Establishment of a reference state for the Tasiallujuak River Arctic charr population, Salluit, summer 2019

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Cover photograph

An anadromous Arctic charr (*iqaluppik*) after its release, Tasiallujuak River, Salluit, August 2019. The hand of Asivak Papigatuk, Inuit Field Assistant, who had just released this specimen upstream from the counting fence, is visible.

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Highlights

1. The upstream migration of anadromous Arctic charr was monitored in the Tasiallujuak River (also known as the Duquet River) in the Deception Bay area to establish a reference state. A total of 5 141 Arctic charr were inventoried at the counting fence between July 31st and August 25th, 2019, of which 66 were randomly sampled during this period to describe the biological parameters of this population. Moreover, no other fish species was inventoried at this site.

2. In the wake of an incident that occurred on August 24th that compromised the safety of its staff, the Ministère de l'Environnement, de la Lutte aux changements climatiques, de la Faune et des Parcs (MELCCFP) had to halt the project on August 25th. The counting fence was completely removed on August 26th to allow the Arctic charr to move freely. As such, the data presented in this report must be deemed partial since the upstream migration of the Arctic charr was not completed. The team had initially planned to carry out field work until late September.

3. Data collected at the same site in 1997 and 1998 by Brian Locke and his team on behalf of the Falconbridge Mine (Locke, 1999) were made available. The data were compared with the data that the MELCCFP collected in 2019 to ascertain whether the biological parameters studied had changed over this period.

4. The Fulton's condition factor (K_F) for the anadromous Arctic charr sampled in 2019 is considered "acceptable," with a standard deviation of 1.08 ± 0.11 for the sample taken (n = 66). This value has scarcely varied since the knowledge acquisition work in 1997-1998, during which the same index (K_F) was estimated at 1.05 ± 0.13.

5. In 2019, 42.3% (n = 26) of females among the Arctic charr sampled that were 7 years of age and over participated in spawning, and 50.0% (n = 8) of the males, compared with values of 45.9% (n = 74) and 16.2% (n = 37), respectively, in 1997-1998.

6. The total annual mortality inferred based on the age structure was estimated at 23% in 2019, slightly lower than the estimated figure in 1997-1998 (28%). Such values are low compared with those for other Arctic charr populations that often display mortality rates ranging from 30% to 45% (Power *et al.*, 2008).

7. The concentrations of mercury found in the Arctic charr in 2019 were below the 0.5 mg/kg threshold established by Health Canada, which suggests that this contaminant does not appear to pose a problem for the consumption of anadromous Arctic charr in this area.

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1. ᒪᔪᕐᓂᖏᑦ ᐃᖃᓗᐹᑦ ᖃᐅᔨᓴᕐᑕᐅᓚᐅᔪᑦ ᑕᓯᐊᓗᑦᔪᐊᑉ ᑰᖓᓂ (ᑌᔭᐅᓶᖑᒻᒥᔪᖅ Duquet River) ᓴᓪᓗᐃᑦ ᐁᑉᐸᖏᓐᓂ ᖃᐅᔨᔭᐅᒐᓯᑦᓯᑎᒃ ᑌᒫᑦᓴᓇᓕᕚᕆᐊᖏᑦ. ᑲᑎᑦᓯᑎᒃ 5 141 ᐃᖃᓗᐹᑦ ᑭᓯᑕᐅᓚᐅᔪᑦ ᑭᓯᑦᓯᕖᒻᒥ ᓴᒍᕐᒥ ᐊᑯᓐᓂᖓᓂ ᔪᓚ 31 ᐊᒻᒪᓗ ᐊᐅᒡᒍᓯ 25, 2019, 66 ᖃᐅᔨᓴᐅᑎᓄᑦ ᖃᐅᔨᓴᕐᑕᐅᑎᓗᒋᑦ ᑖᒃᑯᓇᓂ ᐅᓪᓗᓂ ᓇᓗᓃᕋᓱᑦᓯᕆᑦ ᑖᒃᑯᐊ ᐃᖃᓗᐃᑦ ᖃᓄᐃᓕᖓᓂᖏᑦ. ᐊᒻᒪᓗᕆᐊᓪᓚᒃ, ᐊᓯᖏᑦ ᐃᖃᓗᐃᑦ ᐃᖃᓗᐱᐅᖏᑦᑐᑦ ᑭᓯᑕᐅᓐᓂᖏᑦᑐᑦ ᑖᒃᑯᓇᓂ ᐅᓪᓗᓂ.

2. ᐱᓂᕐᓗᑐᖃᕐᑐᕖᓂᐅᑎᓗᒍ ᐊᐅᒡᒍᓯ 24-ᒥ ᐊᑦᑕᓇᕐᑐᒎᕆᔪᒥᒃ ᐱᓇᓱᑦᑎᖏᓐᓂᒃ, ᑐᖅᑲᑕᕐᕕᖓ ᐊᕙᑎᓕᕆᓂᕐᒧᑦ, ᓱᓚᐅᑉ ᐊᑦᓯᕗᓪᓕᐊᓂᖓᓂᒃ ᓄᖅᑲᑎᑦᓯᒐᓱᓐᓂᒧᑦ, ᐆᒪᔪᓕᕆᓂᕐᒧᑦ ᐊᒻᒪᓗ ᒥᖅᑯᐃᓯᕐᕕᓕᕆᓂᕐᒧᑦ (MELCCFP) ᓄᖅᑲᑎᑦᓯᕆᐊᖃᓚᐅᔪᖅ ᐱᓇᓱᐊᕐᓂᒥᒃ ᐊᐅᒡᒍᓯ 25-ᒥ. ᑭᓯᑦᓯᕖᒃ ᓴᒍᖅ ᐲᕐᑕᐅᓚᐅᔪᖅ ᐊᐅᒡᒍᓯ 26-ᒥ ᐃᖃᓗᐹᑦ ᒪᔪᑦᓯᐊᕐᑯᑦᓯᕆᑦ. ᐊᓖᑦ, ᖃᐅᔨᓴᕐᑕᐅᓯᒪᔪᑦ ᓄᐃᑕᑎᑕᐅᔪᑦ ᑕᒃᑲᓂ ᑐᓴᕐᑎᓯᒍᑎᒥ ᐃᓚᑰᓂᕋᕐᑕᐅᕆᐊᓖᑦ ᐃᖃᓗᐹᑦ ᒪᔪᕐᓂᖓ ᐃᓱᓕᕋᑕᓚᐅᔪᖕᖏᒪᑦ. ᐱᓇᓱᑦᑏᑦ ᐸᕐᓇᓯᒪᖄᓚᐅᔫᒻᒪᑕ ᐱᓇᓱᐊᓵᕆᐊᒥᒃ ᓯᑉᐱᑎᒻᐱᕆᐅᑉ ᓈᓂᑲᓵᖓ ᑎᑭᓗᒍ.

3. ᖃᐅᔨᓴᐅᑎᕖᓐᓄᑦ ᑲᑎᕐᓯᑕᐅᔪᕖᓐᓄᑦ ᑌᑲᓂᑦᓴᓇᖅ ᑰᒻᒥ 1997-ᒥ 1998-ᒥᓗ ᐳᑌᐊᓐ ᑖᒃᒧᑦ ᐱᓇᓱᒃᑎᖏᓐᓄᓗ ᐱᒍᑦᔨᓯᑎᒃ Falconbridge ᐅᔭᕋᓐᓂᐊᓂᒃ (ᑖᒃ, 1999) ᐊᑐᐃᓐᓇᐅᑎᑕᐅᓚᐅᔪᑦ. ᖃᐅᔨᓴᐅᑎᕖᓐᓄᑦ ᖃᓄᖅ ᐊᑦᔨᒌᖕᖏᓂᖃᕐᒪᖔᑕ ᕿᒥᕐᕈᔭᐅᓚᐅᔪᑦ MELCCFP-ᑯᑦ ᑲᑎᕐᓯᑕᕖᓂᖏᑦ 2019-ᒥ ᑕᑯᓐᓇᓱᕆᑦ ᓱᕐᖁᐃᓯᒐᓱᑦᓯᑎᒃ ᐃᖃᓗᐃᑦ ᖃᓄᐃᓕᖓᓂᖏᑦ ᐊᓯᑦᔨᓂᕐᒪᖔᑕ ᑖᒃᑯᓇᓂ ᐊᕐᕌᒍᓂ.

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5. 2019-ᒥ, 42.3%-ᖏᑦ (n = 26) ᐊᕐᕈᑦ ᐃᖃᓗᐹᑦ ᖃᐅᔨᓴᕐᑕᐅᔪᕖᓐᓄᑦ 7-ᓂᒃ ᐅᖓᑖᓄᓗ ᐅᑭᐅᓖᑦ ᐃᓚᐅᔪᕖᓐᓄᑦ ᓱᕙᓕᐅᕐᑐᓂ, ᐊᒻᒪᓗ 50.0%-ᖏᑦ (n = 8) ᐊᖑᑎᖏᑦ, ᑕᑯᓐᓇᓱᕆᑦ ᐅᓄᕐᓂᕖᓂᖏᑦ 45.9% (n = 74) ᐊᒻᒪᓗ 16.2% (n = 37), 1997-1998-ᒥ.

6. ᑲᑎᑦᓯᑎᒃ ᐊᕐᕌᒍᑕᒦᑦ ᑐᕐᑯᖃᑦᑕᑐᑦ ᖃᐅᔨᔭᐅᓯᒪᔪᑦ ᖃᐅᔨᓴᕐᓂᑯᑦ ᑐᖕᖓᕕᓖᑦ ᐅᑭᐅᖏᑦᑕ ᖃᓄᐃᓕᖓᓂᖏᓐᓂᒃ ᒥᑦᓴᐅᓵᕐᑕᕖᓐᓄᑦ 23%-ᒦᑦᓯᑎᒃ 2019-ᒥ, ᐃᑭᓐᓂᓴᐅᓚᕿᐱᑦᑐᑦ ᒥᑦᓴᐅᓵᕐᑕᕖᓂᕐᒥᒃ 1997-1998-ᒥ (28%). ᑖᒃᑯᐊ ᐅᓄᕐᓅᑦ ᐳᒃᑭᑐᐃᑦ ᑕᑯᓐᓇᓱᕆᑦ ᐃᖃᓗᐹᑦ ᓄᐃᑕᑎᑦᓯᔾᔪᑦ ᑐᕐᑯᖃᑦᑕᓂᖏᑦ 30%-ᒥᑦ 45%-ᒧᑦ ᐅᓄᕐᓂᖃᕐᑎᓗᒋᑦ (Power *et al.*, 2008).

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Introduction

Context of the study

Under an agreement between the Société du Plan Nord and what was then the Ministère des Forêts, de la Faune et des Parcs (MFFP), projects seeking to establish reference states targeting fish populations and their habitats were conducted from 2016 to 2019 in regions that the Plan Nord covers, i.e., the Côte-Nord, Saguenay–Lac-Saint-Jean, and Nord-du-Québec regions. In Nunavik, in view of the dietary and cultural importance of Arctic charr (*Salvelinus alpinus*) in Inuit communities, reference states focusing in particular on this species were conducted for four hydrographic systems, including the Tasiallujuak River in the Deception Bay sector in Salluit.

General objective

The general objective of the project was to acquire knowledge of anadromous Arctic charr during upstream migration in the Tasiallujuak (Duquet) River in the Deception Bay sector east of the community of Salluit.

Specific objectives

The project specifically sought to establish a reference state of the anadromous Arctic charr population in the Tasiallujuak River during the upstream migration:

- estimate the size of the anadromous Arctic charr population using a temporary counting fence and describe the phenology of the upstream migration;

- characterize the age and other biological parameters for a random sample of Arctic charr at the counting fence;

- determine the concentration of mercury and other contaminants found in the Arctic charr sampled;

- compare the data collected in the context of this project with those described by Locke (1999) during knowledge acquisition carried out at the same site on the same population for the years 1997 and 1998.

Material and methods

The counting fence

A temporary counting fence was installed on the outlet stream of Tasiallujuak Lake to acquire knowledge on Arctic charr (Figure 1). The Tasiallujuak River flows into the Deception River, which then flows into Deception Bay (Figure 1 and Figure 2). The counting fence was in operation from July 31st to August 25th, 2019. The two wings of the fence comprised tubular steel tripods varying between 6 and 12 feet in length. A holding cage (Figure 3) installed in the centre of the wings was used to count the fish during their upstream migration. The holding cage was visited several times a day to ascertain whether Arctic charr or other species had been caught. A thermograph was installed in the holding cage to monitor changes in water temperature hourly throughout the follow-up conducted.

Figure 1: Aerial view of the outlet stream of Tasiallujuak (Duquet) Lake showing the counting fence and the holding cage to monitor Arctic charr during the upstream migration in August 2019. The white container at the end of the road near the counting fence was used as a laboratory. The temporary camp located near the lake comprised two white tents. The Deception River, into which the Tasiallujuak River flows, is visible in the background at the foot of the hills.

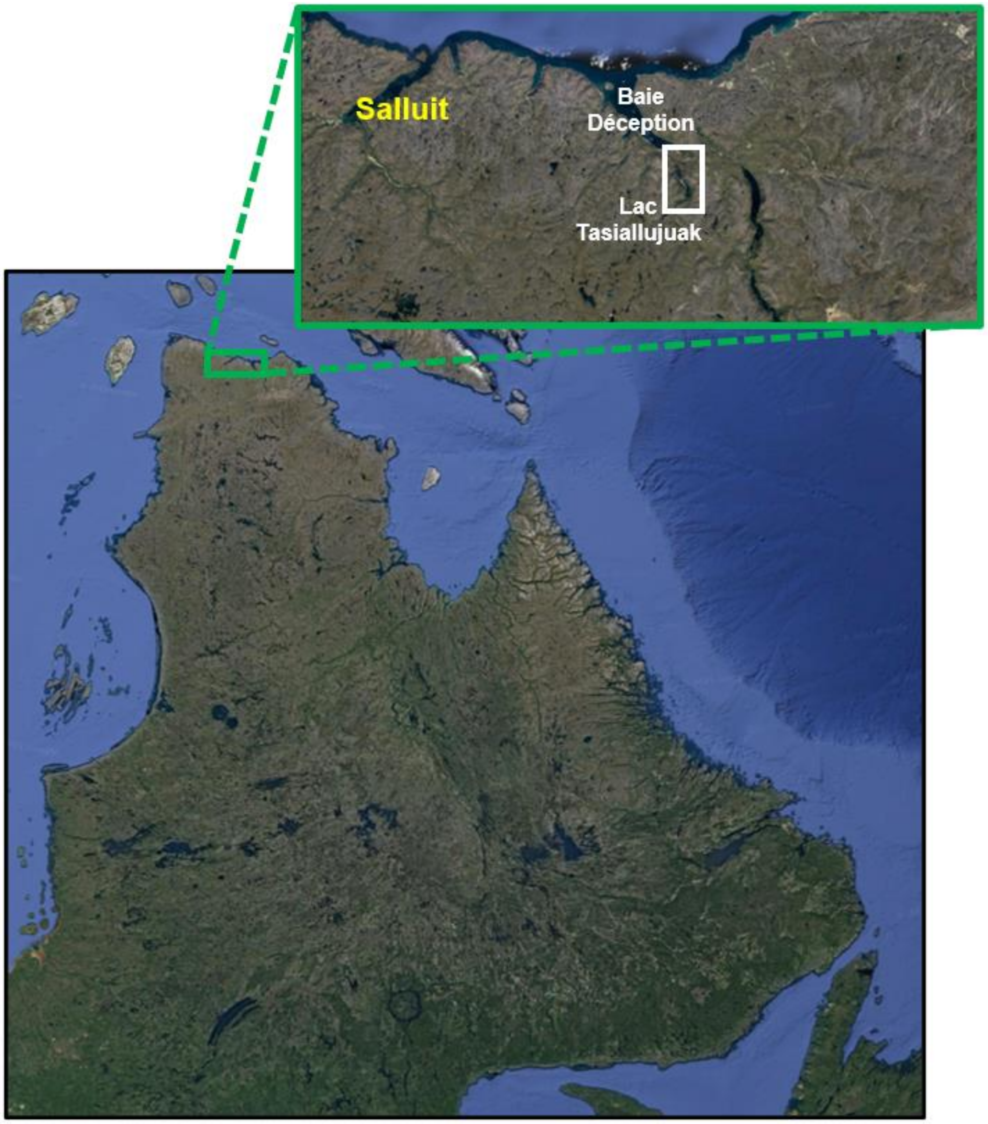

Figure 2: Location of Tasiallujuak Lake (Lac) and the river of the same name associated with the Deception Bay (Baie) system situated east of the community of Salluit in Nunavik

The species of fish caught in the holding cage (Figure 3) were identified, their fork length was measured and recorded before they were released upstream from the fence to enable them to reach Tasiallujuak Lake located several metres upstream. One specimen among those randomly sampled was not deemed anadromous (Appendix 1) and was excluded from the analyses.

Figure 3: Arctic charr caught in the holding cage of the counting fence on the Tasiallujuak River in the Deception Bay area, Salluit

Starting in mid-August, numerous small Arctic charr began to arrive at the counting fence, and it then became impossible to measure all of them. At that point, they were only counted. However, to continue sampling the fork length of the population, all the specimens found in the cage were measured on predetermined days as the upstream migration period progressed.

Measurements and samples

As agreed beforehand with the Northern Village of Salluit, the Local Nunavimmi Umajulirijiit Katujjiqatigiinninga (LNUK), and the Qaqqalik Landholding Corporation, a maximum of 150 Arctic charr could be sampled at the counting fence. This number was divided over the number of weeks, then adjusted as the study advanced. All the randomly selected Arctic charr in the holding cage of the counting fence were transported to the temporary laboratory installed near the river. They were then sacrificed for the purposes of measuring and weighing (Figure 4) and to collect certain samples and determine their sex (Figure 5).

Figure 4: An Arctic charr sampled in the holding cage before its necropsy. The fresh individual's fork length was measured and it was weighed before its sex was determined by opening the abdominal cavity and samples were taken

Among the Arctic charr sampled, fork length was measured using a board with an integrated ruler (± 1 mm) and the mass was determined using a Valor 3000 model O'Haus electronic scale (± 0.1 g). Once the measurements were taken, a filleting knife was used to open each individual's abdominal cavity from the urogenital opening to the base of the operculum to determine its sex. The status of the gonads was then classified as developed or undeveloped, indicating participation or non-participation in spawning for the year under way. The stomach contents were then described with crude categories for insects, small fish, and crustaceans. Certain stomach content samples were preserved in 95% ethanol for possible subsequent identification in the MELCCFP laboratory.

Figure 5: The collection of biological samples, including otoliths, from the Arctic charr selected randomly in the holding cage by the MELCCFP team

Special attention also focused on the examination of the abdominal cavity and the surface of the organs to detect the presence of parasites visible to the naked eye or signs suggesting the presence of pathogens. Certain parasites observed were photographed (Figure 6) and preserved in 95% ethanol for possible subsequent identification in the laboratory.

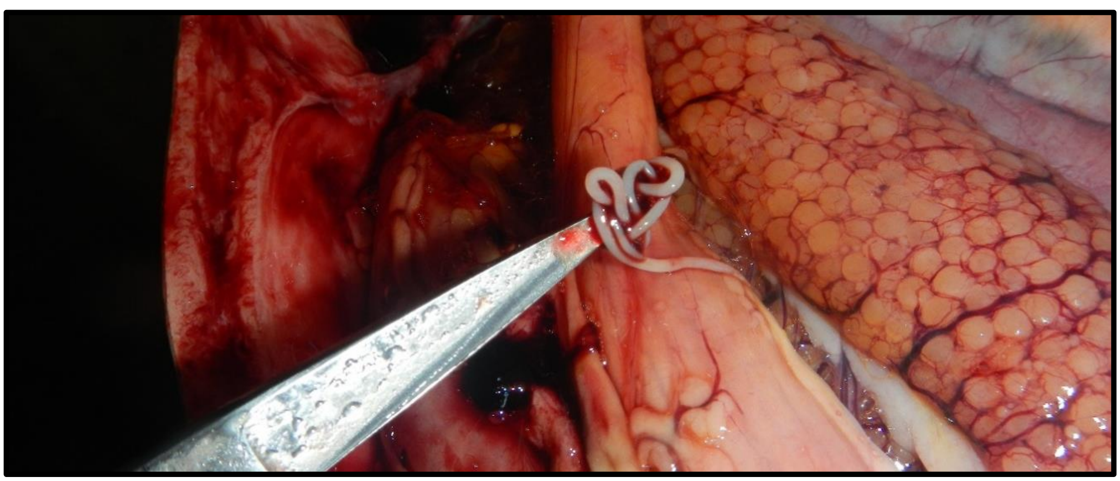

Figure 6: A nematode-type parasite found in the abdominal cavity of a female anadromous Arctic charr sampled at the counting fence on the Tasiallujuak River. The presence of developed eggs should be noted here, indicating that the female would have taken part in spawning later in the fall.

The adipose fin of the specimens sampled was also collected and preserved in 95% ethanol for possible subsequent genetic analyses. A muscle sample (~ 100 g) was also taken laterally behind the dorsal fin, then frozen (-18°C) for future analyses of contaminants in the MELCCFP laboratory. The muscle samples were analyzed individually for mercury. The homogenates of between 4 and 11 individuals from the same size class (Table 1) were analyzed for the other contaminants examined (18 metals all told). Furthermore, other samples were taken for the research of partners in the universities or federal agencies (see Appendix 2).

Table 1: Classes of total maximum length (mm) used to analyze contaminants in Arctic charr (MELCC, 2017). The total maximum length was estimated based on the fork length according to the conversion equation of Mainguy and Beaupré (2019b) presented in Appendix 1 for the MELCCFP's individual assignments to a length class.*

Small	Medium	Large
300-449	450-549	≥ 550

* The thresholds used to assign length class in the MELCCFP were changed to better reflect the size variability of anadromous Arctic charr in Nunavik. The MELCCFP previously used the size classes adopted with respect to *S. alpinus oquassa*, i.e., landlocked Arctic charr, for the total maximum length, i.e., 150 mm to 300 mm for small fish, 301 mm to 400 mm for medium fish, and more than 400 mm for large fish (Mainguy et Beaupré, 2019a, 2019b).

The otoliths were removed, cleaned, then preserved in Eppendorf Tubes to subsequently determine their age in the laboratory. All the fish sacrificed were given to a member of the community of Salluit once the measuring and sampling had been completed, as agreed with the Hunting, Fishing and Trapping Coordinating Committee, the Northern village, and the LNUK in Salluit, and the Qaqqalik Land Corporation.

Data analysis

Fork length

The fork length frequency distribution of the Arctic charr sampled in 2019 was compared with that in 1997-1998 by means of a bootstrapping approach applied to the Kolmogorov-Smirnov test for two samples to ascertain whether they differed from a statistical standpoint.

Growth

Three models that describe the relationship between length and age were applied to the two datasets (1997-1998 and 2019) in a single analysis, i.e., the von Bertalanffy, Gompertz, and logistic growth models. Likelihood ratio tests were then conducted to ascertain whether the K_C, L_{inf} and t_0 parameters differed between the two groups according to the best growth model chosen. See Ogle (2016, Chapter 12) for a detailed description of the growth-related parameters, i.e., the length-age relationship.

Condition factor

We first used Fulton's condition factor (K_F) to characterize mass according to size in the Arctic charr sampled. The following equation describes this index:

$$K_F = (M/L^3) \times 100\,000$$

where

M: mass (g)

L: fork length (mm)

The fork length was adopted to compute the condition factor since this measurement has been used in all the studies devoted to Arctic charr, thus somehow facilitating comparisons with other populations although this index is rather population specific. The condition factor of an Arctic charr is deemed "good" when $K_F > 1$, "acceptable" when $K_F \approx 1$, and "poor" when $K_F < 1$.

The mass-length relationship was also studied using a linear model following base-10 logarithmic transformation of the mass and the fork length according to Ogle (2016, Chapter 7). This relationship was first studied for the years 1997 and 1998 (grouped together) and for 2019 separately to describe the relationships specific to each of the two groups, then compare such relationships to determine whether there is a statistical difference between these.

Reproduction

A logistic regression was used to quantify the influence of fork length or age on the likelihood of observing developed gonads, while testing the possible effect of the period considered, i.e., 1997-1998 in relation to 2019. Both sexes were grouped together given that the 2019 sample was too small, thereby preventing gender-specific analyses.

Mortality

The age-frequency distributions of the two periods considered were first analyzed separately by means of catch-curve analyses (Smith *et al.*, 2012). Instantaneous mortality (Z) was estimated for each period, then the periods were compared using the approach described in Mainguy and Moral (2021). This report presents the values of Z converted into total annual mortality.

Results

Counting fence

The installation of the counting fence was completed on August 2nd, but it was partially operational on July 31st and the first catches were made on August 1st. The counting fence remained in operation until the morning of August 25th, when it was decided to abandon the monitoring of the upstream migration of Arctic charr following an incident that compromised the staff's safety.

During this period, 5 141 Arctic charr were caught in the holding cage. A significant influx of small Arctic charr led to the capture of more than 300 specimens per day between August 13th and 16th, up to a maximum of 1 059 specimens caught on August 15th alone (Figure 7). However, the small specimens could get caught in the mesh of the counting fence and the holding cage, which created a problem of mortality (Figure 7) that required significant changes to the counting fence (see the following page). No other fish species was inventoried at the counting fence.

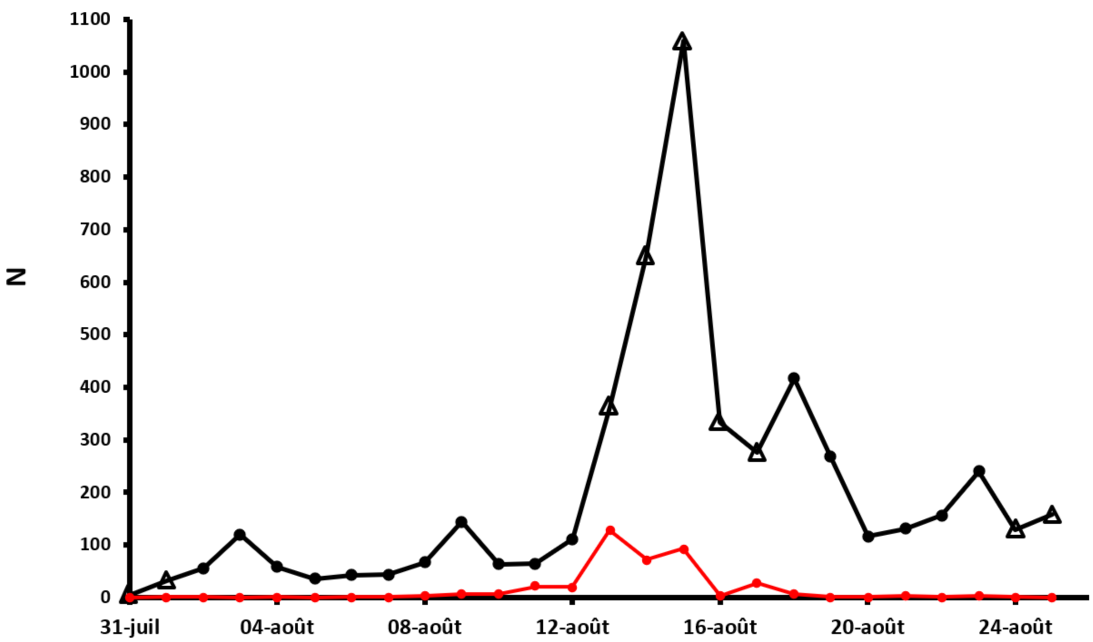

Figure 7: Anadromous Arctic charr counted daily (black line and symbols) at the counting fence installed on the outlet stream of Lac Tasiallujuak in Salluit, Nunavik, from July (juil) 31st to August (août) 25th, 2019. The empty triangles indicate the dates for which daily upstream migration data are incomplete because of the installation or the dismantling of the fence, or because of mortality problems stemming from the meshing in the counting fence of small Arctic charr (counting illustrated in red) in mid-August that required extensive work over several days to remedy the situation.

Once the first deaths of small specimens were detected, remedial measures were promptly adopted by doubling the netting to halve the size of the mesh. The authorities in Salluit were immediately notified of the problem encountered. The remedial measures facilitated the pursuit of the work by eliminating all the subsequent deaths of small specimens in the netting. It should be noted that no such problem arose at the other three sites where anadromous Arctic charr were studied beforehand, i.e., in Aupaluk in 2016, in Tasiujaq in 2017, and in Inukjuak in 2018 (see Mainguy and Beaupré, 2019a, 2019b, 2021). The size of the mesh used was deemed suitable at the other sites. However, the higher latitude of Salluit and the slower growth of Arctic charr in this region might partly explain the problem encountered.

Water temperature was recorded daily at the counting fence. Figure 8 presents the values recorded.

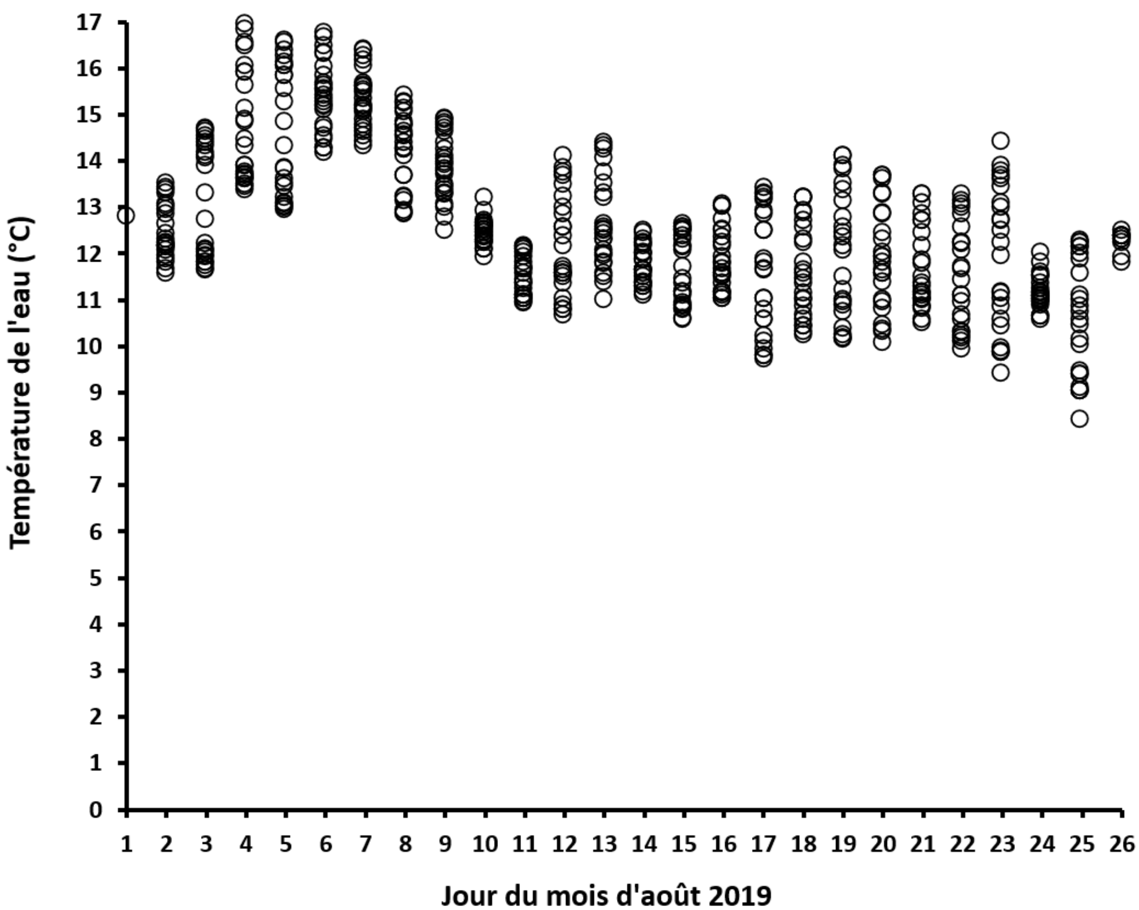

Figure 8: Variations of the water temperature at the counting fence in the Tasiallujuak River in Salluit, Nunavik, from August (août) 1st to 26th, 2019 The circles represent the water temperature according to hourly recordings (*n* = 24/day) made with a Tidbit v2 thermograph (± 0.2°C).

Biological parameters of the fish sampled

Fork length

The average fork length (standard deviation) of all the Arctic charr measured at the counting fence (*n* = 3 148), including the specimens preserved for sampling (*n* = 66), was 306 ± 107 mm, with a range of 118 mm to 711 mm (Figure 9). In 1997-1998, the average was 288 ± 107 mm (*n* = 13 300), with a range similar to that in 2019, i.e., 102 mm to 730 mm.

The frequency distributions in the two periods considered differed statistically (Kolmogorov-Smirnov test on two samples with resampling by means of bootstrapping ($p < 0.001$, *n* = 5 000 bootstrap), certainly because of the bimodal distribution observed in 2019 that was not present in 1997-1998.

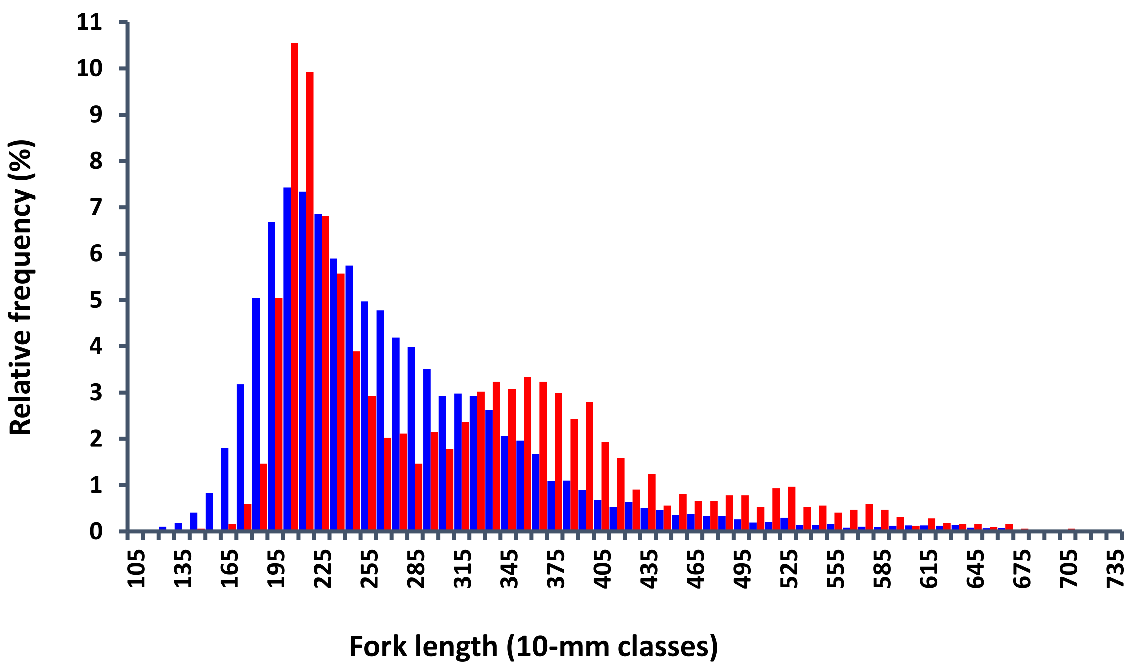

Figure 9: Relative frequency distribution (%) of fork lengths by class of 10 mm of Arctic charr measured at the counting fence in 1997-1998 (blue) and in 2019 (red) on the Tasiallujuak River, Salluit

Large Arctic charr (≥ 600 mm) accounted for 1.34% of the individuals sampled at the counting fence in 2019 (*n* = 43 out of 3 214), as against 0.81% (*n* = 108 out of 13 300) in 1997-1998.

However, the Arctic charr randomly sampled at the counting fence in 2019 displayed a fork length frequency distribution that did not differ statistically from that of the Arctic charr sampled in 1997-1998 (p = 0.43, n = 5 000 bootstrap) (Figure 10).

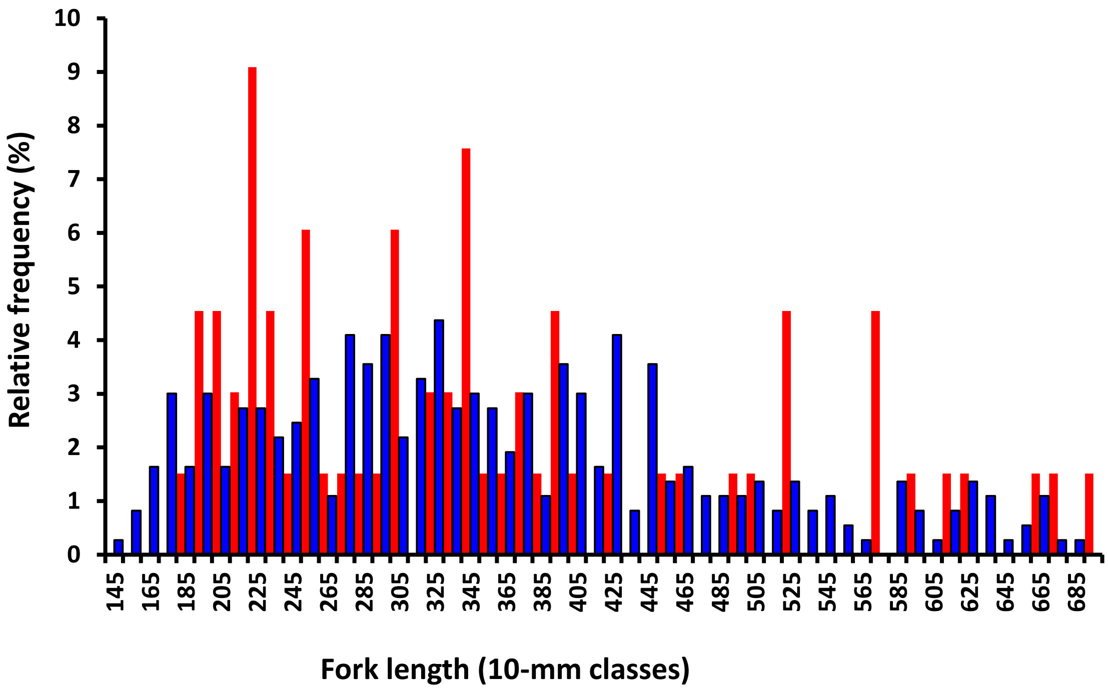

Figure 10: Relative frequency distribution (%) of fork lengths by class of 10 mm of Arctic charr sampled in 1997-1998 (blue) and in 2019 (red) on the Tasiallujuak River, Salluit

Growth

The growth model that best describes the relationship between the fork length and the age of the Arctic charr sampled in 2019 and those sampled in 1997-1998 is the so-called logistic model, which obtained greater statistical support. Growth between the two periods differed sufficiently such that the best model selected was the one that relied on different parameters for L_{inf}, K_c[1] and t_0 (see Ogle, 2016) to describe growth (Figure 11). However, the absence in 2019 of a specimen over 15 years of age compared with 1997-1998 may have affected the comparison since the L_{inf} estimated at 834 mm would be reduced and would, therefore, certainly be closer to that estimated for 1997-1998 (625 mm).

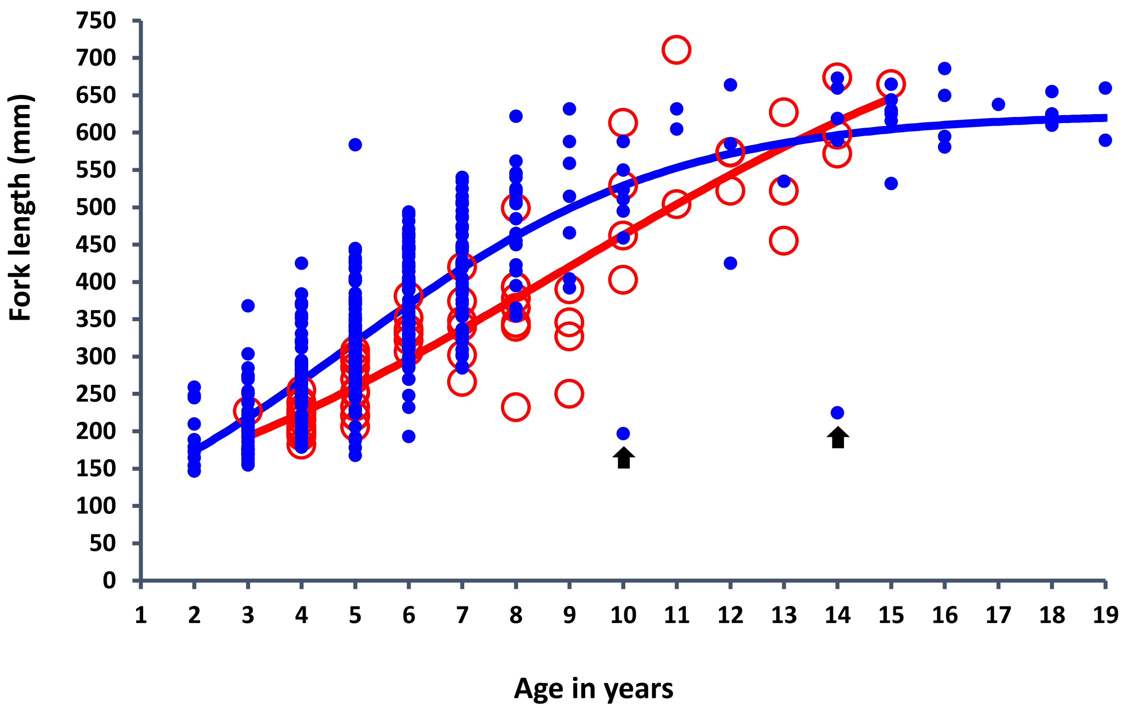

Figure 11: Logistic growth model describing the length-age relationship among the anadromous Arctic charr sampled in 1997-1998 (blue) and in 2019 (red). Certain data from the study conducted in 1997-1998 may be erroneous as regards length or age, including data indicated by black arrows, but their exclusion hardly alters the predicted values.

[1] The "C" index is used here to refer to the growth-related parameter (K_c) that describes at what rate the predicted fork length approaches the L_{inf} according to age (see Ogle, 2016) to distinguish it from Fulton's condition factor (K_F).

Condition factor

The average condition factor (K_F) of the Arctic charr stood at 1.08 with a standard deviation of 0.11 (range: 0.87 to 1.39). A total of 16 specimens out of 66 (24.2%) had an individual value of $K_F < 1$ in 2019, compared with 32.9% in 1997-1998. During Locke's work (1999), the average value of K_F for the specimens sampled in the summer overall stood at 1.05 ± 0.13 (n = 422), with a range of 0.70 to 1.68.

The relationship describing mass according to fork length did not differ statistically between 2019 and 1997-1998 (Figure 12).

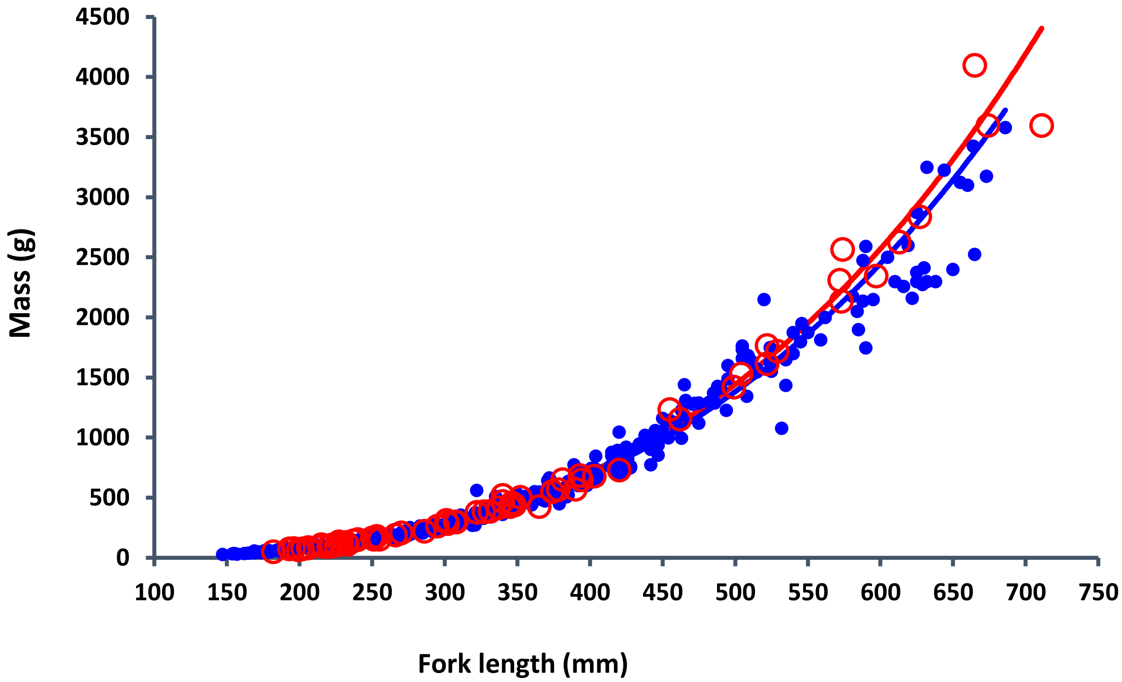

Figure 12: Relationship between the mass and the fork length of Arctic charr sampled in 1997-1998 (blue) and in 2019 (red)

Sex ratio and gonad development

The sex ratio for all the Arctic charr sampled in 2019 (number of females [F] per male [M] caught) was 2.88:1 (n = 66) compared with 1.67:1 (n = 350) in 1997-1998, which indicates a bias toward females in both periods but that was, however, more pronounced in 2019.

Among the 49 female and 17 male anadromous Arctic charr analyzed in the laboratory, 22.7% of the specimens sampled had developed gonads (see Figure 13 for an example in the females). In 1997-1998, Locke's data (1999) indicate that the same percentage was nearly halved, i.e., 11.4%, but included catches for the overall upstream migration period. By limiting the descriptive statistical analyses to individuals 7 years of age and over, since the probability of a specimen participating in spawning is greater starting at that age, in 2019 developed gonads were found in 42.3% (n = 26) of female Arctic charr and in 50.0% of the males (n = 8). The percentages pertaining to the females and males sampled in 1997-1998 were 45.9% (n = 74) and 16.2% (n = 37), respectively.

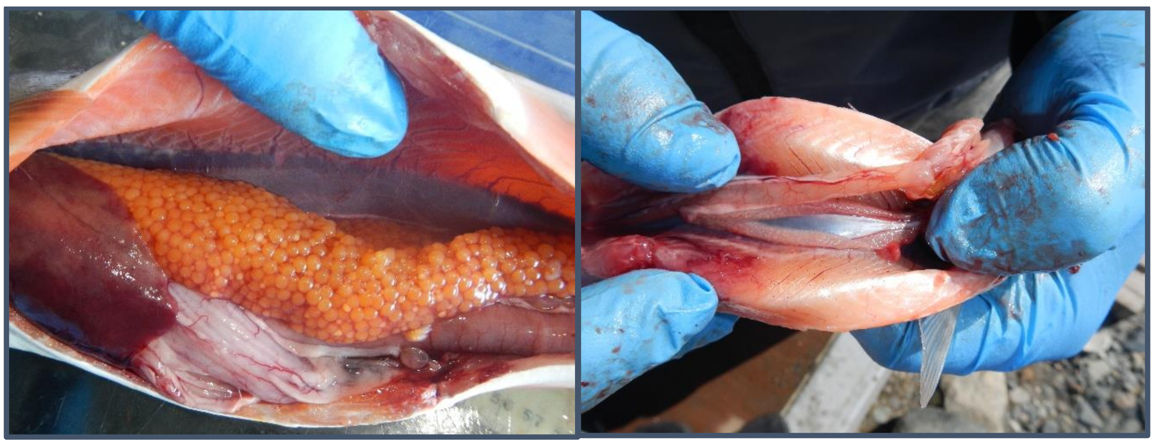

Figure 13: **Female Arctic charr sampled with developed gonads (i.e., "current-year spawner" on the left) and undeveloped gonads (on the right)**

The probability of observing developed gonads differed statistically between the two periods compared when fork length was considered. The anadromous Arctic charr sampled in 2019 reached a probability of 50% at a fork length of 473 mm as against 556 mm in 1997-1998, a difference of 83 mm (Figure 14).

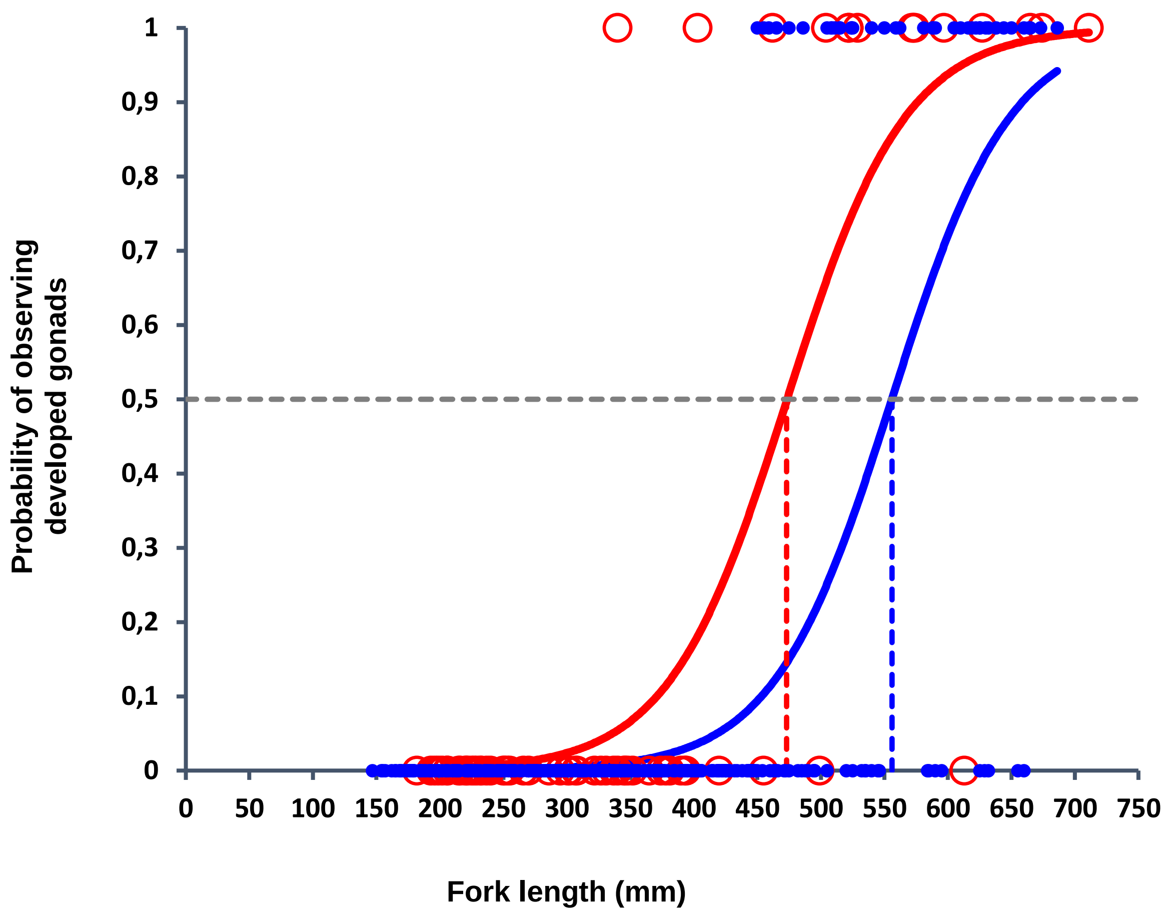

Figure 14: Probability of observing developed gonads depending on the fork length of anadromous Arctic charr sampled in 1997-1998 (blue) and in 2019 (red), regardless of sex

When age was considered instead of fork length, it is starting at 10 years of age that the probability of observing gonads was equivalent to or greater than 50% in 2019, while it took two and a half years more in 1997-1998 to cross this threshold (Figure 15).

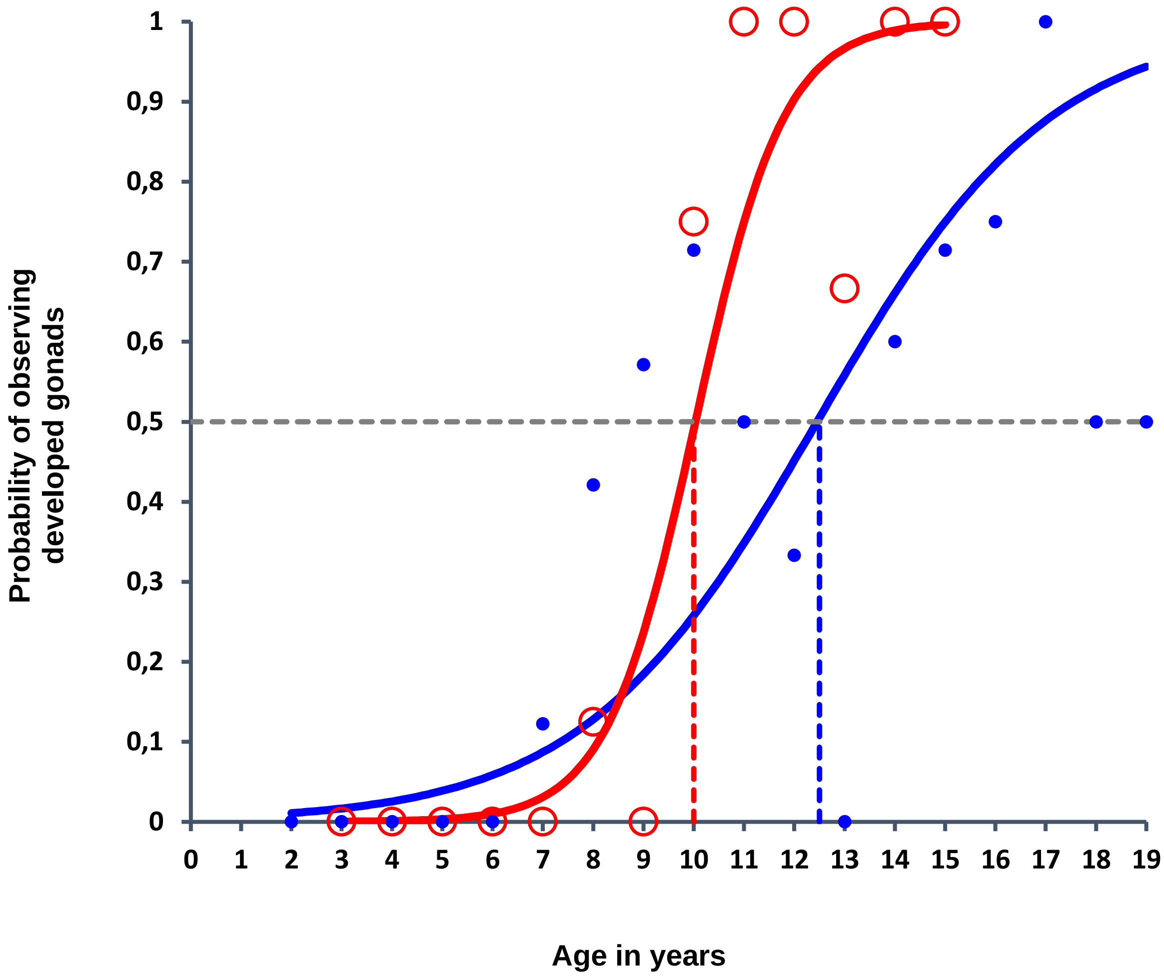

Figure 15: Probability of observing developed gonads depending on the age of anadromous Arctic charr sampled in 1997-1998 (blue) and in 2019 (red), regardless of sex

Age structure and total annual mortality

The age structures were defined for the two periods to calculate the total annual mortality rate, estimated at 22.9% in 2019, i.e., 5.5 percentage points below the estimate in 1997-1998 (28.4%). However, the predicted difference is supported statistically, in particular because of the steeper slope at which the counts decrease with age in 1997-1998 compared with 2019 (Figure 16). Accordingly, the probability of survival estimated in 2019 was just as good if not slightly better than what prevailed 20 years earlier.

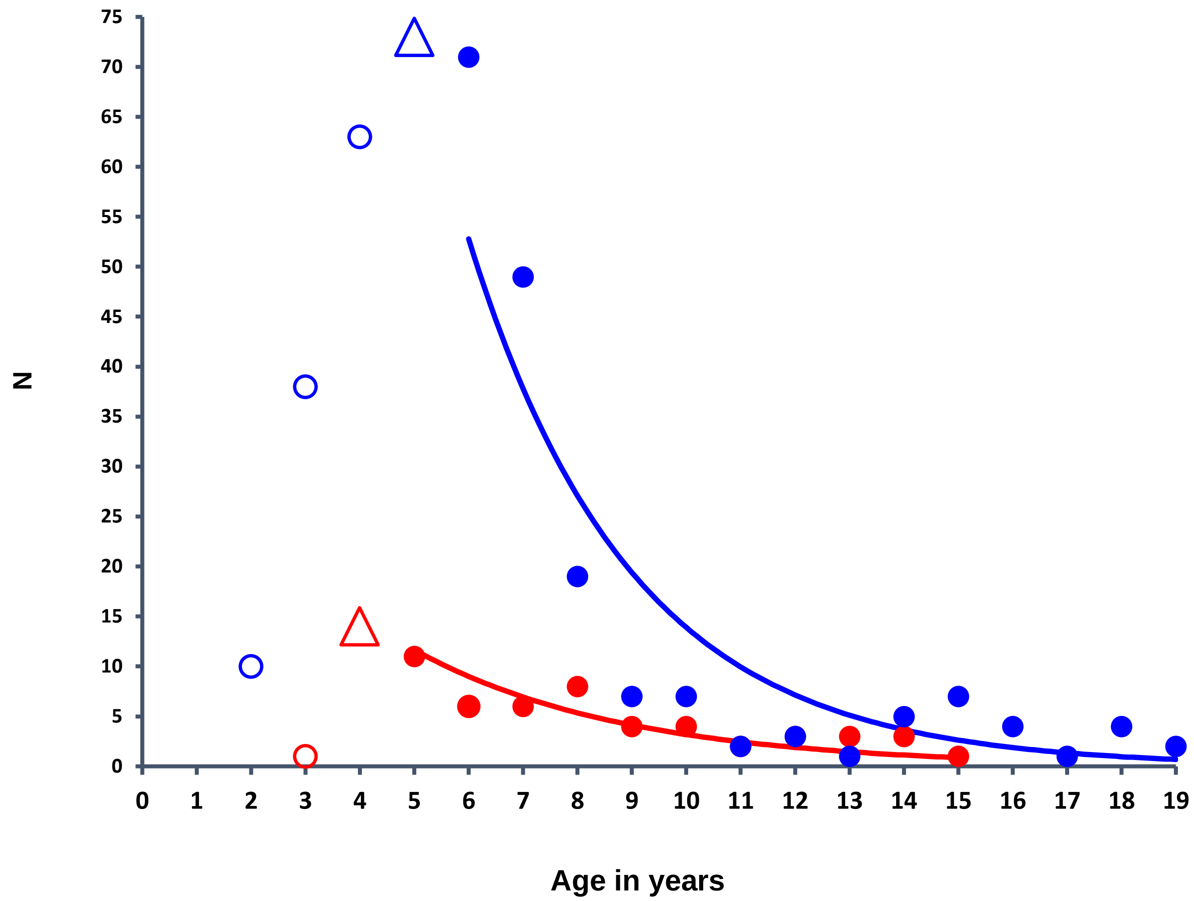

Figure 16: Age structure of Arctic charr from the Tasiallujuak River sampled at the counting fence in 1997-1998 (blue) and in 2019 (red). An empty triangle represents the most abundant age group, i.e. the "Peak" criterion. Full circles indicate the age groups fully recruited by the fishing equipment according to the "Peak Plus" criterion (Smith *et al*., 2012), while empty circles represent the age groups partially recruited by the fishing equipment, which are not considered in the analysis. Regression curves (solid lines) represent the predicted values of the number of individuals (N), which declines depending on age, thus reflecting the instantaneous mortality rate inferred by a log-linear model.

Contaminants

A total of 48 Arctic charr among those sampled in 2019 were analyzed individually to establish concentrations of mercury, which ranged from 0.02 to 0.32 mg/kg (Table 2), whereas the threshold that Health Canada recommends is 0.50 mg/kg. A total of 18 other contaminants (metals) were analyzed. Table 3 presents the average concentrations obtained by size class. Unlike mercury, these values were obtained from homogenates, i.e., a mixture of tissues from different individuals to obtain a single value for a given length class.

Table 2: Concentration of mercury (Hg; mean ± standard deviation) according to the length class considered among the Arctic charr sampled in the Tasiallujuak River, Salluit, Nunavik, summer 2019

Length class[1]	Hg (mg/kg)	*n*
Unranked	0.054 ± 0.022	10
Small	0.042 ± 0.017	23
Medium	0.150 ± 0.118	4
Large	0.100 ± 0.028	11

[1] Table 1 presents the length classes. “Unranked” corresponds to Arctic charr that are smaller than the “small” length class, i.e., under 300 mm in total maximum length according to the MELCCFP’s criteria.

Table 3: Contaminant levels[1] (mg/kg) depending on length class (according to the total maximum length) in the Arctic charr sampled in the Tasiallujuak River, Deception Bay area, Salluit, Nunavik, summer 2019. One value is presented per length class and comes from the homogenate of individuals for a given class.

Length class[2]	*n*	Al	As	Ba	Cd	Cr	Co	Cu	Fe	Mn	Mo	Ni	Pb	Se	Sr	Tl	U	V	Zn
Medium	4	1.0	0.62	0.013	< 0.02	0.011	0.010	0.75	5.7	0.06	0.003	0.14	0.003	0.39	0.08	0.002	< 0.001	< 0.02	4.6
Large	11	< 0.5	0.86	0.010	< 0.02	0.013	0.005	0.70	5.7	0.06	0.003	0.13	0.004	0.38	< 0.07	0.002	< 0.001	< 0.02	4.8

[1] Al: aluminum; As: arsenic; Ba: barium; Cd: cadmium; Cr: chrome; Co: cobalt; Cu: copper; Fe: iron; Mn: manganese; Mo: molybdenum; Ni: nickel; Pb: lead; Se: selenium; Sr: strontium; Tl: thallium; U: uranium; V: vanadium; Z: zinc.

[2] See Table 1 for the length classes.

Discussion

Monitoring on the Tasiallujuak River facilitated the acquisition of detailed knowledge of the biology of anadromous Arctic charr found in the Deception Bay area east of the community of Salluit. Such information overall provides a reference state concerning the condition, growth, reproduction, and total annual mortality of Arctic charr and the metal contamination levels, especially mercury, in this sector that is used for the pursuit of traditional activities, including fishing. However, given that the study could not be conducted during the entire upstream migration period, the results presented in this report must be regarded, at best, as a partial representation of the condition of the stock targeted. On the other hand, a comparison of 2019 data and data collected in 1997-1998 affords a better perspective of the changes that occurred, which, in fact, are not conspicuous despite a gap of more than 20 years, thereby suggesting a stable dynamic in this Arctic charr population. However, the partial nature of the data collected in 2019 limits our ability to adequately compare the two periods, thus restricting the interpretation of the results obtained.

Biological parameters of the fish sampled

A total of 5 141 Arctic charr were counted between July 31st and August 25th, 2019. However, a greater number of individuals would have been counted if the counting fence had been in operation at the outset of the upstream migration and it had been possible to pursue the work until its conclusion as was the case in 1997-1998 (Locke, 1999). What is more, Locke (1999) noted that the dates of peak abundance between the years were similar with the majority of the Arctic charr counted between August 28 and September 9th. Consequently, it was impossible to determine a representative number of anadromous Arctic charr travelling upstream in the Tasiallujuak system in the summer of 2019, but only part of it. It should be noted that Locke (1999) documented significant fluctuations in abundance between 1997 and 1998, thereby indicating that counting in one year does not necessarily guarantee similar abundance the following year. This established fact stems in part from the low fidelity of Arctic charr in the lakes where they winter (Gyselman, 1994; Gilbert *et al.*, 2016). The partial results obtained nonetheless suggest that this population is, in fact, abundant, given that field observations reveal that several Arctic charr still had not crossed the counting fence when the project ended. Regardless, the data collected at the counting fence enabled us to quantify useful biological parameters to better grasp the condition of this stock.

Condition factor

Most of the individuals sampled displayed an "acceptable" condition factor. Indeed, overall, the condition factor of the Arctic charr sampled in the Tasiallujuak River in 2019 (K_F = 1.08) was similar to or lower than other values drawn from the literature. For example, in Cambridge Bay in Nunavut, Moore *et al.* (2016) reported an average K_F value of 1.02 ± 0.14 among resident Arctic charr and 1.06 ± 0.08 among non-resident Arctic charr, whereas on the Hornaday River in the Northwest Territories, Harwood (2009) reported an average annual K_F of 1.24 (range: 1.15 to 1.38). In Nunavik, Boivin (1994) reported that the condition factor of Arctic charr caught in the Sapukkait system north of the community of Kangiqsualujjuaq displayed an average of 1.11, 1.08, and 1.11 in 1990, 1991, and 1992, respectively. In Ungava Bay in 2016, the Arctic charr caught in the rivers and lakes situated near Aupaluk had a higher condition factor of 1.22 (Mainguy and Beaupré, 2019a), whereas in 2017, Arctic charr from the Bérard River in Tasiujaq displayed an even higher condition factor of 1.28 (Mainguy and Beaupré, 2019b). In Hudson Bay, Mainguy and Beaupré (2021) reported average K_F values ranging from 1.13 to 1.16 for different sectors situated north of Inukjuak. While the condition factor of the Tasiallujuak River Arctic charr is adequate, it is lower than the condition factors observed elsewhere in Québec in Ungava Bay and Hudson Bay. Deception Bay is farther north than the other sites studied in Nunavik and the shorter summers in the Salluit area for offshore migrations likely do not allow the Arctic charr to grow and accumulate reserves as do the populations found at lower latitudes that can feed for longer periods in the sea during ice-free periods.

Reproduction

Among the Arctic charr sampled, few individuals would spawn during the year under way, but they were more frequent than what the MELCCFP team reported for this species at the other sites studied in Nunavik (Mainguy and Beaupré, 2019a, 2019b, 2021). The proportion of anadromous Arctic charr sampled during upstream migration in which developed gonads were observed was often low, on the order of less than 1% for the Sapukkait system (Boivin, 1994), but it can be higher in other systems such as in Labrador (Dempson et Green, 1985). Overall, the data suggest some degree of reproductive periodicity in Arctic charr, i.e., that most Arctic charr do not reproduce each year by way of an example since it is possible that they must reconstitute their reserves (Dutil, 1986). Furthermore, Boivin (1994) reported that the first reproductive event among the Arctic charr in the Sapukkait and Sannirarsiq systems north of Kangiqsualujjuaq could occur between 8 and 10 years of age, which is fairly advanced. The age of 10 years estimated for the A_{50} concerning the Tasiallujuak River in 2019 and the higher age of between 12 and 13 years at the same site in 1997-1998 correspond to the fairly advanced ages at which we expect one specimen in two regardless of sex can participate in the next spawning period. Indeed, in Aupaluk in 2016 among the individuals 5 years of age and over the proportion of female spawners during the year stood at 5.6% and of male spawners at 1.9% (Mainguy and Beaupré, 2019a). In the Tasiujaq area, the individuals identified as spawners during the year ranged in age from 4 to 7 years. Among the individuals 5 years of age and over, 8.1% of the females and 19.2% of the males were spawners (Mainguy and Beaupré, 2019b). Of the Arctic charr sampled in the Bérard River (Tasiujaq) whose age could be determined (n = 80), only 3.8% were 8 years of age and over, whereas in Aupaluk in 2016, by contrast, the figure stood at 7.5% (n = 280; Mainguy and Beaupré, 2019a, 2019b). While the age at sexual maturity is unknown for these sites located father south because of the small number of spawners sampled in the year, it is likely that the proportion of Arctic charr between 5 and 9 years of age contributing to reproduction was in fact low.

Total annual mortality

The 23% estimated total annual mortality among Arctic charr from the Tasiallujuak River in 2019, as against 28% in 1997-1998, is deemed from “low” to “moderate” and is thus less worrisome than the estimated total annual mortality rates at other sites that were monitored in Nunavik. For example, Boivin (1994) estimated annual mortality at 28% in 1990 and 40% in 1992 in the Sapukkait system. In Aupaluk in 2016 estimated annual mortality for the Voltz River, Chien Rouge River and Hopes Advance Bay ranged from 47% to 52% (Mainguy and Beaupré, 2019a), whereas the estimated total annual mortality in Tasiujaq in the Bérard River in 2017 was 50% (Mainguy and Beaupré, 2019b). The values observed more recently in Ungava Bay are lower than the value observed in 2018 in Inukjuak, which were on the order of 70% to 80% but hinged, however, on a small sample for this study site. Nevertheless, estimated mortality in Salluit in 2019 was the lowest observed among the MELCCFP studies devoted to Arctic charr in Nunavik between 2016 and 2019. Compared with other populations fished in northern Canadian communities, such as the Arctic charr monitored in the Fraser River in Labrador, Dempson and Green (1987) estimated annual mortality of 44% to 49%, similar to the mortality rates observed in Ungava Bay. Over an 18-year period in the Hornaday River in Paulatuk in the Northwest Territories, the average total annual mortality of the Arctic charr between 6 and 14 years of age sampled stood at 54 ± 10% (range: 35.4% to 70.7% in 1990-2007; Harwood, 2009), which also more closely resembles the mortality estimates observed in Ungava Bay. The same is true of the Kuujjua River on Victoria Island in the Northwest Territories, where Harwood *et al.* (2013) reported average total annual mortality of 45% (95% confidence interval: 42% to 48%) between 1992 and 2009. In the Isuituq River near Pangnirtung on Baffin Island in Nunavut, Arctic charr between 11 and 21 years of age had an average total annual mortality of 34.5 ± 9.5% (range: 24% to 49% during a six-year period in 2002-2006 and 2008; DFO, 2010), which more closely resemble those observed for Salluit in 1997-1998. The same is true of the Cumberland Sound area on Baffin Island, where Moore (1975) estimated annual mortality at 16%, with the highest values (25% to 30%) observed among individuals 10 years of age and from 15 to 17 years of age. Power *et al.* (2008) conducted a literature review on annual mortality estimates in Canadian anadromous and lacustrine populations among Arctic charr between 6 and 15 years of age. They reported that total annual mortality fell within a range of 30% to 45% although they also noted that certain populations displayed rates below 25%, as in this case for 2019. When all this information is considered, the anadromous Arctic charr from the Tasiallujuak River clearly lie in the lower ranger for this biodemographic parameter, which bodes well for the population’s long-term survival. The comparisons that were just made were however approximate at best, as different methods were used to estimate the mortality rates across studies and sites. Nevertheless, estimated mortality rates are judged to be low for the studied population of the Tasiallujuak River.

Contaminants

The results obtained by the MELCCFP's ecotoxicology laboratory indicate that the Arctic charr sampled in the Tasiallujuak system had concentrations of mercury below the 0.5 mg/kg threshold that Health Canada recommends, a finding that is in itself reassuring and is similar to the concentrations found in other populations examined in Nunavik (Mainguy and Beaupré, 2019a, 2019b, 2021). Notwithstanding the foregoing, it is important to refer to local, provincial, and federal health agencies regarding concerns or questions pertaining to fish consumption in relation to mercury or any other contaminant. It should be noted, in this respect, that the concentrations of contaminants presented in Table 4 are provided solely for information purposes. Any interpretation of the findings from a public health perspective should be conducted with the assistance of experts in the fields of ecotoxicology and health.

Conclusion

The Arctic charr sampled in the Tasiallujuak system during the upstream migration in August 2019 displayed an acceptable condition factor, had higher proportions of individuals with developed gonads than elsewhere in Nunavik, with a low mortality rate for the species, in addition to displaying low concentrations of mercury. The combined results can be interpreted overall as reflecting a healthy population. On the other hand, large specimens measuring more than 60 cm for instance were in fact rare, as has been observed elsewhere in Nunavik in recent years. The proportion ranged from 0.81% in 1997-1998 to 1.34% in 2019 on the Tasiallujuak River. Despite differing length-age relationships between the periods, an anadromous Arctic charr must live more than 13 to 14 years to reach a large size, whereas the age to reproduce is more likely to be reached only a few years earlier around the age of 10 to 13 years in this system, which is among the most northerly found in Nunavik. In the absence of long-term data and complete data for 2019, it is difficult to establish a sufficiently accurate status for the population targeted. However, comparisons made between 1997-1998 (Locke, 1999) and 2019 (this study) suggest that little has changed over more than two decades, which suggests some degree of stability in the system over time. On the other hand, the scope of ongoing and future impacts, related in particular to climate change (Reist *et al.*, 2008) and any disturbance of anthropogenic origin engenders considerable uncertainty regarding the long-term survival of anadromous and resident Arctic charr populations in Northern Québec. Periodic monitoring of habitats, the state of the stocks of different populations, including those in the Tasiallujuak system, and the attendant biodemographic parameters, is desirable in this context.

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ᐃᖃᓗᐸᐲᑦ ᖃᐅᔨᓴᕐᑕᕕᓃᑦ ᑕᓯᐊᓗᑦᔪᐊᑉ ᑰᖏᓐᓂ ᒪᔪᕐᑎᓗᒋᑦ ᐊᐅᒡᒍᓯ ᓄᐃᑕᑎᑦᓯᔪᕕᓃᑦ ᓈᒻᒪᑐᒥᒃ ᖃᓄᐃᓕᖓᓂᖓᓄᑦ ᐱᑦᔪᑎᐅᔪᒥᒃ, ᐳᕐᑐᓂᖅᓂᒃ ᐃᖃᓗᑦᑕᖃᓚᐅᔪᖅ ᐊᑕᐅᓯᐅᓈᕐᑎᑐᓂᒃ ᓱᕙᓕᐅᐹᓇᓯᓯᒪᔪᓂᒃ ᐊᓯᓕᒫᖏᓐᓂᑦ ᓄᓇᕕᒻᒥ, ᑐᕐᑯᖃᑦᑕᓂᖏᑦ ᐃᑮᓂᓴᐅᑦᓯᑎᒃ ᑌᒣᑐᓄᑦ ᐃᖃᓗᓐᓄᑦ, ᐃᓚᖃᕐᓯᑎᒃ ᓄᐃᑕᑎᑦᓯᓂᕐᒥᒃ ᐳᒃᑰᑎᐊᖓ ᑭᑭᐊᑦᓴᔮᖅ mercury. ᑲᑎᕐᓱᓯᒪᔪᑦ ᖃᐅᔨᓴᕐᓂᐅᑉ ᓄᐃᑕᕕᓂᖏᑦ ᑐᑭᓯᓇᕐᑎᑕᐅᒍᓐᓇᑐᑦ ᐃᓘᓐᓈᒍᑦ ᓄᐃᑕᑎᑦᓯᔪᑦ ᖃᓄᐃᙱᑦᓯᐊᕐᑐᓂᒃ ᓄᖑᓐᓂᐅᔾᙱᑐᓂᒃ ᐃᖃᓗᐸᓂᒃ. ᐁᐸᓗᒍᑦ, ᐊᖏᓂᖅᓴᑦ ᐃᖃᓗᐃᑦ ᐊᖏᓂᓖᑦ 60 cm ᐅᖓᑖᓄᑦ ᐃᑭᑦᑑᓚᐅᔪᑦ, ᖃᐅᔾᔭᐅᓯᒪᒻᒪᑦ ᐊᓯᖏᓐᓂ ᓄᓇᕕᒻᒥ ᐊᕐᕌᒍᓚᐅᕐᑐᓂ. ᑲᑦᓯᐅᓂᖏᑦ ᐊᑦᔨᕐᙱᖏᓂᖃᓚᐅᕐᓯᒪᔪᑦ 0.81%-ᒥᑦ 1997-1998-ᒥ 1.34%-ᒧᑦ 2019-ᒥ ᑕᓯᐊᓗᑦᔪᐊᑉ ᑰᖓᓂ. ᐊᑦᔨᕐᙱᖏᓂᖃᕋᓗᐊᕐᓯᑎᒃ ᑕᑭᓂᖏᑦᑕ-ᐅᑭᐅᖏᑦᑕ ᐱᑐᑦᓯᒪᐅᑎᓂᖏᑦ ᐊᑯᓐᓂᖓᓂ ᑖᒃᑯᐊ ᐊᕐᕌᒍᐃᑦ, ᐃᖃᓗᐸᒃ ᐆᒪᒋᐊᓕᒃ ᐅᑭᐅᓂᒃ 13-ᓂᑦ 14-ᓄᑦ ᐅᖓᑖᓄᑦ ᐊᖏᓕᑦᓯᐊᓚᖓᒍᓂ, ᐅᑭᐅᖏᑦ ᓱᕙᓕᐅᐹᓇᓯᒍᑎᒃ ᑎᑭᐅᑎᔭᐅᓂᖅᐅᓲᖑᑎᓪᓗᒋᑦ ᐊᒥᓲᙱᑐᓂᒃ ᐊᕐᕌᒍᓂᒃ ᓯᕗᓪᓕᐅᓯᑎᒃ ᐅᑭᐅᖃᓕᕐᒥᒃ 10-ᓂᑦ 13-ᓄᑦ ᑖᒃᑯᓇᓂ ᑰᓂ ᑕᓯᕐᓂᓗ,

ᑕᕐᕿᒦᓐᓂᐸᐅᖃᑕᐅᔪᓂ ᓄᓇᕕᒻᒥ. ᐱᑕᖃᕐᑎᓇᒋᑦ ᐊᑯᓂ ᖃᐅᔨᓴᕐᑕᐅᓯᒪᔪᑦ ᐊᒻᒪᓗ ᐃᓗᐃᑦᑑᓕᑎᒃ 2019-ᒧᑦ, ᐱᔭᕆᐊᑐᔪᖅ ᓈᒻᒪᓈᕐᓯᐊᑐᒥᒃ ᖃᓄᐃᓕᖓᕐᓯᐊᒪᖔᑕ ᖃᑦᓯᐅᓂᖏᑦ ᖃᐅᔨᓴᕐᑕᐅᔪᑦ ᐅᖃᕋᓱᒋᐊᒥᒃ. ᑌᒪᓗᐊᕐᑎᓗᒍ, ᖃᓄᖅ ᐊᑦᔨᒌᖕᖏᓂᖃᕐᒪᖔᑕ ᖃᐅᔨᓴᕐᓃᑦ ᐊᑯᓐᓂᖓᓂ 1997-1998 (ᒑᒃ, 1999) ᐊᒻᒪᓗ 2019 (ᑖᓐᓇ ᖃᐅᔨᓴᕐᓂᖅ) ᓇᓗᓀᕐᓯᔪᖅ ᐊᓯᑦᔨᓯᒪᓪᓗᐊᖏᒋᐊᖓ ᐊᕐᕿᒧᐃᑦ ᐊᕙᑏᑦ ᐅᖓᑖᓂ, ᓇᓗᓀᕐᓯᓱᓂ ᑌᒫᑦᓴᓇᓕᓚᓐᓂᖓᓂᒃ ᑖᒃᑯᓇᓂ ᑰᓐᓂ ᑕᓱᕐᓂᓗ ᐊᕐᕿᒧᓂ ᖄᖏᕐᑐᓂ. ᐁᑉᐹᒧᑦ, ᐊᖏᓂᖏᑦ ᒦᓐᓇ ᐊᒻᒪᓗ ᓯᕗᓂᑦᑎᓂ ᓱᕐᖁᓂᖏᑦᑕ, ᓯᓚᐅᑉ ᐊᓯᑦᔨᕚᓪᓕᐊᓂᖓᓅᓕᖓᓗᐊᖕᖑᐊᑐᑦ (Reist *et al.*, 2008) ᐊᒻᒪᓗ ᐸᕝᕕᓴᕐᑕᐅᓂᖏᓐᓄᑦ ᐃᓄᓐᓄᑦ ᓄᐃᑦᓯᔪᖅ ᐊᖏᔪᒥᒃ ᓇᓗᓇᕐᑐᒦᓐᓂᒥᒃ ᐱᑦᔪᑎᒋᓗᒍ ᐊᑯᓂ ᐊᓐᓇᐅᒪᓚᖓᓂᖓ ᐃᖃᓗᑉᐲᑦ ᑯᐯᒃ ᑕᕐᕿᖓᓂ. ᖃᐅᔨᓴᓕᐅᒥᔮᖃᑦᑕᓃᑦ ᓇᔪᖓᖏᓐᓂᒃ, ᖃᓄᐃᓐᓂᖏᓐᓂᒃ ᖃᑦᓯᐅᓂᖏᑦᑕ ᐊᑦᔨᒌᖕᖏᑐᑦ ᐃᖃᓗᐃᑦ, ᐃᓚᖃᕐᓱᑎᒃ ᑌᒃᑯᓂᖓ ᑕᓯᐊᓗᑦᔪᐊᑉ ᐃᒪᖏᓐᓃᑐᓂᒃ, ᐊᒻᒪᓗ ᑌᑲᓃᑦᑐᑦ ᐃᖃᓗᐃᑦ ᖃᓄᐃᓕᖓᓂᖏᓐᓂᒃ ᓇᓃᓐᓂᖏᓐᓂᓗ, ᐱᒧᒥᓇᕐᑐᖅ ᑌᒪᓕᖓᔫᒥᑦᑎᓗᒍ.

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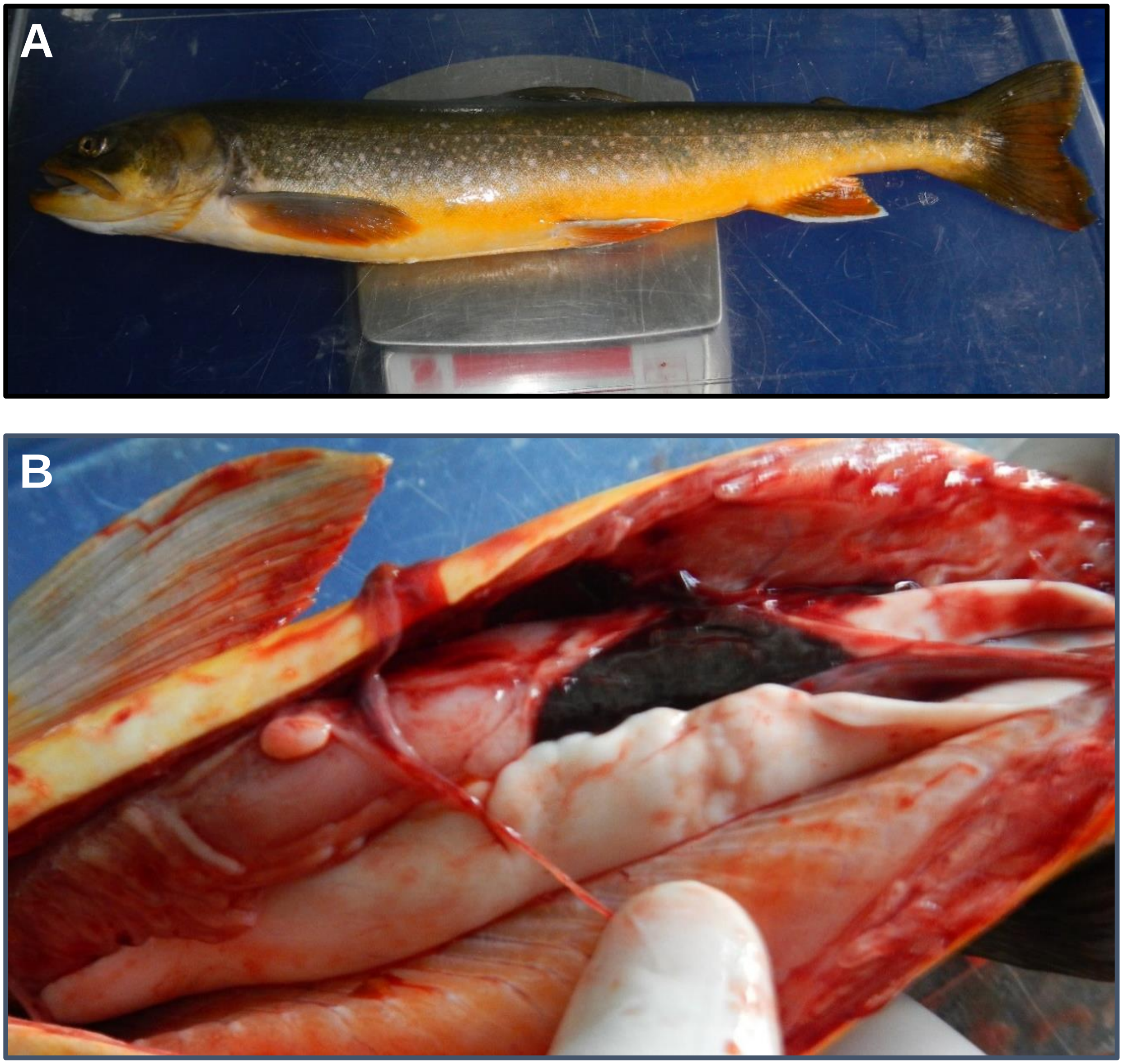
Appendices

Appendix 1



A) Arctic charr sampled at the counting fence that was not deemed anadromous (*iqaluppik*) but "resident" instead that more closely resembled a landlocked (*nutillik*) specimen. The specimen was not, therefore, included in the analyses described in this report.

B) This photo shows a male specimen with fully developed gonads that would participate in spawning in the fall.

Appendix 2

Projects for which biological samples were collected

1) Toxoplasmosis: the brain, heart, and a muscle sample were submitted to Dr. Brent Dixon at Health Canada to study the *Toxoplasma gondii* protozoon.

2) Microbiota: a swab of the mucus covering the skin and samples of the branchial arches and sections of the small intestine and the liver were preserved to study the microorganisms found in the fluids, tissues, and organs by Prof. Nicolas Derome at Université Laval in the context of the Bridging Global Change, Inuit Health and the Transforming Arctic Ocean (BriGHT) project.

3) Nutritional value: a muscle sample was submitted to Prof. Jean-Sébastien Moore at Université Laval to study, by way of an example, the fatty acids found in Arctic charr flesh in the context of the BriGHT project.

Environnement,
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