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Information in support of the identification of critical habitat for speckled dace (R*hinichthys osculus*)

Information à l'appui de la détermination de l'habitat essentiel du naseux moucheté (*Rhinichthys osculus*)

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ABSTRACT

Speckled dace (*Rhinichthys osculus*) is a small, riverine minnow belonging to the family Cyprinidae. Although common in Western North America where hundreds of populations of dace exist from Washington to northern Mexico, it is found in only one drainage in Canada, the Kettle River, and two of its tributaries; West Kettle and Granby Rivers. The Kettle River populations of speckled dace exist at the extreme northern extent of their North American range and it is considered a “peripheral species” that is isolated from the central population by a geographic barrier, Cascade Falls. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the species as endangered because of its limited range and area of occupancy, existence at only three locations, perceived sensitivity to threats and habitat loss, and lack of any potential for rescue. It was listed as endangered under the Species at Risk Act (SARA) in 2009. Field studies conducted after the COSEWIC assessment and following the SARA listing have greatly increased our estimate of speckled dace abundance, extended their range, and increased our knowledge of habitat utilization.

Speckled dace appear widely and somewhat evenly distributed throughout their range in Canada and suitable habitat is abundant. The entire width of the river is utilized although different life stages may occupy different components of the river channel. It does not appear that speckled dace in the Kettle River are threatened by a single “catastrophic event” that could drastically reduce or eliminate all three populations at the same time.

Reduced summer-autumn discharge is well recognized as a threat (COSEWIC 2006). Reduced discharge is due in part to the nature of the watershed, climatic change, and water withdrawals. This threat is somewhat mitigated by the species’ ability to survive and adapt to low flows and warm summer waters, as noted in the more southerly portion of its global range.

The proposed critical habitat depicts the length of river that will supply the amount of habitat necessary to maintain the population abundance required for the persistence of the species in each of the locations where it is presently found. If we accept that a population of 7,000 fish is the minimum population required for long-term persistence of the species and if we assume three fish/metre is a reasonable estimate of abundance; we arrive at 2.4 km of proposed critical habitat. This will be applied to each of the three upper locations to maintain three populations. The three sections of river we have proposed as critical habitat start at the uppermost site where speckled dace were captured during Batty’s distributional study (Batty 2010) and extend downstream for 2.4 km. This approach minimizes the threats of large water withdrawals (mainly for irrigation in the lower watershed) and riparian removal. It is also likely that larval dace produced at these locations will drift downstream and could potentially repopulate or supply genetic material to lower river sections in the event of a catastrophic or transient threat to lower reaches. However, it was not possible to locate all of the critical river sections upstream of *all* withdrawals or all cleared agricultural lands. It is important to conduct a detailed assessment within each of the proposed critical habitat sections to verify dace abundance and length of stream necessary for critical habitat.

RÉSUMÉ

Le naseux moucheté (*Rhinichthys osculus*) est un petit méné fluvial de la famille des cyprinidés. Bien qu'il soit répandu dans l'ouest de l'Amérique du Nord, où l'on dénombre des centaines de populations de l'État de Washington au Mexique, on ne le trouve que dans un seul bassin versant au Canada, celui de la rivière Kettle et de deux de ses affluents, la rivière Kettle Ouest et la rivière Granby. Les populations de naseux moucheté de la rivière Kettle se trouvent à l'extrême nord de leur aire de répartition nord-américaine et sont considérées comme des « espèces périphériques » isolées de la population centrale par une barrière géographique, les chutes Cascades. Le Comité sur la situation des espèces en péril au Canada (COSEPAC) a désigné l'espèce comme en voie de disparition en raison de son aire de répartition et d'occupation limitée, de sa présence dans seulement trois zones, de sa sensibilité aux menaces et aux pertes d'habitats et de l'absence de possibilité d’une immigration de source externe. L'espèce a été inscrite sur la Liste des espèces en péril en vertu de la *Loi sur les espèces en péril* (LEP) en 2009. Les études sur le terrain réalisées après l'évaluation du COSEPAC et l'inscription sur la LEP nous ont permis de nettement relever notre estimation de l'abondance des naseux mouchetés et de leur répartition, ainsi que de mieux connaître leur utilisation de l'habitat.

Le naseux moucheté est très répandu et occupe relativement uniformément ses aires de répartition canadiennes; les habitats convenables sont abondants. Il utilise toute la largeur de la rivière Kettle, mais occupe divers éléments de l'écosystème de la rivière selon les étapes de son cycle biologique. Il ne semble pas qu'un seul événement catastrophique pourrait réduire gravement le nombre de naseux mouchetés ou éliminer les trois populations en même temps dans la rivière Kettle et ses affluents.

On sait que la réduction du débit d'eau de la rivière Kettle en été et en automne est une menace (COSEPAC 2006). Elle est due en partie aux caractéristiques du bassin hydrographique, aux changements climatiques et aux extractions d'eau. Cette menace est quelque peu atténuée par la capacité de l'espèce à survivre et à s'adapter aux faibles débits d'eau et aux eaux chaudes estivales, comme on l'a constaté dans la partie sud de l'ensemble de son aire de répartition.

Les limites proposées de l'habitat essentiel correspondent à la longueur de la rivière offrant la quantité d'habitats nécessaires pour maintenir l'abondance des populations et assurer ainsi la survie de l'espèce dans chaque zone où elle est présente actuellement. Si nous acceptons qu'une population de 7 000 poissons est le nombre minimal de poissons requis pour assurer la persistance à long terme de l'espèce et si nous supposons que trois poissons par mètre est une estimation raisonnable de l'abondance, nous arrivons à un habitat essentiel proposé de 2,4 km. Ce calcul sera appliqué à chacune des trois passages supérieurs pour maintenir les trois populations. Les trois tronçons de la rivière que nous avons proposés comme habitat essentiel commencent dans la zone la plus en amont où des naseux mouchetés ont été capturés durant l'étude de répartition de Batty (Batty 2010) et s'étendent en aval sur 2,4 km. Cette approche réduit au minimum les menaces attribuables aux extractions d'eau importantes (principalement pour l'irrigation dans la partie inférieure du bassin hydrographique) et à l'enlèvement de la végétation riveraine. Il est aussi probable que les larves pondues dans ces trois zones dériveront en aval et pourront contribuer à repeupler ou à fournir du matériel génétique dans les tronçons du cours inférieur de la rivière en cas de catastrophe ou de déclin des populations. Toutefois, il n'a pas été possible de localiser tous les tronçons essentiels de la rivière en amont de *tous* les points d'extraction d'eau ou de toutes les terres agricoles déboisées. Il est primordial de mener une évaluation détaillée dans chaque tronçon d'habitat essentiel proposé pour vérifier l'abondance de naseux mouchetés et la longueur du cours d'eau nécessaire à leur habitat essentiel.

PREAMBLE

For aquatic species, 'habitat', is defined in section 2(1) of the Species at Risk Act (SARA) as: "…spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life process, or areas where aquatic species formerly occurred and have the potential to be reintroduced."

SARA recognizes a subset of habitat or 'critical habitat' that is the habitat necessary for the species survival and recovery. Every Recovery Strategy or Action Plan developed for a species listed under SARA as threatened, endangered or extirpated, must identify critical habitat to the extent possible, using best available information. Critical habitat (CH) is legally identified under SARA only when it is included in a Recovery Strategy or Action Plan document that is posted on the SARA public registry. Information to support the identification of critical habitat is delineated within this paper.

Critical Habitat is defined under SARA as:
"…the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species."

A key distinguishing characteristic is that critical habitat is the component of habitat 'necessary' for survival or recovery of the species. Consequently, habitat functions, habitat biophysical features and its attributes should be clearly delineated as integral components of critical habitat identification. Furthermore, the recovery goals and population objectives as indicated in the Recovery Potential Assessment (RPA) and other recovery documents are important factors in defining a species' critical habitat.

The geospatial and biophysical identification of CH is based on the best information available, bearing in mind that critical habitat identification is an iterative process that is complete when the quantity and quality of critical habitat identified is sufficient to achieve the population and distribution objectives stated in the recovery strategy for the species. When potential critical habitat is identified in the critical habitat paper, examples of activities likely to destroy this habitat should also be provided, as prescribed in SARA. The activities listed should be of human origin and are best delineated with a clear and logical effect pathway. If potential critical habitat cannot be clearly identified with the current best available knowledge, the studies required to obtain that knowledge should be identified.

INTRODUCTION

Over the last two decades, speckled dace (*Rhinichthys osculus*) has moved through the hierarchy of Canadian conservation listings. The process began in 1980, when the species was considered of special concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC); its status was changed to endangered in 2006 following re-evaluations in 2002 and 2006. A recovery potential assessment (RPA) for the species, which summarized the available scientific information related to its recovery potential, was completed in 2007, and the species was listed as endangered under the Species at Risk Act SARA in 2009.

Creation of a formal Recovery Strategy is a requirement for species listed as endangered under SARA, and a key component of any Recovery Strategy is a description, in as much detail as possible, of the species' critical habitat. The Act describes critical habitat as "habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in a recovery strategy or in an action plan for the species." More specifically, the Act goes on to define habitat for aquatic species, such as the speckled dace, as including "spawning grounds and nursery, rearing, food supply, migration, and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced." This definition clearly signals the dual importance of both physical and biological habitat features, as well as the option for identifying presently unoccupied habitat as critical for a species.

As Rosenfeld and Hatfield (2006) point out, critical habitat is not necessarily the same thing as "all habitat" for a species, because some habitats are more important for a species than others. In order to identify what's critical and what isn't, these authors suggest, that there exists a positive relationship between habitat and population size and that there is a certain minimum amount or area necessary to achieve a stated abundance recovery target (usually expressed as a certain number of breeding animals). The first of these core assumptions is another way of saying that habitat is a limiting factor, perhaps even the main such factor, in persistence or limitation of a population. For such species, identifying the habitats that are critical to the population becomes a process of arriving at a recovery target population size, defining the relationship between habitat and population size, and identifying enough habitat to meet the recovery target. Critical habitat should be identified for each life history stage, and is obviously dependent on the amount of scientific information available on the species' life history.

Persistence of speckled dace in Canada was considered to be habitat-limited by COSEWIC (2006). However, the main reasons for assessment as "endangered" included: restricted range in Canada, populations limited to three locations, no rescue potential from downstream due to Cascade Falls, and the projected increase in drought and water demands that could lead to a decline in habitat quality. In 2007, however, the RPA for speckled dace (Harvey 2007) noted significant knowledge gaps concerning life history and habitat use, but accepted a poorly substantiated abundance estimate of 11,000-23,000 fish. The RPA concluded that the main human-caused threat to the species was alteration in stream flow, to which this presumably flow-sensitive fish would be especially susceptible.

Subsequent to the COSEWIC assessment and RPA, several of the recommendations for further research made in the 2007 RPA were pursued. Field research by Batty in 2008, performed in the course of an M.Sc. program (Batty 2010), provided strong evidence for a Canadian population of close to 1 million mature adults (20-40 times the number suggested in the RPA), and a 2010 field study by Andrusak and Andrusak (2011), filled in many gaps concerning habitat use by mature and immature speckled dace.

Abundance of speckled dace appears to be robust, and the large population suggests that suitable habitat is abundant. While the post-2008 reports and data analysis have prompted suggestions that the status of speckled dace as an endangered species be re-evaluated and perhaps revised (Batty 2010), the present paper will concentrate on extracting from the more recent studies those key findings that can be used to examine the relationship between habitat and population size. Assuming such a relationship can be found, even if it remains qualitative, this may lead to the identification of specific areas of habitat that are critical for speckled dace. In the discussion that follows, our latest understanding of abundance, distribution and habitat use will be compared with what we knew in 2008 and subsequent identification of critical habitat will reflect not only those changes, but also any changes in human-induced threats that affect critical habitat.

The provision that "where a species' range has become drastically reduced, CH identification may also include areas of potential habitat that are not currently occupied" does not appear to apply to speckled dace.

BIOLOGY

Dace are minnows belonging to the Family Cyprinidae, Order Cypriniformes, which also includes chub, tench, carp, shiner, minnow and goldfish. The common name “dace” is used for several genera in Canada; they occur from Nova Scotia to B.C. Speckled dace is small (51-94 mm in length), with a prominent snout and a sub-terminal mouth. Speckled dace are members of the genus *Rhinichthys*, which occurs from Nova Scotia to Manitoba as blacknose dace *Rhinichthys atratulus*, from Labrador to B.C. as longnose dace *Rhinichthys cataractae*, and in the Columbia and Fraser River drainages in B.C. as leopard dace *Rhinichthys falcatus*.

There is one more member of the genus *Rhinichthys*, the Umatilla dace *Rhinichthys umatilla*. Its evolutionary origin is believed to be through hybridization between leopard and speckled dace. The Umatilla and speckled dace species coexist within a short section of the Canadian portion of the Columbia drainage (Kettle River below Cascade falls). However, differences in anatomy, especially mouth morphology, have led some authors to conclude that the two forms occupy different ecological niches and merit the distinction of separate species (Peden and Hughes 1988; A.E. Peden pers. comm. 2007). The limited number of genetic analyses of *Rhinichthys* species occupying the Columbia drainage has until recently been insufficient to resolve this taxonomic question (Haas 2001). Mitochondrial sequence data now indicates the Kettle River speckled dace above Cascade Falls have diverged from Snake River and lower Columbia dace populations (McPhail 2007). Mitochondrial DNA analyses of populations of speckled dace in Oregon did, however, identify significant genetic divergence between basins and recommended that the dace in these basins be regarded as evolutionary significant units (Pfrender et al. 2004). Similar evidence of genetic isolation in speckled dace was presented by Oakey et al. (2004) for 59 populations in the Colorado and Snake Rivers.

GENERAL LIFE HISTORY

Batty (2010) concluded that, based on otolith analysis, speckled dace is longer-lived than the four-year span previously accepted, although spawning, for most fish, is still believed to take place in their third summer (males) and fourth summer (females), beginning roughly in mid-July. The first observation of spawning in the wild, made in the course of the survey conducted by Andrusak and Andrusak (2011) and in more southern rivers (Mueller 1984) provides information on reproductive timing and habitat use, although lack of information on guarding of eggs and survival at the various life stages constitutes knowledge gaps that make it hard to comment on residence or estimate recruitment in the Kettle River.

Field studies on speckled dace in Canada, conducted since 2008, allow us to draw a clearer picture of its life history than was possible when the RPA was written in 2007. Based on new observations by Batty (2010) and Andrusak and Andrusak (2011), we can now confirm that, within its Canadian range, habitat preferences of speckled dace are life stage-specific and based on day and night-time snorkel surveys, appear to extend to deeper waters that had previously been difficult to sample using only backpack electrofishing. We now know more about movements of juveniles and adults between shallow and deeper water, including diurnal movements, their use or non-use of different-size substrates including woody debris, and even the potential for downstream autumn migration of adult fish in at least part of the species’ range. These and other observations on habitat use are discussed in more detail in Life History and Habitat Use, below.

The Canadian range of speckled dace above Cascade Falls is shared with other fish species including rainbow trout, westslope cutthroat trout, brown trout, brook trout, northern pikeminnow, redside shiner, largescale sucker, slimy sculpin, chiselmouth, chub and mountain whitefish. Its ecological interactions with these species are not well known, although dace may be assumed to be an important link in aquatic and terrestrial food chains, as food for larger fish and birds.

Although the bulk of the Kettle drainage lies at altitudes above the valley bottom and gets more precipitation, most of the speckled dace habitat is found in the valleys of the lower Kettle River and lower portion of the Kettle River tributaries, which flow through the interior dry belt (ponderosa pine, bunchgrass and Douglas Fir biogeoclimatic zones). This area is home to a number of SARA listed species, many of which utilize riparian habitat, especially cottonwood trees along the Kettle River. These include Lewis woodpecker (TH 2010; *Melanerpes lewis*), Western screech owl (EN 2001; *Megascops kennicottii macfarlanei*), Western skink (SC 2002; *Plestiodon skiltonianus*), Great Basin spadefoot (TH 2007; *Spea intermontana*), blotched tiger salamander (EN 2002, *Ambystoma mavoritum*), and American badger Jeffersonii subspecies (EN 2000; *Taxidea taxus jeffersonii*). Critical habitat has not been delineated (to date) for Lewis woodpecker.

FEEDING

Speckled dace are bottom feeders that eat filamentous algae and bottom dwelling aquatic insects (Peden and Hughes 1981; Wydoski and Whitney 2003). Adults consume mainly aquatic insects (Peden and Hughes 1981; McPhail 2007). Batty (2010) examined 36 Kettle River speckled dace stomachs. The greatest occurrence of insects by type was Ephemeroptera (nymph) 26/35, Trichoptera (larva) 22/36, and Chironomidae (larva) 25/36. Ephemeroptera and Chironomidae were the numerically dominant insect groups, representing 75% of the items recorded (Batty 2010). The high rate of algae occurrence (25/36 stomachs) in the stomachs of adult speckled dace from the Kettle River is of interest (Batty 2010).

The diet of juvenile speckled dace is similar to that of adults, but with a greater emphasis on algae and Chironomidae (McPhail 2007). Consumption of algae may continue throughout the life of speckled dace; very young aquarium-raised fry have been noted feeding exclusively on algae (Scharpf 2011). This implies that speckled dace are either directly consuming algae as part of their diet or foraging in habitats associated with algae throughout their lives.

Batty (2010) used stable isotope analysis in an attempt to identify the species' main source of dietary carbon and nitrogen but was unable to arrive at a definitive conclusion. However, at the Midway site, ^{13}C signatures were close to filamentous algal signatures, allowing Batty (2010) to state that "filamentous algae is likely an influential food in the diet of insects that speckled dace feed on."

RESIDENCE

Laboratory observations of Kaya (1991) and Haas (2001) indicate that the adhesive eggs of speckled dace adhere to the undersides of stones, but the spawning habitat actually used by the species in B.C. can only be inferred from these observations and those of the species in more southern parts of its range in Arizona and New Mexico (John 1963). Based on these studies, spawning probably occurs over clean gravel and may include preparation of a nest by males. If such site preparation occurs, it implies a residence requirement for the duration of spawning and perhaps during larval development as well. Since spawning in the Kettle system probably begins in July (Peden and Hughes 1981) and newly emerged fry appear in the river in early August, the period of residence is approximately one month. If residences do exist they would be extremely difficult to identify in a natural setting.

RANGE, DISTRIBUTION AND ABUNDANCE

GLOBAL RANGE

Speckled dace is common in the western United States; there are hundreds of populations of the species from Washington to northern Mexico. The species is confined in Canada to a short section of the Columbia drainage (Scott and Crossman 1973; Wooding 1994).

DISTRIBUTION AND ABUNDANCE WITHIN CANADA: KETTLE RIVER WATERSHED

In Canada, speckled dace exist at the extreme northern extent of its North American range. Reduced summer flow, due in part to the nature of the watershed, climatic change, and water withdrawals, is the main threat, but this threat is likely mitigated by the species' ability to survive and adapt to low flows and warm summer waters, as noted in the more southerly portion of its global range. In Canada the species is not only a "peripheral species" (Bunnell et al. 2004; Hutchings and Festa-Blanchet 2009) but also a disjunct one; isolated from the central population by a geographic barrier (in this case, Cascade Falls on the Kettle River). Its geographic range protrudes into Canada in one drainage; the Kettle-Granby River system in the west Kootenay area of southern B.C. The Kettle River drains 8,300 square km within B.C., flowing through an ecological transition zone between the Okanagan Valley and the Monashee Mountains (Figure 2).

The Kettle River flows south from its headwaters in the Monashee Mountains. It is a free flowing system with one small headwater lake (Keefer Lake). The river joins the West Kettle river at Westbridge, continues to Rock Creek then turns south-east to Midway where it joins Boundary Creek. The Kettle is a trans-boundary river flowing south into the United States at Midway. It re-enters Canada near Grand Forks where a major tributary, the Granby River, joins. The Kettle River eventually joins the Columbia River in Washington State. In this paper, we refer to the portion of the Kettle River upstream of its confluence with the West Kettle as the "East Kettle River." The more general term "Kettle system" includes the Kettle south of Westbridge, the East and West Kettle branches, and the Granby River.

Within this drainage, the vast majority of the Canadian population of speckled dace is geographically isolated upstream of Cascade Falls. The designation of Canadian speckled dace as endangered reflects this isolation: if the population above Cascade Falls were to become extinct through some catastrophic event, natural recolonization by other populations from below this 30-metre natural barrier would be impossible.

Within the Kettle-Granby system, speckled dace have been collected or observed at a number of sites that encompass approximately 300 km of river length (Triton 1994a; 1994b; Peden and Hughes 1984). Sites where speckled dace were collected between 1957 and 2002 have been summarized by Pollard (pers. comm. 2011). Most of the 93 recorded collections were by the Royal British Columbia Museum, with a limited number by researchers at the University of British Columbia; the most recent sample (2002) was incidental, in the course of in-stream flow studies conducted by the B.C. Ministry of Environment. Speckled dace have to date not been found in Boundary Creek, a tributary that flows adjacent to Greenwood into the Kettle River from the northwest.

The picture was significantly updated by Batty (2010), who derived his new abundance estimates by backpack electrofishing in 28 sites along the lower Kettle, West and East Kettle and Granby Rivers in 2008, and at a further 11 sites (which he termed "exploratory") in their headwaters. Batty (2010) was able to catch speckled dace further upstream than previously recorded in the Kettle and Granby Rivers; he feels they may extend even further north in the Kettle River. Thus, there is no evident of range contraction since the 2006 COSEWIC assessment. The fact that Batty (2010) found significant populations of adult fish in each of the three headwater segments of the Kettle River is a significant finding and suggests protection for the population from a single catastrophic event. Based on the 380 fish caught in all sites, the range of speckled dace in the Kettle, West and East Kettle and Granby Rivers in Canada totals 275 km of river upstream of Cascade Falls. Broken down by river reach, presence of speckled dace was: Mid and East Kettle 118 km, West Kettle 43 km, Lower Kettle 59 km, and Granby 55 km. The actual land area through which the three rivers flow is around 3,000 km^2.

The abundance estimate derived from electroshock sampling adjusted for capture efficiency, was 939,610 mature speckled dace. This number led Batty (2010) to describe the species as "widespread and locally abundant." On a linear basis, abundance was found to be highest in the West Kettle and lowest in the Granby. The average linear density was at least as high as that reported for Sagahen Creek in California, near the centre of the species' continental range. Batty (2010) interpreted this as evidence that the Canadian population is in relatively good health. Speckled dace, like many stream fishes, appear to vary in abundance at any given location with time of year and flow (A.E, Peden pers. comm. 2007, Minckley 1973).

It is important to note that Andrusak and Andrusak's (2011) studies were conducted at two sites in the watershed: the mainstream or lower Kettle River near Midway BC and the West Kettle River ~25 km upstream of the confluence with the Kettle River. Their study was therefore much more restricted geographically than Batty's (2010). Because a total of 2 km out of the approximately 275 km of available habitat were studied, some assumptions need to be made concerning the use of all potential habitat features. Pool habitat, for example, was the least-represented habitat type in the two study areas (pools are relatively rare in the Kettle), and the substrate was mostly the cobble and gravel expected in shallow, open channel areas.

LIFE HISTORY RELATED TO HABITAT USE

In describing the information requirements needed for assessing critical habitat in freshwater fish species, Rosenfeld and Hatfield (2006) noted that, for species whose different life history stages use different habitats, the process of identifying critical habitat must be performed for each life stage. Where there is a lack of knowledge regarding stage-specific survival or recruitment, and where a quantitative relationship between abundance and habitat cannot be demonstrated, defining critical habitat can only be done to the best extent possible; in the authors' own words, "few credible inferences can be made concerning critical habitat when there are significant gaps in understanding of an organism's basic life history."

Such gaps do exist for speckled dace, and will be noted below; fortunately, the post-RPA studies mean that defining speckled dace potential critical habitat "to the best extent possible" is easier now than in 2007. The following discussion summarizes what is currently known concerning habitat use by speckled dace in Canada, as life stage functions: spawning and nest-guarding, first feeding, young of the year feeding, juvenile feeding, adult feeding. The key habitat attributes for each life stage and activity are discussed separately in the next section, Important Habitat Attributes.

SPAWNING HABITAT

Spawning is believed to be triggered by some combination of increased photoperiod and rising water temperature (Kaya 1991). Andrusak and Andrusak (2011) relate filming a spawning event spawning late in July, and suggest that the relative lateness of this event, compared to times previously recorded in the literature, reflects local temperature fluctuations. Unfortunately, their report does not describe spawning habitat, where the event occurred (margin, mid-channel, riffle, pool?) or whether either sex had dug a nest or guarded the adhesive eggs, so we are left with the assumption that spawning habitat comprises clean gravel, of an appropriate substrate size, and water at an appropriate temperature. Thus appropriate attributes likely include; water temperature, flow, and substrate size.

FIRST FEEDING AND YOUNG OF THE YEAR HABITAT

While all studies on speckled dace in Canada, including the most recent ones, make a distinction between habitat preferences for "immature" and "mature" fish, none comment on habitats presumably used by feeding larvae and juveniles below the length range for juvenile fish (18-54 mm) established by Batty (2010). Both Batty (2010) and Andrusak and Andrusak (2011) adopt a size-related (as opposed to age-related) criterion for partitioning between juveniles and "mature" fish, so we are left with the uncertain assumption that speckled dace below 18 mm use the same poorly defined habitat as used for spawning. Important attributes for young fish likely include: water temperature, flow, and substrate size.

JUVENILE FEEDING HABITAT

Based on the 228 juvenile speckled dace captured or observed in 2010, Andrusak and Andrusak (2011) concluded that immature dace were more likely to be found associated with river margins, with no preference for woody debris. Juveniles (90%) were observed where water velocity was below 0.24 m/s, with a "velocity preference" of .01 m/s. They were found at depths of less than 0.4 m, and with a "depth preference" of .07 m. These immature dace used small gravel or cobble substrates, with low to moderate embeddedness. Electrofishing data suggested a preference for pool and run habitat, especially pool margins. Andrusak and Andrusak (2011) indicated there was uncertainty regarding seasonal shifts in habitat use by juveniles. Immature dace did shift from riffle to deeper run habitat in autumn. Overall, the picture presented by Andrusak and Andrusak (2011) and Batty (2010) is similar to that summarized in Harvey (2007). Likely habitat attributes are: water temperature, discharge, depth, and substrate embeddedness.

MATURE FEEDING HABITAT

Based on the 119 mature (55-90 mm) speckled dace captured or observed in 2010, Andrusak and Andrusak (2011) concluded that mature dace were less likely to be found associated with river margins, with no preference for woody debris or overhanging vegetative cover. Mature fish were most often observed where water velocity was between 0.18-.45 m/s, at depths between 0.2 and 0.5 m, and with a "depth preference" of 0.45 m. Mature dace used boulder or cobble substrates with low embeddedness. This implies a role of substrate in providing in-stream cover. Electrofishing data suggested a preference for run habitat, with some use of riffles. Andrusak and Andrusak (2011) indicated there was uncertainty regarding seasonal shifts in habit use as mature dace were not captured at the West Kettle sampling sites in autumn. This finding suggests a possible large-scale migration in the autumn and this possible movement should be further investigated (see Section 10 below). Likely habitat attributes include: water temperature, discharge, depth, and embeddendness.

Batty (2010) also provided data on habitat use. His data were not segregated by life stage and this makes direct comparison with Andrusak and Andrusak's (2011) findings difficult. Mean density contrasted greatly between shoreline areas ($0.146/m^2$) and channel ($0.016/m^2$), confirming that the species is more likely captured, at least in daytime, along the river margins. He concluded that the probability of finding a speckled dace in the Kettle River decreased with increasing depth and water velocity; anywhere in the channel, larger substrate meant a greater probability of finding speckled dace. The range of habitats where fish were found was fairly broad: at depths from .01-1.55 m, in water velocities between zero and 1.08 m/s, over substrates ranging from gravel to boulder and at temperatures between 12.7 and 22.6 C.

The habitat preferences reported by Batty (2010) and Andrusak and Andrusak (2011) are summarized in Tables 1 and 2. While Batty (2010) and Andrusak and Andrusak (2011) have helped refine our understanding of habitat use by speckled dace, like all new research they also raise new questions, and the fact that they treat life stages differently makes comparison difficult. There is also concern that our understanding of dace habitat gained through daytime backpack electrofishing alone is probably incomplete, especially for mature speckled dace. Electrofishing appears to be better suited to capturing individuals in shallow, slower moving edge waters, while snorkelling observations indicate that larger more mature dace use deep water habitat (Korman et al. 2004). These fish would be beyond the electrofishing range fished by Andrusak and Andrusak (2011).

Table 1: Habitat preferences from Andrusak and Andrusak (2011)

Life stage	Flow range	Flow pref	Depth range	Depth pref	Substrate	Habitat type	Notes
immature	Below 0.24 m/s	0.01 m/s	Below 0.4 m	0.07 m	Sm gravel, cobble	Pool, run, margins	Less riffle
Mature	0.18-0.45 m/s	0.06 m/s	0.2-0.5 m	0.45 m	Boulder, cobble	Run, some riffle	May migrate downstream May enter deeper water

Table 2: Habitat preferences from Batty (2010); juvenile and adult fish were not separated for summary.

Flow	Depth	Temperature	Notes
0-1.08 m/s	0.01-1.55 m	12.7-22.6 C	Prefer shallow and slow water; use margins and deeper channel.

HABITAT ATTRIBUTES

The East Kettle, West Kettle and Granby rivers are accessible, especially in the lower gradient, more southern portion, and more arid part of the Province of British Columbia. These areas have been affected by forestry, agriculture, and historic mining and salmonid habitat was considered “poor to fair” (Oliver 2002, cited in Andrusak and Andrusak 2011). Most of the river, apart from the occasional pool, is less than 0.5 m deep during the low flow season (Batty 2010, Figure 17).

The three rivers flow south, and lie between the Okanagan highlands and the Monashee Mountains. Narrow and cool where they arise in forested areas; the rivers widen, water velocity declines, gradient declines, and water temperature increases. Ranchland has replaced forest along many of the lands bordering the lower reaches.

WATER DEPTH

As has already been noted, there is limited pool habitat in the Kettle drainage, although Batty (2010) found the fish across a wide range of depths and as deep as 1.55 m. This is much greater than the “preferred depth” of 0.45 m identified by Andrusak and Andrusak (2011), who believe that preliminary snorkel surveys suggested we have not clearly measured the species’ abundance at greater depths. Water depth is directly related to discharge, identified by most authors as the major threat for fish species in this drainage. Nevertheless, actual isolation through dewatering seems not to have imperiled several populations in the southern part of its

American range (Oakey et al 2004), and may have led to evolution of distinct subpopulations (McPhail 2003).

WATER TEMPERATURE

Water temperature in the Kettle drainage is also discharge-related. As with depth, the range of temperatures at which speckled dace have been found in the area is quite broad, even during a single season of sampling. Daily maximum water temperatures in the lower reaches now routinely reach 24° C by mid-July (Andrusak 2009); in winter, they fall below 0° C as the river surface is frozen and anchor ice can form. The species itself is remarkably tolerant to increases in temperature. Harvey (2007) summarized reports from other parts of its range where maximum temperatures are higher than in B.C. and noted that the species can acclimate in the laboratory to a temperature of 31° C. While we must be careful not to read too much into these reports from another part of the range, speckled dace nevertheless appears to be able to cope with changes in water temperature and discharge which may well occur with climate warming.

Small increases in winter water temperature may also be a factor in the future fish diversity within the Kettle River system. Winter mean water temperature has increased in the southern B.C. mountains by 0.8°C during the last few decades and is predicted to increase by 2.0-7.0 °C in the next few centuries (Allen et al. 2004). Winter warming may reduce the impact and possibility of severe winter ice conditions, may increase growing season of juvenile dace, and may improve the competitive advantage to a species originating in a warmer region.

Fish kills have been reported in the Kettle River below Grand Forks and above Westbridge (Aqua Factor Consulting Inc 2004), although dace were not included among the fish species listed as killed. While high water temperatures associated with low discharge may be a contributing factor; these kills occurred in early summer when discharge was only slightly below threshold, but still well above the late summer – autumn low flows of drought years.

DISCHARGE

The wide range of velocities at which speckled dace was found by Batty (2010) and Andrusak and Andrusak (2011) indicates not only an adaptable species but also one for which flow preference clearly varies with life stage.

The Kettle River is a snowmelt-dominated river with 78% of the total annual discharge occurring between April and June (Maaciak et al 2007). Historically (before man-made effects on the river), velocity in the Kettle drainage varied with season and microhabitat.

Discharge is the most-studied variable and is of greatest concern for managers. The Ministry of Environment considers the Kettle system a priority system, in part due to critical summer low flows exacerbated by agricultural withdrawals and climate change. For reasons that will be discussed below (Description of Land and Water Uses), summer flow in the Kettle often falls below the value of 10% of mean annual discharge (MAD) that is recommended as the minimum value to preserve riffle width in streams (Ptolemy and Lewis 2002; Tennant 1976). For example, in 2003, an unusually dry year, discharge fell below 10% MAD for several months. Because the recent abundance estimate was the first time anyone had systematically sampled the watershed for speckled dace, we can’t say whether this drastic and prolonged period of low water had any effect on the population.

While a rule-of-thumb which suggests a 10% MAD standard to maintain width coverage in riffles in summer - autumn offers a guideline, it is still hard to quantify the expected harm at any level of low seasonal flow, another knowledge gap that will need to be filled if realistic discharge limits for dace are to be set. However discharge guidelines set for trout species should be adequate for dace.

The recent studies of Andrusak and Andrusak (2011) and Batty (2010) provide much more information than was available at the time of writing the RPA. Batty (2010) does note that his abundance sampling, which pointed to around a million mature fish in the system, came five years after the 2003 drought, which produced the lowest flows on record; in his view, speckled dace are either tolerant of drought, or “resilient” to it. Recent drought years have been 1987, and 2002-2004 (Aqua Factor Consulting 2004).

SUBSTRATE AND COVER

Substrate in the Kettle, West Kettle and Granby rivers gets generally smaller as gradient decreases, but it also varies within a given reach, and speckled dace appear to have age-dependent preferences (as noted above). Different sizes of substrate provide different levels of in-stream cover and sediment deposition can increase embeddedness, thus decreasing the utility of courser substrates as cover. It is not clear whether restoration measures aimed at salmonids are beneficial, detrimental or neutral for speckled dace. Andrusak and Andrusak (2011), who were specifically tasked with examining occupation of areas to which large woody debris had been added, were unable to determine whether the sections were occupied by dace and the direct use of the woody debris was not observed. Also, habitats associated with riverside vegetation did not appear to be important to dace in spite of this vegetation being important as salmonid cover. The authors suggested that, based on substrate size preferences, mature speckled dace could benefit from strategically placed rock groins made from boulder and cobble.

THREATS TO CRITICAL HABITAT

While we do have an abundance estimate it is a single estimate and insufficient to draw any conclusions regarding trends. Nevertheless this estimate strongly suggests that the species is present in robust numbers over its entire range. There appears to be abundant, suitable, and widely distributed habitat for the species.

There does not appear to be a high probability that a “catastrophic event” could drastically reduce or eliminate dace in all three locations at the same time. No such event appears consistent with the threats discussed below; which include; water withdrawal, resource extraction, alien species, hydroelectric dams, forestry, and riparian removal.

Water withdrawal is viewed as the single greatest threat as it results in low summer-autumn discharge. These reduced flows are due in part to the nature of the watershed, climatic change, and water withdrawals. This threat may be somewhat mitigated by the species’ ability to survive and adapt to low flows and warm summer waters, as noted in the more southerly portion of its global range. It is important to note that the other threats are also important, however they vary over time and their severity may change with the particular circumstances associated with the threat. Thus, we have not prioritized them. The impact of alien species, for example, could be significant, but is dependent upon the invasive species and time and location of establishment. Resource extraction is directly related to oscillations in global markets and the threat from hydroelectric development must be assessed on a case by case basis.

Historically, the Kettle Valley was first developed for mining (in the late 1890s), served by the Kettle Valley Railway constructed in 1912 to transport coal, ore, and timber. The economy of the area is now mainly logging, ranching and agriculture, with mining much reduced.

The overall socioeconomic trend within the Kettle system is for a declining, aging population, and a shift away from forestry towards mining, energy production, and possibly tourism. Between 2001 and 2011, the population of the Kootenay Boundary region declined slightly, despite overall growth for the Province of B.C. (Statistics Canada 2010;

www.bcstats.gov.bc.ca/census.asp) Penfold (2010) predicted a 2.5% total growth between 2006 and 2020, with most of that growth in Nelson, a city outside of the Kettle watershed; all of this anticipated growth will be in the over 65+ age cohort. In Grand Forks, the largest city in the Kettle drainage, population fell below 4000 in 2010, the lowest in 15 years (Urban Systems Ltd., 2011).

Employment grew by only 1.6% between 2001 and 2008, a period during which the total export value of wood and pulp and paper products declined by 40%. Over the same period, metallic mineral products increased by 182% from a very small base, and energy products increased by 157% (Penfold 2010). The service industry and tourism are also anticipated to be growing industries in the future (Urban Systems Ltd 2011).

WATER WITHDRAWAL

Licenses for surface water withdrawal are granted for consumptive purposes in different sectors (i.e. municipal, domestic, residential, industrial, commercial, irrigation, or stock watering), and for non-consumptive purposes such as hydroelectric facilities. Some of the current licenses are not in use: in 2003, water allocations for the Kettle River system were estimated to be twice the actual usage (Aqua Factor Consulting Inc. 2004).

Big White Water Utility Ltd and Mt. Baldy Strata Corp. hold water licenses for supply to the ski resorts. In winter, some of this water will be used for snowmaking. The authorized consumptive use of water by ski hills represents 3.5% of total use of W. Kettle discharge, compared to >90% by irrigation. Big White and Mt. Baldy's currently licensed usages are completely supported by storage, and there should be little if any impact on summer and autumn flows in the West Kettle system as most of the water usage on the ski hills is in winter (Epp 2012b). Storage for irrigation use is much lower: while ski-hill storage represents 169% of use (more water is stored than is used) only 4% of the water used for irrigation is supported by storage.

Even during those times when natural flow in the sub-basins is estimated to provide the recommended level of flow for salmonids (speckled dace flow levels are not specifically identified), a portion of licensed water withdrawal remains unused. Thus, our ability to provide adequate flow could theoretically decrease under the existing permitted level. Lowest flow in drought years has decreased from 1929 to 2003, probably due to a combination of climate change and an increase in water use (Aqua Factor Consulting 2004). Severe drought years were 1987, 2002, and 2004.

Water abstraction for irrigation in the Kettle basin has for many years been identified as a conflict with fish habitat, although the species of concern have been primarily salmonids (Bull 1973). Groundwater extraction is a growing concern (Epp 2012a,b). A license is currently not required to extract groundwater in British Columbia, and wells are minimally regulated under B.C.'s Groundwater Protection Regulation of 2004 (Government of B.C. 2011).

Much of the water withdrawn from the basin for both domestic and irrigation needs comes from aquifers (Aqua Factor Consulting 2004). Although Midway and Grand Forks do hold licenses for diversion of surface water from the Kettle River, current water withdrawals are from the local aquifers. The City of Greenwood also obtains its water from an aquifer and abandoned its surface water license in 1997. Aqua Factor Consulting Inc (2004) indicated that some ranches in other parts of the basin have also shifted from authorized water intake to drawing from unregulated groundwater sources. Most of the crops in the vicinity of Grand Forks are irrigated from groundwater supplied by the city and improvement districts.

A shift to groundwater over surface water withdrawal such as is evidenced by the above examples injects considerable uncertainty into our ability to link water withdrawal to the severity of its impact on speckled dace. Authorized withdrawals provide only part of the picture. If direct river water withdrawal were restricted, unregulated groundwater usage would likely increase. Modeling suggests that variations in aquifer recharge under different climate change scenarios have a much smaller impact on the groundwater system than do changes in river-stage elevation of the Kettle and Granby Rivers (Allen et al. 2004); in other words, the ability of groundwater sources to maintain stream flow is limited. Epp (2012a) suggested that groundwater withdrawals may be the biggest threat to the hydrology of the basin. If the linkage between aquifers and river discharge is extensive, mitigating fish stress (which has been shown for trout but not for speckled dace) in the Kettle basin may not be as simple as managing direct water withdrawals from the main stem rivers. Diverting demand from one water source to the other may have little effect on overall discharge, but could alter seasonal discharges. In the Kettle River, groundwater and surface water appear tightly connected (Figure 1).

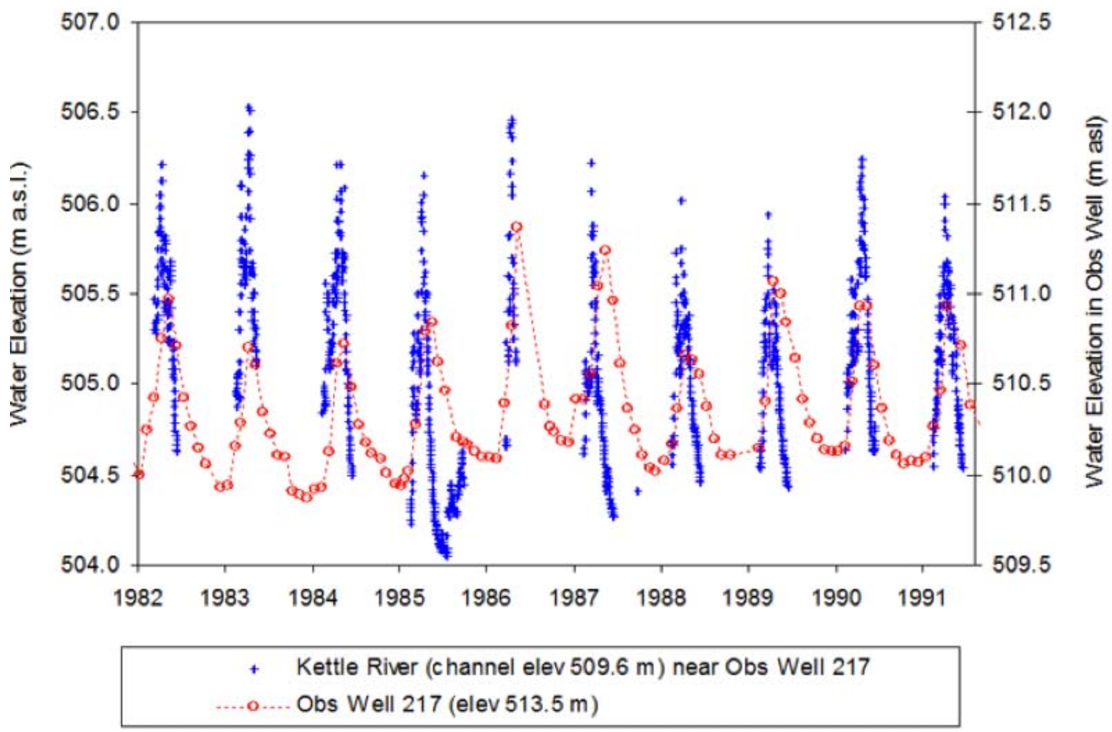

Figure 1. Correlation between surface and ground water fluctuations. Surface water data (blue) are from the Kettle River and ground water data (red) are from the Grand Forks aquifer. *http://livingwatersmart.ca/water-act/groundwater.html*

The linkage between the aquifers, recharge of groundwater, and flow in the main systems is believed to be extensive (Aqua Factor Consulting 2004). However, the exact connection between aquifers and surface water is not clear (Allen et. al. 2004), and it is important to define the relationship between the aquifers and the rivers. R. Ptolemy (BC Ministry of Environment, pers. comm. 2012) indicated that shallow wells placed near the rivers should respond in a similar way to surface flows, but deeper wells may have different recharge times (possibly during snow-melt peak) and may have a different seasonal effect on surface flow. A sensitivity analysis for the Grand Forks aquifer (Allen et al. 2004) indicated that the available water is substantially more than that required for additional allocations, but much less than required for in-stream trout needs.

Changes in flow levels combined with climate-induced changes in temperature and precipitation may be expected to affect speckled dace. Using current climate change scenarios, Allen et al. (2004) predicted that precipitation could increase by as much as 40% within speckled dace range in Canada. Changes include type of precipitation (more rain), earlier snowmelt (as much as 1 month), increased peak flows, and possibly lower summer-autumn flows. Potential negative effects for speckled dace include a reduction in cover (as river margins contract), reduction of riffle habitat, and increased summer water temperature. Unfortunately, given the uncertainties over age-related habitat preference and the ability of the species to thrive in conditions of drought and elevated water temperatures, it is impossible to make any convincing links with dace survival. It should also be noted that an argument could also be made that an increase in winter temperatures, extension of growing season, and a reduction in river freezing could in fact improve conditions for Canadian speckled dace at the northern edge of their range.

Ongoing analyses of water withdrawals and stream flow, supported by the Province of B.C. and coordinated by the Kettle River Technical Advisory Committee, are expected to continue to yield valuable information on the relationship between surface water withdrawal, groundwater use, stream discharge, and aquatic species habitat. Habitat use studies should continue to include those for speckled dace.

Irrigation

Although there are some fruit and vegetable farms near Grand Forks, the vast majority of agricultural land within the watershed is used for livestock and forage crops (L. Tedesco, Habitat Biologist, Ministry of Forests, Lands and Natural Resource Operations, Nelson, B.C., pers. comm., C. Roesler, Land Information Coordinator, BC. Ministry of Agriculture, Abbotsford, B.C., pers. comm. 2012). Agricultural production is heavily reliant on consumptive water use. In 2003, irrigation as a percentage of total annual water usage was estimated to account for 83% at Midway, 69% at Grand Forks, 96% at Granby, and 76% at Cascade (Aqua Factor Consulting 2004).

The amount of water used for irrigation is related to the accumulated area under irrigation licenses, which has varied over the years. Although the allocation of water in the Boundary Region is dominated by irrigation, total water withdrawal (based on irrigated area) has dropped since 1981. In 1977 approximately 11,000 acres were authorized for irrigation in the Midway sub-basin. In 2003, approximately 8,500 acres were authorized for the same area; a total of 2,500 acres were amended, abandoned or cancelled (Aqua Factor Consulting 2004). Irrigated area increased slowly from 1929 to 1962 (5 acres to 160 acres/year), then from 1963 to 1980 grew by an average rate of 585 acres/year. From 1981 to 2003, the area under irrigation declined at an average rate of 65 acres a year (Aqua Factor Consulting 2004).

In the interior of B.C., the highest water demand in relation to flow occurs from May to October. Approximately 75% of the water used for irrigation is withdrawn in June, July, and August (Epp 2012b). In the Kettle basin, more recent irrigation water licenses are valid until the end of September, while older licenses can be used later in the year (R. Ptolemy, BC Ministry of Environment, pers. comm. 2012).

As a fish typically found in arid areas, speckled dace can persist, sometimes in small populations, in streams that are reduced to pools in late summer, as happens in some portions of the Kettle (A.E. Peden pers. comm. 2007). The species' apparent short-term ability to withstand the large fluctuations in discharge typical of a snowmelt river like the Kettle likely provides some resilience (Batty 2010). Nevertheless, this resilience has limits. The volume of water withdrawn from the Kettle system may be less than the total discharge, but the porosity of the channel substrate dramatically reduces the usable portion for fish (because of sub-surface flow). Thus, even small withdrawals can reduce the area of usable fish habitat.

Demands for water withdrawal combined with climatic change pose a threat to summer rearing components of the dace population (COSEWIC 2006). This may be especially true in the lower parts of the drainage where both agricultural and domestic water withdrawal is greatest and the river is wide, shallow, full of porous materials, and exposed.

RESOURCE EXTRACTION

The early mining history of the Boundary area has been described by Basque (1992). Population grew rapidly with the discovery of gold in 1860 to at least 5000 at its peak. Many of these early adventurers soon left for the Cariboo gold rush that followed. Copper and silver mining and smelting spurred growth in the area in the late 1890's to 1920's. In 1900 the population of Greenwood/Anaconda was estimated at 3,500, roughly three times today's census. Phoenix in 1910 was a town of 4,000 to 5,000; it no longer exists. However, waste from the smelters (slag piles) can still be found at Phoenix, Anaconda, and Boundary Falls. This material may once have impacted water quality, but has been left largely undisturbed for the last 100 years (some historic slag material is currently being recycled at Grand Forks).

Rock Creek, Boundary Creek, and to a lesser extent Kettle River were the scene of placer mining and some hydraulic operations. Much of the substrate of these water courses was washed and turned in the pursuit of gold, and it is likely that material was washed into the Kettle River. The lower Kettle River appears to contain volumes of mobile sands and gravels (very porous substrate); some of this material may be attributed to early mining activities.

Mining could increase the level of sedimentation and corresponding embeddedness which may be an important habitat attribute for speckled dace. Mining can also alter water quality, although the impact on speckled dace is difficult to segregate from more general observations about effects of pollutants on aquatic life. Mining activity is dependent upon the price of metals; if prices continue to rise, old and new mines may become active. Most of the current mining applications are for exploration, mainly between Midway and Grand Forks in the areas of Copper and Phoenix Mountain (L. Tedesco, Habitat Biologist, Ministry of Forests, Lands and Natural Resource Operations, Nelson, B.C., pers. comm. 2012). 'Kettle River Resources of Greenwood' is investigating the possibility of recovering gold and other metals from the former Phoenix copper-gold mine. Numerous gold mines and potential mining sites exist in the Washington State portion of the Kettle River basin, and many placer claims within the Kettle watershed are still being maintained. The Merit mine and concentrator near Phoenix and the U.S. border has recently shut down (R. Waterous, Forestry and Land Use Planner, International Forest Products Limited, Grand Forks, B.C., pers. comm. 2012).

The Kettle River has deposits of uranium and thorium (Grant et al 2009; CCKV 2012). In April 2008, the B.C. government announced a moratorium on uranium exploration, development, and registration reservation. This halted an exploratory uranium mining project in the watershed between the West Kettle and the East Kettle (the "Blizzard Uranium Claim," (CCKV 2012) and eliminated the possibility of any future uranium mines. Naturally-occurring uranium has been credited with elevating uranium levels in long-lived freshwater mussels in the Kettle River to nine times greater than federal drinking guidelines (Grant et al. 2009). Water quality in the Kettle River is reported to be generally excellent although two point sources of pollution discharge do exist, namely the sewage treatment facilities of Grand Forks and the village of Midway (Maciak et al. 2007). Non point sources of pollutants include agriculture, rural septic systems, storm waters, and road surface runoff.

HYDRO DEVELOPMENT AND DAMS

Smelter Lake Reservoir

A power generation facility was built on the Granby River in 1900 and provided electricity to the smelter at Grand Forks. From 1920 to 1948, the City of Grand Forks operated the dam and reservoir. The reservoir was drained in 1948 and the dam removed. The location remains a possible future independent power site. Care should be taken when extrapolating water discharge data from years in which the reservoir was used.

Cascade Falls

A proposal for a 25-megawatt run-of-river hydroelectric generation project at Cascade Falls on the Kettle River (about 2.5 km south of the community of Christina Lake) was approved in August, 2006 by the B.C. Environmental Assessment Office (EAO), after modification based on analysis of its potential fish habitat impacts. A short section of the Kettle River immediately upstream of the dam (750m) would become a pond (Hamilton 2005). Possible downstream threats from the Cascade Falls have been suggested. These include limiting water availability, raising downstream water temperatures, and changing the downstream movement of sand and gravel (Maciak et al. 2007). Hamilton (2005) and Bradford (2006) concluded there would not be a significant loss of speckled dace habitat if the power project were built.

In his allowable harm assessment of the Cascade Heritage Hydroelectric Project, Bradford (2006) estimated that less than 2% of speckled dace habitat would be affected by the creation of a head-pond for the dam, mainly due to inundation of riffle areas and reduction of productive capacity. Based on a qualitative risk assessment supported by a quantitative population viability model, Bradford (2006) concluded that the project posed a negligible risk to the speckled dace population. This conclusion was based on the premise that only a small proportion of the population will be exposed to the project. He nevertheless recommended that, in the light of our poor understanding of the species' biology and natural history, quantitative estimates of its abundance by river reach, as well as studies of its habitat use by life stage and season, were urgently required. Some of that information is now available through the efforts of Batty (2010) and Andrusak and Andrusak (2010). Distribution and abundance estimates have greatly increased following these studies and the conclusions reached by Bradford (2006) appear to be well founded.

The Cascade project is still in the review process and the area of potential development is well below the critical habitat locations proposed in the present paper. The project does highlight what may be the typical impacts of this kind of hydroelectric project on speckled dace, namely reduction of productive capacity due to inundation of riffle areas over a restricted stream length.

ALIEN SPECIES

The high prevalence of exotic (introduced) fish species in the Columbia River drainage has been remarked on by several authors (Taylor 2004; Runciman and Leaf 2009). Alien invasive species have the potential to alter native biodiversity and stress or eliminate native species, including those at risk. Alien invasive species have been described as one of the most prevalent threats for Canadian at-risk freshwater fish species (Dextrase and Mandrak 2006). Every introduced fish species or stocking of hatchery-raised fish has the potential to alter biodiversity although, strictly speaking, such alteration as is discussed in this section is more likely to affect individual speckled dace rather than pose a direct threat to their habitat.

In Canada's portion of the upper Columbia watershed, 43 fish species were listed by McPhail and Corveth (1994). Of these, only 27 were native. In the lower/mid Columbia basin many exotics not yet present in Canada have been identified. These include: over 20 water-related vascular plants, 13 non-native fish species, 35 invertebrates, 2 turtles, 1 frog, and 1 mammal (Systsma et al 2004). Although many of these exotics are found only in the lower Columbia River, and multiple dams do limit upstream migrations, each has the potential to be introduced or to move north into the Canadian portion of the basin that is currently occupied by speckled dace.

Brown trout were introduced into the Kettle River in 1957 (Royal B.C. Museum 2010). Although descendants of these fish are occasionally reported caught in the W. Kettle River, these may have been brook trout (S. Matthews, B.C. Ministry of Environment, pers. comm., 2012), and it is questionable whether a population of brown trout still exists.

Brook trout were widely introduced into the province of B.C. in the 1920s and have become established in some regions including the Kettle (McPhail 2007). However, few are believed to persist within the lower Kettle system; because brook trout tend to occupy lakes and prefer cooler waters. They tend to be found in the East Kettle River drainage (R. Ptolemy, BC Ministry of Environment, pers. comm., 2012). For the last decade, all brook trout have been stocked in enclosed interior B.C. lakes and have been sterile.

Numerous stockings of hatchery raised rainbow trout (and some of cutthroat trout) have occurred in the Kettle system (Godin et al 1994; S. Matthews, B.C. Ministry of Environment, pers. comm., 2012). To some extent, our knowledge of speckled dace biology and habitat use has come on the heels of a larger concern for native trout stocks in the Kettle River, and the loss of angling opportunities that has accompanied habitat changes. The Kettle River was considered a prime drift boat trout fishery, but catches have declined in recent decades. All of the trout and char species prefer cooler deeper waters, yet water temperatures in August 2009 in the Kettle River near Midway exceeded 24^{o} C (Epp 2012b). Thus, low seasonal discharge, high summer temperatures, and lack of deep pool habitat are likely the main obstacles for improvement of conditions for trout. These factors may be less important for speckled dace, a warm water fish at the northern extent of its range. Continued rainbow trout stocking is not considered to represent a threat to speckled dace, because the abundance of introduced alien trout species above Cascade Falls is low.

Smallmouth bass, largemouth bass, and pumpkinseed were introduced into Christina Lake in the early 1900s and are currently found below Cascade falls and within Christina Lake (Royal B.C. Museum 2010). Pumpkinseed habitat has been described as including ponds, bays of lakes, and pools in slow-moving stream sections (Jordon 2009; McPhail 2007). Assuming that speckled dace occupy faster waters, there is less likelihood of direct interaction. Largemouth bass are typically larger and more aggressive than other piscivorous fish, who they tend to out-compete (Kerr and Lasenby 2001). They have been known to eliminate native species and reduce minnow populations. In streams and rivers the effects of largemouth bass on small-bodied fish such as minnows may be greater than those of smallmouth bass (Harvey et al 1988). Largemouth bass should be considered an invasive threat to speckled dace, although predation would be reduced if dace only occupy the faster riverine habitats. Smallmouth bass tend to occupy faster waters than do largemouth bass (Brown et al. 2009a) and this may bring them into greater conflict with speckled dace. Smallmouth bass must also be considered a threat to speckled dace because small-bodied fish (minnows) are a prime forage item for the species (Brown et al. 2009b).

Northern pike are piscivorous and considered a threat to native fish species (Harvey 2009). It is likely that pike will continue to move north through trans-boundary dispersal and will increase in abundance within the Canadian portion of the Columbia watershed and lower Kettle River (Harvey 2009; Runciman and Leaf 2009).

Finally, the abundance of walleye has increased substantially within the Columbia River mainstream since the 1980s (R.L. & L.1995). Observed decreases in native prey species coincide with increases in walleye populations (R.L. & L. 1999), suggesting a cause and effect relationship. Walleye are present in Christina Lake and the Kettle River, north of the international boundary (Hartman 2009; Runciman and Leaf 2009). Walleye may impact native fish communities through both competition and predation (Hartman 2009) and may restrict dace use of habitat. They should be considered a threat to speckled dace within the section of the Kettle River below Cascade Falls.

FORESTRY

Historic riparian logging and the clearing of land for agriculture and ranching are activities that have altered the physical structure and function of the Kettle system. Specific effects on speckled dace habitat include reduction of channel complexity and riparian cover. Loss of large woody debris (LWD) and increased erosion has lead to more siltation and increased embeddedness. In this section, we consider the effects of timber harvest, salvage logging, and wood processing; riparian removal is treated separately in section 7.6.

Timber harvest

The majority of speckled dace range—the more southerly portion of the Kettle watershed—lies in the Ponderosa pine-bunchgrass zone. This zone is generally considered to be a prime range and wildlife foraging area and is dryer than the headwaters region; it supports scattered Ponderosa pine, with cottonwood and aspen along the river margins. Ponderosa pine have adaptations that help them survive fire, and a large old tree may have as many as 20 fire scars (R. Waterous, Forestry and Land Use Planner, International Forest Products Limited, Grand Forks, B.C., pers. comm. 2012). The fire return interval is thus estimated to be approximately 15 years, an interval that maintains open range with scattered pine. Currently there is little to no market for Ponderosa pine (L. Tedesco, Habitat Biologist, Ministry of Forests, Lands and Natural Resource Operations, Nelson, B.C., pers. comm. 2012; R. Waterous, Forestry and Land Use Planner, International Forest Products Limited, Grand Forks, B.C., pers. comm. 2012).

The headwaters of the Kettle River and its tributaries are in areas that are actively being logged. In the headwaters, most lands are covered with second growth forest and some of the valley bottom land has been cleared for hay production. Proceeding downstream, the valley is used more for agriculture, there is more rural development, and the climate is more arid. Standing trees are more limited within downstream riparian zones.

Most forestry within the Kettle River basin is concentrated in the more northern Interior Douglas fir and montane spruce zones associated with the tributary valleys and slopes of the East Kettle, West Kettle, and Granby Rivers. Harvest includes a few Douglas fir, hemlock, and western larch at lower elevation, lodgepole pine at lower and mid elevations and Engelmann spruce at mid to upper elevations. These areas are in part defined by a frequent fire return interval. The upper areas have a fire return interval of approximately 150 years (R. Waterous, Forestry and Land Use Planner, International Forest Products Limited, Grand Forks, B.C., pers. comm. 2012). However, numerous stands of trees approximately 80 years in age reflect the last major fire event. Interfor and B.C. Timber Sales are the main forestry players in the area.

Logging can affect streams by:

- removing non-target vegetation,
- reducing shade,
- increasing debris and sediment runoff from road construction, because roads and stream crossings may increase sediment loads to the main channels,
- increasing peak stream flows, and
- removing any buffering effect on snowmelt and storms, soil loss and channel destabilization. Frequency and severity of floods will increase (Chatwin and Alila 2007).

Of all these impacts, sediment from new roads may be the single greatest remaining threat to streams due to forestry activities in the Kettle basin (R. Waterous, Forestry and Land Use Planner, International Forest Products Limited, Grand Forks, B.C., pers. comm. 2012). The other impacts are reasonable assumptions based on what we know from other fish species, but there is some anecdotal evidence on the effect of road building on speckled dace. In parts of the Granby River, cobble and boulder substrate have become smothered in sand from past road construction and harvesting in the watershed and are now almost devoid of speckled dace, which had previously been easily sampled there (McPhail pers. comm., 2007). It is unlikely that high sedimentation and high embeddenesss will occur within the stretch of the Granby River proposed as critical habitat in this paper (see Section 10, Further Research Needs).

Mountain pine beetle and salvage logging

Mountain pine beetle (*Dendroctonus ponderosae*; MPB) was first noted in the Boundary area in the 1970s and was considered episodic by the 1990s (R. Waterous, Forestry and Land Use Planner, International Forest Products Limited, Grand Forks, B.C., pers. comm. 2012). It is believed that the mountain pine beetle epidemic has been caused in part by fire suppression that prevented dense stands of mature pine from completing their natural cycle and in part by warmer winters that have increased MPB survival. The mountain pine beetle attacks both lodgepole pine and Ponderosa pine but its impact on the latter has been less dramatic. In contrast to MPB outbreaks in other areas in B.C., the MPB epidemic in the Boundary region has been slow to develop and infestation rates are still relatively low when compared to other interior regions within the province. (http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/maps.htm). The epidemic should peak around 2014-2017; often, fewer than 40% of the lodgepole in the attacked stand are killed (R. Waterous, Forestry and Land Use Planner, International Forest Products Limited, Grand Forks, B.C., pers. comm. 2012). Thus, some standing trees may remain.

Infestation by mountain pine beetle has the potential to impact the forests of the Kettle-Granby watershed and may ultimately influence hydrology and water quality. Our current understanding is that the effects of beetle disturbance on hydrologic processes are different from timber harvest in that the diseased forests retain some standing timber and understory vegetation. Defoliation of pine forests increases soil moisture content and thus alters groundwater water levels and volume of run-off. The loss of forest canopy will also affect accumulation of snow and rates of snowmelt, with the cumulative effect being an increase in total water yields, higher peak flows and reduced snow melt period. Specific effects on speckled dace habitat are difficult to predict because we are currently unable to make a quantitative link between discharge rate and dace survival. Recent research indicates that hydrological processes within beetle-affected stands are somewhere between a mature forest and a clearcut, with hydrologic recovery taking between 20 and 60 years (Uunila et al. 2006; Redding et al. 2008, cited in Nelitz et al. 2011). As the beetle continues to move into the Kettle watershed forests, the first effect will be complete or partial loss of forest canopy. Evapo-transportations will decline, soil moisture content will increase, and under-story vegetation will increase. Death of lodgepole pine in the watershed will ultimately result in deeper snow pack (because of less interception of snow) and faster snowmelt (because of less shading); the overall result will be earlier, bigger and more frequent floods.

Although salvage logging elsewhere in the province can be twice the normal allowable cut, the impact of salvage logging on Kettle River will likely remain small. As for timber harvest in general, road construction may be expected to have the biggest impact on speckled dace habitat. In the Kettle basin, current harvest includes less than 10% MPB salvage logging, and most of the attacked stands are located well above the valley bottom. Lodgepole pine can only be used for a few years (<7 years) following the death of the tree (B.C. Ministry of Forest Lands and Natural Resource Operations, 2005). Forest management currently attempts to manage harvest with the objective of "staying ahead of the beetle" by cutting blocks that are susceptible or expected to be attacked in the near future (R. Waterous, Forestry and Land Use Planner, International Forest Products Limited, Grand Forks, B.C., pers. comm. 2012). Managers still have the option of removing lodgepole pine damaged or killed by mountain pine beetle, or allowing the trees to fall on their own. If removal is chosen, damage to stream habitat will be minimized by:

- minimizing tree removal within riparian areas;
- salvaging logs in stages over a few years to desynchronize runoff;
- avoiding sensitive terrain and soil types and develop erosion control plans;
- maintaining diversity of cover and minimizing post-salvage reforestation delays;
- leaving woody debris in openings to promote forest regeneration;
- maintaining natural drainage when constructing logging roads.

Wood processing

One of the larger sawmills in the Boundary area, Pope and Talbot in Midway, closed in 2007 but reopened under new management in 2011. The mill is currently operating at reduced capacity. The Canpar particle board mill was a major forest industry in Grand Forks, but closed in 2007 (Urban Systems 2011). Interfor operates a saw-mill in Grand Forks. All of the operating facilities are located in the lower watershed near the main river and there is a limited threat of point source pollution. Such point source pollution does not currently represent a direct threat to speckled dace habitat.

Some timber is exported outside the immediate areas (i.e. Castlegar) for processing. Between 2000 and 2008, the export value of wood and pulp and paper products from the region declined by 39% (Penfold 2010). Currently, markets for wood and wood chips are stable, with approximately 50% of the wood product going to Asia.

RIPARIAN REMOVAL

The West Kettle reach that corresponds to the section of CH proposed in this paper was described by Godin et al. (1994) as a confined channel with bedrock valley walls, riparian second growth, a stream gradient of 1-5%, some undercut banks and over-stream vegetation, a few boulder groupings but sparse pools and sparse large woody debris. The East Kettle and Granby Rivers have a steeper gradient than the lower Kettle, but are less confined than the West Kettle; they are also mainly second growth. In the headwaters and within the 2.4 km sections on the Granby, West Kettle, and East Kettle Rivers that are proposed as critical habitat (Figure 2), the riparian zones are generally mixed second growth forest of which a small percentage (usually on one side only) borders cleared agricultural lands. Within the proposed CH sections and upper sections, most of the cleared fields retain a riparian strip of mixed trees.

Proceeding downstream, agricultural activities increase and the climate becomes more arid. Riparian zones in the ponderosa pine zone consist mainly of sparsely treed cottonwood, aspen and the occasional ponderosa pine. There are also a couple of sections of river where the road encroaches into the riparian zone. Large woody debris is noticeably absent in the Kettle River both below and above Westbridge.

Under current forestry practices, harvest of riparian zones is unlikely. In general, riparian logging and the clearing of land for agriculture and ranching can affect speckled dace habitat by increasing the rate of bank erosion, sediment deposition and embeddedness, cover loss, and eliminating sources of large woody debris. All of these impacts are accompanied by substantial uncertainty; for example, sedimentation appears to have occurred with historic placer mining, but it is unclear whether the alterations to habitat have affected speckled dace populations. Riparian vegetation provides shade, which is likely not of great importance to a species known to be tolerant of relatively high temperatures and that consumes algae and algae eating invertebrates. Overhanging cover has not been shown to be important for speckled dace, which appear to take cover in substrate and has no preference for woody debris. The ability of riparian vegetation to bolster detrital invertebrate food items may be less important for speckled dace, a species that consumes a wide range of algal and plant material in addition to aquatic invertebrates (Batty 2010). However, adequate protection of riparian zones from cattle and private land clearing is a concern at specific sites. Bank stability issues could be addressed thought livestock exclusion.

It is questionable whether the Kettle River riparian zone has had much of a role in supplying large woody debris (LWD) to the system for many decades, because the robust numbers of dace that we find in the system today have clearly persisted in the absence of LWD. There are several reasons for drawing this conclusion. First, although the upper watershed has a fire return interval of 150 years, much of the watershed was burned approximately 80 years ago, creating large even-aged areas of mid-sized trees. The riparian zones bounded by Crown lands are protected from forest harvest removal through current forest harvesting regulations and should continue to mature, but some sections of riparian zones bordering private lands have been cleared for agricultural purposes. Thus, few riparian trees of appropriate size or species are/have been available to provide large woody material. Second, many of the riparian species (cottonwoods and aspen) disintegrate relatively quickly after falling in the river. Third, it is difficult to establish stable woody debris in a channel filled with mobile substrate. Finally, in the lower section of river, the channel is wide and the riparian zone is often far enough from flowing water in summer that little over-stream cover is afforded by the few standing trees. During spring floods, floating woody material is often displaced far from the river channel.

Based on the above examples of the apparent lack of coupling between the known functions provided by riparian buffers and our present understanding of the habitat requirements of speckled dace, it seems reasonable to conclude that qualification of riparian zones as critical habitat for endangered freshwater fishes is not appropriate in the case of speckled dace. Extending critical habitat into the riparian zone would not appear to be necessary for speckled dace persistence or recovery.

RECOVERY TARGETS (POPULATION BENCHMARKS)

The current abundance estimate for adult speckled dace in Canada (939,610, 90% confidence interval of 412,431-1,954,522 individuals) is 20-40 times higher than the one previously accepted in the RPA for the species (Harvey 2007). The large confidence interval reported by Batty (2010) is an indication of uncertainty; in many cases, only a few fish were caught at a given site. Nevertheless, several factors suggest that the current estimate could be low. First, a capture method other than (Korman et al. 2004) fishing might produce a different result. For example, snorkel surveys carried out by Andrusak and Andrusak (2011), while not used quantitatively in their report, strongly suggested that electrofishing may be missing some of the larger individuals. Second, all estimates made by Batty (2010) were derived from daytime sampling, which may underestimate abundance, and catches are scaled by catchability trials that account for gear efficiency. Twenty times more leopard dace were caught at night by pole-seine along the shores of Shuswap Lake than during the day (Brown and Winchell 2004). Finally, a considerable length of un-sampled river exists above the uppermost sites at which fish were caught during the distributional study by Batty (2010). Length estimates of these “unknown” regions are: 18km for West Kettle and 3 km for Granby River and approximately 26 km of length exists between dace occurrence at the uppermost exploratory site on the East Kettle and the uppermost distributional site (Batty 2010). Thus, the total range (and hence the abundance) is likely an underestimate. It is very likely the range could extent well above that indicated by Batty (2010) in the West Kettle River, because the Royal B.C. Museum has observations of speckled dace well above those where Batty (2010) caught speckled dace (COSEWIC 2006).

The RPA for speckled dace, despite being based on an estimated abundance that was a fraction of what we now know it to be, concluded that the population was at no immediate risk. Since distribution did not appear to have changed significantly over the decades during which the area had been sampled, no recovery target population was set, and the goal was stated as “preservation of the species’ current distribution.” A benchmark of 2,500 mature fish was adopted in the RPA, based on the COSEWIC small population criterion and used by Bradford (2006) to model consequences of the proposed hydro operation at Cascade Falls. This benchmark seems unnecessarily low in the light of what we now know about speckled dace abundance.

An option is to consider a higher generic benchmark, for example the 7,000 adults adopted as an “interim recovery target” by Reed et al. (2003) for listed vertebrate species. Since we have no evidence of whether the population trend is down, or up, or stable, the number cannot logically be called a recovery target, but it may be considered a conservative target for the maintenance of a population. The importance of identifying critical habitat would lie in protecting enough of it so that the species never fell below this lower limit – an event that, given the present abundance and distribution, seems very unlikely.

It is very important to conduct a detailed assessment within each of the proposed critical habitat locations to verify the length of stream required to maintain the population above the target. If the estimated abundance turns out to be lower than the target of 7,000, additional stream length should be added; by the same reasoning, if the estimated abundance is well above the target, reach length can be reduced. In other words, the length of stream considered critical habitat in the recovery strategy should relate to the population estimates conducted.

METHODS AND APPROACH USED TO IDENTIFY CRITICAL HABITAT

The identification of critical habitat (CH) in the context of SARA must:

- Specify the geospatial location of the critical habitat or describe the area within which critical habitat is found;
- Describe the known biophysical functions, features and attributes of that critical habitat that are required by the listed wildlife species in order to carry out life processes necessary for its survival or recovery;
- Provide a sufficient level of detail to allow a person to determine whether a particular location is part of critical habitat.

For speckled dace, critical habitat is identified to the extent possible, using the best available information. The critical habitat that we propose is shown in Figure 2, which depicts the geospatial area that will supply the amount of habitat necessary to maintain the population abundance required for the persistence of the species in the locations where it is presently found in Canada.

A biophysical function is a characteristic of critical habitat that corresponds to a biological need or life-process requirement of the listed species. Functions for aquatic species at risk are taken from the SARA definition of habitat: "…spawning, nursery, rearing, feeding, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes." A critical habitat function describes how the critical habitat is necessary to support a life process and informs the rationale for its protection. This protection should in turn support the species' recovery and survival. Once a critical habitat function is identified for a listed species, features and their associated attributes, in combination, enable that particular function. For protection of a listed species, critical habitat functions and their associated features and attributes should be identified to the extent possible.

A feature may support more than one function; e.g. a riffle may be used for spawning as well as for rearing. Features need also to be described in terms of their temporal use and/or availability. Features may change over time and a change or disruption to the feature may affect its function and ability to meet the biological needs of the species. For example, a feature such as a riffle may not be static over time and may in fact be lost entirely as a result of natural processes. Every feature is comprised of many parts or attributes such as temperature range, water depth, velocity, and oxygen level.

The geophysical component and biophysical functions, features and attributes of the speckled dace critical habitat proposed in this paper were derived from published research, including Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports (COSEWIC 2006) and the recovery potential assessment for the species (Harvey 2007). Recent findings by Andrusak and Andrusak (2011) and Batty (2010) concerning habitat use in the Kettle system suggest that there may be different habitat preferences for mature and immature fish, and habitat use may need to be refined by further studies in which sampling is not confined to summer daylight hours using electrofishing. Nevertheless, the current picture is of a rather wide range of discharge, depth, substrate and temperature tolerances, summarized in Tables 1 and 2 (see Section 5). None of the research on the species to date provides any quantitative relationship between habitat type and abundance.

The habitat functions, features and attributes we believe to be appropriate for inclusion in critical habitat are summarized in Table 3:

Table 3 Summary of Habitat functions, features and attributes

Life stage	Function	Feature	Attribute
immature	rearing	pool, run, margin	small gravel/cobble; flow below 0.24 m/s and depth below 0.4 m; low to moderate embeddedness
mature	rearing	run and riffle	boulder/cobble; flow 0.18-0.45 m/s; depth 0.2-0.5 m although may be found over 1 m deep; low embeddedness
	spawning	run and riffle	Large, clean cobble

How do we couple these functions, features and attributes to "survival or recovery"? It appears that, over their lifespan, speckled dace in Canada are distributed fairly evenly over their range, occupy most habitat types within riverine sections, and utilize the entire width of the rivers. The level of available detail for speckled dace, coupled with the unusual circumstance of a robust and apparently resilient population, argue in favour of identifying the amount of critical habitat sufficient to ensure the chosen population target is maintained. This habitat should be located in stream sections where the likelihood of disruption by any of the known threats, as well as any potential conflict with human activities, is minimal.

If we accept that a population of 7,000 is the minimum population required for long-term persistence of the species, how should this population be distributed? We adopted the view that the uncertainty in Batty's (2010) estimates is reflected in the large confidence intervals and this argues for a conservative approach in which the population target of 7,000 is met for each of the three watersheds. If we assume 3.0 fish/m as a reasonable estimate of abundance (based on the capture efficiency-corrected results of Batty 2010), we arrive at 2.4 km of proposed critical habitat within each of the West Kettle, East Kettle and Granby Rivers (Figure 2).

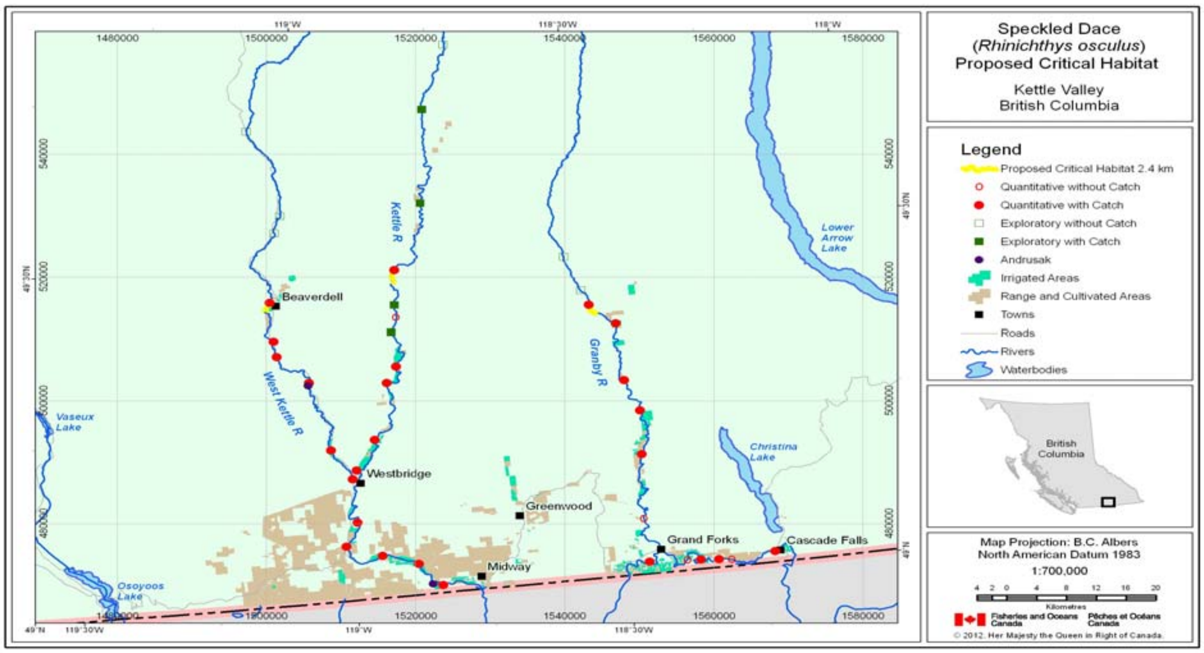

Figure 2. Proposed critical habitat for speckled dace, in relation to land use and abundance sampling. Critical habitat is in yellow. The red and green circles and squares are sampling locations reported by Batty (2010). Solid purple circles are sampling sites reported by Andrusak and Andrusak (2011). See legend for further detail. Land use data supplied by Land Information, Sustainable Resource Management Branch, BC Ministry of Agriculture. Map produced by D. McCullough and K. Lowe. (DFO-GIS unit).

Such a conservative approach takes into account what we know about the dispersal ability of the dace as well as how easily one population could rescue or contribute genetic material to another. COSEWIC (2002) suggested that speckled dace are rapid colonizers of new habitat with at least moderate dispersal ability. Batty (2010) noted that dace were found throughout their range. Having three target populations of 7,000 fish rather than one, takes into account any uncertainty about whether fish in the Granby River could be expected to exert any rescue effect upon those in the West and East Kettle rivers.

Critical habitat should include those areas within the specified length of potential critical habitat where the relevant biophysical attributes occur. In the case of speckled dace, because we suspect the dace use the entire river width and all aspects of the specified lengths during some period of their life, the proposed stream lengths represent critical habitat in their entirety. The three proposed critical habitat sites are each a continuous section of river rather than being split into a number of smaller sections. This simplifies identification and removes some of the uncertainty regarding changing biophysical conditions within short sections.

The sections of river we have delineated as potential critical habitat start at the uppermost site where speckled dace were captured by Batty (2010) during the distributional component of his study and extend downstream for 2.4 km (Figure 2). This approach minimizes the threats of large water withdrawals and riparian removal. Most of the irrigation and land clearing has been in the lower watershed. However, it was not possible to locate the proposed critical river sections upstream of all withdrawals or all cleared agricultural lands:

- In the Granby River, no cleared land or irrigated land is located above or within the proposed critical habitat site.
- In the East Kettle River, cleared lands are found approximately 10 km above the initiation site and a small length of cleared land is evident within the proposed site on one side of the river; but no irrigated lands (from direct river withdrawals) were noted.
- In the West Kettle River, cleared range land borders the river for 1/2 km on one side within the proposed site just below Beaverdell. However, irrigated lands and cleared lands are evident within Beaverdell Creek (a tributary to the West Kettle River entering just above the site) and Beaverdell Creek can go dry.

The specific methodology used to establish the length of proposed critical habitat required for Kettle River speckled dace is summarized below:

1. An interim population target of 7000 adults (Reed et al. 2003) was used.
2. An estimate of 3.0 fish/m or 3000 fish/km was used. This is based on an actual catch of 0.23 fish/m corrected for effort (Batty 2010).
3. Proposed critical habitat length required is 2.4 km (or 7000 fish at 3000 fish/km; rounded up).
4. An interim target of 3 locations was used. The objective was to maintain viable populations in each of the three locations. This requires 2.4 km in each of West Kettle, East Kettle, and Granby Rivers.
5. Critical habitat was sited above major potential threats (water withdrawal and riparian clearing) in each of the three locations. This will also facilitate downstream dispersal of larvae. We used the uppermost known dace site as established in the distributional study (Batty 2010) as our upper limit of proposed critical habitat.
6. Verification: Three population assessments are required to verify abundance within the proposed critical habitat lengths and modify site location if necessary.

FURTHER RESEARCH NEEDS

Critical habitat has been proposed based on the best available information however several knowledge gaps do exist. Research required to verify the proposed critical habitat sites as well as research that can hopefully improve our understanding of speckled dace habitat is listed below:

- Verify that the geospatial areas proposed as critical habitat do indeed contain suitable habitat, and confirm abundance estimates within these proposed critical habitat sections.
- Examine speckled dace winter life history, over-wintering habitat and seasonal movements. Purpose: would help confirm assumptions regarding downstream dispersal from areas designated critical habitat and establish patterns of seasonal habitat use.

- Develop accurate biophysical descriptions of the proposed critical habitat locations and establish monitoring programs at each location. Purpose: confirm suitability of proposed reaches and enable long term monitoring of abundance. Annual monitoring is not required; a well conceived, periodic index program is likely sufficient to detect serious trends.
- Sample the stream sections immediately above the delineated critical habitat for speckled dace. Purpose: refine observations of Batty (2010), confirm suitability of proposed reaches and verify range of dace.
- Study the relationship between discharge and speckled dace productivity. Purpose: would help to replace assumptions with direct observations to assist in preserving dace in the event of a sustained drought.

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