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Range Extension of Northern Form Dolly Varden (*Salvelinus malma malma*) to the Upper Arctic Red River Watershed, Northwest Territories, Canada

Kris W.C. Maier,[1,2] Neil J. Mochnacz,[3] Robert Bajno,[3] Andrew J. Chapelsky,[3,4] Peter Rodger[5] and James D. Reist[3]

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ABSTRACT. Northern form Dolly Varden is an anadromous char with significant ecological value found in high-gradient rivers of the Western Arctic. Because of declines in population abundance, Dolly Varden was recently designated as "Special Concern" under the federal *Species at Risk Act*. This species is also of great cultural and dietary significance to Indigenous Peoples of many communities in the Western Arctic; thus, expanding knowledge of the distribution, biology, and essential habitat is an important priority. We present results of a fisheries survey in the headwaters of the Arctic Red River, Northwest Territories, that focused on confirming the presence of Dolly Varden. Of 143 fish captured among 12 sampling locations, two were Arctic grayling (*Thymallus arcticus*), 33 were slimy sculpin (*Cottus cognatus*), and 108 were char identified using qualitative and quantitative morphological features. A subsample of 44 char voucher specimens were frozen whole and later identified using a linear discriminant function (LDF) based on meristic counts and morphological measurements, and a mitochondrial DNA genetic marker. LDF scores indicated that char collected in the Arctic Red River were northern form Dolly Varden. Genetic analysis showed that all but one char possessed mitochondrial DNA sequences common in northern form Dolly Varden from Canada. Our results confirm the presence of Dolly Varden in the Arctic Red River headwaters, extending the confirmed known distribution of this taxon in the Northwest Territories approximately 450 km south and 100 km east of previously delimited areas.

Key words: Gwich'in Settlement Area; Mackenzie River basin; morphology; mtDNA; range extension; special concern; Species at Risk; Tsiigehnjik

RÉSUMÉ. La forme du nord de l'omble du Pacifique est un omble anadrome de grande valeur écologique se trouvant dans les rivières à fort gradient de l'Arctique de l'Ouest. En raison de la chute de l'abondance de sa population, l'omble du Pacifique est considéré, depuis peu, comme espèce préoccupante en vertu de la *Loi sur les espèces en péril* du Canada. Pour les peuples autochtones de nombreuses collectivités de l'Arctique de l'Ouest, cette espèce comporte également une grande importance culturelle et alimentaire. Par conséquent, il est important de bien se familiariser avec sa répartition, sa biologie et son habitat essentiel. Nous présentons les résultats d'un relevé de poissons de l'eau d'amont de la rivière Arctic Red, dans les Territoires du Nord-Ouest, visant à confirmer la présence de l'omble du Pacifique. Parmi les 143 poissons capturés dans 12 lieux d'échantillonnage, deux étaient des ombres arctiques (*Thymallus arcticus*), 33 étaient des chabots visqueux (*Cottus cognatus*), et 108 étaient des ombles, leur identification s'étant faite à l'aide de caractéristiques morphologiques qualitatives et quantitatives. Un sous-échantillon de 44 spécimens d'ombles de référence a été congelé en entier, puis identifié plus tard à l'aide d'une fonction discriminante linéaire d'après les dénombrements méristiques et les mesures morphologiques ainsi que d'après un marqueur génétique d'ADN mitochondrial. Les résultats obtenus au moyen de la fonction discriminante linéaire ont permis de déterminer que les ombles capturés dans la rivière Arctic Red étaient la forme du nord de l'omble du Pacifique. Leur analyse génétique a permis de démontrer que tous les ombles, sauf un, possédaient des séquences d'ADN mitochondrial communes dans la forme du nord de l'omble du Pacifique du Canada. Nos résultats ont confirmé la présence d'ombles du Pacifique dans l'eau d'amont de la rivière Arctic Red, ce qui a pour effet d'étendre la répartition connue et confirmée de ce taxon dans les Territoires du Nord-Ouest d'environ 450 km vers le sud et de 100 km vers l'est par rapport aux aires anciennement délimitées.

Mots clés : zone de peuplement des Gwich'in; bassin du fleuve Mackenzie; morphologie; ADNmt; élargissement de l'aire de répartition; espèce préoccupante; espèces en péril; Tsiigehnjik

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[1] BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Bag 5000, 3726 Alfred Avenue, Smithers, British Columbia V0J 2N0, Canada
[2] Gwich'in Renewable Resources Board, PO Box 2240, Inuvik, Northwest Territories X0E 0T0, Canada
[3] Fisheries and Oceans Canada, Arctic and Aquatic Research Division, 501 University Crescent, Winnipeg, Manitoba R3T 2N6, Canada
[4] Corresponding author: Andrew.Chapelsky@dfo-mpo.gc.ca
[5] Fisheries and Oceans Canada, Species at Risk Division, 501 University Crescent, Winnipeg, Manitoba R3T 2N6, Canada

INTRODUCTION

The taxonomy of *Salvelinus* spp. in northwestern North America has received considerable attention due to the difficulty in distinguishing closely related species with varying life histories (e.g., migratory anadromous and fluvial, non-migratory resident individuals) and polymorphic forms within each species. Arctic char (*Salvelinus alpinus*) have been distinguished from Dolly Varden (*Salvelinus malma*) in the Mackenzie River basin and Yukon North Slope; the former are generally considered to be relict populations occupying lacustrine habitats whereas Dolly Varden are considered riverine char in the area (Reist et al., 1997; Behnke, 2002; Taylor et al., 2008). Dolly Varden and bull trout (*Salvelinus confluentus*) are also now recognized as two distinct species (Cavender, 1978; Haas and McPhail, 1991; Phillips et al., 1995; Reist et al., 2002), with the geographic distribution of Dolly Varden and bull trout in the Northwest Territories being recently updated (Mochnacz et al., 2013).

Dolly Varden populations grow slowly, mature late, and often do not spawn in consecutive years, which results in populations with small abundances (Reist et al., 1997). They are vulnerable to a range of stressors, including habitat change due to direct manipulations by human activity (e.g., road or pipelines crossing rivers, dam or weir construction, marine offshore development for seasonally anadromous populations), climate change (e.g., groundwater-levels, erosion), and overharvest (Reist et al., 2006; DFO et al., 2019). Dolly Varden includes multiple subspecific taxa and forms, so for the purposes of this paper we focused on northern form Dolly Varden (*S. malma malma*) (Behnke, 1980; Phillips et al., 1999; Kowalchuk et al., 2010; Taylor and May-McNally, 2015), considered to be primarily a riverine fish that mostly occupies high-gradient mountain streams in the western Arctic of North America.

In November 2010, northern form Dolly Varden was assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as "Special Concern" (COSEWIC, 2010) and later listed as such under the federal *Species at Risk Act*. The COSEWIC assessment initiated the development of an Integrated Fisheries Management Plan (IFMP) for northern form Dolly Varden in the Gwich'in and Inuvialuit Settlement regions and suggested the need to identify all stocks of Dolly Varden (DFO et al., 2010). Key elements of the IFMP are to expand knowledge of all Dolly Varden life history types, locate additional populations, and identify essential habitat to delimit protected areas.

The distribution of riverine chars in the Northwest Territories and northern Yukon was recently updated, however, there is still uncertainty regarding the distribution of Dolly Varden and bull trout near their respective distributional boundaries (Fig. 1). Previous work by Mochnacz et al. (2013) did not sample all upstream areas of tributary basins to the lower Mackenzie River. Also, anecdotal information suggested that chars are present in the Arctic Red River (ARR) watershed, but because it is difficult for non-experts to discriminate between bull trout and Dolly Varden using only morphological characteristics, the taxonomic identity of these fish was uncertain and required voucher specimens for formal identification. Our aim was to capture char from this watershed, confirm the identity of these specimens, and update the distribution of riverine chars occupying this area.

METHODS

Our field program was conducted in August 2015 with the assistance of the Gwich'ya Gwich'in Renewable Resource Council (GGRRC) of Tsiigehtchic, whose members have been interested and supportive of conducting research on fish in the headwaters of the ARR for many years. Discussions with the GGRRC, Gwich'in Social and Cultural Institute (GSCI), Gwich'in Land Use Planning Board (GLUPB), and community members indicated no traditional or local knowledge (TLK) for Dolly Varden was available for this area and confirmed that any information on fish distribution and ecology was limited to the lower reaches of the watershed. As a result, we did not include a TLK component in this research, however, all relevant TLK documents for the surrounding area were reviewed and no records of Dolly Varden or similar species were reported for this area (GLUPB, 2005, 2006; Thompson and Millar, 2007; GSCI, 2010). A review of the scientific literature also did not find any records of Dolly Varden or bull trout in the watershed (Fig. 1).

The ARR (known locally as Tsiigehnjik) is a major tributary of the Mackenzie River in the Northwest Territories that drains the Cranswick (Ddhahzhit Gwitsal) and Orthogonal Rivers. The headwaters originate in the northern Mackenzie mountain range and flow northwest through the mountains before veering northeast to the junction with the lower Mackenzie River (Nagwichoonjik) at Tsiigehtchic, approximately 25 km south of the Mackenzie Delta (Fig. 1). With relatively clear water, numerous rapids, and coarse gravel beds, the upper watershed drains into the Peel Plateau canyon and valley system before becoming a wide (500 m), slow moving, turbid, and silty river at the mouth (Howland et al., 2000). Tributaries to the Mackenzie River in this area have peak discharge occurring after the spring freshet, and water levels generally decline throughout the summer and early fall depending on precipitation (Mochnacz et al., 2013). The headwaters are generally frozen from mid-October to late May, and surface water temperatures reach a maximum of 20°C in July (Howland et al., 2000). Perennial groundwater inflows are present throughout tributaries to the Mackenzie River (Mochnacz et al., 2013).

Sampling sites were selected with assistance from Tavis Molnar (Arctic Red River Outfitters, Ltd.), who has over 20 years of experience in the ARR watershed (T. Molnar, pers. comm. 2015). Sampling sites were chosen based on anecdotal evidence of char in the area from hunting guides

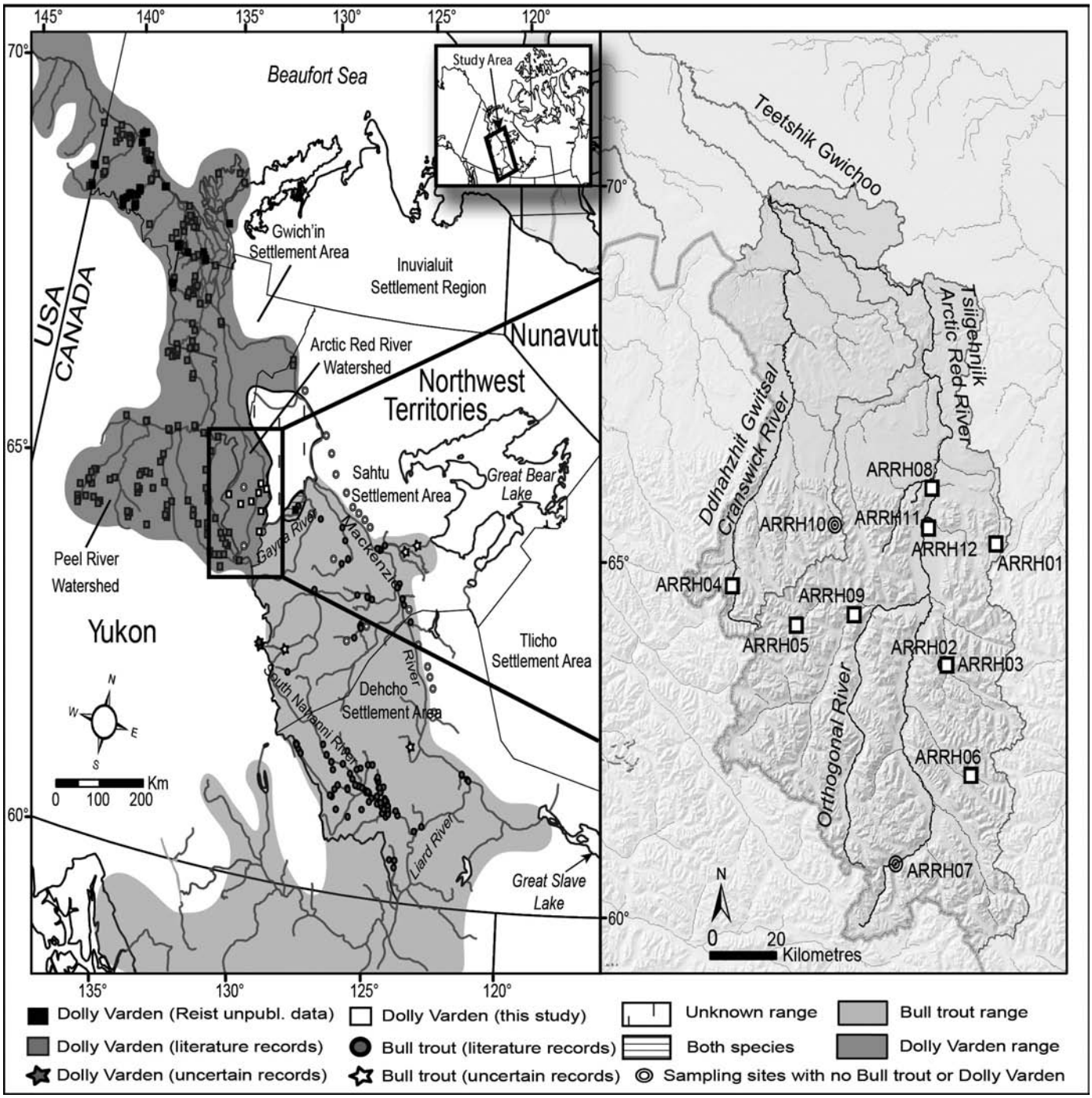

FIG. 1. Distribution of northern Dolly Varden and bull trout in northern British Columbia, Yukon, and Northwest Territories. Map adapted from Figure 1 in Mochnacz et al. (2013) (left panel), with the small inset indicating location in North America. Sampling sites in the upper Arctic Red River drainage basin in this study (right panel); location codes (ARRH##) correspond to those listed in Table 1.

and the availability of suitable habitat (e.g., perennial groundwater springs, which are essential overwintering and spawning habitat; Mochnacz et al., 2010). Once a site was identified, a 500m transect was fished in an upstream fashion using a Smith-Root LR-24 electrofisher. Fishing effort was recorded in seconds, and geographical coordinates at the start and end points of each sampling site were recorded using a Garmin handheld GPS (WGS 84 datum). One crew member operated the electrofisher while two other crew members were responsible for capturing fish using fine mesh dip nets. To minimize stress, all captured fish were placed in shaded buckets filled with regularly replenished river water and were processed at the end of each transect.

In the field, char were identified to species using qualitative morphological features (Reist et al., 2002). Other fish species were confirmed from keys in Scott and Crossman (1973), and total length and fork length (mm)

TABLE 1. Total number of Dolly Varden (DVCH) captured from sampling sites in the Arctic Red River headwaters (ARRH, this study) and Gayna River (Mochnacz et al., 2013) with corresponding length ranges, mean fork length (± SD), and age. Preserved fish were returned to Winnipeg, Manitoba, for further analyses and identification by genetic methods; remaining fish (captured minus preserved number) were released live in the surveyed stream reach.

Location	Coordinates	Date	Number of DVCH		Fork length (mm) mean ± SD (range)	Age (years) median (range)
			Captured	Preserved		
ARRH01	65°15′31″ N, 130°45′48″ W	21 August 2015	4	4	167.3 ± 15.2 (147–182)	3.5 (3–4)
ARRH02	64°59′32″ N, 131°08′02″ W	21 August 2015	0	0	–	–
ARRH03	64°59′28″ N, 131°07′23″ W	21 August 2015	3	3	125.7 ± 62.6 (50–188)	2 (1–3)
ARRH04	65°12′11″ N, 132°28′56″ W	22 August 2015	19	8	182.9 ± 40.7 (97–235)	5.5 (3–7)
ARRH05	65°06′16″ N, 132°04′36″ W	22 August 2015	36	6	176.6 ± 25.3 (111–230)	5 (3–6)
ARRH06	64°43′59″ N, 131°00′29″ W	23 August 2015	14	5	133.5 ± 27.3 (99–187)	3 (3–5)
ARRH07	64°32′31″ N, 131°30′32″ W	23 August 2015	0	0	–	–
ARRH08	65°23′54″ N, 131°09′35″ W	24 August 2015	7	6	143.1 ± 27.9 (114–175)	3 (3–5)
ARRH09	65°07′11″ N, 131°42′07″ W	24 August 2015	21	12	97.6 ± 63.3 (41–248)	2 (0–5)
ARRH10	65°19′38″ N, 131°48′08″ W	25 August 2015	0	0	–	–
ARRH11	65°18′44″ N, 131°11′59″ W	25 August 2015	0	0	–	–
ARRH12	65°18′25″ N, 131°11′49″ W	25 August 2015	4	0	162.5 ± 23.9 (137–192)	–
Gayna 1	65°17′27″ N, 129°21′02″ W	30 September 2007, 21 August 2008	49	13	258.7 ± 27.9 (215–339)	7 (4–10)
Gayna 2	65°17′54″ N, 129°21′20″ W	30 September 2007, 21 August 2008	2	2	313.0 ± 91.9 (248–378)	8 (8)

FIG. 2. A representative voucher sample of total catch from site ARRH08. Slimy sculpin (n = 3) are shown on the left and Dolly Varden (n = 6) are shown on the right.

were recorded before each fish was released. A random subset of char were lethally sampled, frozen whole, and shipped to the Freshwater Institute in Winnipeg, Manitoba, to confirm field-based identifications and collect additional biological data (Table 1; Fig. 2). Ages were determined using whole otoliths, which is a reliable method for ageing northern form Dolly Varden less than age nine (Gallagher et al., 2016).

Putative Dolly Varden sent to Winnipeg were further identified using a linear discriminant function (LDF) developed by Haas and McPhail (1991). Preserved specimens were measured for standard length (maximum length of snout to the end of the caudal peduncle/start of caudal fin; mm), upper jaw length (mm), and the anal fin and branchiostegal rays were counted. These counts and measurements were then used in equation (1):

$$\text{score} = 0.629*\text{BRC} + 0.178*\text{ARC} + 37.310*\text{UJL/SL} - 21.8$$

where BRC = branchiostegal ray count; ARC = anal fin ray count; UJL/SL = upper jaw length divided by standard length. Each char was assigned an LDF score and fish with scores greater than 0 were identified as bull trout and those with scores below 0 were Dolly Varden (Haas and McPhail, 1991). This LDF has been found by others to be effective for distinguishing bull trout from northern form Dolly Varden (Reist et al., 2002; Mochnacz et al., 2013).

The LDF scores from this study were compared to scores derived from bull trout collected at locations across the Northwest Territories and Dolly Varden from the Gayna River system, a more southerly drainage adjacent to the ARR watershed (Mochnacz et al., 2013; Fig. 1). LDF calculations and boxplots presenting results were completed in R v.3.5.1 (R Core Team, 2018) using the 'ggplot2' (Wickham, 2016) and 'patchwork' packages (Pedersen, 2019).

A mitochondrial DNA marker assessed the taxonomic status of ARR chars. Adipose fin tissue was sampled from frozen specimens and stored in 95% non-denatured ethanol until processing. Genomic DNA extraction and sequencing of the mitochondrial DNA control region (d-loop) was done following protocols reported in Alekseyev et al. (2009). Haplotype and nucleotide diversity were calculated using ARLEQUIN ver. 3.5.2.2 (Excoffier and Lischer, 2010). To assign specimens to species, DNA sequence data were analysed against internal laboratory char DNA sequences in addition to using the Basic Local Alignment Search Tool (BLAST) function in GenBank (https://www.ncbi.nlm.nih.gov/genbank/), the National Center for Biotechnology Information sequence database. Mitochondrial DNA control region sequences from Brunner et al. (2001), Alekseyev et al. (2009), Mochnacz et al. (2013), and Yamamoto et al. (2014) for species of the *Salvelinus* char complex collected in North America were used to identify the genetic lineage of ARR chars. To determine the evolutionary distance between a pair of mitochondrial DNA sequences, a phylogenetic tree was constructed using

a maximum-likelihood analysis. The most appropriate nucleotide substitution model to fit the DNA sequence dataset was determined in jModelTest 2.1.10 (Darriba et al., 2012). To estimate the reliability of the tree, a bootstrap test was performed by randomly resampling nucleotides with replacement in each sequence, reconstructing the tree using the same tree-building methods as before and then comparing inner branches of the reconstructed tree to the original. This process was repeated 1000 times and the percentage of instances where an inner branch from the reconstructed tree matched the original is represented by the bootstrap value (percentage consensus support). Phylogenetic trees and the bootstrap test were completed in the program MEGA ver. 10.1.6 (Kumar et al., 2018).

RESULTS

A total of 143 fish were captured during the field survey of 12 locations in the headwaters of the ARR (Fig. 1). Two Arctic grayling (*Thymallus arcticus*), 33 slimy sculpin (*Cottus cognatus*) and 108 Dolly Varden were captured and identified in the field. Four locations yielded no Dolly Varden; the remaining eight yielded three to 36 individuals (Table 1). Of the 108 total char captured, 44 were returned to Winnipeg to confirm their identity using the LDF equation and genetic assays (Table 1). Ray counts could not be obtained from three fish (one from ARRH08 and two from ARRH09), therefore, these fish were omitted from LDF analysis. Otoliths were collected from 38 of the 44 char. The median age was 3 years and ranged from young-of-the-year (age 0) to age 7 (Table 1).

All char had LDF scores lower than 0, which indicates that these fish were Dolly Varden. LDF scores for Dolly Varden found in the ARR watershed ranged from −6.66 to −1.03, which were similar to LDF scores for Dolly Varden found in the Gayna River (Fig. 3).

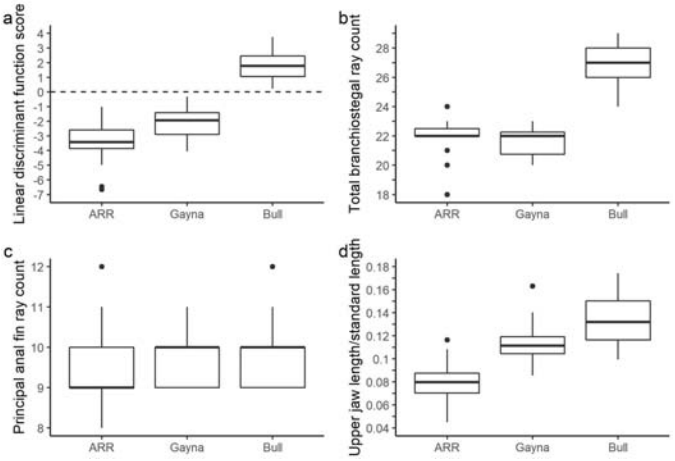

FIG. 3. Comparison of morphometric measurements and meristic counts used in the linear discriminant function (LDF) analysis for Dolly Varden from the Arctic Red River (ARR) collected in this study (n = 41), northern form Dolly Varden from the Gayna River (Gayna; n = 12), and bull trout (Bull) from various locations in the Northwest Territories (n = 67). For each box, the median value (heavy bar), interquartile range (box), 1.5*interquartile range (vertical lines), and outliers (dots) are shown.

Sequencing of the mitochondrial DNA control region resulted in the generation of a 487 base pair (bp) sequence for all samples. A total of nine nucleotide positions were polymorphic accounting for the detection of four haplotypes (Table 2). Haplotypes ARRdv09A, ARRdv09E, and ARRdv30B (GenBank accession numbers MT441558, MT441559, MT441560, respectively) appeared in 43 of the 44 sequenced samples. These three haplotypes differed from each other by 1–2 (0.2%–0.4%) nucleotide polymorphisms. Haplotype ARRdv48A occurred in a single fish collected at location ARRH06 and differed from all other haplotypes by 7–9 (1.4%–1.8%) nucleotide polymorphisms. Haplotype ARRdv09A was the most common haplotype, occurring in 77% of char and present at all sampling locations. Locations ARRH04 and ARRH09 contained two haplotypes, ARRH06 showed the greatest

TABLE 2. Mitochondrial DNA (mtDNA) haplotypes observed for char collected in the Arctic Red River. Haplotype sequence equivalents (corresponding to the 487bp DNA fragment generated in this study) from North American Dolly Varden analyzed in other studies are: ARRdv09A= BER18[1], BER19[1], SM28[2], SM53[2], BER12[3], BERING07[4] and BERING08[4]; ARRdv09E = BER15[1] and SM57[2]; ARRdv30B = BER16[1] and SM43[2]; ARRdv48A = ARC34[1] and SM58[2].

Location	Number of DVCH with mtDNA haplotypes				Diversity ± SD	
	ARRdv09A	ARRdv09E	ARRdv30B	ARRdv48A	haplotype	nucleotide
ARRH01	4	–	–	–	0	0
ARRH03	3	–	–	–	0	0
ARRH04	2	–	6	–	0.4286 ± 0.1687	0.001764 ± 0.001567
ARRH05	6	–	–	–	0	0
ARRH06	3	1	–	1	0.7000 ± 0.2184	0.006584 ± 0.004688
ARRH08	6	–	–	–	0	0
ARRH09	10	2	–	–	0.3030 ± 0.1475	0.000624 ± 0.000780

[1] Haplotypes taken from GenBank. Originally published in Moore et al. (2015).
[2] Haplotypes taken from GenBank. Originally published in Yamamoto et al. (2014).
[3] Haplotype taken from GenBank. Originally published in Alekseyev et al. (2009).
[4] Haplotypes taken from GenBank. Originally published in Brunner et al. (2001).

diversity with three haplotypes observed among five individuals, and the remaining four locations had only a single haplotype present (Table 2). BLAST searches of the 487 bp DNA fragment revealed that haplotypes in this study matched sequences associated with Dolly Varden haplotypes reported in other studies (Table 2). The maximum-likelihood tree was constructed using the TrN+I+G nucleotide substitution model fit using a gamma distribution with invariant sites (Tamura and Nei, 1993) and grouped haplotype ARRdv48A with sequences identified to be from both *S. malma* and Arctic char (*S. alpinus*) (Fig. 4).

DISCUSSION

Dolly Varden populations occur in the Peel and Gayna River watersheds of the Yukon and Northwest Territories, respectively; however, there is an area of uncertain distribution to the east and north of these areas (Mochnacz et al., 2013). We show that Dolly Varden are present in the upper ARR, Cranswick River, and associated tributaries, thus extending the known range of this species approximately 450 km south and 100 km east in the southeast portion of the range.

Genetic results indicate that of the 44 samples analysed, 43 possess a haplotype (ARRdv09A, ARRdv09E, ARRdv30B) common in Dolly Varden from the Northwest Territories and Yukon Territory (R. Bajno, unpubl. data), and grouped with haplotypes belonging to the Bering lineage (Brunner et al., 2001) and Central lineage (Yamamoto et al., 2014). A single haplotype (ARRdv48A) found in specimens identified as Dolly Varden appears to rarely occur in North America. Haplotype ARRdv48A matched two sequences previously reported for *Salvelinus* collected in North America: ARC34 (Moore et al., 2015, GenBank accession number KR011245) and SM58 (Yamamoto et al., 2014, GenBank accession number AB684835). These previously documented sequences were from *S. malma* from the Anaktuvuk River in Alaska's North Slope and the Noatak River in northwestern Alaska, respectively. Haplotype ARRdv48A has also been identified in two char from the Yukon North Slope, Canada, and three char from the Seward Peninsula, Alaska (R. Bajno, unpubl. data). Although these haplotypes were obtained from Dolly Varden, phylogenetic analyses suggest they belong to an *S. alpinus* lineage and may represent introgressed individuals. Brunner et al. (2001), Yamamoto et al. (2014), and Moore et al. (2015) describe the phylogeography of chars in northwestern North America, and although those investigations attempted to identify the geographic boundaries of genetic and taxonomic lineages of char in Alaska and Canada, the scale of those studies did not include a broad assessment of char populations in the interior of Alaska, Yukon, and Northwest Territories. Building upon our work and further delineating the distribution of chars and the extent of overlapping lineages

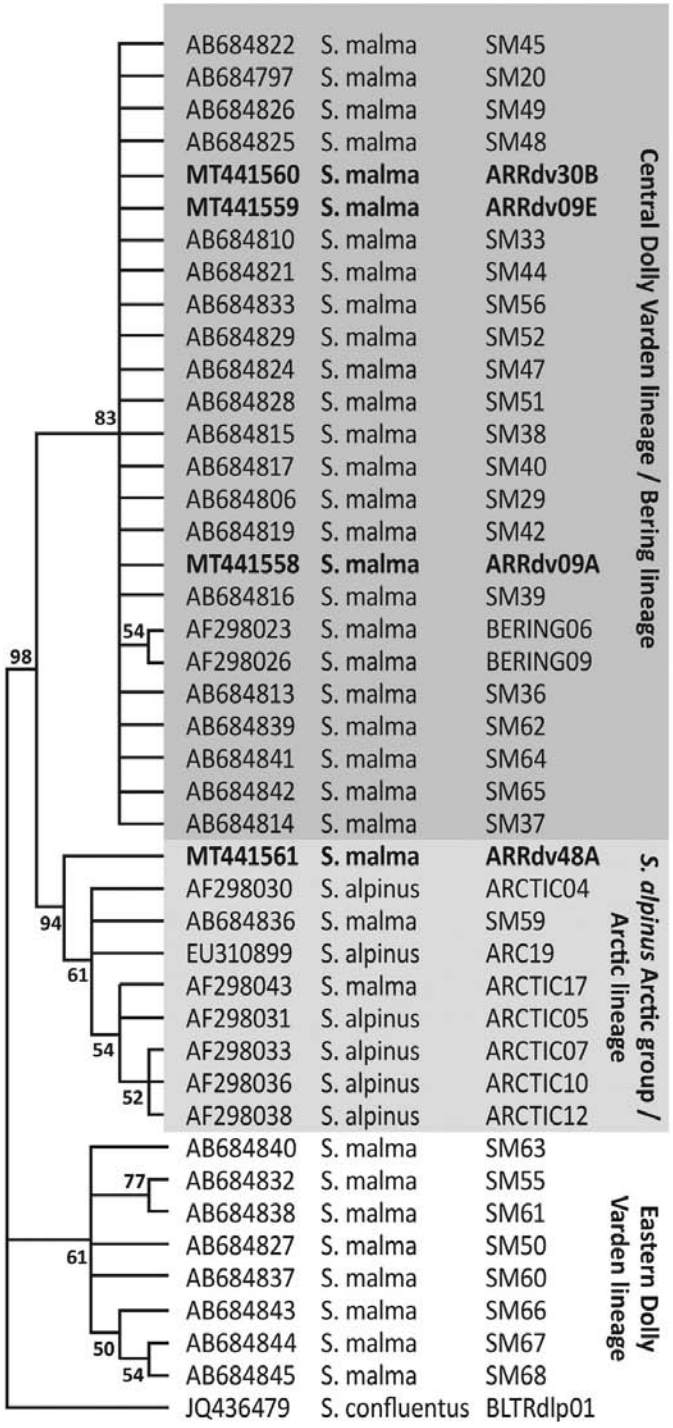

FIG. 4. Maximum-likelihood phylogenetic tree of select char haplotypes reported in the North American Arctic. A consensus tree constructed with branches of 50% or more bootstrap support is shown (numbers at the nodes indicate percentage consensus support). Mitochondrial DNA haplotypes identified in this study are shown in bold text. Accession numbers are provided for haplotypes retrieved from GenBank. Char lineages as discussed in the text are indicated. The tree is rooted with bull trout (*Salvelinus confluentus*).

of the *Salvelinus* complex would improve our understanding of the taxonomic status of chars in the region.

Additional surveys across a broader array of habitats would also improve our understanding of distribution, population size and structure, and life history diversity

of Dolly Varden found in this watershed, thus extending understanding of this taxon generally and contributing to its conservation and recovery (e.g., as outlined in the IFMP; DFO et al., 2019). Subsequent surveys should also include lacustrine habitats and focus on delineating spawning and overwintering habitats across this watershed. Previous studies have found that habitats with perennial groundwater inflows are often associated with spawning and overwintering habitat and are critical for the long-term persistence of populations of northern Dolly Varden (Mochnacz et al., 2010, 2020; Loewen et al., 2015; Dunmall et al., 2016). The field crew observed a significant number of potential groundwater sources throughout the ARR watershed as well as a large number of potential overwintering areas, including several lakes and the main stem of the Arctic Red, Orthogonal, and Cranswick Rivers. These observations suggest that essential habitat may be prevalent in the watershed.

Three life history types of northern Dolly Varden are known: anadromous, residual (or resident) co-occurring with anadromous fish but remaining in fresh water, and populations isolated by impassible falls or distance (Reist, 1989; Reist et al., 1997; Reist and Sawatzky, 2014; Loewen et al., 2015). Analyses of life history (e.g., otolith microchemistry, Loewen et al., 2015) were not conducted, however, given the distances involved in potential migrations and the presence of a 3 m waterfall located on the ARR downstream of our sampling sites (Howland et al., 2000), it is assumed at this time that Dolly Varden in the upper ARR basin are non-anadromous and isolated by distance. This assumption should be tested in future work (e.g., sampling of larger, older fish and microchemistry analyses of the larger fish from this study).

The expansion in known distribution to the ARR headwaters and the likely addition of one or more northern Dolly Varden populations are relevant to future assessments of the "at risk" status of this taxon. Similarly, refining the distribution, habitat usage, and life history details for additional populations of this species in watersheds radiating out from this central location, particularly the Rampart River, will also be important for understanding the level of population overlap (if any) and potential hybridization between Dolly Varden and related chars, such as bull trout. Such knowledge will be invaluable for informing future management and conservation actions for this species.

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