Ministère des Forêts, de la Faune et des Parcs

# Establishment of a reference state for the Arctic charr population of the Bérard River in Tasiujaq

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Québec

**Cover page photograph:**

Pascal Ouellet

**Photographs found in this report:**

Employees of the ministère des Forêts, de la Faune et des Parcs who participated in the research project

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# Highlights

The upstream migration of Bérard River Arctic charr was subject to monitoring to establish its reference state. A total of 1,823 anadromous Arctic charrs were recorded at the counting fence from August 8 to September 8, 2017, of which 83 were randomly selected during this period to characterize different biological parameters.

- Fulton's condition factor (K) of Arctic charr sampled from the Bérard River is considered as "good" with a mean K value (± standard deviation) of 1.28 ± 0.19 in a sample of 73 individuals.
- The proportion of current-year spawners was low among sampled Arctic charr five years and older, with only 8.1% of females (*n* = 37) and 16.1% of males (*n* = 21) observed to have mature gonads.
- The annual total mortality calculated from the age structure data was estimated at 50.4 ± 4.5%, i.e. a value evaluated as "moderate" to "high" when compared with those of other Arctic charr populations.
- Mercury concentrations in sampled Arctic charr were lower than the 0.5 mg/kg threshold established by Health Canada.

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ᑰᒃᑯᑦ ᒪᔪᕐᐸᓪᓕᐊᓕᕐᑎᓪᓗᒋᑦ ᑕᓯᐅᔭᐅᑉ ᑰᖓᒍᑦ ᐃᖃᓗᑉᐲᑦ ᖃᐅᔨᓴᕐᑕᐅᓯᒪᒻᒪᑕ ᓇᓗᓇᒃᑯᓯᕐᑕᐅᑦᓱᑎᒃ ᖃᐅᔨᒪᔭᐅᒍᑎᒃᓴᖏᓐᓄᑦ. ᑲᑎᓪᒫᕐᓱᒋᑦ ᑭᓯᑦᑕᐅᓯᒪᔪᑦ 1,823 ᐃᖃᓗᑉᐲᑦ ᐱᒋᐊᕐᓱᑎᒃ ᐊᐅᒡᒍᓯ 8 ᓯᑎᐱᕆ 8-ᒧᑦ 2017-ᒥ, ᑖᒃᑯᓇᖕᖓᑦ 83 ᓂᕈᐊᕐᑕᐅᓚᐅᕐᑐᑦ ᓇᓗᓇᕐᑕᐅᓯᒪᓚᖓᑎᓪᓗᒋᑦ ᐊᑦᔨᒋᔭᐅᒍᓐᓂᑎᑕᐅᑦᓱᑎᒃ ᖃᐅᔨᒪᔭᐅᒍᑎᑦᓴᖏᓐᓄᑦ.

- Fulton's-ᑯᑦ ᓇᓗᓇᕆᓯᒪᕚᑦ (K) ᐃᖃᓗᑉᐱᓂᒃ ᖃᐅᔨᓴᕐᑕᐅᓯᒪᔫᓂᒃ ᑕᓯᐅᔭᐅᑉ ᑰᖓᓂ 'ᐱᐅᔫᓂᕋᐃᒍᑎᓂᒃ' ᑐᑭᓕᒃ k ᐅᑑᑎᖃᕐᑐᖅ (± ᐃᒣᑦᑐᒥᒃ ᓇᓗᓂᕐᓯᒪᐅᑎᓕᒃ) 1.28 ± 0.19 ᖃᐅᔨᓴᕐᑕᐅᓯᒪᔫᓄᑦ 73-ᓄᑦ.
- ᑕᒪᓂ ᐊᕐᕋᒍᒥ ᓱᕙᓖᑦ ᐊᒥᓲᓚᐅᖏᒻᒪᑕ ᖃᐅᔨᓴᕐᑕᐅᔫᓂᑦ ᐃᖃᓗᑉᐱᓐᓂᑦ ᐊᕐᕋᒎᓖᑦ ᑕᓪᓕᒪᓂᒃ ᐅᖓᑖᓄᓪᓗ, ᖃᐅᔨᔭᐅᓚᐅᕐᑐᑦ 1.8% ᖑᓚᐅᕐᐳᑦ ᐊᕐᓇᓂᑦ (*n* = 37) ᐊᒻᒪᓗ 16.1% ᖑᑎᓪᓗᒋᑦ ᐊᖑᑎᓂᑦ (*n* = 21) ᑕᑯᔭᐅᓚᐅᕐᑐᑦ ᐊᖑᑏᑦ ᖃᐯᔨᕿᓐᓇᓕᕐᑐᑦ ᓱᕚᔭᕐᑎᑦᓯᓗᑎᒃ.
- ᐊᕐᕋᒍᓕᒫᒥ ᐱᕈᓅᕐᓯᒪᔫᓇᑐᐃᑦ ᖃᐅᔨᓴᕐᑕᐅᓂᖏᑦᑎᒍᑦ ᐊᕐᕋᒍᖏᑦ ᒪᓕᓪᓗᒋᑦ ᓄᐊᑕᐅᓯᒪᔪᑎᒍᑦ ᐃᓱᒪᒋᔭᐅᓚᐅᕐᑐᑦ 50.4 + 4.5% ᑲᑎᑦᓱᒋᑦ ᓇᓗᓇᕐᑕᐅᓚᐅᕐᑐᑦ 'ᓈᒻᒪᒐᔭᕐᑐᐃᑦ' 'ᕐᑰᕂᓯᑦᑐᐃᑦ' ᖃᐅᔨᓴᕐᑕᐅᓯᒪᔪᑦ ᐊᓯᖏᓐᓂ ᐃᖃᓗᑉᐲᑦ ᐆᑦᑐᕋᐅᑎᒋᑦᓱᒋᑦ.
- ᓴᕕᕋᔭᒃᓴᖃᕐᓂᖏᑦ ᖃᐅᔨᓴᕐᑕᐅᓯᒪᓂᖏᑦᑎᒍᑦ ᐃᖃᓗᑉᐲᑦ ᑲᑎᖕᓂᖏᑎᒍᑦ ᐊᑉᐸᓯᓐᓂᓴᐅᓚᐅᕐᑐᑦ 0.5 mg/kg ᑲᓇᑕᒥ ᖃᓄᐃᖏᑦᓯᐊᕐᓂᓕᕆᔨᒃᑯᑎᒍᑦ.

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# Introduction

## Study context

Thanks to an agreement between the Société du Plan Nord and the ministère des Forêts, de la Faune et des Parcs (MFFP), projects designed to establish reference states of fish populations and their habitats have been carried out in various regions within the territory covered by the Plan Nord (Côte-Nord, Saguenay–Lac-Saint-Jean and Nord-du-Québec) prior to any new or any additional development that is anthropic in origin. Given the importance of the Arctic charr (*Salvelinus alpinus*) for Inuit communities, the reference states of fish populations in Nunavik are principally focused on this species and associated habitats, although other salmonid populations are also taken into consideration.

## Overall objective

Acquire an understanding of the anadromous Arctic charr in the Bérard River in Tasiujaq.

## Specific objectives

Acquire a detailed understanding of the anadromous Arctic charr population in the Bérard River during the upstream migration period:

- Estimate the abundance of the anadromous Arctic charr population using a temporary counting fence;

- Characterize a sample of the Arctic charr population by determining age and obtaining morphometric measurements as well as other biological parameters;

- Determine contaminant concentrations in the Arctic charr sampled.

# Material and methods

## Counting fence

A temporary counting fence (Figure 1) was installed on the Bérard River and remained there from August 8 to September 8, 2017. The two wings of the fence were composed of tripods made of steel tubes with lengths of 6, 9 or 12 feet. A steel grill was attached to the tripods to create an impassible barrier. A retention cage, which allowed Arctic charr to be captured during their run, was used to count individuals of the species. The retention cage (Figure 2), located at the apex of the V formed by the two wings of the barrier, was the only place where the Arctic charr can cross the fence. The cage was visited many times each day to verify if Arctic charr had been captured. Water level and temperature were noted at each visit.

**Figure 1. Counting fence used to monitor Arctic charr during upstream migration in August and September 2017 on the Bérard River, in Tasiujaq, Nunavik. A canoe (visible in the photo) provided access to the retention cage from the riverbank. A tent, also visible in the photo, was used to protect the temporary laboratory.**

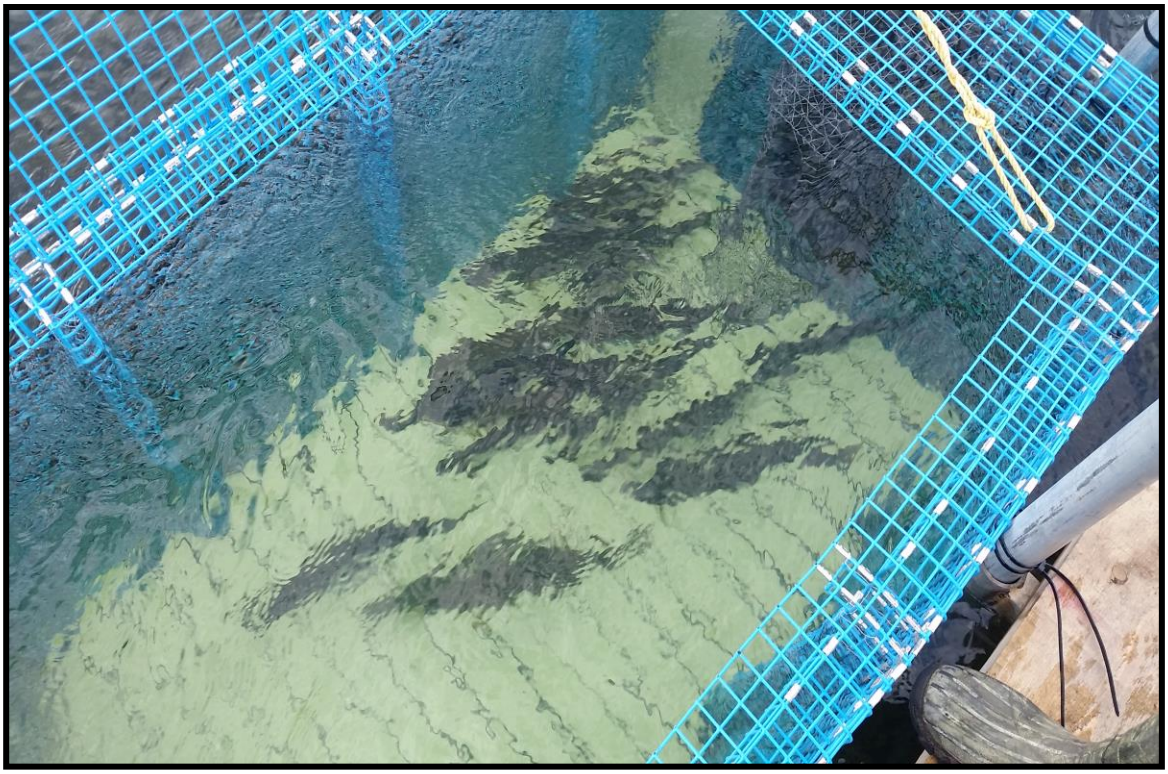

**Figure 2. Arctic charrs captured in the retention cage.**

## Measurements and sampling

Fish captured in the retention cage were identified by species, measured for total length using a measurement board installed on the cage and released upstream of the barrier to allow them to continue their run. All fish selected at random in the retention cage were brought to the temporary laboratory installed near the river (Figure 1) to be measured and weighed and for certain samples to be taken.

**Figure 3. An Arctic charr randomly selected from the retention cage prior to its necropsy. The individual was measured (to the nearest millimeter) and weighed (to the nearest 0.1 g) prior to sampling and determination of sex by opening the abdominal cavity.**

The maximum total length, total length and fork length of the Arctic charr sampled were measured using a ruler (± 1 mm, Figure 3), and their mass was determined by using an electronic scale (O'Haus, Valor 3000 model, ± 0.1 g). Then, the abdominal cavity of each fish was opened using a fillet knife, starting from the urogenital opening and reaching the base of the operculum to identify the sex of the individual. The status of the gonads was then categorized as either mature or immature (i.e. classified as mature if they are fully developed, otherwise classified as immature). Stomach contents were then described using general categories for insects, small fish and crustaceans. Some stomach samples were stored in 95% ethanol for more specific identification in the MFFP central office laboratory. The adipose fin was harvested and kept in 95% ethanol for genetic analysis in the Université Laval laboratory of Prof. Jean-Sébastien Moore. A muscle sample (~ 100 g) was also removed from one side (laterally, behind the dorsal fin) and placed in a "Ziploc" type resistant plastic bag and then inserted into a second plastic bag in which an identification tag was placed. The sample was then frozen (-20 °C) for future contaminant analyses at the ministère de l'Environnement et de la Lutte contre les changements climatiques (MELCC) laboratory. The muscle samples were individually analyzed for mercury, while homogenates of 2 to 7 individuals of a same size class for a given species (Table 1) were analyzed for the other contaminants under study (*n* = 18).

**Table 1. Length classes (mm) used for the Arctic charr and brook trout for contaminant analysis by the MELCC (2017) were the same. Fork length was the measure used to assign length classes.**

| Small | Medium | Large |
|---|---|---|
| 150–300 | 301–400 | > 400 |

As a final stage, otoliths were removed and preserved in Eppendorf tubes to determine age. All sacrificed fish were brought to the Tasiujaq community freezer after measurements and samples removal, as agreed upon with the Hunting, Fishing and Trapping Coordinating Committee, the Arqivik LHC of Tasiujaq and the Local Nunavimmi Umajulirijiit Katujjiqatigiinninga (LNUK).

The Fulton condition factor (K) was used to relate mass to length following the equation developed by Neumann et al. (2012):

$K = (M/L^3) \times 100{,}000$, where M = mass (g) and L = fork length (mm)

Fork length was used to calculate the condition factor because this measurement has been used in almost all studies on the Arctic charr, thus allowing comparisons with other populations. Generally, the condition factor of an Arctic charr is considered “good” when higher than 1 ($K > 1$), “acceptable” when close to 1 ($K \approx 1$) and “poor” when lower than 1 ($K < 1$).

Since the team measured fork length, total length and maximum total length for each Arctic charr sampled, a chart to convert a given length to another is presented in the appendix (Table 4), in addition to a graphic example showing the correlation between two length measurements (Figure 10).

# Results

## Counting fence

At the time of installation of the counting fence, which became operational on August 8, 2017, some Arctic charr were observed by the field team, indicating that the migration had already started. In all, a total of 1,823 anadromous Arctic charr were captured in the retention cage (Figure 4). The barrier was in operation until September 8, 2017, and then dismantled prior to the end of the upstream migration, at the request of the LNUK and Makivik Corporation. Some brook trout (*n* = 218), Longnose sucker (*n* = 3) and Atlantic salmon (*n* = 2) were also captured in the retention cage during the time the barrier was installed. The water level and temperature recorded daily at the counting fence are presented in Figures 5 and 6.

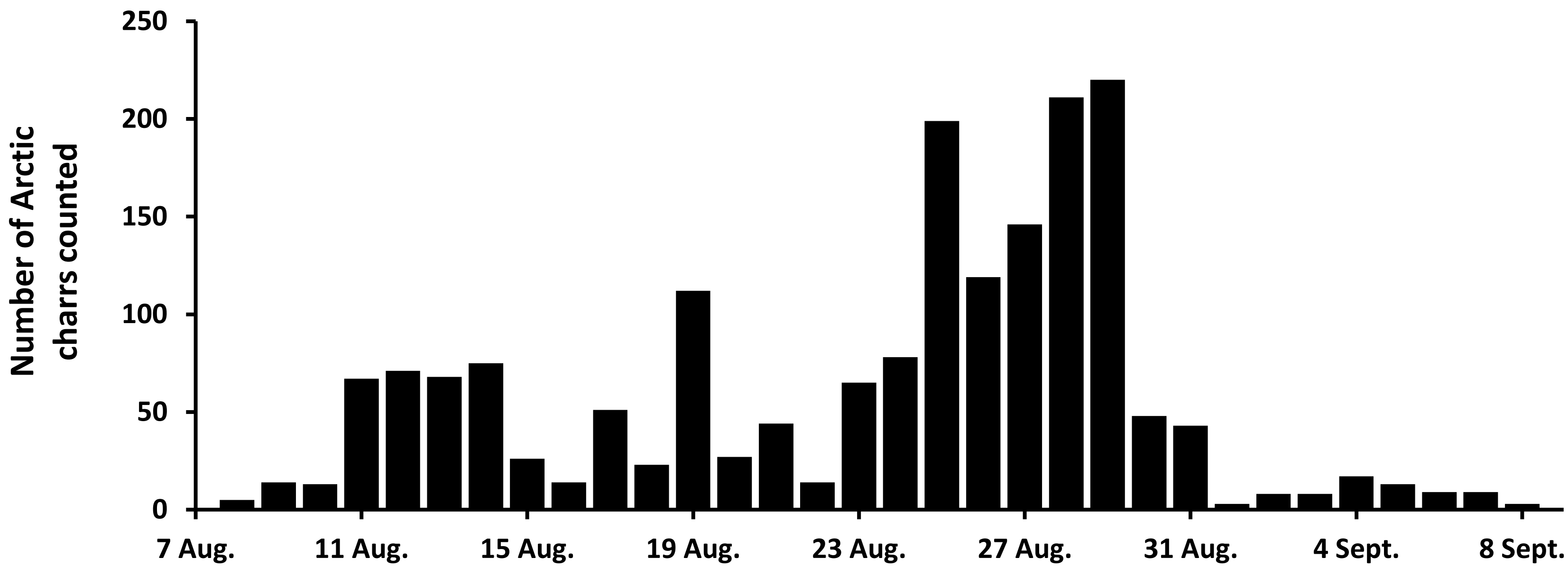


**Figure 4. Number of anadromous Arctic charrs monitored on a daily basis with the counting fence installed on the Bérard River in Tasiujaq, Nunavik, from August 8 to September 8, 2017.**

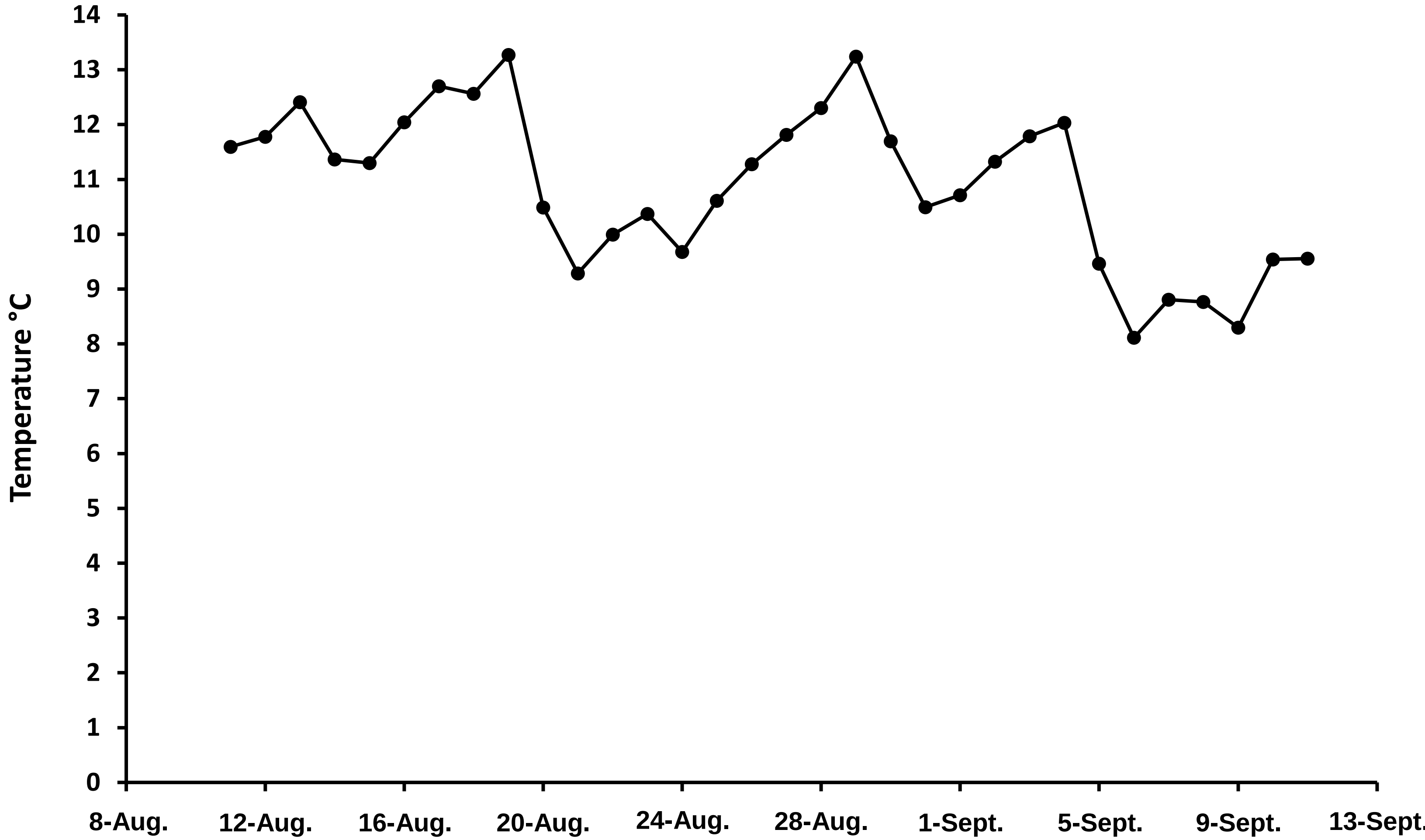


**Figure 5. Variations in water temperature in the Bérard River at the counting fence (at Tasiujaq, Nunavik) from August 11 to September 11, 2017. Points represent the daily mean water temperature according to the hourly records (*n* = 24/day) made with a thermograph (*Tidbit v2*, ± 0.2 °C).**

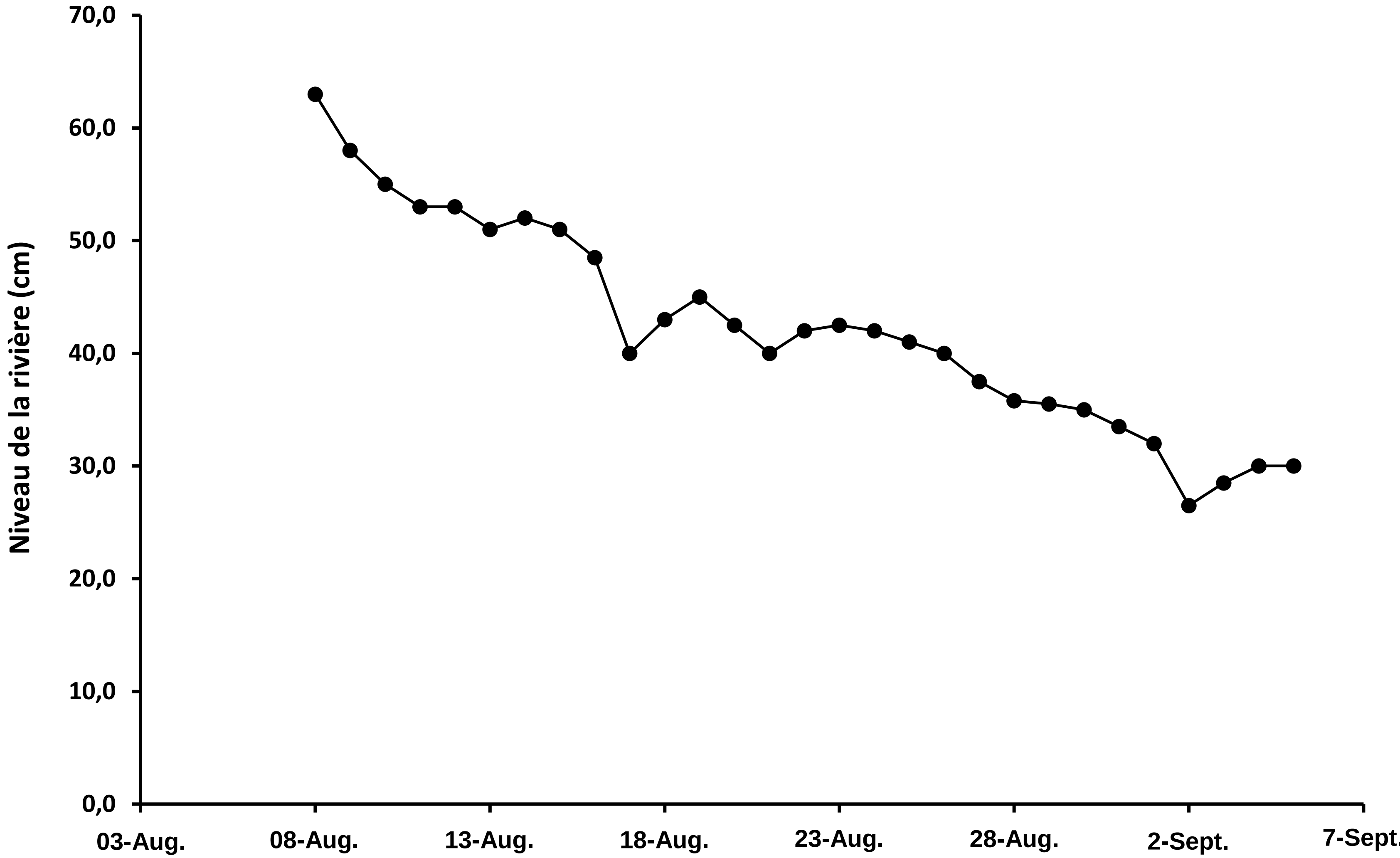


**Figure 6. Variations in water level in the Bérard River at the counting fence (at Tasiujaq, Nunavik) from August 11 to September 11, 2017.**

## Biological parameters of sampled fish

The frequency distribution of total length is presented in Figure 7 for all Arctic charr monitored at the counting fence (*n* = 1,823). The mean total length of Arctic charr measured at the counting fence was 470 ± 94 mm (18 ½”), with a range from 245 (9 ⅝”) to 900 mm (35 ⅜”), and a modal value (most frequent length) of 400 mm (15 ¾”). Large individuals (≥ 600 mm or ≥ 23 ⅝”) represented 9.1% of individuals monitored at the counting fence.

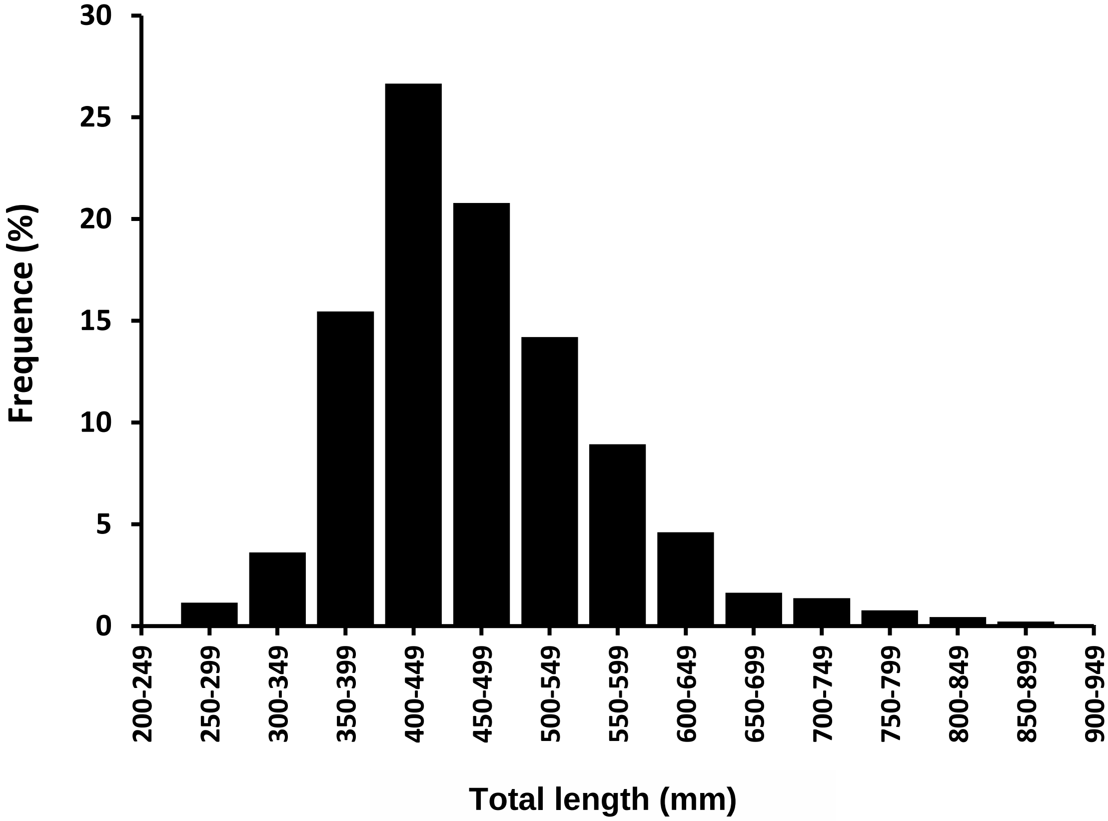


**Figure 7. Total length frequency distribution, in 50 mm (≈ 2”) categories, of anadromous Arctic charr captured in the retention cage of the counting fence installed on the Bérard River in Tasiujaq, Nunavik, from August 8 to September 8, 2017. Total length is approximate, often ± 5 mm, because the measurement was made while the Arctic charr were in the net. A 245 mm and a 900 mm Arctic charr were captured, but they do not appear on the graph because their frequency was only 0.05%.**

## Arctic charr condition factor

The condition factor (K) of Arctic charr in the Bérard River averaged 1.28 with a standard deviation of 0.19. Only two individuals (3%) of the 73 analysed had a K-value < 1.

## Sex ratio and gonad maturity in Arctic charr sampled

The overall sex ratio (number of females [F] per male [M]) among sampled Arctic charr in the Bérard River was 1.13:1. Among a total of 83 Arctic charr (44 F, 39 M) analyzed, 10.8% of individuals had mature gonads. Maturity of gonads among females (Figures 8 and 9) was weak (6.8%) and appeared to be lower than in males (15.4%). Among the few individuals sampled who were current-year spawners (*n* = 9), three were females (all 6 years old) and six were males, aged from 4 to 7 years. Limiting the descriptive statistical analysis to individuals 5 years and older, the proportion of Arctic charr with mature gonads was 8.1% among females (n = 37) and 19.2% of males (*n* = 26).

**Figure 8. Sampled female Arctic charr with mature gonads.**

**Figure 9. Sampled female Arctic charr with immature gonads.**

## Age class structure and annual mortality

Among the Arctic charr randomly sacrificed at the counting barrier (*n* = 83), the age structure was established in a graph (Figure 9) to permit the calculation of total annual mortality (**A**) according to the maximum likelihood survival estimator (S) of Robson and Chapman (1961). Since very few individuals of an advanced age (> 8 years) were captured, the Robson and Chapman estimator (1961) was used because it is preferable to other models based on the catch curve, such as those based on the instantaneous mortality rate (Z), because age classes with few individuals (< 5) for a given site can bias the regression curve, and, consequently, the **A** estimate. Although the Robson and Chapman estimator was used for our analyses due to its robustness, we also calculated the Z-derived **A**, but only using the data from consecutive age classes for which at least two individuals were sampled (since a count of 1, once transformed into a log-normal scale, is equal to zero) to permit a comparison between these two methods. See Miranda and Bettoli (2007) for more details.

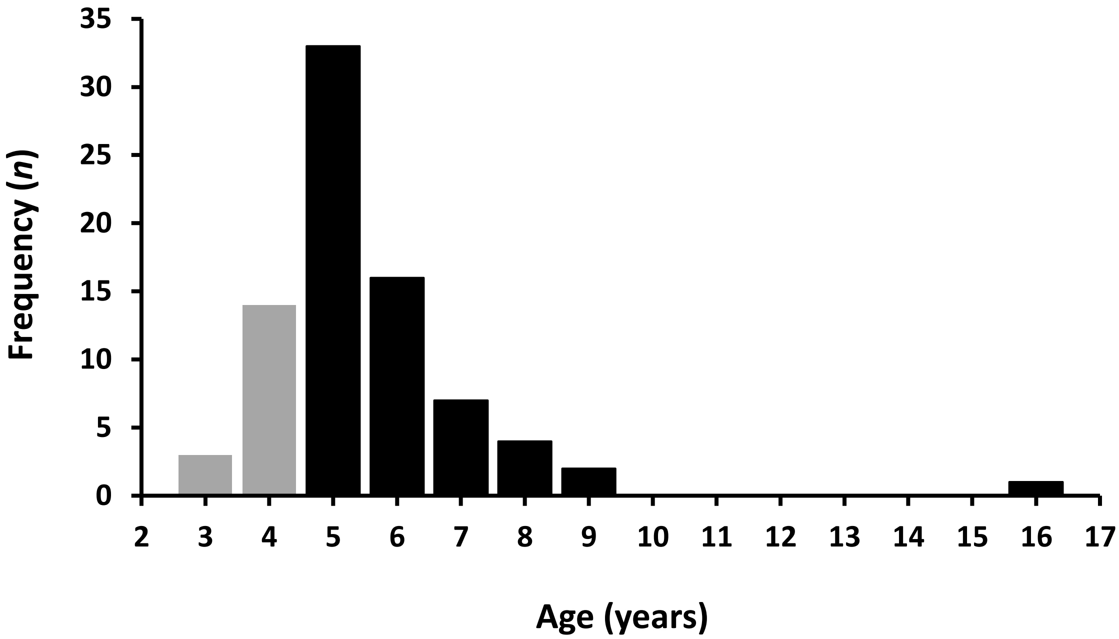


**Figure 10. Age structure of Arctic charr sampled at the Bérard River counting barrier. Age classes fully recruited by the fishing equipment are indicated in black, while those partially recruited by fishing equipment appear in grey.**

According to the Robson and Chapman (1961) survival estimator (S), annual mortality (**A** = 1-S) among Arctic charr was (± standard error) 50.4 ± 4.5% for the Bérard River. Using another method (instantaneous mortality Z converted into **A** from a catch curve), the parameter **A** would instead be estimated to be 50.3%, i.e. a value practically identical to that obtained with the Robson and Chapman method (1961). Estimating mortality from an age curve requires that certain premises are respected:

- Exact age: each fish in the sample can be accurately assigned to an age. In longitudinal data, this means that a cohort can be monitored over time;
- Constant recruitment: the initial number of individuals is the same for each fish cohort, or, at least, observed variations do not show trends over time;
- Constant mortality: the total instantaneous mortality rate is independent of age or year (i.e. constant) for ages associated with the age curve descending slope;
- Constant vulnerability: fish vulnerability to fishing, for ages associated with the curve descending slope, is independent of age and year (i.e. constant).

While we believe that these premises are to a great extent respected for the sample used, in reality it is not possible to be completely certain. Mortality analyses were still done to provide estimates based on available information.

Inspection of Figure 10 indicates that only 8.75% of sampled individuals were 8 years or older among those for which an age could be determined (*n* = 80).

## Contaminants

For mercury concentration, in total 83 Arctic charr and 12 brook trout were analyzed individually. Mean mercury concentrations for Arctic charr were 0.04 mg/kg in the Bérard River for each size class considered and varied from 0.11 to 0.28 mg/kg depending on the size class for brook trout (Table 2). These values are lower than the maximum concentration of 0.5 mg/kg for mercury in the edible parts of fish (Health Canada). Eighteen other contaminants (metals) were analyzed in total and concentrations obtained are presented in Table 3, according to species and size class (Table 1), although these values were obtained from homogenates (i.e. a mixture of 2 to 7 individuals to obtain only one concentration value).

**Table 2. Mercury concentrations (Hg; mean ± standard deviation) in Arctic charr and brook char as a function of length class considered, in Tasiujaq, Nunavik, in 2017.**

| Species | Length class[2] | Hg (mg/kg) | *n* |
|---|---|---|---|
| Arctic charr | Small | 0.04 ± 0.01 | 2 |
| Arctic charr | Medium | 0.04 ± 0.01 | 15 |
| Arctic charr | Large | 0.04 ± 0.02 | 66 |
| Brook trout | Small | 0.11 ± 0.03 | 3 |
| Brook trout | Medium | 0.12 ± 0.03 | 7 |
| Brook trout | Large | 0.28 ± 0.23 | 2 |

[2] Length classes by species are those presented in Table 1.

**Table 3. Contaminant concentrations[3] (mg/kg) in Arctic charr and brook trout as a function of length class, in Tasiujaq, Nunavik, in 2017. One value is presented per length class and was generated by a homogenate of 2 to 7 individuals per length class.**

| **Species** | Length class[4] | ***n*** | Al | As | Ba | Cd | Cr | Co | Cu | Fe | Mn | Mo | Ni | Pb | Se | Sr | Tl | U | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arctic charr | M | 5 | 0.5 | 0.22 | 0.031 | 0.02 | 0.007 | 0.005 | 0.47 | 5.4 | 0.08 | 0.001 | 0.007 | 0.002 | 0.31 | 0.09 | 0.002 | 0.001 | 0.02 | 5.7 |
| Arctic charr | M | 5 | 0.5 | 0.33 | 0.006 | 0.02 | 0.007 | 0.003 | 0.37 | 2.8 | 0.05 | 0.001 | 0.006 | 0.002 | 0.27 | 0.07 | 0.001 | 0.001 | 0.02 | 3.9 |
| Arctic charr | M | 5 | 0.5 | 0.54 | 0.012 | 0.02 | 0.007 | 0.005 | 0.49 | 4.2 | 0.08 | 0.001 | 0.006 | 0.002 | 0.30 | 0.09 | 0.001 | 0.001 | 0.02 | 5.1 |
| Arctic charr | L | 5 | 0.5 | 0.41 | 0.009 | 0.02 | 0.007 | 0.003 | 0.45 | 3.3 | 0.06 | 0.001 | 0.006 | 0.002 | 0.29 | 0.07 | 0.001 | 0.001 | 0.02 | 4.5 |
| Arctic charr | L | 5 | 0.5 | 0.46 | 0.006 | 0.02 | 0.007 | 0.002 | 0.44 | 3.2 | 0.05 | 0.001 | 0.006 | 0.002 | 0.26 | 0.07 | 0.001 | 0.001 | 0.02 | 4.5 |
| Arctic charr | L | 5 | 0.5 | 0.58 | 0.007 | 0.02 | 0.007 | 0.004 | 0.52 | 3.7 | 0.06 | 0.002 | 0.006 | 0.002 | 0.32 | 0.07 | 0.001 | 0.001 | 0.02 | 4.8 |
| Arctic charr | L | 5 | 2.0 | 0.51 | 0.010 | 0.02 | 0.007 | 0.005 | 0.82 | 5.0 | 0.07 | 0.001 | 0.006 | 0.002 | 0.32 | 0.07 | 0.001 | 0.001 | 0.02 | 4.9 |
| Arctic charr | L | 5 | 0.5 | 0.61 | 0.013 | 0.02 | 0.007 | 0.004 | 0.52 | 3.8 | 0.05 | 0.001 | 0.006 | 0.002 | 0.27 | 0.07 | 0.001 | 0.001 | 0.02 | 4.3 |
| Arctic charr | L | 5 | 0.8 | 0.52 | 0.007 | 0.02 | 0.007 | 0.004 | 0.49 | 3.3 | 0.05 | 0.001 | 0.006 | 0.002 | 0.30 | 0.07 | 0.001 | 0.001 | 0.02 | 4.3 |
| Arctic charr | L | 5 | 0.5 | 0.53 | 0.007 | 0.02 | 0.007 | 0.003 | 0.43 | 3.2 | 0.05 | 0.001 | 0.006 | 0.002 | 0.30 | 0.07 | 0.001 | 0.001 | 0.02 | 4.2 |
| Arctic charr | L | 5 | 0.5 | 0.59 | 0.007 | 0.02 | 0.007 | 0.003 | 0.43 | 3.3 | 0.05 | 0.001 | 0.006 | 0.002 | 0.31 | 0.07 | 0.001 | 0.001 | 0.02 | 4.4 |
| Arctic charr | L | 5 | 0.5 | 0.75 | 0.009 | 0.02 | 0.016 | 0.002 | 0.54 | 5.9 | 0.06 | 0.001 | 0.011 | 0.002 | 0.34 | 0.07 | 0.001 | 0.001 | 0.02 | 4.7 |
| Brook trout | S | 3 | 0.5 | 0.06 | 0.012 | 0.02 | 0.007 | 0.009 | 0.42 | 4.5 | 0.08 | 0.002 | 0.006 | 0.002 | 0.35 | 0.07 | 0.002 | 0.001 | 0.02 | 4.0 |
| Brook trout | M | 7 | 0.5 | 0.07 | 0.016 | 0.02 | 0.007 | 0.007 | 0.31 | 3.3 | 0.16 | 0.001 | 0.007 | 0.002 | 0.36 | 0.16 | 0.003 | 0.001 | 0.02 | 3.8 |
| Brook trout | L | 2 | 0.5 | 0.12 | 0.008 | 0.02 | 0.007 | 0.005 | 0.32 | 3.5 | 0.04 | 0.001 | 0.006 | 0.002 | 0.30 | 0.07 | 0.003 | 0.001 | 0.02 | 3.5 |

[3] Al: Aluminum; As: Arsenic; Ba: Barium; Ca: Cadmium; Cr: Chrome; Co: Cobalt; Cu: Copper; Fe: Iron; Ma: Manganese; Mo: Molybdenum; Ni: Nickel; Pb: Lead; Se: Selenium; Sr: Strontium; Tl: Thallium; U: Uranium; V: Vanadium; Z: Zinc.
[4] Length classes: M = Medium; L = Large; see Table 1 for classes according to species.

# Discussion

Sampling of the Bérard River allowed us to complete a detailed study of the biology of Arctic charr. All this information, together, constitutes a reference state with regard to the Arctic charr condition factor, its annual mortality, reproduction and contamination by various metals, including mercury, in the Bérard River system. However, given that the study was only carried out during one summer (no longitudinal data), results must be interpreted only as a partial representation of the Arctic charr population studied. In other words, this information may be useful if anthropogenic development occurs, with potential impact on the Bérard River. In the following sections, the main results of the study on the Tasiujaq Arctic charr are interpreted according to available literature.

## Monitoring of the Arctic charr and the counting fence

A total of 1,823 Arctic charr were recorded from August 8 to September 8, 2017, but more individuals would have been counted if the barrier had been in place from the start of the upstream migration until its end. Consequently, it was not possible to determine an exact number of Arctic charr that use the Bérard system in Tasiujaq in 2017. Data collected at the counting fence however allowed the quantification of useful biological parameters, from condition factors to annual total mortality estimates deduced from age structure data.

## Arctic charr condition factor

Most of the fish sampled had a condition factor ranging from “acceptable” to “good.” Overall the condition factor of sampled Arctic charr in the Tasiujaq sector (K = 1.28) was similar or superior when compared to other values in the literature. For example, in Cambridge Bay, Nunavut, Moore et al. (2016) reported a mean K value of 1.02 ± 0.14 in resident Arctic charr and 1.06 ± 0.08 in non-resident Arctic charr, while in the Hornaday River in Paulatuk, Northwest Territories, Harwood (2009) reported an annual mean K of 1.24 (range: 1.15–1.38). In Nunavik, Boivin (1994) reported that the condition factor of Arctic charr captured in the Sapukkait system north of the community of Kangiqsualujjuaq had a mean of 1.11, 1.08 and 1.11 in 1990, 1991 and 1992, respectively. In 2016, Arctic charr captured in the rivers and lakes located near Aupaluk had a mean condition factor of 1.22 (Mainguy and Beaupré 2019), i.e. a value similar to that observed at Tasiujaq. Thus, it can be concluded that Arctic charr sampled in the Tasiujaq region were similar or above the mean condition factor of other Arctic charr populations. Given these results, it is likely that the majority of Arctic charr captured in the Bérard River of Tasiujaq were able to obtain the resources required to maintain a good condition factor.

## Reproduction of the Arctic charr

Among the Arctic charr sampled at Tasiujaq, few individuals were found to be current-year spawners. This situation was also observed elsewhere in Nunavik, e.g. in the Sapukkait system where Boivin (1994) reported that only 0.9% of 1,839 Arctic charr randomly sampled at the counting fence during the upstream migration (between 1990 and 1992) had mature gonads. These data related to reproduction indicate that there may be a long reproductive periodicity among Arctic charr in Ungava Bay, i.e. that most Arctic charr do not reproduce each year and may possibly skip more than one year. Moreover, Boivin (1994) reported that for the major portion of Arctic charr in the Sapukkait and Sannirarsiq systems (north of Kangiqsualujjuaq), the first reproduction event could arise when they reach 8 to 10 years. At Aupaluk in 2016, the proportion of current-year spawners was 5.6% in females and 1.9% in males among individuals aged 5 years or older (Mainguy and Beaupré, 2019). In the Tasiujaq region, individuals identified as current-year spawners were aged from 4 to 7 years. Of the Arctic charr sampled in the Bérard River for which an age could be determined (*n* = 80), only 8.8% were ≥ 8 years. For comparison purposes, at Aupaluk in 2016, this percentage was 7.5% (*n* = 280; Mainguy and Beaupré, 2019). While age at sexual maturity remains unknown for Tasiujaq Arctic charr, due to the low numbers of current-year spawners sampled, it is probable that it would have the same age range as Arctic charr in the Sapukkait system, i.e. from 8 to 10 years, even if a few males may have mature gonads from the age of 4. Therefore, it is possible that an undetermined number of Arctic charrs of both sexes may not be able to survive long enough to reach the age of maturity, thereby reducing the number of potential spawners in the system.

## Annual mortality of Arctic charr

An annual mortality (**A**) estimated at approximately 50% among Tasiujaq Arctic charr is considered as being from "moderate" to "high" and, therefore, of concern, but still similar to that of other populations fished in northern communities such as the Arctic charr of the Hornaday River, in Paulatuk, Northwest Territories, where Arctic charr aged between 6 and 14 years had a mean annual **A** (± standard deviation) of 53.8 ± 9.8% (range: 35.4–70.7% over an 18-year period, 1990-2007; Harwood 2009). In the Isuituq River, near Pangnirtung, on Baffin Island, Nunavut, Arctic charr aged from 11 to 21 years had a mean annual **A** of 34.5 ± 9.5% (range: 24–49% for a 6 year period, 2002–2006 and 2008, DFO 2010). In the Cumberland Sound region of Baffin Island, Nunavut, Moore (1975) estimated that mean annual mortality was 16.0%, with the highest values (25–30%) observed in ages 10 and 15–17 years. In the Kuujjua River, on Victoria Island, Northwest Territories, Harwood et al. (2013) reported a mean annual **A** of 45% (confidence interval: 42–48%) between 1992 and 2009. In Labrador, Dempson and Green (1987) estimated an annual mortality of 44–49% in the Fraser River. In Nunavik, Boivin (1994) estimated the annual mortality at 28% in 1990 and at 40% in 1992 in the Sapukkait system. In Aupaluk, in 2016, the estimated annual mortality in two rivers and the Hopes Advance Bay varied between 47 and 52% (Mainguy and Beaupré, 2019), i.e. values quite similar to those found at Tasiujaq in 2017. Power et al. (2008) reviewed the literature on annual mortality estimates in Canadian anadromous and lacustrine Arctic charr populations aged 6 to 15 years. The principal result was that **A** generally had a value located in a 30–45% range, although they also noted that some populations presented rates below 25%. When considering all these data, it appears that Tasiujaq Arctic charr are located in the higher range of **A**, which can be interpreted as being of concern for the demographic stability of this population.

## Contaminants found in Arctic charr

According to results obtained by MELCC, Arctic charr sampled in the Bérard River had mercury concentrations that were below the threshold recommended by Health Canada (0.5 mg/kg). For any question on consumption of fish related to mercury and other contaminants, refer to the local, provincial or federal health agencies. Regarding contaminant concentrations presented in Table 3, these are provided as reference data for the fish sampled during this study. Any interpretation of these results from a public health perspective must be done with the help of health experts.

# Conclusion

Arctic charr sampled near the community of Tasiujaq had, in general, a good condition factor and presented low mercury concentrations, which is interpreted as being good indicators of the health status of this population. However, the proportion of current-year spawners, as well as that of Arctic charr 8 years or older, were low, with an annual mortality of 50%. Given that Boivin (1994) previously reported that Arctic charr of another system in the Ungava Bay (i.e. Sapukkait) did not reach sexual maturity before the age of 8 to 10 years, which corresponds to fork lengths ranging from 51.4 to 62.0 cm (20 ¼ to 24 ⅜") or 45.6 to 76.1 cm (18 to 30") for the 8-to-9-year-olds in the Bérard River, it appears to be very probable that some Arctic charr die before participating in their first spawn, thereby reducing the reproductive potential of the adult segment. Overall, this biological information indicates that the Arctic charr population of Tasiujaq may be subject to a demographic decline that could be explained by the relatively high mortality rate as well as by a low proportion of individuals able to reach sexual maturity. One way to minimize the impact of fishing would be to reduce the size (length) of Arctic charr harvested, so that larger individuals (> 55 cm or > 21 ⅔"), male and female, could have an opportunity to reproduce at least once because they are near to, or have reached, the size required for sexual maturity. However, it is important to remember here that due to the lack of long-term data, it is not possible to establish a clear status with regard to the population studied. However, the biological parameters documented in 2017 indicate that additional monitoring is recommended. Laurie Beaupré and Julien Mainguy, MFFP biologists studying Nunavik Arctic charr, remain available to respond to questions related to this report or the species. If the Tasiujaq community would like to develop a monitoring program implemented and led by its members (e.g. LNUK), they can contact the representative of the Direction de la gestion de la faune du Nord-du-Québec (MFFP) to obtain advice and suggestions. Here is the contact information of the authors of this report:

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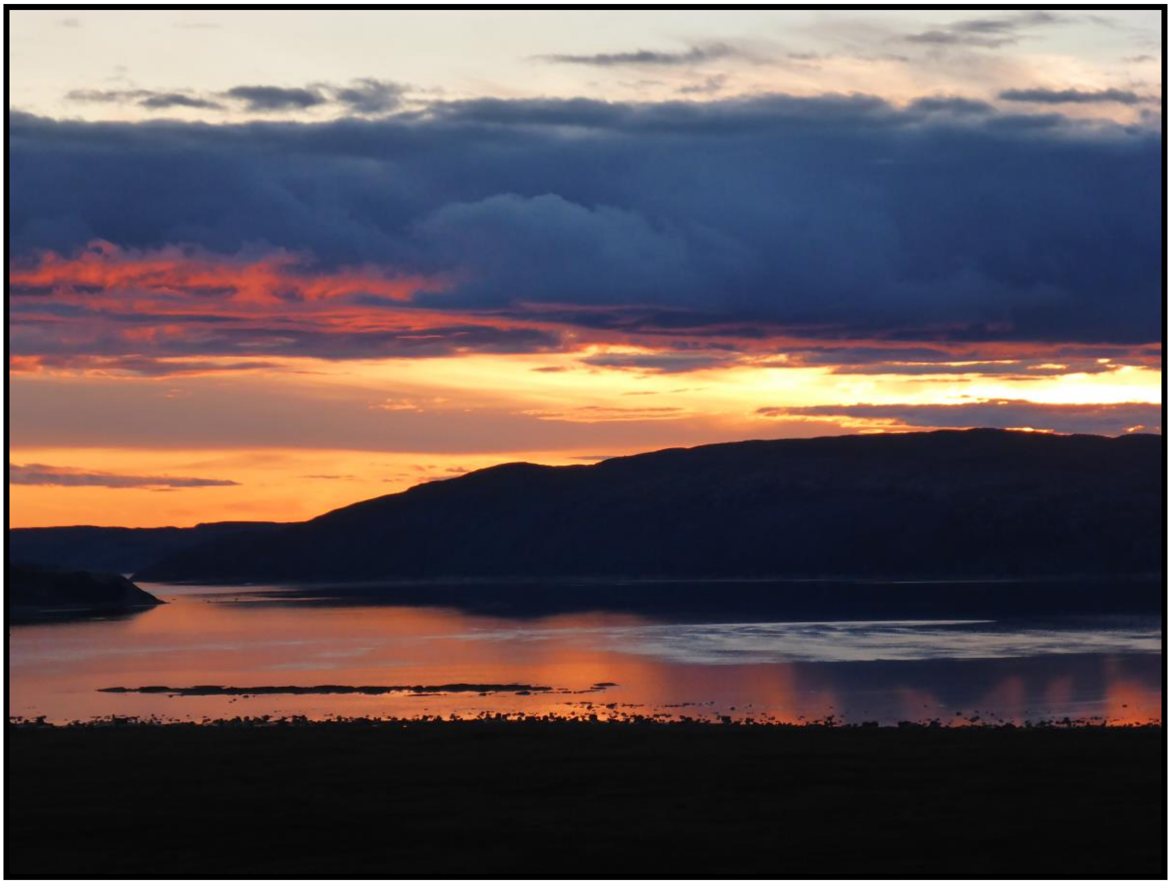
# ᑭᖑᓪᓚᐸᐅᑎᓪᓗᒋᑦ

ᐃᖃᓗᐸᐱᑦ ᖃᐅᔨᓴᕐᑕᐅᓯᒪᔪᑦ ᑕᓯᐅᔭᐅᑉ ᖃᓂᒌᔭᓂ, ᑲᑎᓐᓂᖕᒋᑎᒍᑦ, ᖃᓄᐃᖕᒋᑦᓯᐊᑐᐃᑦ ᓴᕋᕋᔭᒃᓴᖃᕐᓂᖕᒋᓪᓗ ᐊᐸᑦᓯᑦᑐᒻᒪᕆᐅᑦᓱᑎᒃ, ᑕᒪᓐᓇ ᐱᐅᓂᖕᒋᓐᓂᒃ ᖃᓂᒪᖃᖅᓇᖕᒋᑦᓯᐊᕐᓂᖕᒋᓐᓂᓗ ᓇᓗᓃᕐᑕᐅᓚᐅᕐᑐᑦ ᖃᐅᔨᓴᕐᑕᐅᓂᖕᒋᑦᑎᒍᑦ ᑲᑎᓚᒦᕐᓱᒋᑦ ᐃᖃᓗᐸᐱᑦ. ᑭᓯᐊᓂᓚ, ᑖᒃᑲᓂ ᐊᕐᕌᒍᒥ ᓱᕙᓖᑦ, ᐊᒻᒪᓗ ᐃᖃᓗᐸᐱᑦ ᐊᕐᕌᒍᓖᑦ 8-ᓂᒃ ᐅᖓᑖᓄᓪᓘᓐᓃᑦ, ᐊᐸᑦᓯᑦᑑᔪᑦ, ᐊᕐᕌᒍᓚᒦᒥ ᐱᕈᕆᕋᓯᐊᕐᓂᕆᓲᖕᒋᑦ ᖃᐅᔨᓴᕐᑕᐅᓂᖕᒋᑦᑎᒍᑦ 50% -ᑐᐃᓐᓇᐅᒻᒪᑕ. ᖃᐅᔨᓴᕐᓂᐅᓚᐅᔪᔪᑦ ᐳᐃᕚᒥ (1994-ᒥ) ᐅᓂᒃᑳᓚᐅᕐᓯᒪᒻᒪᑕ ᐃᖃᓗᐸᐱᑦ ᓄᓇᐅᐸ ᐊᓯᖕᒋᓐᓃᑦᑐᐃᑦ ᐅᖓᕙᒥ (ᐆᒃᑑᑎᒋᓗᒍ ᓴᐳᕿᓂ) ᐱᕈᕆᕐᓯᒪᓂᖕᒋᑦ ᐃᖃᓗᐸᐱᑦᓴᓚᐅᕐᓗᑎᒃ ᖃᐅᔨᔭᐅᓯᒪᒻᒪᑕ ᐊᕐᕌᒍᖃᓚᕈᑎᒃ ᑭᓯᐊᓂ 8-ᒥᑦ 10-ᓄᑦ, ᑕᑭᓂᖃᓚᕈᓐᓇᒪᑕ 51.4-ᒥᑦ 62.0-ᒨᑦcm (ᐅᕝᕙᓗ 45.6-ᒥᑦ 76.1-ᒨᑦ cm 8-ᓂᑦ 9-ᓄᑦ ᐊᕐᕌᒍᖃᓚᕈᑎᒃ ᑖᓐᓂ ᑕᓯᐅᔭᐅᑉ ᑰᖓᓐᓂᑦᑐᑦ) ᑕᑯᑦᓱᒋᑦ ᐃᓱᒪᓇᕐᑐᑦ ᐃᖃᓗᐸᐱᑦ ᐃᖃᓗᒃᓴᓚᐅᕈᓐᓇᓯᓚᐅᕿᑎᒃ ᑐᕐᑯᖃᑦᑕᑐᑦ ᓱᖁᔭᕈᓐᓇᓯᓚᐅᕿᑎᒃ ᓯᕗᓪᓚᐹᒥᒃ, ᐅᑦᑐᓂᖓᓄᑦ ᐅᓄᕐᓯᕙᓪᓚᐊᓂᖕᒋᑦ ᐃᖃᓗᐸᐱᑦ ᐱᕈᕆᕐᓯᒪᓚᕐᑐᑦ ᐃᑭᓐᓂᓴᐅᓚᕐᑐᐃᑦ. ᖃᐅᔨᓴᕈᑕᐅᓯᒪᔪᓚᒫᑎᒍᑦ, ᑐᓴᕐᑎᑦᓯᐅᑕᐅᓯᒪᔪᑦ ᑖᓐᓂ ᓇᓗᓐᕐᓯᕗᑦ ᐃᖃᓗᐸᐱᑦ ᐅᓄᕐᓂᖕᒋᑦ ᑕᓯᐅᔭᒥ ᐅᓄᕈᓐᓅᐸᓪᓚᓚᐊᔪᑦ ᑐᑭᓯᓇᕐᑎᑕᐅᑦᓯᑎᒃ ᑕᒪᒃᑯᐊ ᐃᓄᑑᓈᕐᑎᑐᐃᑦ ᐃᖃᓗᐸᐱᑦ ᐃᖃᓗᑦᓴᓚᐅᕈᓐᓇᓯᓂᕐᒨᑦ ᑎᑭᓚᐅᕿᑎᒃ ᐱᕈᓃᓚᐅᕿᑎᓪᓗ ᓄᓚᐊᕈᓐᓇᓯᓂᕐᒨᑦ ᐊᐸᑦᓯᓗᐊᓚᕐᓂᖕᒋᓐᓄᑦ. ᐊᑕᐅᓯᐅᓚᖓᑎᓪᓗᒍ ᐃᖃᓗᒐᓲᓐᓂᐅᖃᑦᑕᖅ ᐃᑭᓚᒥᐊᓇᐊᖃᓚᕐᐸᓪᓗᔪᖅ ᑕᒪᒃᑯᓂᖓ ᐊᖕᒋᔫᓂᖕᒋᓐᓂᒃ ᐃᖃᓗᐸᐱᑦ ᐱᔭᐅᖃᑦᑕᑐᐃᑦ, ᑕᒪᒃᑯᐊ ᐊᖕᒋᔫᑕᐅᓂᖕᒋᑦ ᐊᖕᒋᓃᓪᓚᑦ (55cm ᐅᕝᕙᓗ 22-ᐃᓐᓯᓂᒃ), ᐊᖑᑏᑦ ᐊᕐᖏᓪᓗ, ᐃᖃᓗᒃᓴᓚᐅᕈᓐᓇᓯᕐᑯᓪᓗᒋᑦ ᐊᑕᐅᓯᐊᕐᓗᑎᐅᓐᓃᑦ ᑎᑭᐅᑎᒋᐊᕕᓯᒪᓚᒐᓗᐊᕐᒪᑕ, ᐅᕝᕙᓗ ᐊᖕᒋᓚᔫᓇᓯᕐᑯᓪᓗᒋᑦ ᐃᖃᓗᒃᓴᓚᐅᕈᓐᓇᓯᓂᕐᒨᓪᓗ ᓄᓚᐊᕈᓐᓇᓯᓂᕐᒨᓪᓗ. ᑭᓯᐊᓂᓚ, ᐃᖅᑲᐅᒪᔭᐅᓪᓗᑐᓇᐊᓚᒃ ᑖᓐᓂ ᓯᕗᑐᔪᒨᑦ ᑕᑯᓐᓇᓇᐊᖃᓂᖅ, ᓱᖅᑯᐃᓇᓪᓗᑐᖕᒋᒻᒪᑦ ᖁᓚᕐᓂᓯᒪᑦᓯᐊᑐᒥᒃ ᖃᐅᔨᓴᕐᑕᐅᓯᒪᔪᑦ ᐅᓄᕐᓂᖕᒋᑎᒍᑦ ᑐᑭᓯᓇᕐᑎᑕᐅᔫᓇᓯᐊᕐᓂᖕᒋᑦ. ᑭᓯᐊᓂᓚ, ᖃᐅᔨᓴᕈᑕᐅᓯᒪᔪᓂᒃ ᑕᑯᑦᓯᑕ 2017-ᒥ ᓇᓗᓐᕐᓯᒪᑦᓯᐊᑐᑦ ᓱᓚ ᖃᐅᔨᓴᕐᑕᐅᑦᓯᐊᕆᐊᓪᓚᕆᐊᖃᕐᓂᖕᒋᓐᓂᒃ ᑌᒥᐊᖃᕐᑐᓇᔭᐅᔪᑦ. ᓚᐅᓇ ᐱᐅᐱᓇ ᐊᒻᒪᓗ ᔫᓖᓐ ᒣᒥ, ᐃᒪᕐᒥᐅᑕᓂᒃ ᖃᐅᔨᓴᕐᑎᐅᔫᒃ MFFP-ᑯᓐᓂ ᖃᐅᔨᓴᕐᓯᒪᒪᑎᒃ ᓄᓇᕕᒻᒥ ᐃᖃᓗᐸᐃᓐᓂᒃ, ᓱᓚ ᐊᑐᐃᓐᓇᐅᓚᔭᕐᑑᒃ ᐊᐱᕐᓱᓇᐊᕐᑕᐅᔪᒪᑐᐊᕈᑎᒃ ᑕᒪᒃᑯᓄᖓ ᐅᓂᒃᑰᖑᓯᒪᔪᓄᑦ. ᑕᓯᐅᔭᕐᒥᐅᑦ ᓄᓇᓚᖕᒋᑦ ᖃᐅᔨᓴᕐᓂᖃᕈᒪᒍᑎᒃ ᐅᕝᕙᓗ ᐱᒋᐊᕐᑎᑦᓯᔪᒪᒍᑎᒃ ᖃᐅᔨᓴᕐᓂᐅᓚᔭᕐᑐᒥᒃ ᑲᒪᔾᖃᕐᑎᓪᓗᒋᑦ ᐅᑯᓂᖓ (ᐆᒃᑑᑎᒋᓗᒋᑦ LUNK-ᑯᑦ) ᖃᐅᔨᒋᐊᕐᕕᖃᕈᓐᓇᐳᑦ ᑖᒃᑯᓄᖓ ᑲᒪᔨᐅᔪᓄᑦ ᑯᐯᒻᒥ Direction de la gestion de la faune du Nord-du-Québec (MFFP-ᑯᓐᓄᑦ) ᑖᒃᑯᐊ ᐃᑐᓕᐅᕈᓐᓇᐳᔩᓗᒍᑎᓂᒃ ᐁᑦᑐᐃᒍᓐᓇᒪᑕ ᐅᕝᕙᓗ ᐃᓱᒪᑖᕈᑎᑦᓴᓂᒃ ᐁᑦᑐᐃᒍᓐᓇᓯᐊᕐᒪᑕ. ᐅᑯᐊ ᑕᓗ ᓯᓚᑎᑦᓴᖕᒋᑦ ᖃᐅᔨᒋᐊᕐᕕᐅᒍᓐᓇᑐᑦ ᑖᒃᑯᓂᖓ ᐅᓂᒃᑳᓚᐅᕐᓯᒪᔪᑦ ᑖᒻᒪᓂ ᐊᓪᓚᓯᒪᕗᑦ (see previous page).



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# Appendix

**Table 4. Equation parameters for conversions among the three length measurements (FL: Fork Length; TL: Total Length; MTL: Maximum Total Length) of Arctic charr in Bérard River, Tasiujaq, August-September 2017. The Equation is presented in the form: y = *a*x + *b*.**

| Dependent variable (y) | Independent variable (x) | Slope coefficient (*a*) | Constant (*b*) | $R^2$ |
|---|---|---|---|---|
| FL | MTL | 0.9505 | -4.3381 | 0.9972 |
| FL | TL | 0.9653 | -2.7467 | 0.9963 |
| TL | MTL | 0.9832 | -0.9243 | 0.9978 |
| TL | FL | 1.0321 | 4.5516 | 0.9963 |
| MTL | FL | 1.0491 | 5.8663 | 0.9972 |
| MTL | TL | 1.0149 | 1.9735 | 0.9978 |

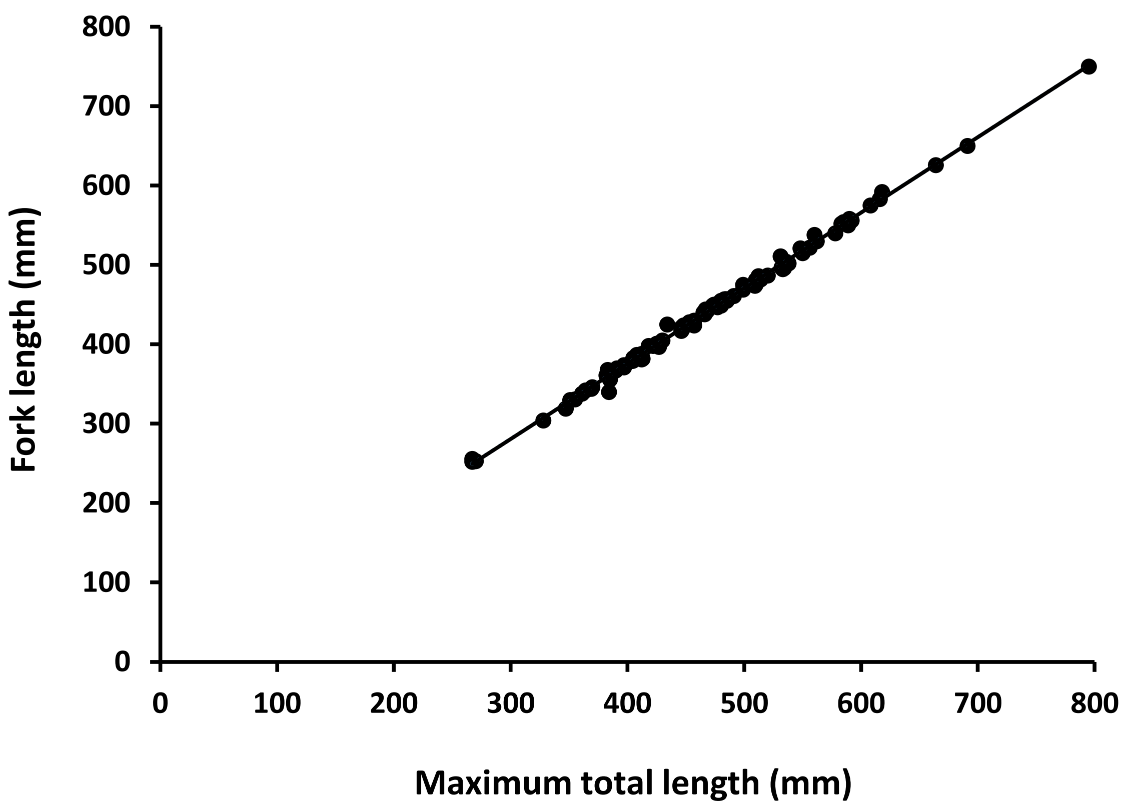


**Figure 11. Relationship between fork length and maximum total length in anadromous Arctic charr in the Bérard River, Tasiujaq, August-September 2017.**

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