenshini-Alsek, Unuk; Category *EG*: Kitsault; Figure 7, Table 8).

2. <u>Low-to-moderate</u>: 2 TCU (10%) were estimated to have low severity exploitation threats for a moderate-to-high proportion of the TCU (Category *F*: Kitimat; Figure 7, Table 8), low-to-moderate severity exploitation threats for a low-to-moderate proportion of the TCU (Category *EF*: no TCUs), or moderate-to-high severity exploitation threats for a low proportion of the population(s) or area (Category *E*: Tsimshian Penninsula).

3. <u>Moderate</u>: 3 TCUs (15%) were estimated to have low-to-moderate severity exploitation threats for a moderate proportion of the TCU, or moderate-to-high severity threats for a low-to-moderate proportion of the TCU (Category *BDEF*: Lakelse-Kalum, Lower Nass, Skeena Coastal; Figure 7, Table 8).

4. <u>Moderate-to-high</u>: No TCUs were estimated to have moderate-to-severe exploitation threats for a moderate proportion of the population(s) or area (Category *BD*).

5. <u>High</u>: No TCUs were estimated to have moderate-to-severe exploitation threats for a high proportion of the population(s) or area (Category *AC*).

The key result of our analysis was that the majority of Skeena Region TCUs were estimated to have relatively low exploitation threats (85% in categories G, EG, F, G above), and even in the remainder moderate-to-severe threats did not affect the majority of the population(s) or area. The first important factor behind this result was that vulnerability was estimated to be lower relative to Coastal Cutthroat trout, because of the greater degree of anadromy (i.e. time periods when fish are in a relative refuge from angling exploitation) assumed for Dolly Varden, and the greater extent of saltwater movements (Currens et al. 2003).[23] Second, effort was estimated to be relatively low in most TCUs, reflecting both the inaccessibility of many coastal TCUs, and less frequent targeting of the species relative to other stream-dwelling salmonids. The third important factor was of course the regional non-retention regulation. Elevated levels of exploitation threats in the Lakelse-Kalum, Lower Nass, and Skeena Coastal TCUs reflect the assumption of relatively high catch-and-release mortality in high-use, summer salmon fisheries permitting the use of bait.

It is important to note that within TCUs with low exploitation threats overall, some local populations may be targeted and therefore warrant special attention. For example, Princess Royal TCU was considered to have low exploitation threats (Table 8, Figure 7), but a unique, regionally-significant population of piscivorous Dolly Varden inhabiting Whalen Lake[24] is targeted by anglers and may be of concern over the longer term.

Habitat threats, which were summarized for all TCUs of Skeena Region in Section *3.1* (Table 6, Figure 3), were also estimated to be of low or low-to-moderate scope and severity in the majority of migratory Dolly Varden TCUs (Table 8). The exceptions were the Kemano, Kitimat, and Lower Nass TCUs, where moderate-to-severe habitats threats of low-to-moderate extent were estimated, and the Francois-Endako and Lakelse-Kalum TCUs, in which moderate-to-high habitat threats of high and moderate extents, respectively, were estimated.

[23] Movements out of coastal river systems in Skeena Region to unknown locations are anecdotally observed, but have not been quantified.

[24] Body sizes of up to 580 mm and ages to 18 yrs have been recorded (Mason and Lewis 1997).

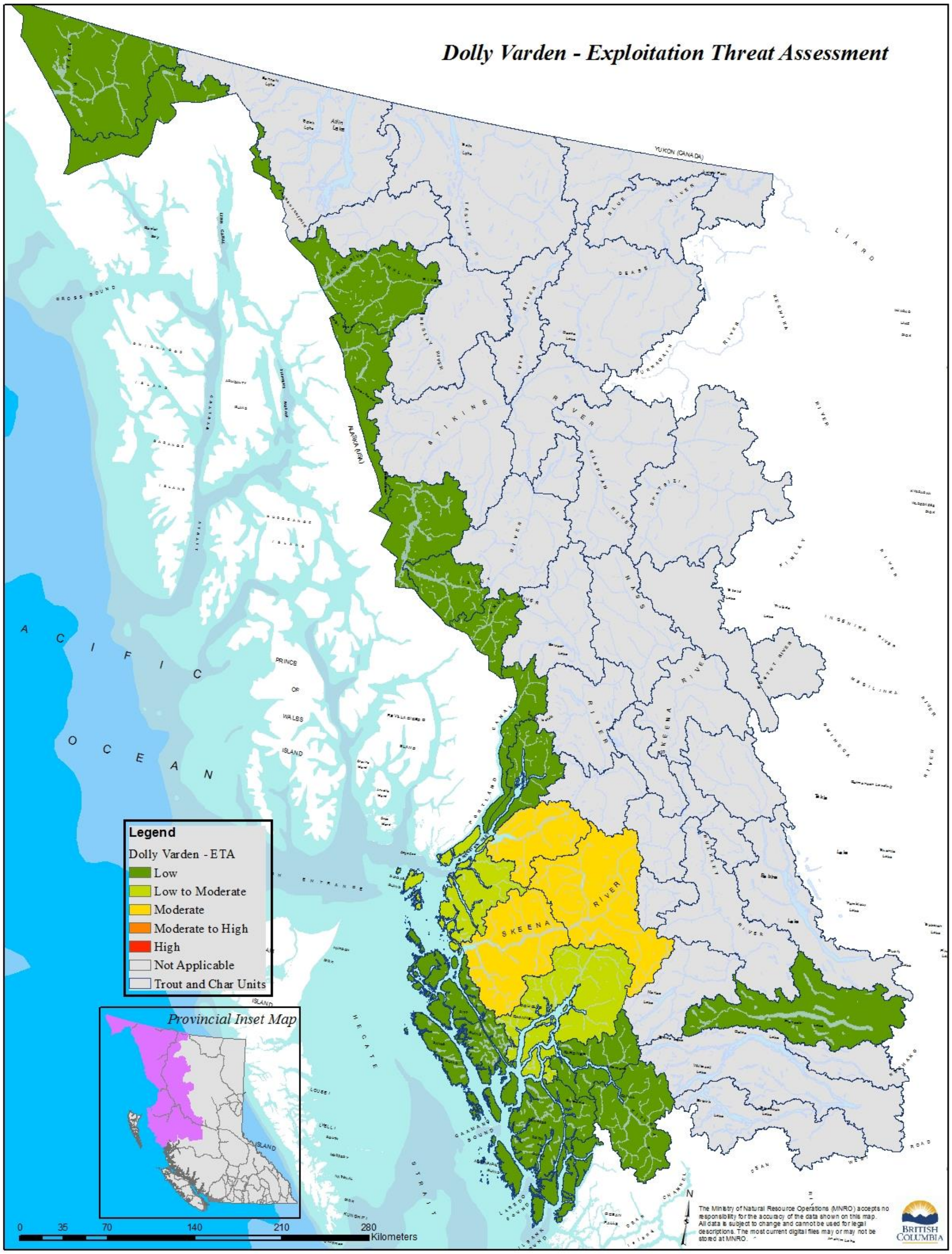

Figure 7. Exploitation threats estimates for 20 TCUs of the Skeena Region (see Figure 2 for TCU identification) in which migratory populations Dolly Varden are present.

3.3.4 Risk assessment

For Dolly Varden, conservation status and risk rankings (C-Ranks; USFWS 2005), computed from the numerical scores associated with codes for *Distribution*, *Abundance*, *Trend*, *Habitat Threats*, and *Exploitation Threats* (see Section *2.3.1*), were *C1-High Risk* for no TCUs, *C2-At Risk* for no TCUs, *C3-Potential Risk* for 7 TCUs (35%), *C4-Low Risk* for 13 TCUs (65%), and *CU-unranked* for no TCUs (Table 8, Figure 8).

Table 8. Categorical estimates for conservation status and risk indicators for Dolly Varden within 20 Skeena Region Trout and Char Units, resulting cumulative numeric scores, and associated conservation status and risk assessments (C-Ranks; see Section *2.3.1*).

Trout-Char Unit	Distribution	Population size	Trend	Exploitation threats	Habitat threats	*Numeric score*	C-rank for occurrence
Banks-Pitt	D	U	U	G	G	4.00	C4-Low Risk
Francois-Endako	D	U	U	G	AC	3.25	C3-Potential Risk
Kemano	D	U	U	G	BDEF	3.50	C3-Potential Risk
Kitimat	E	U	U	F	BDEF	3.38	C3-Potential Risk
Kitlope	E	U	U	G	H	4.38	C4-Low Risk
Kitsault	DE	U	U	EG	G	3.94	C4-Low Risk
Lakelse-Kalum	E	E	U	BDEF	BD	3.13	C3-Potential Risk
Lower Iskut	D	U	U	G	G	4.00	C4-Low Risk
Lower Nass	D	U	U	BDEF	BDEF	3.00	C3-Potential Risk
Lower Stikine	D	U	U	G	G	4.00	C4-Low Risk
Lower Taku	D	U	U	G	H	4.13	C4-Low Risk
Northern Transboundary	C	U	U	G	G	3.75	C4-Low Risk
Porcher-Pitt	D	U	U	G	G	4.00	C4-Low Risk
Portland	E	U	U	G	F	3.88	C4-Low Risk
Princess Royal	D	U	U	G	G	4.00	C4-Low Risk
Skeena Coastal	E	U	U	BDEF	EF	3.38	C3-Potential Risk
Spiller-Mathieson	D	U	U	G	G	4.00	C4-Low Risk
Tatshenshini-Alsek	D	U	U	G	G	4.00	C4-Low Risk
Tsimshian Penninsula	E	U	U	E	F	3.50	C3-Potential Risk
Unuk	D	U	U	G	G	4.00	C4-Low Risk

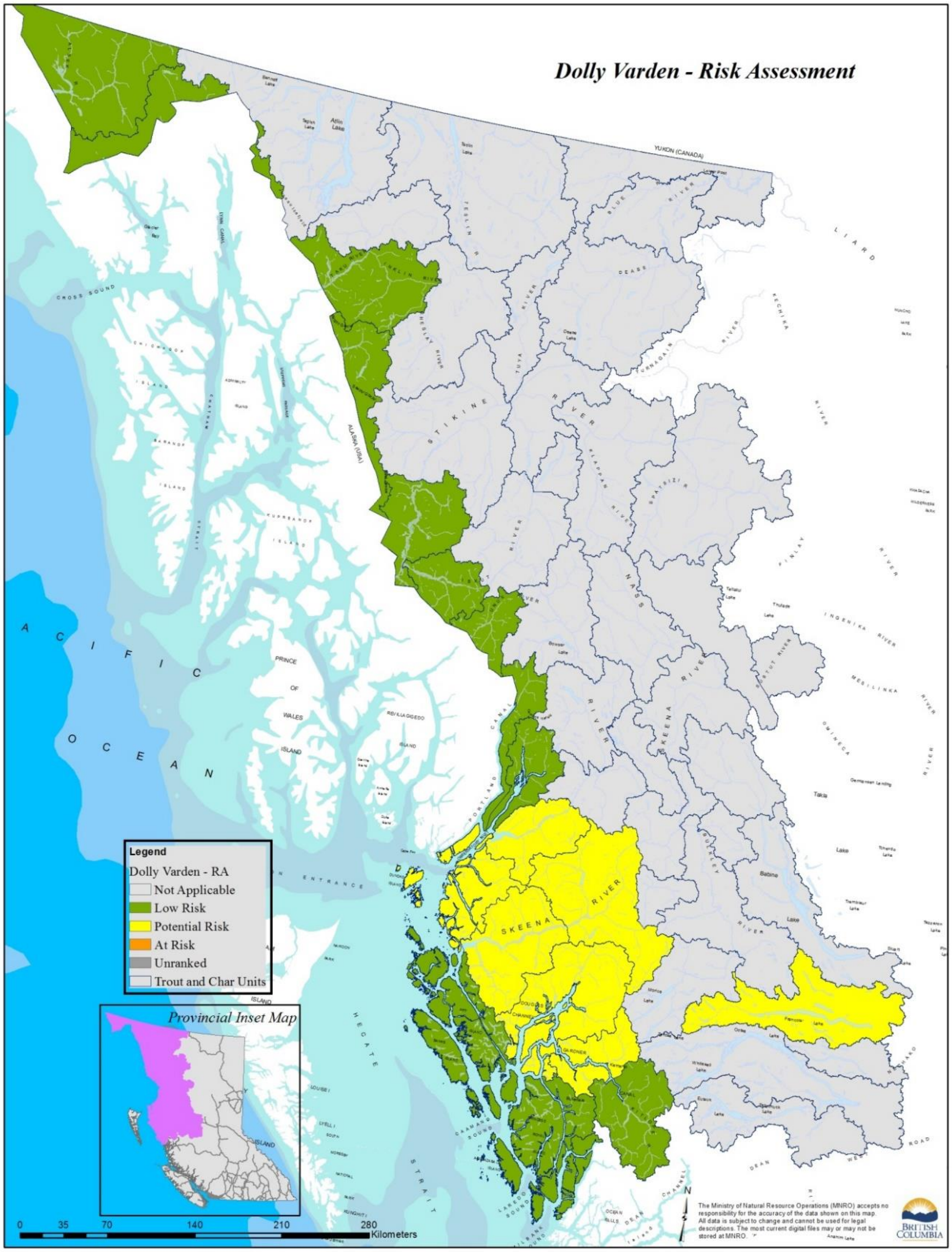

Figure 8. Conservation status and risk assessment rankings for 20 TCUs of the Skeena Region (see Figure 2 for TCU identification) in which migratory Dolly Varden populations are present.

The 7 TCUs where migratory Dolly Varden populations received a ranking *C3-Potential Risk* were generally more accessible, and/or closer to human population centers (Figure 8). The most important factors determining the 7 *Potential Risk* rankings were elevated threats, in most cases elevated habitat threats but also elevated exploitation threats in the Lakelse-Kalum, Lower Nass, and Skeena Coast TCUs where bait is permitted in intensive summer fisheries targeting salmon.

The most important factors in rankings of *C4-Low Risk* were low estimated levels of both habitat and exploitation threats (Table 7) in these TCUs, which are either relatively inaccessible or located away from major human population centers.

3.4 Coastal Cutthroat Trout

For Coastal Cutthroat Trout, categorical estimates for conservation status indicators *Distribution*, *Abundance*, *Trend*, and *Threats* in TCUs of Skeena Region are described in sections *3.4.1* to *3.4.4* below, and are tabulated together in one location at the end of Section *3.4* (Table 9).

3.4.1 Distribution

Similar to Dolly Varden, Coastal Cutthroat Trout across most of their range have a relatively narrow distribution within approximately 150 km of the coast (Costello 2008). The Skeena Region, and in particular the Skeena River watershed, presents a unique situation in that the species distribution extends well inland to headwater reaches of the Babine (Babine Lake, Babine River TCUs), Bulkley (Bulkley, Morice River, and Suskwa TCUs), and Zymoetz[25] (Upper Zymoetz) systems. Isolated, inland records also exist for the Taku Interior (Tatsatua Lake, Nahlin-Sheslay confluence), Upper Nass (Upper Damdochax watershed and Sacred Headwaters area), and Francois-Endako (unconfirmed presence in Henkel Creek and Tatalaska Lake) TCUs.

Records identified within the BCGW as Cutthroat Trout indicate the species' presence in 32 Skeena Region TCUs (Table 9). Coastal Cutthroat Trout were judged to utilize less than 4 km of stream habitat in 1 TCU, to utilize 4-40 km of habitat in 8 TCUs, to utilize 40-200 km in 12 TCUs, to utilize >200 km in 9 TCUs (Table 9), and to have an unknown distribution in 2 TCUs (Kitsault, Tatshenshini-Alsek). Distribution estimates for coastal TCUs were boosted by one category to account for potential anadromy (assuming a lower level of risk following risk assessment protocol; see Table 3), as were those containing significant adfluvial populations (Banks-Pitt, Bulkley, Lakelse-Kalum, Middle Skeena, Upper Zymoetz).

The boosting of the distribution estimates to account for potential anadromy is offset by underestimation bias related to low sampling effort in many TCUs, especially in remote or pristine TCUs with low levels of industrial activity. In a sample of 14 Coastal Cutthroat Trout

[25] An isolated but relatively extensive distribution of Coastal Cutthroat Trout in the upper Zymoetz River watershed was the basis for delineating the Upper Zymoetz TCU.

TCUs that received more detailed estimates of distribution and sampling effort, for example, the percentage of the watershed units within each TCU that had been sampled ranged from 10%-95%, averaging 49%. As mentioned previously for Bull Trout and Dolly Varden, it is highly likely that many watersheds that have received little or no sampling effort contain undetected Coastal Cutthroat Trout populations.

3.4.2 Abundance and Trend

Very little quantitative data exists with which to estimate total abundance and trend for Coastal Cutthroat Trout populations in Skeena Region, but it is likely that populations are relatively small in most coastal TCUs. Across their range, Coastal Cutthroat Trout local populations are frequently small, often numbering in the 10s to 100s of mature individuals (Costello 2008). Furthermore, in Prince William Sound, Alaska, Coastal Cutthroat Trout are characterized by small population sizes relative to Dolly Varden[26] (Currens et al. 2003).

Total abundance could be estimated only for two Skeena Region TCUs known to have relatively major populations – Kitmat TCU and Lakelse-Kalum TCU – on the basis of mark-recapture studies (Table 9). Total abundance of mature individuals was estimated to be 1,000-2,500 for the Kitimat TCU, based on the late-1980s mark-recapture estimate of 1,700 age-4+ in the most significant local population, the Kitimat River (Lough 1990a, 1990b).

We estimated the total population of mature Coastal Cutthroat Trout in the Lakelse-Kalum TCU to be in-between the categories 1,000-2,500 and 2,500-10,000 (i.e., 2,500 ±), which was based on age-structured mark-recapture population estimates in the Lakelse River from the 1950s and 1980s, and on the assumption that total adult abundance in the TCU is dominated by Lakelse fish.[27] Mark-recapture studies from the early-1950s indicated a population of up to 3,000 mature fish utilizing the Lakelse River seasonally (Bilton and Shepard 1955, and references therein). Further mark-recapture population estimates from seine netting in 1986 suggested a total population of approximately 2,000 mature fish (DeLeeuw 1991) utilizing the river. It is unknown whether potentially additional, mature Lakelse Lake fish avoid the Lakelse River and would therefore have been missed in the above estimates.

Trend in Coastal Cutthroat Trout abundance was considered unknown for all Skeena Region TCUs with the exception of the Kitimat and Lakelse-Kalum TCUs. Anecdotal reports in recent years have indicated declining catch-per-effort in both TCUs. This was considered to be the best available indicator of trend in the Kitimat TCU (Category *D* ‘declining;’ Table 9), while trend in the Lakelse-Kalum TCU was estimated to be intermediate between ‘declining’ and ‘stable’ categories based also on the relatively stable mark-recapture population estimates between the

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[26] As well as greater geographic isolation and genetic divergence (Currens et al. 2003).

[27] Although other areas of Coastal Cutthroat Trout production, and fisheries, are known e.g. Kitsumkalum, Zymagotiz, Zymoetz.

1950s and 1980s time periods, despite relatively high estimated exploitation in the Lakelse River of 18-31% (Bilton 1954 and references therein).

Additional Coastal Cutthroat Trout population data are available in the form of incidental captures at salmon and steelhead counting facilities, and may potentially be important sources of trend information. As mentioned previously for Dolly Varden, these data are in the process of being requested and compiled by MFLNRO.

3.4.3 Exploitation threats summary

Under current regional angling regulations for trout in streams, (1 per day between July 1 and October 31, with a minimum size limit of 30 cm), potential exploitation threats to Coastal Cutthroat Trout populations ranged widely in TCUs of Skeena Region from 'insignificant' (Category *H*) to 'moderate-to-high severity, high scope' (Category *AC*; Table 9). In order of increasing conservation concern:

1. <u>Low</u>: 22 TCUs (69%) were categorically estimated to have low or low-to-moderate severity exploitation threats for a low proportion of the population(s) or area (Category *G (or H)*: Babine River, Banks-Pitt, Francois-Endako, Kemano, Kitlope, Lower Stikine, Lower Taku, Middle Nass, Morice River, Porcher-Pitt, Portland, Princess Royal, Spiller-Mathieson, Suskwa, Taku Upper, Tatshenshini-Alsek, Unuk, Upper Nass, Upper Skeena; Category *EG*: Kitsault, Lower Iskut; Figure 9, Table 9), or low severity exploitation threats for a low-to-moderate proportion of the population(s) or area (Category *FG*: Babine Lake; Figure 9, Table 9).

2. <u>Low-to-moderate</u>: 2 TCU (6%) were estimated to have low severity exploitation threats for a moderate-to-high proportion of the TCU (Category *F*: Upper Zymoetz; Figure 9, Table 9), low-to-moderate severity exploitation threats for a low-to-moderate proportion of the TCU (Category *EF*: no TCUs), or moderate-to-high severity exploitation threats for a low proportion of the population(s) or area (Category *E*: Bulkley).

3. <u>Moderate</u>: 1 TCU (3%) was estimated to have low-to-moderate severity exploitation threats for a moderate proportion of the TCU, or moderate-to-high severity threats for a low-to-moderate proportion of the TCU (Category *BDEF*: Lower Nass; Figure 9, Table 9).

4. <u>Moderate-to-high</u>: 6 TCUs (19%) were estimated to have moderate-to-severe exploitation threats for a moderate proportion of the population(s) or area (Category *BD*: Kispiox, Lakelse-Kalum, Middle Skeena, Skeena Coastal, Tahltan, Tsimshian Peninsula; Figure 9, Table 9).

5. <u>High</u>: 1 TCU (3%) was estimated to have moderate-to-severe exploitation threats for a high proportion of the population(s) or area (Category *AC*: Kitimat; Figure 9, Table 9).

A significant discrepancy exists between the large percentage of Skeena Region TCUs, which were estimated to have relatively low exploitation threats (75% in categories *H*, *G*, *EG*, *FG*, *F*, and *G* above), and the remaining TCUs which were estimated to have relatively severe exploitation threats. Three factors appear to divide Coastal Cutthroat Trout populations into one or the other of these two categories. The first of these three factors is accessibility. A proportion of the TCUs which have low exploitation threats for Coastal Cutthroat Trout are relatively inaccessible, particularly coastal TCUs away from human population centers and transportation corridors in the lower Skeena, Nass, and Kitimat valleys. A second important factor affecting exploitation risk is whether fluvial fish have a migratory life history resulting in larger body sizes >30 cm targeted by anglers, and vulnerable to legal harvest. In certain relatively accessible TCUs in the interior Skeena River watershed (e.g. Morice River), Coastal Cutthroat Trout may exist as small-bodied stream-residents or adfluvial fish which are relatively lower in vulnerability. The third factor is the presence of high-use summer fisheries targeting salmon, in which effort is high and the use of bait is permitted. TCUs in which Coastal Cutthroat Trout are subject to elevated overexploitation threats (25% in categories *AC*, *BD*, and *BDEF*) are in every case relatively accessible, are subjected to relatively high use recreational and/or First Nations fisheries, and harbor migratory Coastal Cutthroat Trout populations which attain body sizes >30 cm.

Within TCUs with low exploitation threats overall, some local populations may be targeted and therefore warrant special attention. For example, Banks-Pitt TCU was considered to have low exploitation threats (Table 9, Figure 9), but a unique, regionally-significant population of piscivorous Coastal Cutthroat Trout[28] inhabiting Red Bluff Lake is targeted by anglers and may be of concern over the longer term.

Habitat threats, which were summarized for all TCUs of Skeena Region in Section *3.1* (Table 6, Figure 3), also exhibit a broad range from 'negligible' to 'moderate-to-severe, high scope' in TCUs utilized by Coastal Cutthroat Trout (Table 9). Exploitation threats do not necessarily follow the spatial pattern exhibited by habitat threats. In interior TCUs, life history variation affecting body size and vulnerability, as described above, appears to break up potential correlation between high habitat threats and high exploitation threats in highly accessible TCUs. In the Skeena Coastal, Tahltan, and Tsimshian Penninsula TCUs, habitat threats are not estimated to be severe (although at a high level in some watersheds), and overexploitation risk is the major component of estimated threats overall (Table 9).

[28] Which attain an average size of 45 cm on a kokanee diet. While stream angling in that watershed is unknown, it should be considered as a possibility due to a lack of information.

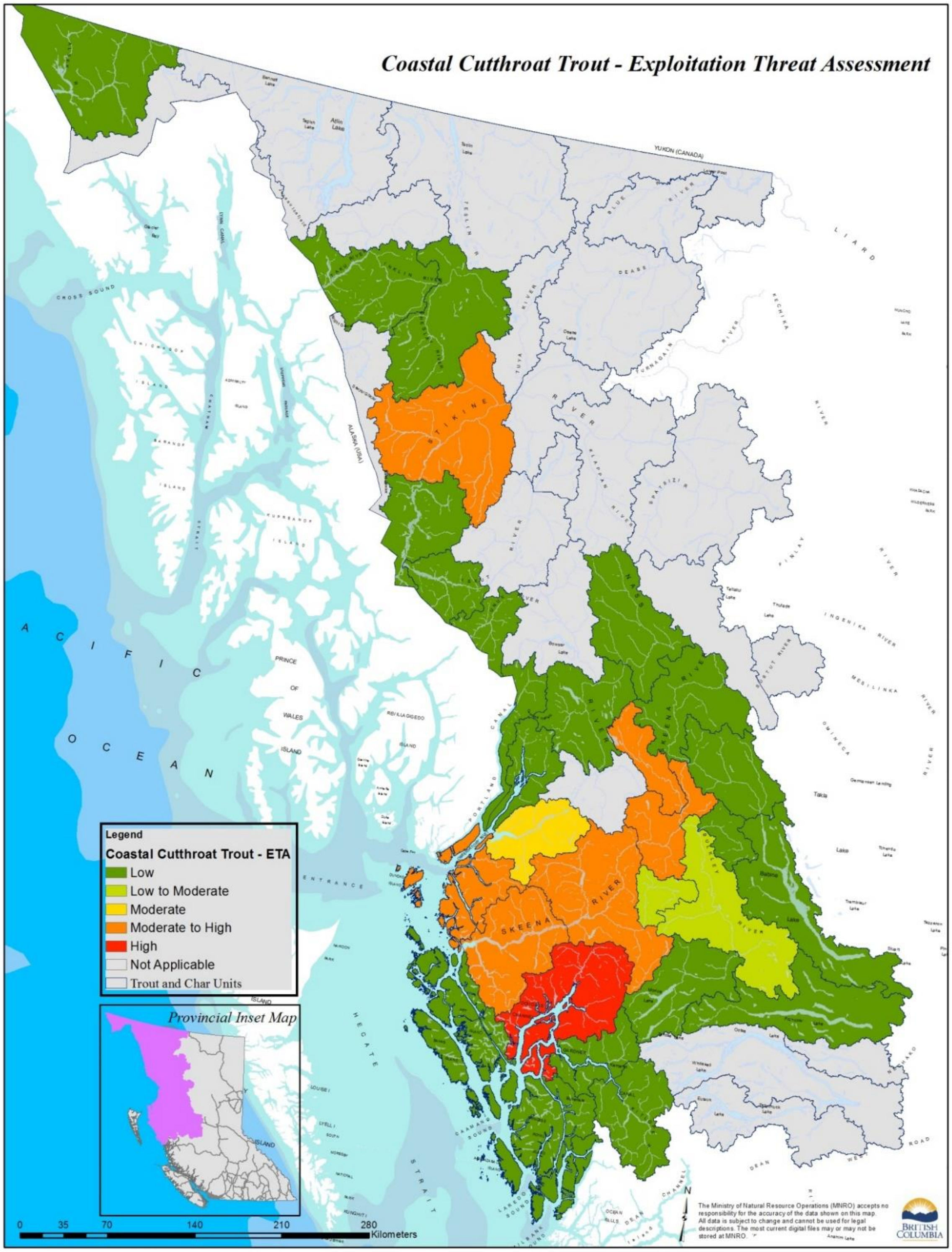

Figure 9. Exploitation threats estimates, in five categories of increasing risk, for 32 TCUs of the Skeena Region (see Figure 2 for TCUs) in which Coastal Cutthroat Trout are present.

3.4.4 Risk assessment

For Coastal Cutthroat Trout, conservation status and risk rankings (C-Ranks; USFWS 2005), computed from the numerical scores associated with codes for *Distribution*, *Abundance*, *Trend*, *Habitat Threats*, and *Exploitation Threats* (see Section *2.3.1*), were *C1-High Risk* for no TCUs, *C2-At Risk* for 1 TCU (3%), *C3-Potential Risk* for 18 TCUs (56%), *C4-Low Risk* for 11 TCUs (34%), and *CU-unranked* for 2 TCUs (6%; Table 9, Figure 10).

Under the current regional regulation of 1 trout per day >30 in streams (July 1-October 31), Coastal Cutthroat Trout populations in the Kitimat TCU were ranked *C2-At Risk* in our analysis (Table 9, Figure 10). The Kitimat River watershed is a well-documented core of the distribution in the TCU for multiple Coastal Cutthroat Trout life histories, including the regionally-significant anadromous population (Vogt *in prep*.). While elevated habitat threats and anecdotal suggestions of declining abundance in the Kitimat watershed were significant factors affecting the risk assessment ranking, the most important factor was the estimated level of exploitation threats, which were higher than for any other TCU (Table 9, Figure 9). Elevated exploitation threats were a function of: 1) no winter angling closure during a vulnerable period of aggregation, 2) high angling effort throughout the year, and especially during the fall coho fishery when cutthroat are vulnerable, and 3) the use of bait during the fall, winter and spring fisheries.[29]

The majority of Skeena Region TCUs were ranked *C3-Potential Risk* with respect to their Coastal Cutthroat Trout populations. Within this risk category, elevated habitat threats and/or limited distribution were generally the most important factors in TCUs of the interior Skeena and Nass watersheds, where Coastal Cutthroat Trout are not highly vulnerable to overexploitation (Table 9). In most coastal TCUs and interior Skeena River TCUs in which Coastal Cutthroat Trout have higher vulnerability, exploitation threats were either an important (in combination with habitat threats for interior watersheds) or the most important driver of the risk ranking. While the potential for legal harvest was a factor in situations of elevated exploitation risk, an exacerbating factor in some TCUs was the presence of sport and First Nations fisheries targeting salmon, in which the use of bait is permitted.

It is encouraging that under the current regional harvest regulation a significant number of TCUs were ranked *C4-Low Risk* with respect to their Coastal Cutthroat Trout populations. With the exception of the pristine Upper Nass TCU, *Low Risk* TCUs were all located on the coast away from human population centers and the transportation corridors traversing the lower Kitimat, lower Nass, and lower/middle Skeena watersheds.

[29] Bait use is currently allowed Sept 1–May 15. Winter conditions in the Kitimat have been quite variable in recent years with mild years enabling year-round angling with bait (during the 0/day harvest quota period). Kitimat River Coastal Cutthroat Trout have a similar adult freshwater life history to summer steelhead. For the latter, fishing closures and bait restrictions on most summer steelhead populations/watersheds apply. Without a move towards regulation parity with summer steelhead populations, significant negative consequences to the Kitimat population may be likely.

Table 9. Categorical estimates for conservation status and risk indicators for Coastal Cutthroat Trout within 32 Skeena Region Trout and Char Units, resulting cumulative numeric scores, and associated conservation status and risk assessments (C-Ranks; see Section *2.3.1*).

Trout-Char Unit	Distribution	Population size	Trend	Exploitation threats	Habitat threats	*Numeric score*	C-rank for occurrence
Babine Lake	D	U	U	FG	BD	3.19	C3-Potential Risk
Babine River	C	U	U	G	BD	3.13	C3-Potential Risk
Banks-Pitt	D	U	U	G	G	4.00	C4-Low Risk
Bulkley	E	U	U	E	AC	3.13	C3-Potential Risk
Francois-Endako	B	U	U	G	AC	2.75	C3-Potential Risk
Kemano	C	U	U	G	BDEF	3.25	C3-Potential Risk
Kispiox	D	U	U	BD	BD	2.75	C3-Potential Risk
Kitimat	D	D	D	AC	BDEF	2.25	***C2-At Risk***
Kitlope	CD	U	U	G	H	4.00	C4-Low Risk
Kitsault	U	U	U	EG	G	4.06	CU-Unranked
Lakelse-Kalum	E	DE	DE	BD	BD	2.75	C3-Potential Risk
Lower Iskut	C	U	U	EG	G	3.56	C4-Low Risk
Lower Nass	D	U	U	BDEF	BDEF	3.00	C3-Potential Risk
Lower Stikine	C	U	U	G	G	3.75	C4-Low Risk
Lower Taku	BC	U	U	G	H	3.75	C4-Low Risk
Middle Nass	B	U	U	G	BD	2.88	C3-Potential Risk
Middle Skeena	E	U	U	BD	AC	2.88	C3-Potential Risk
Morice River	CD	U	U	G	BD	3.25	C3-Potential Risk
Porcher-Pitt	C	U	U	G	G	3.75	C4-Low Risk
Portland	B	U	U	G	F	3.13	C3-Potential Risk
Princess Royal	C	U	U	G	G	3.75	C4-Low Risk
Skeena Coastal	D	U	U	BD	EF	3.00	C3-Potential Risk
Spiller-Mathieson	C	U	U	G	G	3.75	C4-Low Risk
Suskwa	C	U	U	G	AC	3.00	C3-Potential Risk
Tahltan	C	U	U	BD	G	3.13	C3-Potential Risk
Taku Upper	C	U	U	H	G	3.88	C4-Low Risk
Tatshenshini-Alsek	U	U	U	G	G	4.25	CU-Unranked
Tsimshian Penninsula	D	U	U	BD	F	3.00	C3-Potential Risk
Unuk	C	U	U	G	G	3.75	C4-Low Risk
Upper Nass	B	U	U	G	H	3.63	C4-Low Risk
Upper Skeena	B	U	U	G	EG	3.31	C3-Potential Risk
Upper Zymoetz	D	U	U	F	BD	3.00	C3-Potential Risk

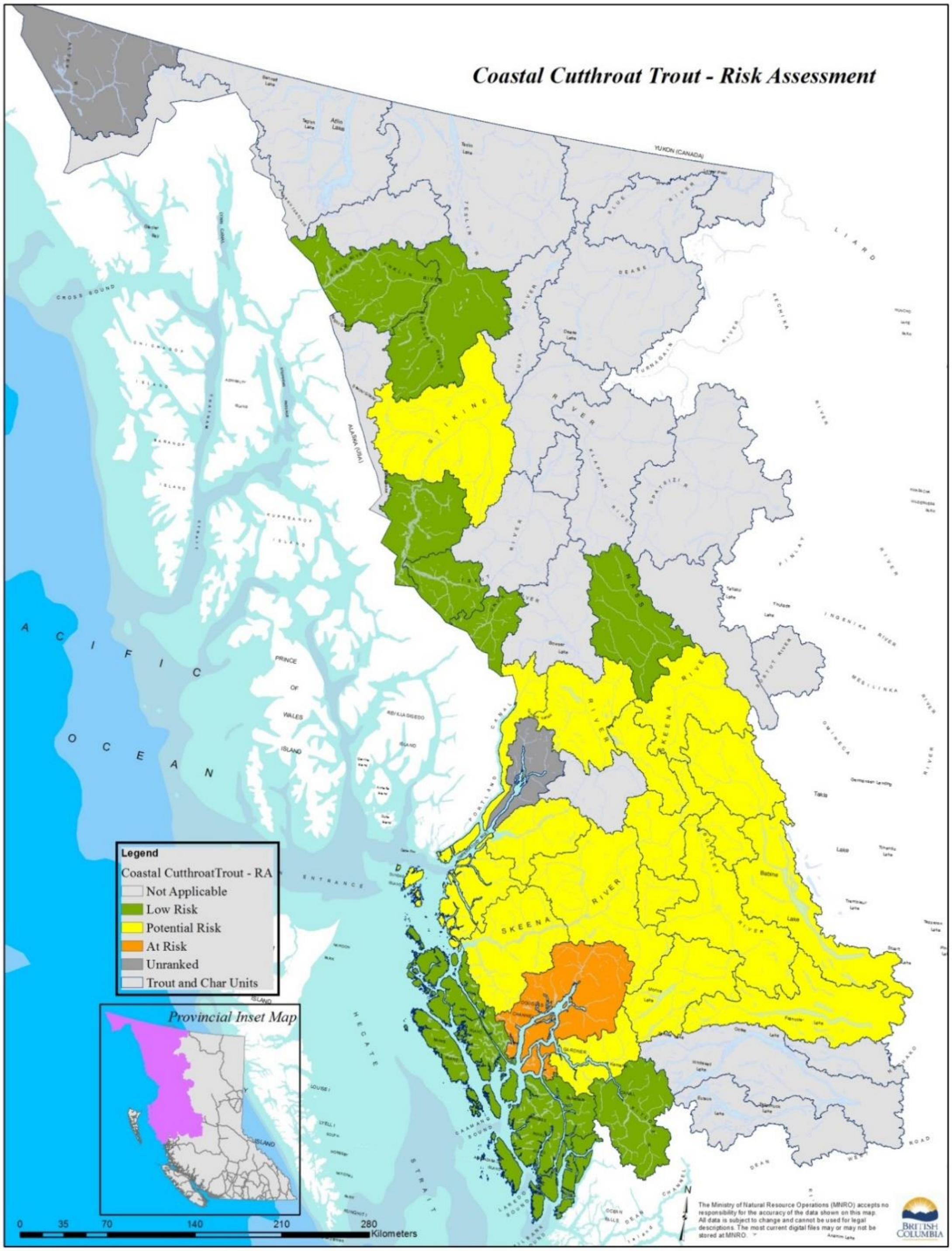

Figure 10. Conservation status and risk assessment rankings for 32 TCUs of the Skeena Region (see Figure 2 for TCU identification) in which Coastal Cutthroat Trout are present.

3.5 Rainbow Trout

For Rainbow Trout, categorical estimates for conservation status indicators *Distribution*, *Abundance*, *Trend*, and *Threats* in TCUs of Skeena Region are described in sections *3.5.1* to *3.5.4* below, and are tabulated together in one location at the end of Section *3.5* (Table 10).

3.5.1 Distribution

Rainbow Trout are widely distributed in Skeena Region, and are absent or have a negligible distribution in only 7 far-northern TCUs (Atlin-Tagish, Lower Dease, Northern Transboundary, Teslin, Tuya, Upper Dease). Records identified within the BCGW as Rainbow Trout indicate the species' presence in the remaining 45 Skeena Region TCUs (Table 10). Populations of the species are also widely distributed within TCUs. Rainbow Trout judged to utilize less than 4 linear km of habitat in no TCUs, to utilize 4-40 km of habitat in 3 TCUs, to utilize 40-200 km in 22 TCUs, to utilize >200 km in 19 TCUs (Table 10), and to have an unknown distribution in 1 TCU (Tatshenshini-Alsek). These distribution estimates were boosted by one category for virtually all TCUs (Table 10) to account for potential anadromy or significant adfluvial populations (assuming a lower level of risk following risk assessment protocol; see Table 3). As previously mentioned, distribution estimates are likely to be underestimates related to low sampling effort in many TCUs, especially in remote or pristine TCUs with low levels of industrial activity or fishery management activities requiring inventory or assessment.

3.5.2 Abundance and Trend

As described in Section *2.1*, we treated Rainbow Trout in TCUs with anadromous steelhead populations as a special case in our analysis. In these circumstances, we assumed that partial anadromy, which refers to a situation of life history polymorphism in which a single gene pool exhibits both anadromous and non-anadromous forms (Jonsson and Jonsson 1993), was the norm. Because demographic and genetic support between fluvial and anadromous forms is likely, we included steelhead population data, where it was known to us, in our estimates of abundance and trend.

Total abundance was categorically estimated for five Skeena Region TCUs (Upper Sustut, Babine Lake, Kitimat, Bulkley, Francois-Endako), and considered uknown in the remainder. Total abundance of mature individuals was estimated to be 250-1,000 for the Upper Sustut TCU, 1,000± in the Babine Lake TCU, and >2,500 in the Kitimat, Bulkley, and Francois-Endako TCUs.

Trend in Rainbow Trout abundance was estimated for 3 Skeena Region TCUs, and considered 'stable' (Category E) in the Bulkley, Francois-Endako, and Upper Sustut TCUs (Table 10). In the Bulkley and Upper Sustut TCUs, steelhead abundance is monitored annually by MFLNRO utilizing mark-recapture and fence counts, respectively (MFLNRO Skeena Region, data on file), while in the Francois-Endako TCU abundance is monitored via annual snorkeling surveys on the Stellako River (MFLNRO Omineca Region, data on file).

Additional Rainbow Trout population data are available in the form of incidental captures or observations at salmon counting facilities, and may potentially be important sources of trend information. As mentioned previously for the other trout and char species, these data are in the process of being requested and compiled by MFLNRO.

3.5.3 Exploitation threats summary

Potential exploitation threats to Rainbow Trout populations ranged widely in Skeena Region TCUs, under current regional angling regulations for trout in streams (1 per day between July 1 and October 31, with a minimum size limit of 30 cm), from 'low severity, low scope' (Category *G*) to 'moderate-to-high severity, high scope' (Category *AC*; Table 10). In order of increasing conservation concern:

1. Low: 28 TCUs (62%) were categorically estimated to have low severity exploitation threats for a low proportion of the population(s) or area (Category *G*: Banks-Pitt, Cheslatta, Eutsuk, Francois-Endako, Iskut Lakes, Kemano, Kispiox, Kitlope, Kitsault, Klappan, Lower Iskut, Lower Stikine, Lower Taku, Ootsa, Porcher-Pitt, Portland, Princess Royal, Spiller-Mathieson, Stikine Canyon, Suskwa, Taku Upper, Tatshenshini-Alsek, Unuk, Upper Iskut, Upper Nass, Upper Skeena, Upper Sustut, Upper Zymoetz; Figure 11, Table 10).

2. Low-to-moderate: 4 TCUs (9%) were estimated to have low severity exploitation threats for a moderate-to-high proportion of the TCU (Category *F*: Babine River, Upper Skeena Headwaters, Upper Stikine; Figure 11, Table 10), low-to-moderate severity exploitation threats for a low-to-moderate proportion of the TCU (Category *EF*: Lower Nass), or moderate-to-high severity exploitation threats for a low proportion of the population(s) or area (Category *E*: no TCUs).

3. Moderate: 5 TCUs (11%) were estimated to have low-to-moderate severity exploitation threats for a moderate proportion of the TCU, or moderate-to-high severity threats for a low-to-moderate proportion of the TCU (Category *BDEF*: Bell-Irving, Lakelse-Kalum, Middle Nass, Nakina, Tahltan; Figure 11, Table 10).

4. Moderate-to-high: 7 TCUs (16%) were estimated to have moderate-to-severe exploitation threats for a moderate proportion of the population(s) or area (Category *BD*: Bulkley, Babine Lake, Cranberry-Kiteen, Middle Skeena, Morice River, Skeena Coastal, Tsimshian Penninsula; Figure 11, Table 10).

5. High: 1 TCU (2%) was estimated to have moderate-to-severe exploitation threats for a high proportion of the population(s) or area (Category *AC*: Kitimat; Figure 11, Table 10).

A relatively large percentage of Skeena Region TCUs were estimated to have relatively low exploitation threats (71% in categories *G*, *F*, and *EF* above). A factor in many of these estimates was the complicating presence of sympatric anadromous populations in many TCUs. In many

TCUs in which the anadromous life history form is dominant, discrete, vulnerable (>30 cm) populations of fluvial rainbow trout were unknown to us or have not been recorded. In these TCUs, fluvial RB may be residualized steelhead forming a stable proportion of the anadromous population (which is protected by the Provincial non-retention regulation for steelhead[30]), and the exploitation threat estimate would reflect the exploitation threat to steelhead (e.g. many coastal TCUs). Other factors influencing estimates of low exploitation risk were more familiar: 1) inaccessibility, 2) low levels of angler effort and targeting, and 3) life histories (e.g. significant adfluvial component, combined with spring closures in spawning streams) reducing vulnerability.

In TCUs in which Rainbow Trout are subject to elevated overexploitation threats (29% in categories *AC*, *BD*, and *BDEF* above), several factors were in play: 1) targeting of discrete populations of large-bodied fluvial trout (e.g. Babine Lake, Morice River), 2) evidence of vulnerable populations of fish >30 cm (e.g. Kloya River within Tsimshian Penninsula TCU), 3) accessibility (e.g. Kitimat, Bulkley TCUs) and 4) the presence of high-use fisheries targeting salmon or steelhead, in which angler effort is high and the use of bait may also permitted (e.g. Lakelse-Kalum, Skeena Coastal, Tahltan TCUs).

Habitat threats (Section *3.1*: Table 6, Figure 3), also exhibit a broad range from 'negligible' to 'moderate-to-severe, high scope' in TCUs utilized by Rainbow Trout (Table 9), which is unsurprising given the broad distribution of the species in Skeena Region. Exploitation threats follow the spatial pattern exhibited by habitat threats only in inaccessible TCUs away from population centers and transportation corridors (Figure 11, Table 10), similar to the other trout and char species. In the TCUs where habitat threats were estimated more severe, which generally lie within the southern portion of the region in relatively close proximity to human population centers and major transportation corridors, the complex factors affecting Rainbow Trout exploitation threats estimates, as described above, broke up the correlation with habitat threats (Table 10).

[30] Unless they are between 30-50 cm from July 1-October 31.

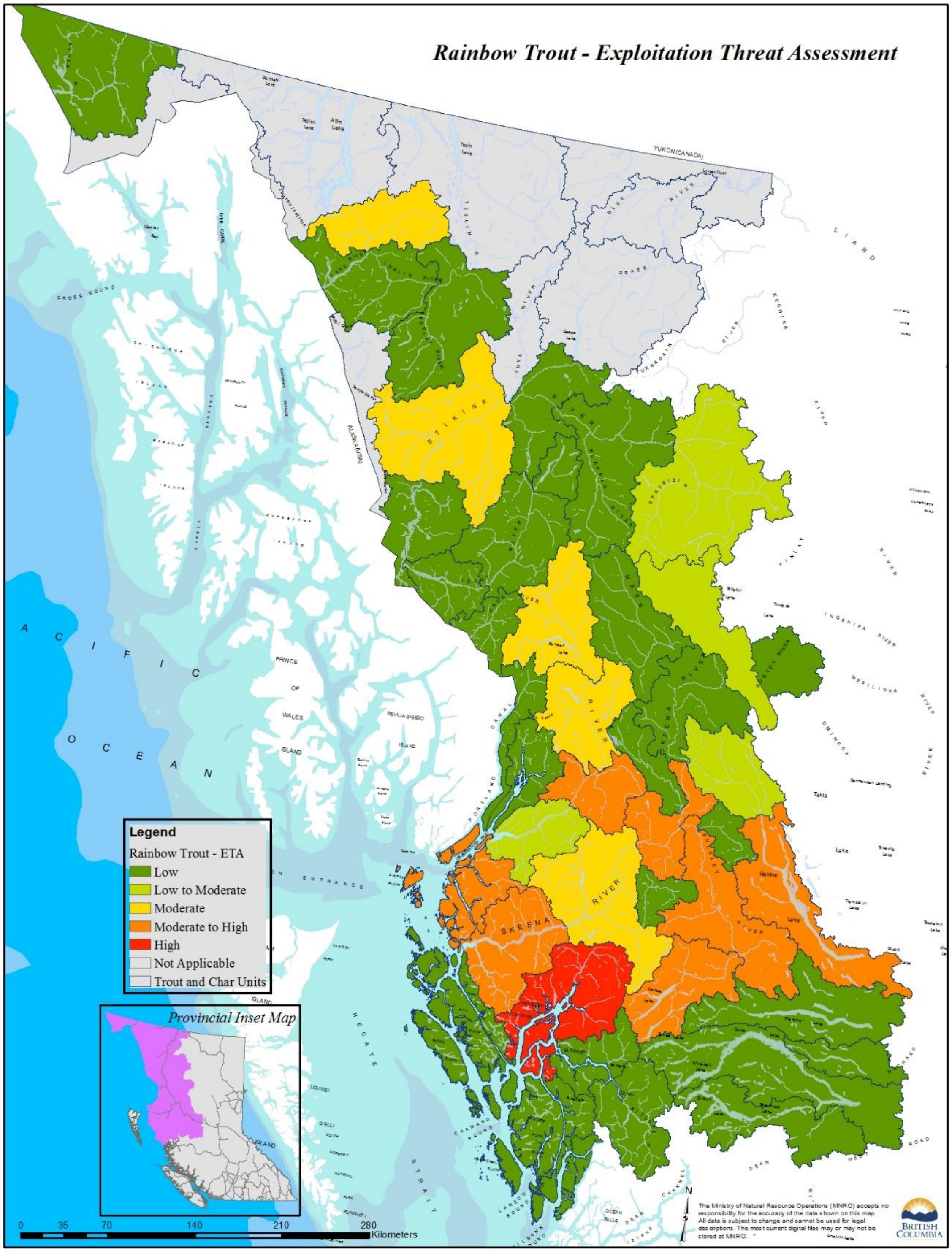

Figure 11. Exploitation threats estimates, in five categories of increasing risk, for 45 TCUs of the Skeena Region (see Figure 2 for TCUs) in which Rainbow Trout are present.

3.5.4 Risk assessment

Conservation status and risk rankings (C-Ranks; USFWS 2005) for Rainbow Trout, computed from the numerical scores associated with codes for *Distribution*, *Abundance*, *Trend*, *Habitat Threats*, and *Exploitation Threats* (see Section *2.3.1*), were *C1-High Risk* for no TCUs, *C2-At Risk* for no TCUs, *C3-Potential Risk* for 26 TCUs (56%), *C4-Low Risk* for 18 TCUs (34%), and *CU-unranked* for 1 TCU (Tatshenshini-Alsek) (Table 10, Figure 12).

For Rainbow Trout, the *C3-Potential Risk* ranking applies to the majority of Skeena Region TCUs. Within this risk category, the order of importance for factors driving the ranking was: 1) habitat threats, 2) habitat threats in concert with exploitation threats, 3) exploitation threats, and 4) limited distribution. Generally speaking, all TCUs in accessible portions of the Skeena, Nass, Kitimat, and Nechako watersheds received a *Potential Risk* ranking (Table 10, Figure 12). While the spatial patterns of habitat threats and exploitation threats were not identical (see section *3.5.3*), elevated levels of either one or the other, or both, were the main reasons for the rankings in these TCUs. However, a number of relatively inaccessible or northern TCUs also received a *Potential Risk* ranking because of localized exploitation threats (e.g. Tahltan) or limited distributions (e.g. Upper Stikine).

Low Rainbow Trout exploitation threats, or the combination of low exploitation threats and low habitat threats, were the key drivers of *C4-Low Risk* rankings, similar to other Skeena Region trout and char species. *Low Risk* TCUs for Rainbow Trout were all located away from human population centers and transportation corridors, i.e., in the northern portion of the region, in inaccessible portions of the Nechako River watershed, and on the coast outside of the lower Nass, lower Skeena, and Kitimat watersheds.

Table 10. Categorical estimates for conservation status and risk indicators for Rainbow Trout within 45 Skeena Region Trout and Char Units, resulting cumulative numeric scores, and associated conservation status and risk assessments (C-Ranks; see Section *2.3.1*).

Trout-Char Unit	Distribution	Population size	Trend	Exploitation threats	Habitat threats	*Numeric score*	C-rank for occurrence
Babine Lake	E	CD	U	BD	BD	2.63	C3-Potential Risk
Babine River	E	U	U	F	BD	3.25	C3-Potential Risk
Banks-Pitt	C	U	U	G	G	3.75	C4-Low Risk
Bell-Irving	DE	U	U	BDEF	E	3.25	C3-Potential Risk
Bulkley	E	E	E	BD	AC	2.88	C3-Potential Risk
Cheslatta	D	U	U	G	AC	3.25	C3-Potential Risk
Cranberry-Kiteen	DE	U	U	BD	BD	2.88	C3-Potential Risk
Eutsuk	E	U	U	G	BDEF	3.75	C4-Low Risk
Francois-Endako	E	E	E	G	AC	3.50	C3-Potential Risk
Iskut Lakes	D	U	U	G	F	3.63	C4-Low Risk
Kemano	D	U	U	G	BDEF	3.50	C3-Potential Risk
Kispiox	D	U	U	G	BD	3.38	C3-Potential Risk
Kitimat	D	E	U	AC	BDEF	2.75	C3-Potential Risk
Kitlope	D	U	U	G	H	4.13	C4-Low Risk
Kitsault	D	U	U	G	G	4.00	C4-Low Risk
Klappan	CD	U	U	G	G	3.88	C4-Low Risk
Lakelse-Kalum	E	U	U	BDEF	BD	3.13	C3-Potential Risk
Lower Iskut	D	U	U	G	G	4.00	C4-Low Risk
Lower Nass	DE	U	U	EF	BDEF	3.25	C3-Potential Risk
Lower Stikine	D	U	U	G	G	4.00	C4-Low Risk
Lower Taku	D	U	U	G	H	4.13	C4-Low Risk
Middle Nass	E	U	U	BDEF	BD	3.13	C3-Potential Risk
Middle Skeena	E	U	U	BD	AC	2.88	C3-Potential Risk
Morice River	E	U	U	BD	BD	3.00	C3-Potential Risk
Nakina	D	U	U	BDEF	G	3.50	C3-Potential Risk
Ootsa	E	U	U	G	BD	3.63	C4-Low Risk
Porcher-Pitt	CD	U	U	G	G	3.88	C4-Low Risk
Portland	D	U	U	G	F	3.63	C4-Low Risk
Princess Royal	D	U	U	G	G	4.00	C4-Low Risk

Table 10, continued.

Trout-Char Unit	Distribution	Population size	Trend	Exploitation threats	Habitat threats	*Numeric score*	C-rank for occurrence
Skeena Coastal	E	U	U	BD	EF	3.25	C3-Potential Risk
Spiller-Mathieson	D	U	U	G	G	4.00	C4-Low Risk
Stikine Canyon	C	U	U	G	EF	3.38	C3-Potential Risk
Suskwa	D	U	U	G	AC	3.25	C3-Potential Risk
Tahltan	D	U	U	BDEF	G	3.50	C3-Potential Risk
Taku Upper	DE	U	U	G	G	4.13	C4-Low Risk
Tatshenshini-Alsek	U	U	U	G	G	4.25	CU-Unranked
Tsimshian Penninsula	E	U	U	BD	F	3.25	C3-Potential Risk
Unuk	C	U	U	G	G	3.75	C4-Low Risk
Upper Iskut	C	U	U	G	F	3.38	C3-Potential Risk
Upper Nass	DE	U	U	G	H	4.25	C4-Low Risk
Upper Skeena	D	U	U	G	EG	3.81	C4-Low Risk
Upper Skeena Headwaters	E	U	U	F	EF	3.50	C3-Potential Risk
Upper Stikine	C	U	U	F	G	3.38	C3-Potential Risk
Upper Sustut	E	C	E	G	E	3.38	C3-Potential Risk
Upper Zymoetz	D	U	U	G	BD	3.38	C3-Potential Risk

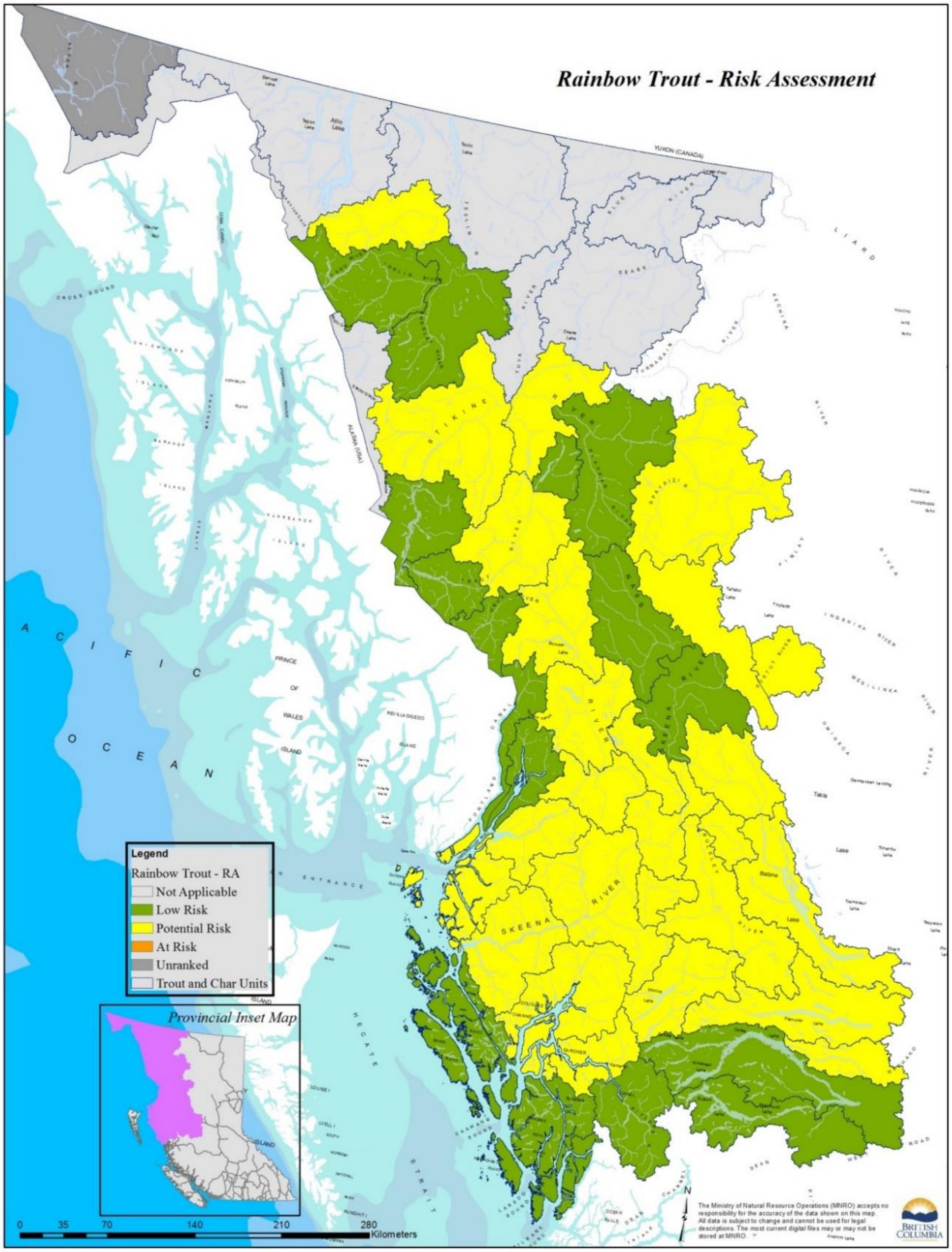

Figure 12. Conservation status and risk assessment rankings for 45 TCUs of the Skeena Region (see Figure 2 for TCU identification) in which Rainbow Trout are present.

4.0 RECOMMENDATIONS TOWARDS A MANAGEMENT FRAMEWORK

4.1 Overview

In this report, we use the term ‘management framework’ to mean a conceptual structure intended to serve as a support or guide for management. Key components of a management framework for stream-dwelling trout and char populations in the Skeena Region include:

1. Goals and objectives compatible with Provincial Fisheries Program Goals (MOE 2007), and with the Precautionary Principle.
2. Recommendations for an appropriate spatial scale(s) for management.
3. A mechanism for assessing conservation status and risk.
4. Guidelines for fisheries management.
5. A set of recommended actions for managing trout and char in streams, and for addressing information gaps.

Some of these potential management framework components are addressed in part already, through our selection of a methodology for assessing conservation status and risk, and applying it at the scale of TCUs. The results of the risk assessment have further implications for a potential management framework, however, and these are discussed in the following sections.

4.2 Goals and objectives for managing trout and char in streams

Provincial Fisheries Program Goals (MOE 2007) and the Precautionary Principle (reviewed in Hilborn et al. 2001) have been described in detail in preceding pages (Section *1.0*). Briefly, Fisheries Program Goals are for conservation and sustainable use, along with science-based management and effective cooperation with stakeholders and First Nations, while the Precautionary Principle implies that when scientific confidence is lacking decisions should be sufficiently risk averse to avoid serious or irreversible harm.

With respect to the management of stream-dwelling trout and char populations in the Skeena Region, the guidance provided by Fisheries Program Goals and the Precautionary Principle can perhaps be summarized in a single goal statement:

<u>Goal</u>: *Long-term maintenance of trout and char species within their current distributions in the Skeena Region, at abundance levels capable of providing sustainable recreational opportunities.*

We recommend the following specific objectives to support this goal:

1. Maintain the current distributions and population structure of stream-dwelling trout and char species within the region.
2. Maintain or increase the abundance of stream-dwelling trout and char within the Skeena Region.

3. Maintain or restore the productive capacity of critical habitats of stream-dwelling trout and char species within the region.
4. Maintain or increase quality angling opportunities for stream-dwelling trout and char within the Skeena Region, including harvest, where these opportunities are estimated to be sustainable.
5. Improve the scientific basis for assessing the sustainability of recreational angling opportunities within the region.
6. Where a monitoring framework is not in place to assess progress towards the preceding objectives, maintain a risk-averse approach to fishery and land use decisions.

These objectives are compatible with objectives outlined in the Draft Provincial Bull Trout Management Plan (Pollard et al. 2015). Provincial management plans for Dolly Varden, Coastal Cutthroat Trout, and Rainbow Trout have not been completed by the Province. In future, when these management plans emerge, the Skeena Region objectives for managing stream-dwelling trout and char should be updated to ensure their compatibility.

4.3 Spatial scales for fisheries management

Currently, recreational fishing opportunities for populations of stream-dwelling trout and char are managed at three widely-divergent scales in the fishing regulations synopsis: 1) general regulations applied at the provincial scale, 2) regional regulations applied at the scale of entire management regions, and 3) water-specific regulations, which have the potential to be applied at the scale of local populations. The results of this risk assessment suggest that fisheries management at a scale intermediate between the scales of the entire region and the local population may also be required, in order to achieve the goals of conservation and quality angling opportunities.

For each species of stream-dwelling trout and char, our analysis indicated significant variation in risk within the Skeena Region. The most obvious pattern was the general association of elevated levels of risk, across all four species, in areas close to human population centers or transportation corridors. Therefore, the Skeena Region should probably be broken into two or more management zones for application of angling regulations. Precise boundaries for these zones are not recommended here, but could be based on the spatial patterns of risk presented in this report (Figures 3-12 of Section *3*).

Protective regulations should also reflect the landscape scale at which fish populations complete their life cycle, and at which important recruitment processes occur (Fausch et al. 2002; Neville et al. 2006). Therefore, we also recommend that the system of Trout and Char Units (TCUs), developed for this analysis,[31] also be retained as a spatial scale for management. This is because the TCU represents our best estimate of the scale at which movements are likely to occur, as well as important demographic and genetic processes that increase the long-term

[31] as an approximation of the scale at which putative metapopulation dynamics occur (section *2.2*).

viability of populations. Groups of TCUs and their boundaries can potentially be utilized to delineate management zones as described in the preceding paragraph. The system of TCUs is also of importance because it is the spatial scale for applying the Core Area Conservation Status and Risk Assessment Methodology (Section *2.3*). TCU boundaries should not be considered fixed, and should be updated as new evidence becomes available for delineating population structure.

Circumstances of exceptional exploitation threats, which are operating at smaller scales than TCUs (e.g. vulnerable aggregations), are known throughout the Skeena Region. Water-specific regulations are the key tool for managing the risk of overexploitation at this scale.

4.4 Conservation status and risk assessment methodologies

The risk assessment mechanism utilized in this study, and the reasons for its selection, have been described in a previous section (Section *2.3*). Our application of the Core Area Conservation Status and Risk Assessment Methodology (USFWS 2005) to TCUs of the Skeena Region has confirmed three key attributes of the methodology. The first is its flexibility to accommodate population data and threats information in both standard (i.e. quantitative population data) and non-standard forms (e.g. non-quantitative methods for estimating exploitation threats). The second is its efficiency, permitting a relatively systematic and comprehensive coverage for a large area of the province in a single assessment. This efficiency should be increased still further in future years, because the TCU spatial layer for the GIS will already have been developed, and methods for estimating habitat and exploitation threats need not be developed from scratch. Consequently, reassessments of conservation status and risk in TCUs of the Skeena Region can reasonably be conducted at 5-year or longer intervals without an unreasonable expenditure of effort, especially if reassessments are focused on TCUs where changes are likely to have occurred. The third key attribute of the methodology was that it necessitated a comprehensive review of available knowledge, thus improving the basis for developing future monitoring and management plans for the Skeena Region.

There are, however, a number of important limitations that apply to the output of the risk assessment methodology. First, it is highly uncertain whether the system of TCUs provides a reliable proxy for the metapopulation structure, outside of areas where this structure is defined by genetic and/or movement data (e.g. Morice River TCU; Bahr 2002) or obvious barriers to gene flow (e.g. Iskut Lakes TCU). Fortunately, the acquisition of movement and population structure data is becoming more efficient (e.g. otolith microchemistry: Clarke et al. 2005; molecular genetics: Costello et al. 2003), and the TCU can be updated as new information emerges. The second and perhaps most serious limitation to the risk assessments was a general absence of quantitative abundance data for stream-dwelling trout and char populations. For example, small population size is a significant indicator of compromised population viability, yet total population sizes for trout and char were unknown in the large majority of TCUs. If adult population size is frequently small among TCUs, then missing abundance data would have the effect of underestimating risk. A third key limitation of the methodology is that it has not been sufficiently evaluated against real or simulated population and habitat data for British Columbia trout and char populations. Therefore, it is not clear whether they accurately represent the probability of serious or irreversible harm to a TCU population over the longer term.[32]

On the whole, we consider the Core Area Conservation Status and Risk Assessment Methodology (USFWS 2005) to be valuable for providing a relative indication of risk across the landscape, especially at large spatial scales such as management regions. In envisioning a potential management framework for stream-dwelling trout and char, we recommend that the methodology be utilized as a tool for assessing the appropriateness of regional regulations in the Skeena Region, and for delineating distinct management zones when necessary. However, we also recognize that greater accuracy will be required from estimates of risk in some cases. Such instances may be of significant conservation concern (e.g. *High Risk* and *At Risk* rankings), for example, or the societal cost of mitigating the identified risk factor(s) may be high (e.g. closure of a valued or economically important fishery). In these situations, we recommend that assessments and decisions be based on more quantitative information. We consider population viability estimates based on quantitative population data (e.g. Staples et al. 2005) to be a potentially suitable approach.

4.5 Fisheries management

Precautionary fishery management framework. Fisheries and Oceans Canada has developed a fishery management framework incorporating the Precautionary Approach (available at: http://www.dfo-mpo.gc.ca/fm-gp/peches-fisheries/fish-ren-peche/sff-cpd/precaution-eng.htm), which incorporates the following components:

1. Two biologically-derived reference points delineating three stock status zones. The *Limit Reference Point* (LRP) forms the boundary between *Critical* and *Cautious* zones, while the *Upper Stock Reference* (USR) forms the boundary between the *Cautious* and *Healthy* zones.
2. A harvest strategy and decision rules associated with these stock status zones.
3. Recognition of the need to take uncertainty into account when developing reference points and implementing decision rules.

Within this precautionary fishery management framework, if adapted for stream-dwelling trout and char of the Skeena Region as we recommend, the risk assessment rankings *C1-High Risk* to *C4-Low Risk* are well suited for delineating LRP and USR reference points signaling the need for management changes.

[32] In the one instance known to us in which a *C1-High Risk* ranking for a southern British Columbia Bull Trout Core Area was evaluated in a more quantitative manner, however, using time series of adult and juvenile abundance data and an evaluation of limiting factors, the accuracy of the ranking was confirmed and a recovery plan recommended (Hagen and Nellestijn 2015).

Reference points and stock status zones. In order for the management framework to be sufficiently risk-averse, given significant uncertainty in the assessed levels of conservation status and risk, we recommend that the two risk assessment rankings of highest concern, *C1-High Risk* and *C2-At Risk*, be included in the *Critical* zone. The *C3-Potential Risk* ranking would correspond with the *Cautious* zone, while the *Healthy* zone would correspond to the *C4-Low Risk* ranking. Accordingly, the LRP would be the boundary between *C2-At Risk* and *C3-Potential Risk* rankings, while the USR would be the boundary between *C3-Potential Risk* and *C4-Low Risk* rankings. We recommend that this conceptual framework be utilized in a consistent manner for all four stream-dwelling trout and char populations in the Skeena Region.

Harvest strategy. While stock status zones would be defined in a similar manner across species, we do not recommend the same harvest decision rules for all four species. This is because of a general recognition across the range of Bull Trout that this species in particular is highly vulnerable to overexploitation under liberal harvest regulations, as evidenced primarily by positive trends in depressed stocks following the introduction of catch-and-release or other restrictions (High et al. 2008; Johnston et al. 2007; Hagen and Decker 2011).

Dolly Varden are the only one of the four species for which the dominant risk assessment ranking among TCUs was *C4-Low Risk* under the existing regional regulation (non-retention for char in streams). Outside of the Lakelse-Kalum, Lower Nass, Lower Stikine, Skeena Coastal, and Lower Taku TCUs, where overlap between Bull Trout and migratory Dolly Varden may lead to elevated exploitation threats for the former, an opportunity for harvest of Dolly Varden should probably be provided similar to Coastal Cutthroat Trout and Rainbow Trout. Such an opportunity may have at least as high a likelihood of being sustainable, and would also serve to reduce the shifting of effort towards trout populations where a 1-per-day harvest is currently allowed under regional regulations. Therefore, we recommend the grouping of Coastal Cutthroat Trout, Rainbow Trout, and Dolly Varden in one category for harvest decision rules, and Bull Trout in a second. The Lakelse-Kalum, Lower Nass, Lower Stikine, Skeena Coastal, and Lower Taku TCUs should be classified as ‘Bull Trout-designated,’ and harvest quotas for char greater than 30 cm should be those appropriate for Bull Trout.

Decision rules for Coastal Cutthroat Trout, Rainbow Trout, Dolly Varden. For trout and Dolly Varden (outside of Bull Trout-designated TCUs), potential harvest regulations corresponding to *Critical*, *Cautious*, and *Healthy* stock status zones are as follows:

Critical (*C1-High Risk* and *C2-At Risk*): Harvest should not be permitted for the *Critical* status zone, and additional measures to reduce fishing mortality from catch-and-release angling may also be warranted. Such measures include: 1) bait ban, 2) hook size restrictions, 3) seasonal closures to protect vulnerable aggregations, and, as a last resort for regionally significant populations, 4) total fishery closure. If catch-and-release mortality is expected to be high, and mitigating measures are not implemented, a plan for assessing population viability based on quantitative population data should be implemented. Measures to protect, restore, or enhance critical habitats would also be warranted, although these fall outside the scope of the regulations synopsis.

Cautious (*C3-Potential Risk*): The current regional quota for trout (1 per day between July1 and October 31) should be conditionally applied in this zone of stock status for trout, and also for Dolly Varden populations outside of the Lakelse-Kalum, Lower Nass, Lower Stikine, Lower Taku, and Skeena Coastal TCUs (where Bull Trout regulations would apply to all fluvial char). Local populations exposed to high exploitation threats, within areas which are otherwise ranked *C3-Potential Risk*, should be protected with water-specific non-retention regulations, and additional measures to reduce catch-and-release mortality (see preceding paragraph) if warranted. The sustainability of recreational angling for trout and Dolly Varden in areas of *Cautious* management status can be improved through the use of minimum size limits. A minimum size limit which is greater than the expected size of first maturity may guard against recruitment overfishing, where recruitment is affected because too few mature adults persist in the population, yet still allow for harvest of a large fish 'trophy' (Wright 1992; Post et al. 2003). For example, a minimum size limit of 35 cm has been previously recommended for Coastal Cutthroat Trout in Washington State, in order to protect female trout until they have spawned for the first time (Wright 1992). A higher minimum size limit than the current regional regulation (30 cm) may be warranted to protect female trout and Dolly Varden prior to their first spawning.

Healthy (*C4-Low Risk*): For fluvial trout and Dolly Varden of the Skeena Region, *C4-Low Risk* rankings are associated with low angling effort. Under conditions of low effort, a relatively broad range of harvest regulations may be sustainable. It is only in the *Healthy* stock status zone that the pre-2013 regional quota of 2 per day should be considered. Alternatively, a 1-per-day quota would be consistent with regulations in *Cautious* areas, and provide a consistent picture across the region (with the exception of *Critical* areas). Similar to the *Cautious* status zone, a precautionary step to increase the sustainability of recreational fishing in *Healthy* TCUs would be minimum size limits which protect females spawning for the first time.

Decision rules for Bull Trout. Our recommendations for harvest regulations for Bull Trout (and Dolly Varden in Bull Trout-designated TCUs) are more conservative than those for trout and Dolly Varden:

Critical (*C1-High Risk* and *C2-At Risk*): Harvest should not be permitted for this status zone, and additional measures to reduce fishing mortality from catch-and-release angling should also be implemented where possible. Similar to the situation for trout and Dolly Varden, these measures include: 1) bait ban, 2) hook size restrictions, 3) seasonal closures to protect vulnerable aggregations, and, as a last resort for regionally significant populations, 4) total fishery closure. Measures to protect, restore, or enhance critical habitats would also be warranted. Population monitoring is strongly recommended within TCUs of this status zone in order to assess population viability, and to assess the effectiveness of protective regulations or habitat restoration at enabling population recovery.

Cautious (_C3-Potential Risk_): The current regional quota for Bull Trout (non-retention in streams) is rcommended for this status zone. The regional non-retention regulation is a potentially powerful tool for maintaining or improving the conservation status of Bull Trout in Skeena Region TCUs (Johnston et al. 2007; High et al. 2008; Hagen and Decker 2011). However, in certain high-use fisheries for salmon where the use of bait is permitted, additional measures to reduce Bull Trout catch-and-release mortality (bait ban, hook size restrictions) may also be required. Consequently, tracking of Bull Trout abundance in representative TCUs where bait is permitted should be included within a long-term Bull Trout monitoring framework.

Healthy (_C4-Low Risk_): In our assessment, *C4-Low Risk* rankings for Bull Trout are associated with low angling effort. As mentioned previously, a relatively broad range of harvest regulations may be sustainable under conditions of low effort (Post et al. 2003). In this stock status zone, a regional quota of 1 Bull Trout per day should be considered. Similar to recommended harvest regulations for trout and Dolly Varden, a recommended precautionary regulation to increase the sustainability of recreational fishing in *Healthy* TCUs would be minimum size limits which protect Bull Trout females spawning for the first time. This would help to address concerns about uncertainty in this risk assessment ranking, and the lack of monitoring potential in remote TCUs away from human population centers and transportation corridors.

4.6 Recommended actions

It is our hope that, as a result of this risk assessment, the basis for setting fishing regulations for stream-dwelling trout and char has improved. We remain concerned, however, that the base of population data for Bull Trout, Dolly Varden, Coastal Cutthroat Trout, and Rainbow Trout in the Skeena Region is extremely limited. We recommend the following five actions to increase the availability of population data, and to facilitate its use in future fishery and habitat management.

1. Monitoring plans for stream-dwelling trout and char. The development of a monitoring plan(s) would help to prioritize among potential studies designed to support the management of stream-dwelling trout and char. Among the four species covered in this assessment, Bull Trout and Coastal Cutthroat Trout should be prioritized for monitoring plan development because of their status as species of special concern in Skeena Region. As mentioned, one component of the recommended monitoring plan is already underway: compilation and synthesis of abundance data collected at counting fences in the Skeena Region, to improve the basis of population data for future risk assessments.

We recommend that the highest priorities for population monitoring studies be populations in TCUs ranked *C2-At Risk* (*Critical* status zone), which are the Bull Trout of the Bulkley and Morice TCUs, and the Coastal Cutthroat Trout of the Kitimat TCU. Existing studies of the distribution of critical habitats in all three TCUs (e.g. Morice: Bahr 2002; Bustard and Schell 2002; Kitimat: Vogt *in prep.*; Bulkley: Bustard 1998 and additional data on file) can aid in the design of population monitoring programs. Of highest priority are study methodologies for estimating the abundance of mature individuals, because these estimates integrate the effects of mortality factors operating across the life cycle, and because they facilitate the risk assessment methodology (and other potential methodologies). Monitoring studies have already been initiated for Bull Trout of the Morice TCU, where adult abundance, monitored using a redd count methodology, was resumed in 2014 following a 13-year hiatus.

Uncertainty about a key potential mortality factor, elevated catch-and-release mortality resulting from the use of bait, should also influence the design of a monitoring plan. For one or more TCUs where this potential threat exists, monitoring of a representative population(s) is recommended to track population viability.

Populations in TCUs ranked *C4-Low Risk* (*Healthy* status zone) may be difficult or expensive to study (due to locations away from human population centers and transportation corridors), but monitoring in representative locations may also be of value for reference purposes, and to identify potential issues related to the harvest of Bull Trout.

Studies of the genetic population structure for each species should also be included within the monitoring plan, so that TCUs can be refined over time into more accurate conservation units. Opportunistic collection of tissue samples (e.g. fin clips for genetic analysis, otoliths for microchemistry analysis) could be begin as soon as a location is identified (and responsible staff) for archiving samples and maintaining sampling data.

2. Studies of size-at-maturity. In this report, minimum size limits have been recommended as a potentially valuable tool for reducing the risk of recruitment overfishing, and increasing the sustainability of harvest fisheries. Studies of size-at-maturity for Bull Trout, migratory Dolly Varden, and fluvial Coastal Cutthroat Trout and Rainbow Trout should also be undertaken. Some of the necessary data will be present in existing reports, but additional work may be required in order to recommend suitable minimum size limits applicable at relatively broad scales (i.e. regional regulations).

3. A timeline for reassessing conservation status and risk. Risk assessments should be periodically done in future to identify potential changes in conservation status, and to incorporate new information into the file(s) warehousing background information and comments related to populations in each TCU. As a starting point, we recommend that information be updated and trends in population data be analyzed every 5 years. If the reassessment utilizes a similar methodology and format, this can be done in a relatively efficient manner. The review and/or incorporation of new methodologies for estimating conservation status, risk, and threats (e.g. models of fishing sustainability) will be important as these are developed, and may increase the time budget required for 5-year reviews.

4. Incorporation of models of recreational fishing sustainability into risk assessments. Because angling exploitation is a key factor affecting population viability, and is a variable which MFLNRO has substantial control over, it is highly desirable that the repeatability and accuracy of angling exploitation threats estimates be improved. For most TCUs, exploitation threats indicators *Vulnerability*, *Effort*, and *Mortality Rate* suffer from a lack of supporting data. Furthermore, a quantitative model for estimating the cumulative effects of these and other factors on angling sustainability has not been fit to Skeena Region biological or fishery data. The recreational fishery sustainability model of Post et al. (2003) is a potential tool for estimating exploitation threats in a more quantitative manner, and a Bull Trout Management Model is also being developed by the Government of British Columbia (Pollard et al. 2015). The application of these models, to simulated or estimated Skeena Region population data, may potentially provide important guidance for decision makers seeking to optimize recreational fishing opportunities while ensuring conservation.

The outputs of recreational fishery models may not be a significant improvement over the categorical estimates of exploitation threats presented in this report, if both approaches utilize the same subjective guesses about stock productivity, vulnerability, effort, and fishing mortality. In order to have confidence in the predicted effects of exploitation threats (i.e., to increase their applicability in the region), Skeena Region-specific field studies of model parameters may be required (e.g. stock productivity, growth rate, age-at-maturity, catch-and-release mortality).

5. Protection and restoration of critical habitat. Our assessment of potential habitat threats, based on the estimated levels of cumulative effects indicators *Road Density*, *Road Density near Streams*, and *Stream Crossing Density*, has indicated that aquatic habitat condition is likely to be an important factor affecting the long-term viability of stream-dwelling trout and char in parts of the Skeena Region. The Government of British Columbia has delineated tools for protecting critical habitats for stream-dwelling fishes (e.g. Wildlife Habitat Areas,[33] Fisheries Sensitive Watersheds), and described methodologies for locating and identifying potential habitat enhancements (Slaney and Zaldokas 1997). A key requirement for designing effective habitat conservation and enhancement actions is the identification of critical habitats limiting the trout or char population of concern. Fine-scale (i.e. within TCUs) studies of critical habitats, utilizing a synthesis of existing information and/or additional field studies (e.g. Hagen et al. 2015), may potentially be time-consuming and costly work. Therefore, initial efforts should be focused on hotspots of elevated conservation concern (e.g. *At Risk* populations of Bull Trout and Coastal

[33] For Bull Trout only, as the only fish species named as 'Idenfied Wildlife' within the Forest and Range Practices Act.

Cutthroat Trout, or *Potential Risk* populations for which elevated habitat threats are the most important factor driving the risk assessment ranking).

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***Appendix 1**. Skeena Regional Trout/Char Habitat Threats, GIS Assessment June, 2016.*

Indicator 1.0 - Road Density

Scientific Context

Roads and roaded areas are an anthropogenic fact of nature not only for travel from point A to point B but more extensively resource development and extraction. Road density has been widely researched in relation to impacts to natural areas and systems. Increasing road networks increases exposed surface materials to erosion while peak flows may be magnified as road density increases because roads act as surface drainage networks that increase runoff. During heavy precipitation or snow melting events, roads increase flow concentrations into streams. For example, ditches intercept sub-surface and surface flows, and roads reduce infiltration and transfer flows to the ditches, which then are rapidly transported to nearby stream channels. Road density can also influence low flow and water temperature by increasing surface runoff and modifying subsurface flows. Roads may also increase coarse and fine sediment delivery to streams depending on surficial geology and terrain stability. Currently there are several acceptable thresholds for density levels.

Indicator

- Total length of road (road density measured as kilometers of road per square kilometer) divided by the total watershed area (km/km2)

Thresholds

In BC the following thresholds have been described for road density analysis.

- Lower risk - density < 0.6 km/km2
- Moderate risk – density 0.6 – 1.2 km/km2
- Higher risk – density > 1.2 km/km2

Recent watershed analysis work in the Morice watershed (part of this study area) utilized the following thresholds based on the Federal Wild Salmon Policy:

- *Lower risk - density < 0.4 km/km2*
- *Moderate risk – density 0.4 – 1.2 km/km2*
- *Higher risk – density > 1.2 km/km2*

Data Sources

Roads:

- The author of this assessment created a regional road file for the specific purpose of this project. This file was based on and derived from exiting data sources managed by DataBC. Updates and accuracy were derived based on existing and available imagery across the region. Bing maps were the primary image service used for this process. It should be noted that approximately 80% of the region had sufficient imagery for this task while the remaining 20% had less than desirable imagery available. Roads within these areas have been coded as 'unconfirmed'.
- Mine access roads (within mine tenure areas) are not tracked in any known provincial databases. Imagery from Bing was integral to delineating these access areas.

Watersheds:

- Freshwater Atlas – Assessment watersheds. These have been delineated at the third order specifically designed for watershed type assessments. For further information of this data, see Carver and Gray 2010.

Reporting strata

- Trout-Char Assessment Units (coarse scale)
- Assessment scale watershed areas (3rd Order) as per the Freshwater Atlas.

Results

Analysis results for road density across the TCU's were initially derived at the watershed assessment unit (AU) scale. There is limited research and consensus on appropriate methods/metrics to 'roll-up' indictors assessed at the AU scale into some useful interpretation at the Trout-Char unit scale. Daust et. al. 2015 reported on an assortment of indictors for watershed assessment. Table 1 represents the matrix used for this project to 'roll-up assessment' results. Here only high and moderate AU's contribute to the 'roll up' as a proportion of the total number of units in each TCU. This matrix is applies to all indicators within this assessment.

Table 1.

	Risk-Extent Class				
	Very Limited	Limited	Moderate	Extensive	Very Extensive
% moderate or high risk	<10	10 - 33	33 - 67	67 - 90	> 90

Within the Skeena study area only 2 (Cheslatta and Francois-Endako) of the 53 TCU's had a risk-extent class rated as very extensive. Within the extensive category only 2 TCU's (Babine Lake, Bulkley) ended up within this category. Eight of the 53 TCU's resulted in a moderate risk-extent class with the remaining in the limited or very limited categories. It is also helpful to note that one TCU (Upper Nass) doesn't have any roaded development and the Kitlope has very minimal.

2.0 Road Density near Streams (< 100m)

Scientific Context

High road density in close proximity to streams may contribute significant amounts of sediment to streams, affecting water quality, stream bed morphology and biota. Erosion and transport processes depend on precipitation, soil texture, road construction and maintenance practices. The inverse also has merit in such that a single road into a watershed such as a mine access road (i.e. wildfire road into KSM) can have significant impacts when in proximity to waterways not effectively captured by a road density calculation.

Indicator

- Total length of roads within 60-100m of a stream, divided by the total watershed area (km/km2);

Data Sources

- Skeena Region roads
- North Area (Selection for Skeena Region) riparian management and reserve zone file.
  - A 100m buffer is applies to S2-S3 streams (60m reserve zone with 40m management zone).
  - A 60 m buffer is applied to S4 streams.

(i) This captures possible discrepancies in resolution of spatial data,
(ii) Rational is supported by literature on spatial extent of riparian buffer functions;
(iii) All AU streams are used for analysis, including intermittent and indefinite streams (for now).
(iv) S1 Rivers have been added into the riparian file with a 60m buffer either side of the river polygon.

- ***A known data limitation*** *is the spatial accuracy and accountability for S4*-S6 streams (especially S5 and S6). Therefore the may be high variability with respect to roaded areas and impacts to smaller waterways that have not been accurately spatially delineated in the AU database.

Reporting strata

- Trout-Char Assessment Units (coarse scale)
- Assessment scale watershed areas (3rd Order) as per the Freshwater Atlas.

Thresholds

- < 0.08 km/km2 (lower risk)
- 0.08 – 0.16 km/km2 (moderate risk)
- > 0.16 km/km2 (higher risk)

Results

As shown in table 3 (appendices) none of the 53 TCU's received a very extensive risk extent ranking. Again the Francois – Endako unit received the highest rank in the extensive category, followed by the Bulkley in the moderate category.
As noted in above, small streams are not captured in the riparian dataset as these have not been delineated in any comprehensive provincial data source.

3.0 Stream Crossing Density

Scientific Context

Stream crossings (i.e., roads, utility lines, other linear developments) represent a potential focal point for local sediment and intercepted flow delivery, as well as representing a potential physical impediment to connectivity of fish populations (aquatic ecosystem connectivity including **fish populations**). Connectivity is a crucial component to life-cycle stages of fish growth and development. A higher density of stream crossings in a watershed is generally indicative of greater risks of fine sediment inputs, although these risks will be dependent on the construction type (i.e., open box vs. closed box culverts), as well as the condition of stream crossing structures.

Indicator

- Total number of stream crossings divided by the total watershed area (#/km2)

Thresholds

Interior watersheds

- < 0.16/km2 - lower risk
- 0.16 - 0.32/km2 - moderate risk
- > 0.32/km2 - higher risk

Coastal watersheds

- < 0.40/km2 - lower risk

- 0.40 - 0.80/km2 - moderate risk
- > 0.80/km2 - higher risk

Recent work in the Morice watershed following the guidelines below;

- *Lower Risk - < 0.20 crossings/km2*
- *Moderate risk - >=0.20 to <0.58*
- *Higher Risk - >= 0.58*

Data Sources

- Skeena Regional roads;
- Road Stream Crossings (BC Culvert Assessment Project).
- Ecological Aquatic Units of BC (EAUBC) Ecoregions used for delineation of coastal vs interior areas
    - ***Data Assumptions:*** Coastal considered to be EAUBC FRESHWATER_ECOREGION = 'North Pacific Coastal'. All other areas in BC are considered to be Interior.

Reporting Strata

- Trout-Char Assessment Units
- Assessment scale watershed areas (3rd Order) as per the Freshwater Atlas.

Results

This indicator is highly variable in its interpretation. As noted above, the roads data layer used for this particular assessment was derived by the author of this report. The culvert (stream crossing) file produced for the province as described by Mount et.al. is based on existing road data sources managed by the province of BC. Since it is unfeasible to re-create the assessment of fish habitat inferences and observations as completed for the provincial assessment, the data point were used 'as-is' for this indicator. Due to the variable nature of the crossing itself, there is little opportunity to in-reality classify crossings as good, acceptable or poor. Extensive field verification would be required to increase the level of confidence in this indicator, in relation to deriving a more realistic interpretation for risk.
The operation and maintenance of roads is a complex beast especially when considering the number of unmanaged 'non-status' roads in the area. In this case the term 'non-status' is meant to convey that no entity or governing body has responsibility for operation or maintenance. Many of these may be classed as 'wilderness' roads with some level of deactivation, but achieving a level of accuracy to report on these classifications are beyond the scope of this project.

Appendices

Table 2. Road Density Assessment

Trout-Char Unit	Area (SqKm)	No. AUs	High AU's	Mod AU's	Low AU's	Nil AU's	TCU Risk Roll-up
Atlin-Tagish	11719.42	213	3	12	59	139	7.04
Teslin	13287.02	279			26	253	0.00
Lower Dease	4366.13	88			33	55	0.00
Upper Dease	10277.28	220	2	10	52	156	5.45
Nakina	4025.75	80			18	62	0.00
Tuya	3575.25	68			2	66	0.00
Tahltan	9435.36	195	1	2	37	155	1.54
Taku Interior	7187.21	151		1	13	137	0.66
Lower Taku	5444.79	104			7	97	0.00
Upper Liard	5892.46	129	1	6	42	80	5.43

Upper Stikine	10993.29	231		1	16	214	0.43
Lower Iskut	2424.68	48			9	39	0.00
Lower Stikine	4020.52	66			15	51	0.00
Klappan	7815.31	167		1	35	131	0.60
Stikine Canyon	4379.75	90		4	33	53	4.44
Iskut Lakes	1405.21	36		1	17	18	2.78
Upper Iskut	5585.57	120	1	5	36	78	5.00
Bell Irving	5332.73	102	4	8	34	56	11.76
Upper Nass	5327.35	108				108	0.00
Middle Nass	4574.67	93	11	26	30	26	39.78
Upper Sustut	2373.75	50			13	37	0.00
Upper Skeena Headwaters	5379.18	111	3	5	30	73	7.21
Babine River	3895.21	79	7	16	27	29	29.11
Babine Lake	6554.59	136	60	41	31	4	74.26
Unuk	1822.49	36			8	28	0.00
Portland	1790.37	39			22	17	0.00
Kitsault	2306.96	50			13	37	0.00
Cranberry - Kiteen	3060.42	68	12	18	19	19	44.12
Lower Nass	3187.29	60	6	5	32	17	18.33
Kispiox	2100.66	41	11	10	10	10	51.22
Middle Skeena	3112.10	69	21	19	19	10	57.97
Lakelse - Kalum	7386.68	160	28	32	57	43	37.50
Upper Zymoetz	1419.88	32	1	9	12	10	31.25
Skeena Coastal	5197.79	99		6	39	54	6.06
Suskwa	1337.53	32	5	11	13	3	50.00
Bulkley	6424.51	136	74	29	26	7	75.74
Morice River	4379.09	92	22	16	24	30	41.30
Cheslatta	2140.35	40	27	9	3	1	90.00
Ootsa	8870.79	185	60	30	42	53	48.65
Eutsuk	5199.72	105	8	10	20	67	17.14
Kitimat	6188.72	129	13	8	62	46	16.28
Kitlope	4062.87	89			3	86	0.00
Kemano	2444.49	53		5	17	31	9.43
Princess Royale	4434.48	102		1	21	80	0.98
Banks Pitt	3057.61	68			14	54	0.00
Porcher - Pitt	1964.14	43			18	25	0.00
Tsimshian Peninsula	3281.97	63	3	2	25	33	7.94
Francois - Endako	6574.73	136	110	18	7	1	94.12
Tatshenshini - Alsek	8016.35	125			20	105	0.00
Upper Skeena	4842.21	110		6	16	88	5.45
Northern Transboundary	6432.23	94		2	13	79	2.13
Spiller - Mathieson	824.53	16		1	3	12	6.25

Table 3. Riparian Road Density

Trout-Char Unit	Area (SqKm)	No. AUs	High AU's	Mod AU's	Low AU's	Nil AU's	TCU Risk Roll-up
Atlin-Tagish	11719.42	213	6	9	53	145	7.04
Teslin	13287.02	279		1	24	254	0.36
Lower Dease	4366.13	88	1	4	26	57	5.68
Upper Dease	10277.28	220	1	11	48	160	5.45
Nakina	4025.75	80		2	15	63	2.50
Tuya	3575.25	68			2	66	0.00
Tahltan	9435.36	195	1	3	33	158	2.05
Taku Interior	7187.21	151		1	12	138	0.66
Lower Taku	5444.79	104			5	99	0.00
Upper Liard	5892.46	129	2	3	37	87	3.88
Upper Stikine	10993.29	231		1	14	216	0.43
Lower Iskut	2424.68	48		1	7	40	2.08
Lower Stikine	4020.52	66			12	54	0.00
Klappan	7815.31	167			32	135	0.00
Stikine Canyon	4379.75	90		3	33	54	3.33
Iskut Lakes	1405.21	36			18	18	0.00
Upper Iskut	5585.57	120	1	5	33	81	5.00
Bell Irving	5332.73	102	3	4	37	58	6.86
Upper Nass	5327.35	108				108	0.00
Middle Nass	4574.67	93	6	22	35	30	30.11
Upper Sustut	2373.75	50			13	37	0.00
Upper Skeena Headwaters	5379.18	111	3	2	31	75	4.50
Babine River	3895.21	79		10	37	32	12.66
Babine Lake	6554.59	136	14	41	74	7	40.44
Unuk	1822.49	36			8	28	0.00
Portland	1790.37	39	1	6	15	17	17.95
Kitsault	2306.96	50		2	10	38	4.00
Cranberry - Kiteen	3060.42	68	1	11	36	20	17.65
Lower Nass	3187.29	60	3	7	31	19	16.67
Kispiox	2100.66	41	1	11	19	10	29.27
Middle Skeena	3112.10	69	7	16	35	11	33.33
Lakelse - Kalum	7386.68	160	22	35	58	45	35.63
Upper Zymoetz	1419.88	32	1	7	13	11	25.00
Skeena Coastal	5197.79	99	6	5	31	57	11.11
Suskwa	1337.53	32		7	21	4	21.88
Bulkley	6424.51	136	23	49	56	8	52.94
Morice River	4379.09	92	2	18	42	30	21.74
Cheslatta	2140.35	40	2	17	19	2	47.50

Ootsa	8870.79	185	16	32	79	58	25.95
Eutsuk	5199.72	105		1	33	71	0.95
Kitimat	6188.72	129	9	16	56	48	19.38
Kitlope	4062.87	89		2	1	86	2.25
Kemano	2444.49	53	2	8	10	33	18.87
Princess Royale	4434.48	102		2	17	83	1.96
Banks Pitt	3057.61	68			10	58	0.00
Porcher - Pitt	1964.14	43		1	17	25	2.33
Tsimshian Peninsula	3281.97	63	3	4	21	35	11.11
Francois - Endako	6574.73	136	44	60	30	2	76.47
Tatshenshini - Alsek	8016.35	125	1	1	17	106	1.60
Upper Skeena	4842.21	110		5	15	90	4.55
Northern Transboundary	6432.23	94		2	12	80	2.13
Spiller - Mathieson	824.53	16		1	3	12	6.25

Table 4. Stream Crossing (Culvert) Density

Trout-Char Unit	Area (SqKm)	No. AUs	High AU's	Mod AU's	Low AU's	Nil AU's	TCU Risk Roll-up
Atlin-Tagish	11719.42	213	25	14	28	146	18.31
Teslin	13287.02	279	3	12	9	255	5.38
Lower Dease	4366.13	88	5	8	16	59	14.77
Upper Dease	10277.28	220	18	15	26	161	15.00
Nakina	4025.75	80		2	5	73	2.50
Tuya	3575.25	68		1	1	66	1.47
Tahltan	9435.36	195	2	5	23	165	3.59
Taku Interior	7187.21	151		1	5	145	0.66
Lower Taku	5444.79	104			2	102	0.00
Upper Liard	5892.46	129	7	16	20	86	17.83
Upper Stikine	10993.29	231	1	3	10	217	1.73
Lower Iskut	2424.68	48				48	0.00
Lower Stikine	4020.52	66		1	1	64	1.52
Klappan	7815.31	167	7	11	20	129	10.78
Stikine Canyon	4379.75	90	11	9	15	55	22.22
Iskut Lakes	1405.21	36		3	15	18	8.33
Upper Iskut	5585.57	120	3	5	18	94	6.67
Bell Irving	5332.73	102	14	7	13	68	20.59
Upper Nass	5327.35	108		1	3	104	0.93
Middle Nass	4574.67	93	40	13	8	32	56.99
Upper Sustut	2373.75	50	6	5		39	22.00
Upper Skeena Headwaters	5379.18	111	13	8	10	80	18.92
Babine River	3895.21	79	29	12	5	33	51.90
Babine Lake	6554.59	136	91	24	13	8	84.56

Unuk	1822.49	36			2	34	0.00
Portland	1790.37	39	1	3	14	21	10.26
Kitsault	2306.96	50			11	39	0.00
Cranberry - Kiteen	3060.42	68	3	16	27	22	27.94
Lower Nass	3187.29	60	2	7	28	23	15.00
Kispiox	2100.66	41	25	1	4	11	63.41
Middle Skeena	3112.10	69	43	8	7	11	73.91
Lakelse - Kalum	7386.68	160	36	42	33	49	48.75
Upper Zymoetz	1419.88	32	6	5	8	13	34.38
Skeena Coastal	5197.79	99	4	16	20	59	20.20
Suskwa	1337.53	32	16	9	2	5	78.13
Bulkley	6424.51	136	110	5	14	7	84.56
Morice River	4379.09	92	41	12	7	32	57.61
Cheslatta	2140.35	40	30	6	2	2	90.00
Ootsa	8870.79	185	81	18	22	64	53.51
Eutsuk	5199.72	105	4	18	14	69	20.95
Kitimat	6188.72	129	19	23	36	51	32.56
Kitlope	4062.87	89	1	1		87	2.25
Kemano	2444.49	53	5	5	8	35	18.87
Princess Royale	4434.48	102	3	1	10	88	3.92
Banks Pitt	3057.61	68			8	60	0.00
Porcher - Pitt	1964.14	43	1	4	11	27	11.63
Tsimshian Peninsula	3281.97	63	4	3	20	36	11.11
Francois - Endako	6574.73	136	124	8	1	3	97.06
Tatshenshini - Alsek	8016.35	125	3	1	12	109	3.20
Upper Skeena	4842.21	110	7	7	11	85	12.73
Northern Transboundary	6432.23	94		3	11	80	3.19
Spiller - Mathieson	824.53	16		1	1	14	6.25

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