Ministère des Forêts, de la Faune et des Parcs

Establishment of a reference state for Arctic charr population(s) in Aupaluk

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Québec

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The scientific team from the Ministère des Forêts, de la Faune et des Parcs (MFFP) involved in planning and carrying out the fieldwork in Aupaluk in August and September 2016, included employees from:

The Direction de l'expertise sur la faune aquatique

- Ariel Arsenault, Wildlife Technician
- Jean-Nicolas Bujold, Wildlife Biologist, M.Sc.
- Guillaume Lapierre, Wildlife Biologist, M.Sc.
- Julien Mainguy, Wildlife Biologist, Ph.D.
- Yanick Soulard, Wildlife Technician

The Direction de la gestion de la faune Nord-du-Québec

- Laurie Beaupré, Wildlife Biologist, M.Sc.
- Catherine Bruneau, Wildlife Technician
- Andréanne Landry, Wildlife Technician
- Mathieu Oreiller, Wildlife Biologist, M.Sc.
- Pascal Ouellet, Wildlife Technician

Highlights

Samples were taken from four lakes, seven watercourses and Hopes Advance Bay, using a combination of fishing techniques, with the aim of characterizing the Arctic charr and other fish found in the Aupaluk region. The purpose was to establish an ichthyological reference state.

- The Fulton's condition factor (K) for Arctic charr in the Aupaluk region is considered to be good, since the mean was 1.22 ± 0.16 for a sample of 253 fishes.

- The percentage of current-year spawners among sampled Arctic charrs aged 5 or older was low, with just 5.6 % of females (*n* = 72) and 1.9 % of males (*n* = 53) having mature gonads.

- The deduced annual mortality based on age structure data varied from 41 to 52 %; these values were assessed as moderate to high compared to those for other Arctic charr populations.

- Mercury concentrations in the muscle samples of Arctic charr and brook trout were below the 0.5 mg/kg threshold set by Health Canada. However, mercury concentrations in the muscle samples of lake trout were sometimes above the recommended threshold, and precautions should therefore be taken when consuming this species, especially larger fish.

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ᐆᑦᑐᕋᐅᑎᑕᕐᕕᐅᓯᒪᔪᑦ ᓯᑕᒪ ᑕᓰᑦ, ᓯᑕᒪᐅᔪᖕᖏᓚᕐᑐᑦ ᑰᑦ ᐊᒻᒪᓗ ᑕᓯᐅᔭᖅ Hopes Advance Bay, ᐊᑐᕐᓱᒋᑦ ᐊᑦᔨᒌᙱᑐᑦ ᐃᖅᑲᓪᓯᐅᕈᑏᑦ, ᖃᓄᐃᑦᑑᓂᖏᓐᓂᒃ ᐊᐅᐸᓘᑉ ᓴᓂᐊᓂ ᐃᖃᓗᒃᐲᑦ ᐊᒻᒪᓗ ᐊᓯᖏᑦᑦ ᐃᖃᓗᐃᑦ ᖃᐅᔨᓚᓱᐊᕐᓂᖅᓱᑎᒃ. ᐱᑦᔪᑎᐅᓚᐅᖁᖅ ᓄᐃᑦᓯᓂᖅ ᐃᖃᓗᓕᕆᓂᕐᓂ ᑕᑯᓚᓱᐊᕋᑦᓴᓂᒃ ᐊᑐᐃᓐᓇᖑᕐᑎᓯᓂᖅ.

- Fulton's condition factor (K) ᖃᓄᐃᓕᙵᓕᕐᓂᖏᓄᑦ ᖃᐅᔨᓚᓱᐊᕐᓯᒪᔫᒃ ᐊᐅᐸᓘᑉ ᓴᓂᐊᓂ ᐃᓱᒪᒋᔭᐅᔪᖅ ᐱᐅᔫᒋᐊᖓ, ᐊᑯᓐᓂᖅᑯᕐᓂᒪᑕ 1.22 ± 0.16 ᐆᑦᑐᕋᕐᑕᐅᓱᑎᒃ 253 ᐃᖃᓗᐃᑦ.

- ᐳᓯᐊᓐᑎᖏᑦ ᐊᕐᕋᒍᒥ ᐊᑐᓕᕐᑐᒥ ᒪᓐᓂᑖᓇᐊᕐᑐᓯᒪᔪᑦ ᐆᑦᑐᕋᕐᑕᐅᔪᓂ ᐃᖃᓗᒃᐱᓂ ᐅᑭᐅᖃᕐᓱᑎᒃ 5-ᓂ 5.6 %-ᒋᔭᐅᔪᕙᓃᑦ ᐊᕐᓇᓄᑦ (*n* = 72) ᐊᒻᒪᓗ 1.9 %-ᒋᔭᐅᔪᑦ ᐊᖑᑎᑕᖏᑦᑕ ᐆᑦᑐᕋᕐᑕᐅᔪᑦ (*n* = 53) ᐱᐊᕋᑦᓴᓕᐅᕈᑎᖃᕐᓱᑎᒃ ᓈᒻᒪᓕᕐᑐᓂᒃ.

- ᐋᕐᑕᐅᓂᕆᓘᖏᑦ ᑲᑎᖏᓐᓂᑦ ᐊᕐᕋᒍᑕᒫᑦ ᑐᕐᑯᕓᓐᓂᖏᑦᑕ ᑐᙵᕕᒋᑦᓱᒋᑦ ᐅᑭᐅᖏᑦᑕ ᑐᑭᓯᔭᐅᒍᑎᒋᓯᒪᔭᖏᑎᒍᑦ ᐊᑦᔨᒌᙱᖏᓂᖃᓚᐅᔩᑦ ᐃᒣᓗᐊᓂᕋᕐᑕᐅᓱᑎᒃ 41-ᓂᑦ 52 %-ᒧᑦ; ᑖᒃᑯᐊ ᑭᑎᑦᓯᓯᒪᐅᑏᑦ ᖃᐅᔨᓴᕐᑕᐅᓱᑎᒃ ᐊᑯᓪᓚᓂᑦ ᐳᕐᑐᔫᑦ ᐆᑦᑑᑎᒋᑦᓱᒋᑦ ᐊᓯᖏᑦ ᐃᖃᓗᐋᑦ ᑲᑎᒪᔪᑦ ᖃᑦᓯᐅᓂᕆᓃᑦᑕᖏᑦ ᐊᓯᖏᓐᓂ.

- ᒥᐅᑯᔨᑦᓴᖄᑦᑕᓚᐅᕐᑐᑦ ᓄᑭᖏᑦ ᐆᑦᑐᕋᕐᑕᐅᔪᑦ ᐃᖃᓗᐋᑦ ᐊᒻᒪᓗ ᐃᓱᕋᓕᑦᑖᑦ 0.5 mg/kg ᐊᑖᓃᑦᑐᓂᒃ ᑳᓇᑕᒥ ᐃᓗᓯᕐᓱᓂᓕᕆᔨᒃᑯᑦ ᐃᑭᓐᓂᐸᐅᒎᓇᕕᓕᐊᕆᓯᒪᔭᖓᑕ. ᑭᓯᐊᓂ, ᒥᐅᑯᔨᑦᑕᖏᑦ ᑲᑎᕐᓯᓯᒪᔪᑦ ᓄᑭᖏᓐᓂ ᐆᑦᑐᕋᕐᑕᐅᔪᑦ ᐃᓱᕋᓕᑦᑖᑦ ᐃᓛᓐᓂ ᖁᓛᓃᖅᑕᐅᓚᕐᑐᑦ ᑌᒣᓗᐊᑐᑦ, ᐊᒻᒪᓗ ᐃᑉᐱᒋᔭᐅᑦᓯᐊᕆᐊᖃᓕᕐᓱᑎᒃ ᑌᒣᑦᑐᓂᒃ ᐃᖃᓗᑦᑐᑦ, ᐱᓗᐊᕐᑐᒥᒃ ᐃᖃᓗᕐᓚᐅᓂᕐᓴᓂᒃ.

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Introduction

Background to the study

The Ministère des Forêts, de la Faune et des Parcs (MFFP) obtained a subsidy from the Société du Plan Nord to prepare priority population reference states for fish species in different regions of Northern Québec, prior to new development projects in the areas in question. The Arctic charr (*Salvelinus alpinus*) is important to the Inuit communities, and most population reference state studies in Nunavik have focused on that species, although some other species, including the salmonids, have also been taken into consideration.

General objective

The general aim of the project was to gather information on Arctic charr populations in rivers and lakes located close to the Aupaluk community.

Reassessment of the original specific objectives for the Red Dog River

Originally, the objective of the project was to gather detailed information on the Arctic charr population in the Red Dog River, during upstream migration, by:

- using a temporary counting fence to estimate the size of the anadromous Arctic charr population;
- characterizing a sample of the Arctic charr population by establishing its age and obtaining morphometric measurements and other biological parameters;
- assessing the presence of contaminants in the sampled fishes.

Following a field assessment, however, the scientific team concluded that the waterfalls on the Red Dog River were an insurmountable barrier to upstream migration by Arctic charr. This opinion was shared by certain Aupaluk community residents consulted by the team. Since there were no significantly-sized coastal lakes between Hopes Advance Bay and the Red Dog River falls that could have been used as reproduction or wintering sites by the Arctic charr, it was decided to install the counting fence on another river instead. After discussion with the Aupaluk Local Nunavimmi Umajulirijiit Katujjiqatigiinninga (LNUK), the Voltz River was identified as an alternative site for the fence. The location of this particular river, close to the Aupaluk community, made project logistics easier, but on the other hand, the river was smaller than the team's original choice. The team therefore agreed with the LNUK to expand the framework of the study to include fish species in certain rivers and lakes near Aupaluk. This meant characterizing Arctic charr (and other fish species) sampled via the counting fence on Voltz River as well as those harvested in the other target lakes and rivers by means of electro-fishing or gill nets. The aim of this process was to take morphometric measurements, determine age from otoliths, determine gender, detect the presence of contaminants and note other biological parameters. Although the size of the Arctic charr populations in Red Dog River and Voltz River could not be estimated (see the "Results" section), fish population parameters were nevertheless quantified in Red Dog Lake, Red Dog River and Voltz River, as well as in other lakes, rivers and streams, and in Hopes Advance Bay.

Materials and Methods

Counting fence

A temporary counting fence (Figure 1) was installed and activated on Voltz River from August 9 to September 26, 2016. The two fence wings were composed of tripods made of steel pipes measuring 6, 9 or 12 feet in length. A holding cage that captured the fish as they migrated upstream was used to count the number of Arctic charrs and measure them against evenly-spaced lines on the bottom of the cage (Figure 2). In accordance with the upstream migration monitoring protocol, the cage was visited every day, and the 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 2016, on Voltz River, Aupaluk, Nunavik.

Figure 2. Measuring lines 10 cm apart on the floor of the holding cage, used to estimate the size of the Arctic charr before they were released upstream.

Gill net fishing in Red Dog River and in the coastal lakes

Because there were no anadromous adult Arctic charr in Voltz River during the period in which upstream migration would normally reach its peak (from mid-August onwards), it was decided to use gill nets to sample Arctic charr in Red Dog River and in some coastal lakes in the Aupaluk sector (Figure 3). This decision improved the sample's spatial representiveness. In all, four lakes (Nipirqanaq, Voltz, Brûlé and Red Dog), known by the Inuit to be used by Arctic charr, were targeted for standardized gill net fishing at different times between August 7 and September 9, 2016. This lethal sampling technique was used to characterize the species present in the lakes and to measure their size and age structure, as well as their relative abundance where enough individual specimens of a given species were captured. At each lake, gill nets were deployed at predetermined random sites, depending on the size and depth of the lake in question (Service de la faune aquatique, 2011). However, to minimize the impacts of this methodology, a maximum limit was set at 150 individuals for the most abundant species, at which point standardized fishing would be halted in the lake in question. Otherwise, fishing would halt once the number of predetermined sample stations had been reached. For example, if, at the seventh of 12 predetermined stations, a cumulative catch of 157 lake trout (*S. namaychus*; the most abundant species) was achieved, the station would be the last one sampled, and fishing would cease at that lake regardless of the number of brook trout (*S. fontinalis*) and Arctic charr caught. In addition, between September 11 and 24, 2016, we used large-meshed and fine-meshed gill nets (see the definition later in the text) between the mouth of Red Dog River (Hopes Advance Bay estuary) and the bottom of the waterfalls, and between the top of the waterfalls and the effluent of Red Dog Lake.

The large-meshed nets used in Red Dog River were 49.6 metres long and 1.8 metres high. They were composed of two strips each containing eight panels (3.1 metres long by 1.8 metres high). Mesh sizes in each strip were as follows: 76, 114, 51, 89, 38, 127, 64 and 104 mm. The small-meshed nets, composed of two strips each containing five panels (2.5 metres long by 1.8 metres high), were also used in Red Dog River, and mesh sizes in each strip were as follows: 32, 19, 38, 13 and 25 mm (Service de la faune aquatique, 2011).

For lake-based net fishing, we used experimental small-meshed nets. The experimental nets contained eight panels measuring 7.6 metres long by 1.8 metres high (total length of 60.8 metres), with the following mesh sizes in each panel: 25, 38, 51, 64, 76, 102, 127 and 152 mm (Service de la faune aquatique, 2011).

In addition, to increase the sample size for anadromous Arctic charr, Ida Akpahatak and Martin Scott from the Aupaluk community gave us permission to measure and sample specimens from their own personal harvests carried out in the period August 28 to 31, 2016 in Hopes Advance Bay, using 4-inch mesh gill nets.

Figure 3. An Arctic charr caught in an experimental gill net in Voltz Lake.

Electro-fishing in rivers and streams

To identify the fish species present in certain rivers and streams near Aupaluk, we used electro-fishing to sample one to three sites per watercourse. The sites were surrounded by very small-mesh nets (seine nets), T-shaped iron bars and ropes, so that the fish were unable to escape. In the smaller watercourses, such as Voltz River, the banks were used as lateral barriers and a net was placed at each end of the site to create an area of roughly 100 m^2. In Red Dog River, a single long net was deployed with T-bars and ropes to form three sides of a rectangle, with the river bank serving as the fourth side. In this case, only part of the river, i.e. the shallowest part, was sampled. In doing this, we were able to target mainly juvenile fish. Three electro-fishing sweeps took place at each closed station. Each sweep was performed by a team of three people, in an attempt to cover the river bed as fully as possible so as to catch fish hidden between rocks and under debris. The electro-fishing device[1] was operated by an experienced person, and two other people, each with a landing net, followed behind to catch the fish that had been immobilized by the electro-fishing device (Figure 4). Some open stations were also fished in this way, to increase the possibility of catching other species. However, the density for a given species (e.g. Arctic charr) could not be calculated at these stations. The sites of the stations at which electro-fishing took place were recorded by means of a GPS device.

1. Hans Grassl, model ELT60IIHI, adjustments: current pulsed at a frequency of 50 to 75 generating roughly 800 volts.

Figure 4. Electro-fishing by three people at a closed station on Voltz River; part of the Aupaluk community and the counting fence can be seen in the background.

All the sites sampled using gill nets and electro-fishing, along with the counting fence, are shown on the map in Figure 5.

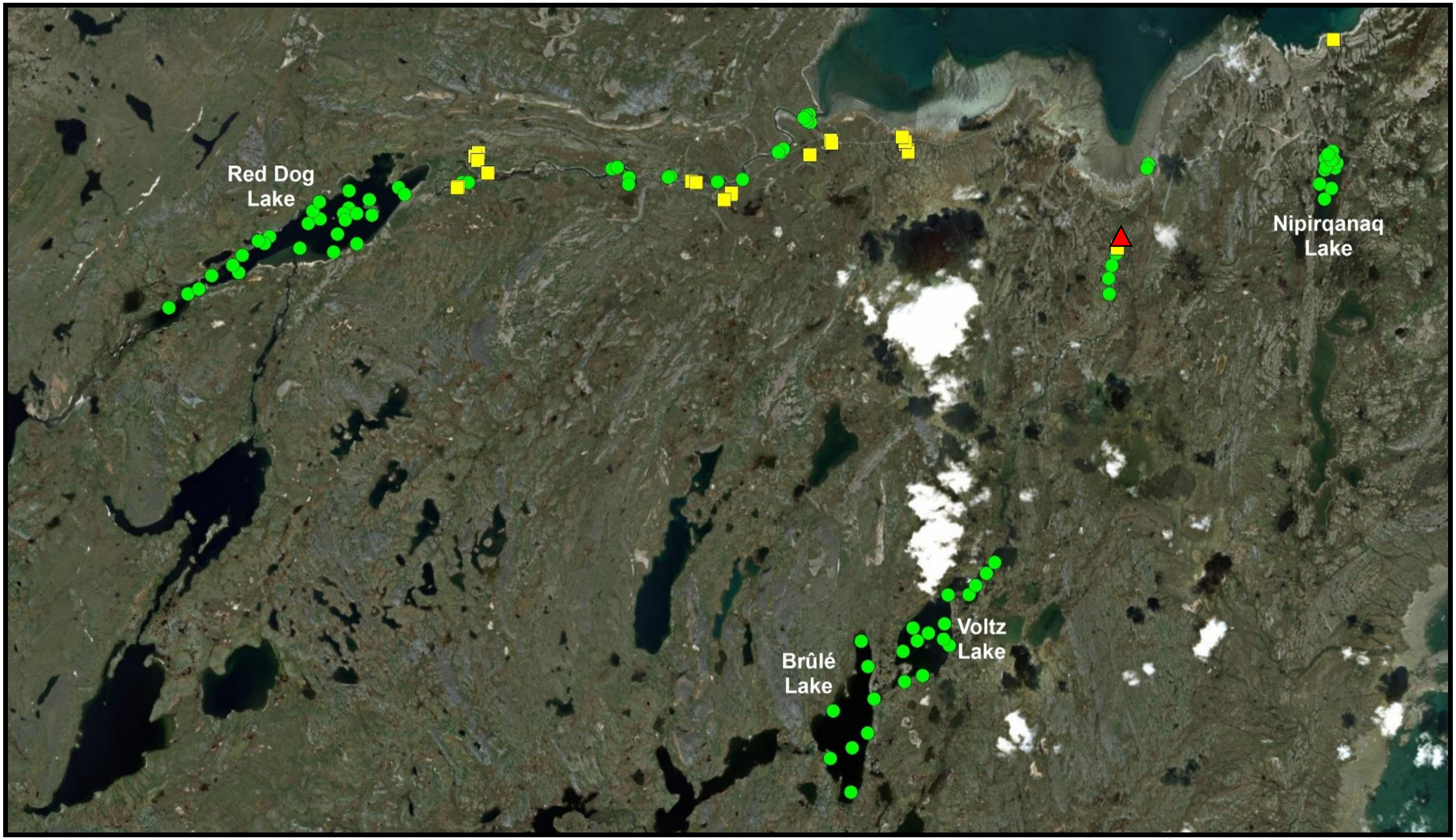

Figure 5. **Location of sampled sites near the Aupaluk community in Nunavik. The green circles indicate sites fished using gill nets, and the yellow squares indicate sites at which electro-fishing was used. The red triangle shows the location of the counting fence.**

Measurements and samples

All the fish caught by means of electro-fishing, selected from the counting fence holding cage or killed in a gill net were taken to a temporary laboratory at our base camp (Figure 6).

Figure 6. An Arctic charr taken from a gill net, before necropsy. At this stage, the specimen has been measured to the nearest millimetre and weighted to the nearest 0.1 g.

The sampled fishes were identified by species. For salmonids (Arctic charr, lake trout and brook trout), total maximum length was measured using a ruler (± 1 mm) and mass was measured using an electronic scale (O'Haus, Valor 3000 model, ± 0.1 g). Each fish was then gutted using a knife. This was done by cutting from the urinogenital opening to the base of the operculum, among other things to determine gender. Gonad status was then classified as mature or immature (i.e. mature if the gonads were fully developed, and immature in all other cases). In the case of females with mature gonads, both gonads were harvested, weighed and placed in a recipient containing 95 % ethanol, so that the eggs could subsequently be counted in the laboratory. Stomach contents were then described and loosely categorized as insects, small fish or crustaceans. Some stomach samples were preserved in 95 % ethanol for more detailed analysis in Québec City, at the MFFP laboratory. The adipose fin was harvested and preserved in 95 % ethanol for genetic analysis in collaboration with Professor Jean-Sébastien Moor at Laval University. A muscle sample (~ 100 g) was also taken from one side of the fish (laterally, behind the dorsal fin) and was then wrapped in aluminium foil, placed in a plastic Ziploc bag and frozen (-20 °C) for subsequent contaminant analysis by the Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques (MDDELCC). The muscle samples were examined individually for the presence of mercury, and homogenates from one to twelve individuals from the same size class for a given species (Table 1) were analyzed for the other study contaminants (n = 18). Eggs were counted from the sampled mature female gonads by species: Arctic charr (n = 4), lake trout (n = 46) and brook trout (n = 14). Once the eggs had been counted, the diameters of 30 eggs from each female were measured using a caliper. However, in the case of lake trout and brook trout, some preservation problems were encountered between the time the eggs were sampled and the time they were analyzed in the laboratory. As a result, the eggs for these two species could not be counted.

Table 1. Length categories (mm) by species used for contaminant analysis by the MDDELCC, in 2017; the total maximum length was used for length classification assignments in Aupaluk.

Species	Small	Medium	Large
Arctic charr	150–300	301–400	> 400
Lake trout	450–550	551–700	> 700
Brook trout	150–300	301–400	> 400

As a last step, the otoliths (small bones in the internal ear of fish) were removed and placed in Eppendorf tubes to determine age, and subsequently to perform laboratory analyses of otolith microchemistry. As agreed with the Aupaluk Land Corporation and the LNUK, all sacrificed fish were placed in the Aupaluk community freezer once the required measurements had been taken and the samples removed.

To calculate Arctic charr condition, we used the Fulton's factor (K), which calculates the weight-length relationship by means of the following equation: $K = (M/L^3) \times 100\,000$ (Neumann et al., 2012), where M is mass (g) and L is fork length (mm). Fork length was chosen to calculate the condition factor because it was also used in other Arctic charr studies consulted in connection with this research, thereby allowing for comparisons with other populations. Generally, in Arctic charr, body condition is considered to be good when $K > 1$, fair when $K \approx 1$ and poor when $K < 1$. Since only total maximum length was measured in fish caught in Aupaluk, we used the following equation ($R^2 = 0.9972$) obtained from anadromous Arctic charrs measured in Tasiujaq, in 2017, to convert total maximum length to fork length (Mainguy and Beaupré, unpublished data):

Fork length = (0.9505 x total maximum length) – 4.3381.

This equation can only be used for Arctic charr with a total maximum length of between 267 and 795 mm.

Results

Counting fence

Given that water levels in 2016 were abnormally low, no anadromous Arctic charr were found in the holding cage until September 20, 2016, despite daily visits by our team. Two charrs were caught on that date, and the number subsequently increased to roughly 20 charrs per day until the end of the study on September 26, 2016 (Figure 7). Overall, 124 anadromous Arctic charrs were caught in the holding cage, and this was the only species caught at this site during the entire study period. Daily water temperatures and levels at the counting fence throughout the study period are shown in Figures 8 and 9.

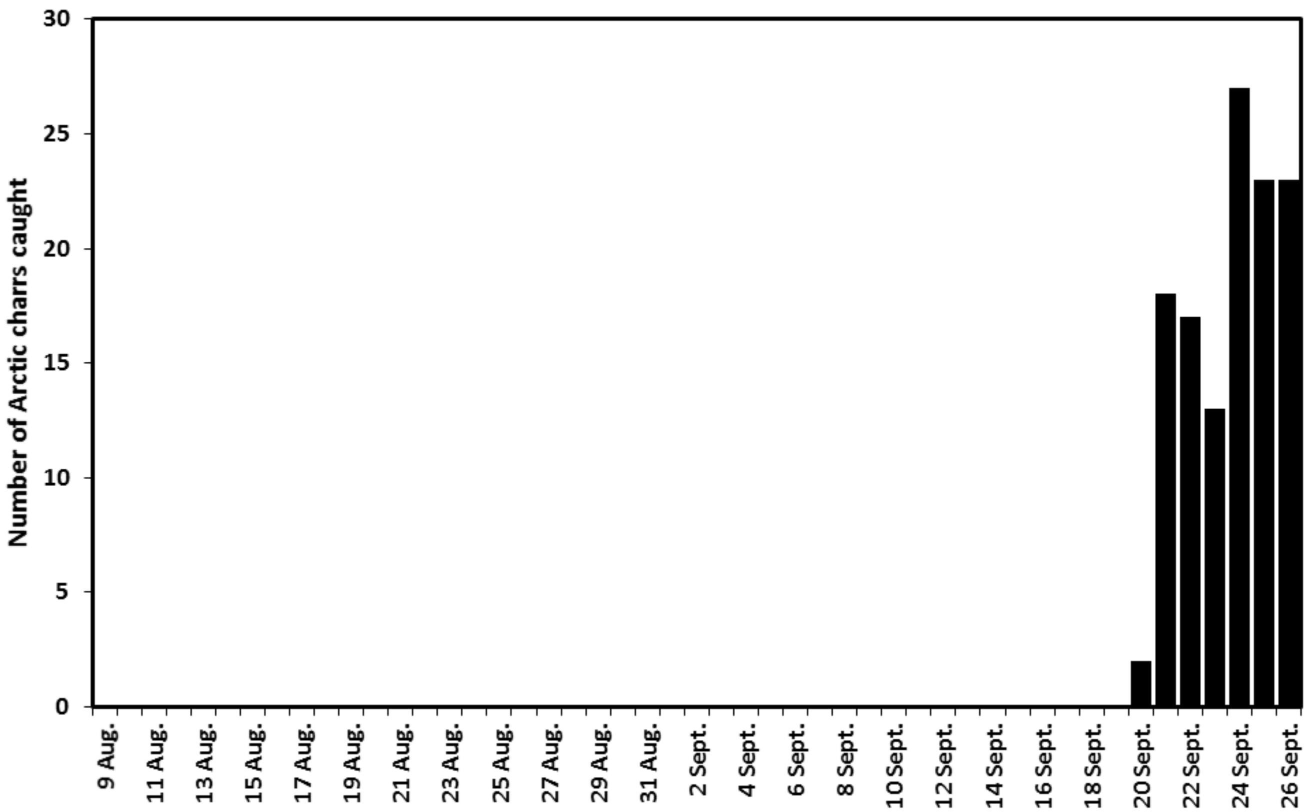

Figure 7. Number of anadromous Arctic charr monitored on a daily basis at the counting fence on Voltz River near Aupaluk, Nunavik, from August 8 to September 26, 2016.

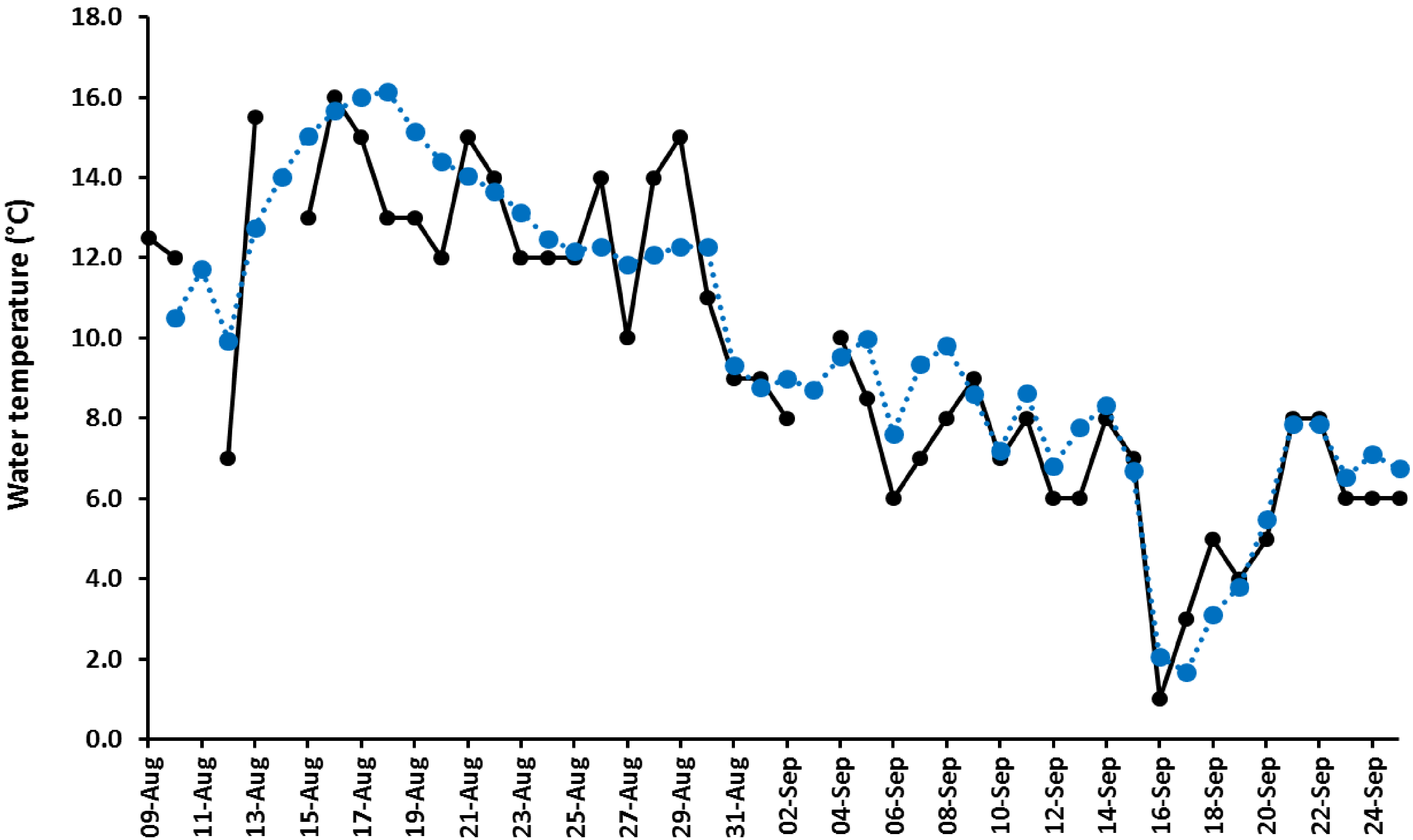

Figure 8. Variations in the water temperature, Voltz River, upstream of the counting fence at Aupaluk, Nunavik, from August 9 to September 25, 2016. The black circles (solid line) show water temperatures measured with a thermometer, while the blue circles (dotted line) show the average daily water temperature from hourly recordings (*n* = 24/day) with a thermograph.

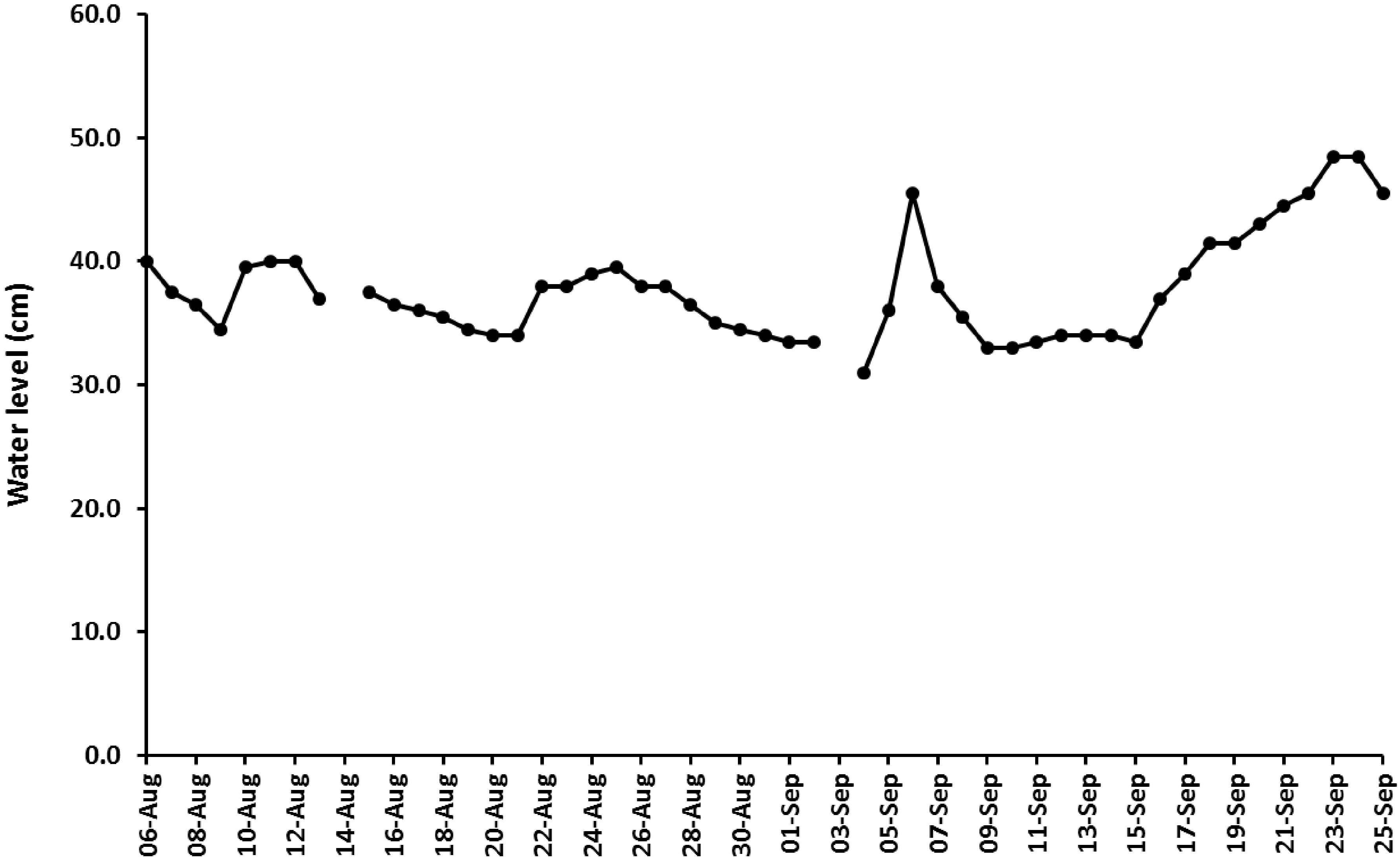

Figure 9. Variations in water levels, Voltz River, upstream of the counting fence at Aupaluk, Nunavik, from August 6 to September 25, 2016.

Biological parameters of sampled fishes

The number of fishes caught (per species) with the counting fence and gill nets is shown in Table 2, and the number caught by means of electrofishing is shown in Table 3 (closed stations) and Table 4 (open stations).

Table 2. Fish species caught by sampling site, date and fishing method in the rivers and lakes located near the Aupaluk community, Nunavik, in 2016.

	Voltz River	Voltz River	Voltz Lake	Brûlé Lake	Red Dog Lake	Red Dog River (upstream of the falls)	Red Dog River (downstream of the falls)	Nipirqanaq Lake	Hopes Advance Bay
Date (dd/mm)	09/08–26/09	15/09–16/09	01/09–06/09	08/09–09/09	24/08–30/08	11/09–24/09	11/09–24/09	07/08–24/08	28/08–30/08
Catch method	Counting fence	Gill nets SM[a]	Gill nets EXP[b]+SM	Gill nets EXP+SM	Gill nets EXP+SM	Gill nets LM[c]+SM	Gill nets LM+SM	Gill nets mi-EXP[d]+SM	Gill nets 4”
Species									
Arctic charr (*Salvelinus alpinus*)	124	61	13	1	5	0	94	8	94
Lake trout (*Salvelinus namaychus*)	0	0	115	75	141	3	0	0	0
Brook trout (*Salvelinus fontinalis*)	0	0	0	0	3	13	28	0	0
Cisco (*Coregonus artedi*)	0	0	106	2	39	0	0	0	0
Cisco (*Coregonus sp.* – unidentified, *autumnalis*?)	0	0	62	7	0	0	0	0	0
Blackspotted stickleback (*Gasterosteus wheatlandi*)	0	0	125	23	35	0	0	0	0
Burbot (*Lota lota*)	0	0	3	2	2	1	1	0	0
Ninespine stickleback (*Pungitius pungitius*)	0	2	2	0	3	0	0	2	0
Slimy sculpin (*Cottus cognatus*)	0	0	0	2	0	0	0	0	0
Round whitefish (*Prosopium cylindraceum*)	0	0	0	0	81	0	0	0	0
Longhorn sculpin (*Myoxocephalus octodecemspinosus*)	0	0	0	0	0	0	14	0	0
Unidentified	0	0	16	1	2	0	0	0	0
CPUE[e] – Arctic charr	N.A.	N.A.	0.93	0.13	0.19	N.A.	N.A.	N.A.	N.A.
CPUE – Lake trout	N.A.	N.A.	8.21	9.38	5.22	N.A.	N.A.	N.A.	N.A.

[a] Small-mesh gill net (see section 2.2.)
[b] Experimental gill net (see section 2.2.).
[c] Large-mesh gill net (see section 2.2.).
[d] Experimental gill net, height of which is half that of a conventional net.
[e] Catch per unit effort (CPUE) expressed as an average number of fishes of a given species caught per net night (regardless of type of net).

Table 3. Fish species caught by means of electro-fishing at closed stations, by catch site and date, in the rivers and streams located near the Aupaluk community, Nunavik, in 2016.

	Nipirqanaq Stream	Aarsutaup Stream	Red Dog River		Red Dog River Tributary 1	Red Dog River Tributary 2	Red Dog River Tributary 3	Voltz River	
Date (dd/mm)	21/08	20/08	13/08	15/08	17/08	18/08	19/08	12/08	16/08
Station no.	**1**	**1**	**1**	**5**	**1**	**1**	**4**	**1**	**10**
Arctic charr (*Salvelinus alpinus*)		2		1	1			8	1
Lake trout (*Salvelinus namaychus*)									
Brook trout (*Salvelinus fontinalis*)			23	2			20		
Slimy sculpin (*Cottus cognatus*)			50	2		1			
Ninespine stickleback (*Pungitius pungitius*)	13	44	1		8			1	2
Round whitefish (*Prosopium cylindraceum*)									
Approximate area covered (m^2)	150	150	105	100	105	100	113	80	125
Arctic charr density (fish /100 m^2)	0.00	1.33	0.00	1.00	0.95	0.00	0.00	10.0	0.80

Table 4. Fish species caught by means of electro-fishing at open stations, by catch site and date, in the rivers and streams located near the Aupaluk community, Nunavik, in 2016.

	Aarsutaup Stream				Red Dog River Tributary 1				Red Dog River Tributary 2		Red Dog River Tributary 3			Voltz River								Red Dog River			
Date (jj/mm)	20/08				17/08				18/08		19/08			15/08								13-14/08			
Station no.	**2**	**3**	**4**	**5**	**2**	**3**	**4**	**5**	**2**	**3**	**1**	**2**	**3**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**2**	**3**	**4**	**6**
Arctic charr (*Salvelinus alpinus*)						5		2							2	8	3	6		2					
Lake trout (*Salvelinus namaychus*)						1																			
Brook trout (*Salvelinus fontinalis*)										1	1	14	4									10	11		
Slimy sculpin (*Cottus cognatus*)																						8	5		
Ninespine stickleback (*Pungitius pungitius*)	8	39	17	17	20			5								1				1					
Round whitefish (*Prosopium cylindraceum*)						1																			

The average total maximum length of Arctic charr, by age and catch site, is shown in Table 5, and the average mass is shown in Table 6. With respect to the counting fence in Voltz River, the visual estimate of size (total length) for the 58 adult Arctic charrs released upstream of the holding cage to continue their migration produced an average of 373 mm (range: 330 to 550 mm). Electro-fishing resulted in catches of fishes aged 0+ (total maximum length: 64 mm, mass: 2.7 g, *n* = 1), 1+ (average length: 95.5 mm, average mass: 7.9 g, *n* = 10), 2+ (average length: 154 mm, average mass: 33.7 g, *n* = 21) and 3+ (average length: 216 mm, average mass: 86.1 g, *n* = 7). Information on lake trout caught in the lake can be found in Appendix 1 and Appendix 5. For brook trout, information on distribution, frequency, total maximum length and mass (no data on age) is presented in Appendix 3.

Table 5. Average total maximum length (in mm) of Arctic charr, by age and catch site, near Aupaluk, Nunavik, in 2016. Sample size (*n*) and range [minimum-maximum] are also shown. The longest Arctic charr caught is shown in boldface.

Age	Hopes Advance Bay	Red Dog River	Red Dog River Tributary no. 1	Red Dog Lake	Voltz River	Voltz Lake	Brûlé Lake	Nipirqanaq Lake
0+					64 (1)			
1+					96 (12) [84–107]			
2+		190 (2) [188–191]	201 (3) [188–209]		156 (58) [126–191]			
3+	410 (5) [371–464]	322 (37) [255–373]	225 (5) [188–259]		261 (46) [148–364]			301 (5) [253–326]
4+	430 (27) [374–482]	393 (27) [321–475]			395 (17) [239–482]	261 (2) [250–272]		352 (3) [336–379]
5+	471 (31) [400–593]	436 (21) [319–589]			418 (14) [343–544]	430 (2) [401–459]		
6+	556 (10) [445–697]	510 (4) [468–543]			479 (5) [414–548]	445 (3) [420–490]		
7+	610 (7) [536–654]	594 (2) [556–632]				536 (2) [400–672]		
8+	716 (5) [656–752]				616 (1)	548 (1)		
9+	780 (1)					523 (1)		
10+	714 (2) [705–723]							
11+					731 (1)	524 (1)		
12+		**871** (1)		603 (1)		705 (1)	524 (1)	
13+				710 (1)				
14+				640 (2) [638–642]				
15+								
16+				661 (1)				

Table 6. Average mass (in g) of Arctic charr, by age and catch site, near Aupaluk, Nunavik, in 2016. Sample size (*n*) and range [minimum-maximum] are also shown. The heaviest Arctic charr caught is shown in boldface.

Age	Hopes Advance Bay	Red Dog River	Red Dog River Tributary n. 1	Red Dog Lake	Voltz River	Voltz Lake	Brûlé Lake	Nipirqanaq Lake
0+					3 (1)			
1+					8 (12) [4–12]			
2+		58 (2) [54–63]	64 (3) [50–73]		31 (58) [17–52]			
3+	853 (3) [780–1 220]	343 (37) [134–518]	97 (5) [56–140]		189 (46) [23–446]			326 (5) [169–406]
4+	872 (26) [490–1 248]	642 (27) [348–1 103]			583 (17) [91–1 169]	140 (2) [126–155]		489 (3) [415–616]
5+	1 279 (26) [703–2 789]	942 (21) [289–2 147]			662 (14) [348–1 417]	692 (2) [514–870]		
6+	2 054 (10) [820–5 000]	1 431 (4) [1 067–1 769]			1 011 (5) [655–1 697]	811 (3) [588–1 152]		
7+	2 495 (4) [1 659–3 540]	2 511 (2) [1 931–3 091]				1 744 (2) [550–2 938]		
8+	4 898 (4) [3 900–5 620]				2 270 (1)	1 528 (1)		
9+	4 700 (1)					1 448 (1)		
10+	3 745 (2) [3 590–3 900]							
11+					3 891 (1)	1 225 (1)		
12+		**6 143** (1)		1 798 (1)		2 588 (1)	1 181 (1)	
13+				3 115 (1)				
14+				2 347 (2) [2 269–2 424]				
15+								
16+				1 840 (1)				

Arctic charr – condition factor

For Arctic charr, the condition factor (K) ranged from 0.98 ± 0.13 in Red Dog Lake to 1.40 ± 0.10 in Nipirqanaq Lake, with K factors above 1 in most of the lakes and rivers (Table 7).

Table 7. Condition factor (K) for Arctic charrs sampled in the rivers and lakes located close to the Aupaluk community, Nunavik, in August and September 2016. Each K value is presented as a mean ± standard deviation (*n* = sample size).

Sampling site	K	*n*
Hopes Advance Bay	1.33 ± 0.15	76
Red Dog River	1.24 ± 0.10	91
Red Dog Lake	0.98 ± 0.13	5
Voltz River	1.08 ± 0.09	61
Voltz Lake	1.05 ± 0.11	12
Brûlé Lake	0.98	1
Nipirqanaq Lake	1.40 ± 0.10	7
All lakes combined	**1.13 ± 0.20**	**25**
All Arctic charrs	**1.22 ± 0.16**	**253**

Sex ratio and gonad maturity in sampled Arctic charrs and lake trout

The overall sex ratio (number of females [F] per male [M]) for Arctic charrs sampled near the Aupaluk community was 1.07:1. The sex ratio was biased towards females in Hopes Advance Bay (1.68:1), was close to even in Red Dog River (0.98:1) and was slightly biased towards males in Voltz River (0.81:1). Arctic charr samples from the lakes were too small to calculate a sex ratio, but the numbers were as follows: Red Dog River (0F/5M), Brûlé Lake (1F/0M), Nipirqanaq Lake (4F/4M) and Voltz Lake (6F/7M). For lake trout, the overall gender ratio was 0.90:1, and was biased towards males in Lac Brûlé (0.63:1) and Lac au Chien Rouge (0.83:1), but biased towards females in Lac Voltz (1.31:1). The three lake trout caught in gill nets in rivers were all males.

Out of a total of 280 Arctic charr (146 F, 134 M) analyzed, 1.79 % had mature gonads. Gonad maturity among females (Figures 10 and 11) was low (2.74 %), but was nevertheless higher than among males (0.75 %). Of the small number of sampled charrs that were current-year spawners (*n* = 5), four were females (5 to 9 years old) and one was a 5-year-old male. Limiting the statistical descriptive analysis to charrs aged 5 or over, 5.6 % of the females had mature gonads (*n* = 72) compared to 1.9 % of the males (n = 53). In the case of lake trout, the percentage of fish with mature gonads was much higher than that for Arctic charrs; specific detailed information on gonad maturity for this species by sex, age and total maximum length can be found in Appendix IV. A general linear model with a binomial error structure was applied to these data and revealed that the total maximum length and age above which 50 % of female lake trout would probably have mature gonads were 608 mm (Appendix V) and 22 years (Appendix VI) respectively. For males, the values were 492 mm (Appendix VII) and 12 years (Appendix VIII).

Figure 10. Female Arctic charr with mature gonads (current-year spawner), sampled near the Aupaluk community, Nunavik, in 2016.

Figure 11. Female Arctic charr with non-mature gonads, sampled near the Aupaluk community, Nunavik, in 2016.

Egg counts in the four female Arctic charrs ranged from 904 to 6,481 eggs. Catch weight varied from 426 to 2,938 g, leading to the following predictive equation (R^2 = 1,000):

Number of eggs = – 0.0003(mass^2) + 3.1756(mass) – 382.15

where mass refers to the whole female (before egg removal). With regard to egg size, average diameter per fish (30 eggs measured/fish) ranged from 2.7 to 4.0 mm for Arctic charr, giving an overall average of 3.3 mm. For brook trout, individual averages ranged from 2.0 to 3.8 mm, with an overall average of 3.0 mm, and for lake trout, individual averages ranged from 3.4 to 5.7 mm, with an overall average of 4.9 mm. Measurements were taken after the eggs had been stored in ethanol; the diameter measurements are therefore not from fresh eggs.

Age structure and annual mortality

Arctic charr age structure was established by means of a graph (Figure 12) to allow for calculation of the annual mortality rate (**A**) according to Robson and Chapman (1961)'s maximum likelihood estimator of survival. Age structure was constructed using Arctic charr sacrificed randomly at the counting fence (*n* = 66), as well as those harvested lethally in experimental gill nets in Red Dog River (*n* = 93) and in gill nets used by Aupaluk residents (4-inch mesh; *n* = 94). Robson and Chapman's estimator was used because very few of the charrs caught at these three sites (i.e. 0, one or sometimes two fish in a given age class [see Figure 12]) were old (> 8 years old). It is better suited to this type of dataset than models that use instantaneous total mortality (Z), because age classes containing small numbers of individuals (< 5) at a given site can introduce bias into the regression curve and hence into estimates of **A**. Although Robson and Chapman's estimator was used for our analyses because of its robustness, we also calculated **A** derived from Z, but using only data from consecutive age classes for which at least two charrs were sampled (the reason being that, for a count of one, the transformed value on a normal log scale is equal to 0) to allow for comparison between the two methods. For example, in the case of Voltz River, only the data from age classes 3, 4, 5 and 6 (Figure 12) were used to calculate Z and then **A**. For further details, see Miranda and Bettoli (2007).

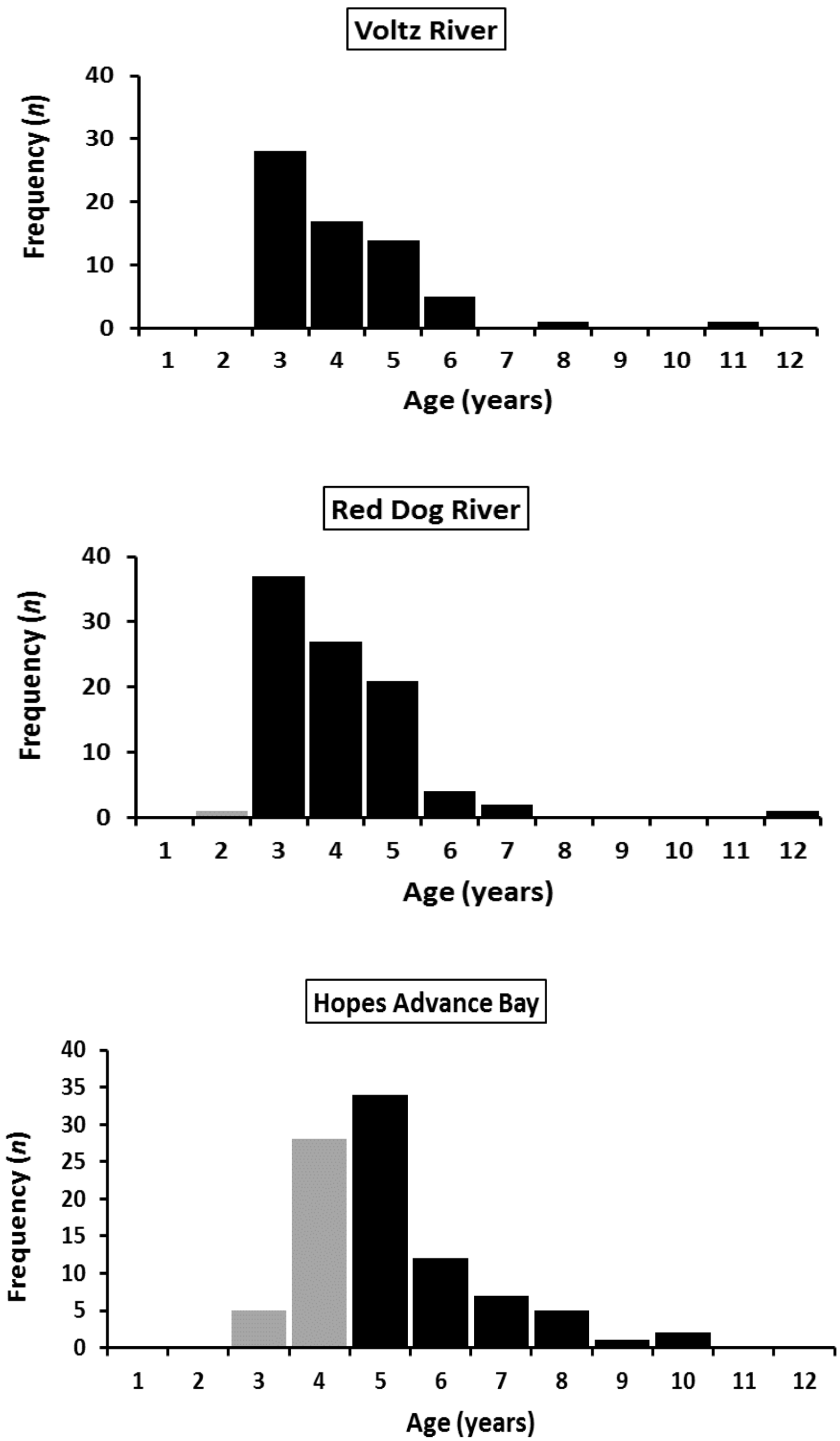

Figure 12. Age structure of Arctic charr sampled by means of the counting fence in Rivière Voltz, the experimental gill nets in Red Dog River or the gill nets (4-inch mesh) used in Hopes Advance Bay by local fishermen. The age classes recruited entirely by means of fishing equipment are shown in black, and those recruited partially by means of fishing equipment are shown in grey.

According to Robson and Chapman's survival estimator (S), annual mortality (**A** = 1–S) for Arctic charr was (± standard deviation) 47.1 ± 4.2 % for Voltz River, 48.1 ± 3.6 % for Red Dog River and 52.2 ± 4.7 % for Hopes Advance Bay. Using an alternative method (instantaneous total mortality Z converted to **A** using a catch curve), **A** would be estimated at 41.5 % for Voltz River, 53.9 % for Red Dog River and 46.7 % for Hopes Advance Bay.

For lake trout, annual mortality was estimated using Robson and Chapman's estimator only, based on age structure data (Figure 13). The analysis was limited to fish that were 9 years of age or older. Annual mortality was estimated at 10.6 ± 1.4 % for Brûlé Lake (n = 54), 9.4 ± 1.0 % for Voltz Lake (n = 77) and 7.9 ± 0.8 % for Red Dog Lake (n = 88). The fact of including fishes aged 3 years or over in the mortality analyses did not really change the values obtained from the older fishes (8.2 ± 0.9; 7.5 ± 0.7; and 7.3 ± 0.6 %, respectively).

It was not possible to calculate an annual mortality rate for brook trout due to the small number of fish caught in Red Dog River (n = 41).

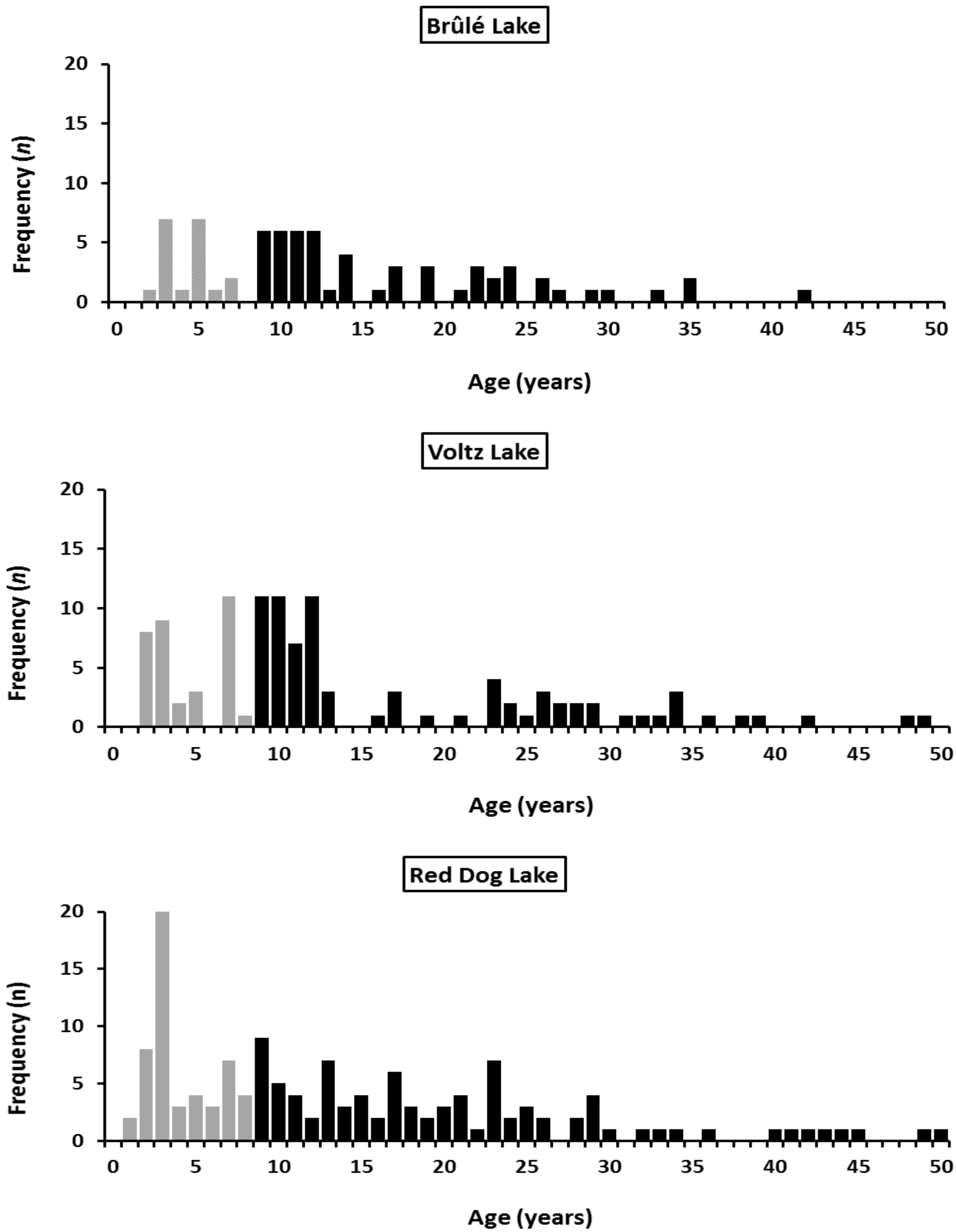

Figure 13. Age structure of lake trout in three different lakes located near Aupaluk, Nunavik, in 2016; only data from lake trout 9 years of age or older (black bars) were used in the mortality analyses.

Contaminants

In all, 261 fishes of three different species were examined individually for mercury concentrations (Table 8). In the case of Arctic charr, average mercury concentrations ranged from 0.05 to 0.06 mg/kg in Voltz River, depending on age class, from 0.06 to 0.27 mg/kg in Voltz Lake, Brûlé Lake, Nipirqanaq Lake and Red Dog Lake combined, and from 0.04 to 0.05 mg/kg in Red Dog River (Table 8). Data were not available for Hopes Advance Bay because muscle samples were not taken from fish caught by the local community. In brook trout, mean Hg concentrations varied from 0.06 to 0.23 mg/kg. In the case of lake trout, average mercury concentrations were higher than for the other two salmonid species studied, with the highest concentrations found in fish from Voltz Lake and Red Dog Lake (Table 8). Mercury concentrations were higher in large lake trout than in smaller fish of the same species (Table 8), due to bioaccumulation, i.e. the increase in mercury concentration as a result of age and food chain accumulation. Eighteen other contaminants (metals) were also examined and concentrations are shown in Table 9, by species and size class. However, it is important to note that these values were obtained from homogenates (i.e. combinations of one to 12 fish to obtain a single concentration value).

Table 8. Mercury concentrations (Hg; mean ± standard deviation) in Arctic char, lake trout and brook trout, by sampling site and length class near Aupaluk, Nunavik, in 2016. Where the mercury concentration (mg/kg) is greater than 0.5 mg/kg[a] or when the standard deviation includes this value, it is shown in boldface.

Sampling site	Species	Length class[b]	Hg (mg/kg)	*n*
Voltz River	Arctic charr	Small	0.06 ± 0.01	2
Voltz River	Arctic charr	Medium	0.05 ± 0.04	37
Voltz River	Arctic charr	Large	0.06 ± 0.03	22
Voltz Lake	Arctic charr	Medium	0.08	1
Voltz Lake	Arctic charr	Large	0.23 ± 0.14	7
Voltz Lake	Lake trout	< Small	0.28	1
Voltz Lake	**Lake trout**	**Small**	**0.43 ± 0.19**	**9**
Voltz Lake	**Lake trout**	**Medium**	**0.81 ± 0.25**	**10**
Voltz Lake	**Lake trout**	**Large**	**2.28 ± 0.77**	**5**
Brûlé Lake	Arctic charr	Large	0.27	1
Red Dog Lake	Arctic charr	Large	0.16 ± 0.05	5
Red Dog Lake	Brook trout	Small	0.06	1
Red Dog Lake	Lake trout	< Small	0.27 ± 0.10	2
Red Dog Lake	Lake trout	Small	0.38 ± 0.11	8
Red Dog Lake	**Lake trout**	**Medium**	**0.53 ± 0.25**	**12**
Red Dog Lake	**Lake trout**	**Large**	**0.68 ± 0.26**	**3**
Red Dog River	Brook trout[c]	Small	0.06 ± 0.03	3
Red Dog River	Brook trout[c]	Medium	0.13 ± 0.06	11
Red Dog River	Brook trout[c]	Large	0.21 ± 0.06	8
Red Dog River	Lake trout[c]	Small	0.30	1
Red Dog River	**Lake trout[c]**	**Medium**	**0.75**	**1**
Red Dog River	Brook trout[d]	Small	0.17 ± 0.16	2
Red Dog River	Brook trout[d]	Medium	0.12 ± 0.05	11
Red Dog River	Brook trout[d]	Large	0.23 ± 0.16	2
Red Dog River	Arctic charr[d]	Small	0.05 ± 0.02	6
Red Dog River	Arctic charr[d]	Medium	0.04 ± 0.02	51
Red Dog River	Arctic charr[d]	Large	0.05 ± 0.03	34
Nipirqanaq Lake	Arctic charr	Small	0.07	1
Nipirqanaq Lake	Arctic charr	Medium	0.08 ± 0.02	4

[a] Value of maximum mercury concentration (Hg) in edible portions of fish according to Health Canada: https://www.canada.ca/en/health-canada/services/food-nutrition/food-safety/chemical-contaminants/maximum-levels-chemical-contaminants-foods.html
[b] Length classes by species are shown in Table 1.
[c] Brook trout or lake trout caught between the falls and Red Dog Lake.
[d] Brook trout and Arctic charr caught between Hopes Advance Bay (mouth) and the falls.

Table 9. Contaminant concentrations[a] (mg/kg) in Arctic charr, lake trout and brook trout, by sampling site and length class, near Aupaluk, Nunavik, in 2016. One value is shown per length class[b] and is obtained from a homogenate of 1 to 12 fishes for each age class.

Site	Species	Leng. class	*n*	Al	As	Ba	Cd	Cr	Co	Cu	Fe	Mn	Mo	Ni	Pb	Se	Sr	Tl	U	V	Zn
Voltz River	Arctic charr	M	10	0.5	0.53	0.006	0.02	0.007	0.008	0.40	2.5	0.07	0.002	0.013	0.002	0.37	0.07	0.001	0.001	0.02	4.1
Voltz River	Arctic charr	M	10	0.5	0.40	0.006	0.02	0.007	0.009	0.39	2.3	0.05	0.002	0.008	0.002	0.35	0.07	0.001	0.001	0.02	3.8
Voltz River	Arctic charr	M	10	0.5	0.32	0.009	0.02	0.007	0.009	0.39	2.9	0.07	0.002	0.010	0.002	0.39	0.41	0.001	0.001	0.02	4.1
Voltz River	Arctic charr	L	10	0.5	0.39	0.006	0.02	0.007	0.012	0.54	3.5	0.06	0.002	0.006	0.002	0.33	0.15	0.001	0.001	0.02	4.0
Voltz River	Arctic charr	L	12	0.5	0.55	0.006	0.02	0.007	0.005	1,00	3.1	0.06	0.002	0.006	0.030	0.37	0.07	0.001	0.001	0.02	4.1
Voltz Lake	Arctic charr	L	7	0.5	0.08	0.007	0.02	0.007	0.014	0.43	5.8	0.12	0.002	0.013	0.002	0.35	0.07	0.005	0.001	0.02	4.1
Voltz Lake	Lake trout	M	10	1,0	0.03	0.006	0.02	0.028	0.006	0.48	5.4	0.11	0.001	0.010	0.004	0.44	0.07	0.006	0.001	0.02	3.1
Voltz Lake	Lake trout	L	5	0.5	0.07	0.006	0.02	0.009	0.004	0.34	3.0	0.06	0.001	0.010	0.002	0.49	0.07	0.005	0.001	0.02	3.4
Brûlé Lake	Arctic charr	L	1	0.5	0.02	0.006	0.02	0.007	0.012	0.19	4.2	0.03	0.001	0.009	0.002	0.22	0.07	0.010	0.001	0.02	3.1
Red Dog Lake	Arctic charr	L	5	0.5	0.02	0.006	0.02	0.007	0.032	0.28	4.1	0.05	0.002	0.022	0.002	0.30	0.07	0.008	0.001	0.02	3.7
Red Dog Lake	Lake trout	M	12	1,5	0.02	0.006	0.02	0.007	0.019	0.47	5.5	0.09	0.001	0.011	0.002	0.32	0.07	0.009	0.001	0.02	3.1
Red Dog Lake	Lake trout	L	3	0.5	0.02	0.006	0.02	0.007	0.025	0.40	4.8	0.10	0.001	0.011	0.002	0.36	0.07	0.010	0.001	0.02	3.2
Red Dog River	Brook trout[c]	M	11	0.5	0.02	0.016	0.02	0.008	0.011	0.37	3.1	0.11	0.002	0.028	0.002	0.34	0.19	0.002	0.001	0.02	3.9
Red Dog River	Brook trout[c]	L	8	1,0	0.02	0.006	0.02	0.007	0.010	0.41	4.4	0.06	0.003	0.006	0.002	0.36	0.07	0.003	0.001	0.02	4.4
Red Dog River	Lake trout[c]	M	1	0.5	0.02	0.006	0.02	0.009	0.013	0.44	10.0	0.07	0.001	0.007	0.002	0.35	0.07	0.005	0.001	0.02	4.7
Red Dog River	Arctic charr[d]	M	11	0.5	0.41	0.009	0.02	0.007	0.007	0.35	2.8	0.08	0.002	0.011	0.002	0.33	0.15	0.001	0.001	0.02	3.9
Red Dog River	Arctic charr[d]	M	10	0.5	0.47	0.007	0.02	0.007	0.008	0.37	2.4	0.06	0.002	0.008	0.002	0.34	0.09	0.001	0.001	0.02	4.1
Red Dog River	Arctic charr[d]	M	10	0.5	0.42	0.006	0.02	0.007	0.005	0.37	2.7	0.06	0.002	0.006	0.001	0.39	0.07	0.001	0.001	0.02	3.8
Red Dog River	Arctic charr[d]	L	10	0.5	0.47	0.010	0.02	0.007	0.006	0.41	2.7	0.05	0.002	0.006	0.002	0.31	0.07	0.001	0.001	0.02	4.1
Red Dog River	Arctic charr[d]	L	10	0.8	0.48	0.011	0.02	0.007	0.006	0.48	4.0	0.08	0.002	0.006	0.002	0.32	0.07	0.001	0.001	0.02	4.1
Red Dog River	Arctic charr[d]	L	10	0.5	0.53	0.006	0.02	0.007	0.003	0.44	3.0	0.05	0.002	0.006	0.002	0.32	0.07	0.001	0.001	0.02	3.7
Red Dog River	Brook trout[d]	M	11	0.5	0.02	0.008	0.02	0.007	0.009	0.40	3.6	0.07	0.002	0.006	0.002	0.35	0.09	0.002	0.001	0.02	3.3
Red Dog River	Brook trout[d]	L	2	0.5	0.13	0.006	0.02	0.007	0.019	0.42	3.7	0.04	0.001	0.006	0.002	0.30	0.07	0.003	0.001	0.02	3.0
Nipirqanaq Lake	Arctic charr	M	4	0.5	0.02	0.006	0.02	0.007	0.006	0.50	3.4	0.08	0.002	0.006	0.002	0.36	0.07	0.003	0.001	0.02	4.6

[a] Al: Aluminium; As: Arsenic; Ba: Baryum; Ca: Cadmium; Cr: Chromium; Co: Cobalt; Cu: Copper; Fe: Iron; Ma: Manganese; Mo: Molybdene; Ni: Nickel; Pb: Lead; Se: Selenium; Sr: Strontium; Tl: Thallium; U: Uranium; V: Vanadium; Z: Zinc.
[b] Length class: M = medium; G = large; See Table 1 for species-specific classes.
[c] Brook trout or lake trout caught between the falls and Red Dog Lake.
[d] Brook trout and Arctic charr caught between Hopes Advance Bay (mouth) and the falls.

Discussion

Samples taken from seven rivers and streams, four lakes and Hopes Advance Bay were used to carry out a detailed study of the biology of Arctic charr and other fish species found near the Aupaluk community. Taken together, the information gathered provides a reference state for body condition, annual mortality, reproduction and contaminant concentrations among Arctic charr population(s) in the Aupaluk region. However, given that 2016 was an atypical year due to very low water levels, and given that the study took place over a single summer (no longitudinal data), the findings should be regarded (at best) as a partial representation of the Arctic charr population in question. In addition, although this report contains useful information on lake trout, as well as descriptions of species found at the various sample sites, the discussion below will focus solely on Arctic charr. Briefly, the information presented here may prove to be useful if anthropic developments are carried out near Aupaluk with potential impacts on the rivers, lakes and bay. In the following sections, the study’s main findings in connection with Aupaluk Arctic charr population are interpreted in light of available knowledge and documentation.

Monitoring of Arctic charr at the counting fence

It was not possible to build a temporary counting fence on Red Dog River, and Voltz River was chosen as an alternative site. Since Voltz River was narrower than Red Dog River, we expected to catch fewer Arctic charr in the counting fence during upstream migration. In addition, water levels in 2016 were very low, and the first Arctic charr were not caught in the Voltz River counting fence until September 20. In all, just 124 Arctic charr were caught between September 20 and 26, 2016. More would have been caught if the fieldwork period could have been prolonged, but a 10-day extension had already been granted. For comparison purposes, in a 2017 study, the first Arctic charr were caught in a counting fence on Bérard River at Tasiujaq on August 8, and upstream migration was more or less complete by September 8, when the project ended. Unfortunately, in 2016, it was not possible to identify a minimum number of Arctic charrs using the Voltz system at Aupaluk. The data collected at the Voltz River counting fence and those obtained from other sample sites (Hopes Advance Bay and Red Dog River in the case of Arctic charr) were nevertheless sufficient for us to establish some useful biological parameters, ranging from condition factors to annual mortality estimates deduced from age structure data.

Arctic charr condition factor

Generally speaking, the sampled charrs exhibited condition factors ranging from “fair” to “good”, except those taken from Red Dog Lake, where the mean K value was slightly below 1 – although this latter observation was based on a very small sample ($n = 5$). Overall, the condition factor for sampled Arctic charrs in the Aupaluk region (K = 1.22) was similar to or above other values published in the scientific literature. For example, in Cambridge Bay (Nunavut), Moore et al. (2016) reported an average K value of 1.02 ± 0.14 for resident Arctic charr and 1.06 ± 0.08 for non-residents. For Hornaday River in Paulatuk (Northwest Territories), Harwood (2009) reported an annual average of 1.24 (range: 1.15–1.38). In Nunavik, Boivin (1994) reported a condition factor for Arctic charr caught in the Sapukkait system, north of the Kangiqsualujjuaq community, of 1.11, 1.08 and 1.11 in 1990, 1991 and 1992, respectively. It is therefore possible to conclude that the Arctic charr sampled in the Aupaluk region, with an average of 1.22, were either comparable to or above the average condition factor for other Arctic charr populations. In light of these findings, it is probable that most Arctic charrs in Aupaluk are able to obtain the resources they needed to maintain a good condition factor, even though 7.9 % of the sampled charrs for which it was possible to calculate a condition factor ($n = 253$) obtained values of $K < 1$.

Reproduction of Arctic charr

Very few of the Arctic charrs sampled near Aupaluk were current-year spawners. Similar situations have also been observed elsewhere in Nunavik. For example, Boivin (1994) reported that only 0.8 % of the 1,839 Arctic charrs sampled randomly at the counting fence in the Sapukkait system during upstream migration between 1990 and 1992 had mature gonads. These data on reproduction suggest that Ungava Bay Arctic charrs may have a fairly long reproductive periodicity; in other words, most do not reproduce every year. Moreover, most Arctic charr may not reproduce until they are 8 to 10 years old, as reported by Boivin (1994) for Arctic charrs in the Sapukkait and Sannirarsiq systems, north of Kangiqsualujjuaq. In the Aupaluk region, fish identified as current-year spawner were between 5 and 9 years of age. Of all the Arctic charrs sampled near Aupaluk for which it was possible to determine age (n = 280), only 7.5 % were ≥ 8 years of age. It is therefore possible that an undetermined number of Arctic charrs of both genders are unable to survive long enough to attain maturity. This age is unknown for the Aupaluk Arctic charr, since the sample did not contain enough current-year spawners. However, we assume that it would fall into the same age range as for Arctic charr in the Sapukkait system (i.e. 8 to 10 years), which effectively reduces the number of potential reproductive fishes in the system.

Annual mortality of Arctic charr

In the Aupaluk Arctic charr population, an annual mortality rate (**A**) estimated at roughly 50 % is considered "moderate" to "high". It is therefore of concern. On the other hand, it is similar to that of other populations fished by Northern Canadian communities, including the Hornaday River population in Paulatuk, Northwest Territories, where Arctic charr between 6 and 14 years of age had an annual **A** average (± standard deviation) of 53.8 ± 9.8 % (range: 35.4 to 70.7 % over an 18-year period, 1990-2007; Harwood, 2009). In the Isuituq River near Pangnirtung, on Baffin Island in Nunavut, Arctic charr aged 11 to 21 had an annual **A** average of 34.5 ± 9.5 % (range: 24 to 49 % over a 6-year period, 2002-2006 and 2008, DFO 2010). In the Cumberland Sound region, also on Baffin Island in Nunavut, Moore (1975) estimated that annual mortality was 16 %, with the highest values (25 to 30 %) observed in fish that were 10 and between 15 and 17 years of age. In the Kuujjua River, on Victoria Island in the Northwest Territories, Harwood et al. (2013) reported an annual average of 45 % for **A** (confidence interval of 95 % from 42 to 48 %) in the period 1992 to 2009. In Labrador, Dempson and Green (1987) estimated an annual mortality of 44 to 49 % in the Fraser River. In Nunavik, Boivin (1994) estimated an annual mortality rate of 28 % in 1990 and 40 % in 1992 in the Sapukkait system. Power et al. (2008) reviewed the literature on annual mortality rates among Arctic charrs between 6 and 15 years of age in Canadian anadromous and lacustrine populations. Their main finding was to the effect that, generally speaking, the value of **A** fell within a range of 30 to 45 %, although they also noted that some populations exhibited rates below 25 %. In light of all this information, the Aupaluk Arctic charr population appears to fall in the higher portion of the range for **A**, a situation that can be interpreted as worrying for its demographic stability.

Contaminants found in Arctic charrs and other salmonids

Based on the MELCC's findings, Arctic charrs taken from Red Dog River, Red Dog Lake, Nipirqanaq Lake, Voltz River and Voltz Lake exhibited mercury concentration levels below the recommended Health Canada threshold (0.5 mg/kg). The same can be said for brook trout caught in Red Dog River. Based on these Hg concentrations observed in Arctic charr and brook trout, the Nunavik Public Health Department recommends to Nunavimmiuts to include these fish species in their diet. As for lake trout caught in Voltz Lake and Red Dog Lake, some had mercury concentrations above the recommended threshold by Health Canada. This was particularly true for larger lake trout, since an increase in fish size was often paired with an increase in the mercury concentration. For all questions relating to concentrations of mercury and other contaminants in fishes for consumption, people should refer to their local health clinic (CLSC) and to the Nunavik Public Health Department. The information on contaminant levels presented in Table 9 is provided for reference purposes only, in connection with the fishes sampled for this study. Any attempt to interpret these findings from a public health perspective should be undertaken only with expert assistance.

Conclusion

Generally speaking, the Arctic charr sampled near the Aupaluk community exhibited good condition factors and low mercury concentrations, both of which are interpreted as good indicators of population health. However, the percentage of current-year spawners and the percentage of Arctic charrs 8 years of age or older were low, with an annual mortality rate of nearly 50 %. According to Boivin (1994), Arctic charrs in another Ungava Bay system (Sapukkait) did not reach sexual maturity until they were 8 to 10 years of age, with a length range of 51 to 62 cm, or 64 to 67 cm in the Aupaluk region. It is therefore very probable that some Arctic charr die or are fished before their first reproductive experience, which reduces the number of fish contributing to future generations. Overall, this biological information suggests that the Aupaluk Arctic charr population is in demographic decline, a situation explained by a relatively high mortality rate and the low percentage of charrs reaching sexual maturity. One way of minimizing the impacts of fishing would be to reduce the permitted catch size (length) for fishing, so that larger fish (> 55 cm or > 22 in.), both male and female, have the opportunity to reproduce at least once, having achieved or being close to achieving the size required for sexual maturity. However, it is important to note that, given the lack of long-term data, it is not possible to establish a clear benchmark status for the population under study. Based on the biological parameters documented in 2016, additional monitoring is recommended. The MFFP's biologists remain available to answer questions about this report. If the Aupaluk community wishes to implement a monitoring program prepared and managed by its members (e.g. LNUK), they may contact the representatives of the MFFP's Direction de la gestion de la faune du Nord-du-Québec for opinions and advice. Contact information for the authors of this report is shown below.

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ᐃᓘᓐᓈᒍᑦ ᐅᖃᕐᓱᒍ, ᐃᖃᓗᐸᐻᑦ ᐆᑦᑐᕋᕐᑕᐅᔪᑦ ᐊᐅᐸᓗᒃ ᓄᓇᓕᖓᑕ ᓴᓂᐊᓂ ᑕᑯᑦᓴᐅᖃᑦᑕᓚᐅᔫᑦ ᐱᐅᔫᕆᐊᖏᑦ ᐊᒻᒪᓗ ᒥᐅᑯᔩᑦᑕᖃᓪᓗᐊᕋᑎᒃ, ᐃᓗᓯᕐᓯᓯᐊᕐᓂᖏᓐᓂᒃ ᐅᑐᒃᑲᒥᒃ ᖃᐅᔨᓇᓚᐅᔫᑦ. ᑭᓯᐊᓂ, ᐊᕐᕋᒍᒥ ᐊᑐᕐᑐᒥ ᒪᓐᓂᑎᐅᓇᐊᕐᑐᑐᑦ ᐊᒻᒪᓗ ᐳᓯᐊᓐᑎᖏᑦ ᐃᖃᓗᐸᐻᑦ 8-ᓂᒃ ᐅᑭᐅᓖᑦ ᐅᖓᑖᓄᓪᓗ ᐃᑭᑦᑑᑎᓚᐅᔫᑦ, ᐊᕐᕋᒍᑕᓖᑦ ᑐᕐᑯᑦᓯᑎᒃ 50%-ᑎᒍᑦ. ᐃᑉᐱᕆᓗᒋᑦ Boivin (1994), ᐃᖃᓗᐸᐻᑦ ᐊᓯᖓᓃᑦᑐᑦ ᐅᖓᕙᐅᑉ ᐃᖃᓗᑦᑕᑎᖓᓂ (ᓴᐳᒃᑫᑦ) ᐱᐊᕐᕿᐅᔾᔪᖕᖏᕆᐊᖏᑦ 8-ᓂᑦ 10-ᓂᓘᓐᓃᑦ ᐅᑭᐅᖃᑎᕋᑦᑕᕐᓯᑎᒃ ᖃᐅᔮᔭᐅᓯᒪᒻᒥᔫᑦ, ᑕᑭᓂᖃᐹᓇᔫᒍᑦᓯᑎᓪᓗ 51-ᓂᑦ 62-ᓄᑦ cm-ᓂᒃ, ᐅᕝᕙᓘᓀᑦ 64-ᓂᑦ 67-ᓄᑦ cm-ᓂᒃ ᐊᐅᐸᓗᒃ ᓴᓂᐊᓂ. ᑌᒫᑦ ᐃᖃᓗᐸᐻᑦ ᐃᓚᖏᑦ ᑐᕐᑯᔫᒍᔪᕆᔭᐅᑎᕐᑐᑦ ᐅᕝᕙᓘᓐᓃᑦ ᐃᖃᓗᑦᑕᐅᔫᒍᔪᕆᔭᐅᑎᕐᑐᑦ ᓯᕗᓪᓕᐹᒥ ᒪᓐᓂᑎᐅᐹᓇᓯᓚᐅᕐᑎᓇᕆᑦ, ᐃᑭᓪᓕᐅᒥᔭᐅᓯᒪᕙᑦᑎᓗᕆᑦ ᐃᖃᓗᐃᑦ ᓯᕗᓂᕐᒥ ᐱᐊᕐᕿᐹᐅᑎᕆᒍᒫᕐᑕᖏᑦ. ᐃᓘᓐᓈᒍᑦ, ᑕᒪᓐᓇ ᑐᑭᓯᐅᑎᑦᓴᖅ ᐃᒣᖓᔪᕆᑦᓯᐅᑕᐅᓕᕐᑐᖅ ᐊᐅᐸᓗᒃ ᓴᓂᐊᓃᔩᑦ ᐃᖃᓗᐸᐻᑦ ᐃᓂᕆᔩᒥᓃᑦᑐᑦ ᐃᑭᓪᓕᕙᓪᓕᐊᓕᕐᓂᖏᓐᓂᒃ, ᑐᑭᓯᓇᐹᑕᐅᓯᒪᒐᒥᒃ ᑐᕐᑯᓴᓗᐊᕐᐸᓕᓇᐊᖏᑦ ᐊᒻᒪᓗ ᐃᑭᑦᑐᐃᑦ ᐃᖃᓗᐸᐻᑦ ᒪᓐᓂᑎᐅᐹᓇᓯᕋᑕᕋᑎᒃ ᑐᕐᑯᕙᓕᕐᑎᓗᕆᑦ. ᑐᕐᑯᕋᓗᐊᕐᐸᓕᕐᓂᖏᑦ ᐃᑯᓪᓚᑎᕐᑕᐅᒍᑎᕆᒐᔭᕐᑕᖓ ᐃᖃᓗᑦᑕᐅᔫᑦ ᐃᑭᓪᓕᑎᕐᑕᐅᒪᓯᑎᓪᓗᕆᑦ (ᑕᑭᓂᖏᑎᒍᑦ), ᐊᖏᓂᕐᓴᑦ ᐃᖃᓗᐃᑦ (> 55 cm ᐅᕝᕙᓘᓐᓃᑦ > 22 in.) ᑕᒪᖏᑦ ᐊᖑᑏᑦ ᐊᕐᓄᓗ, ᐊᑕᐅᓯᕼᓪᓗᑎᐅᓐᓃᑦ ᐱᐊᕐᕿᐅᐹᓇᓯᓯᒪᑎᑲᓯᐊᓯᓗᕆᑦ, ᐱᐊᕐᕿᐅᕕᕆᔩᒥᓄᑦ ᑎᑭᒍᓐᓇᓯᑎᕆᐊᕐᓗᕆᑦ ᐅᑭᐅᖏᑦ. ᑭᓯᐊᓂ, ᐱᒻᒪᕆᐅᕗᖅ ᑐᑭᓯᑎᑦᓯᕆᐊᒥᒃ ᐃᒫᒃ, ᑐᑭᓯᐅᑎᑦᓴᑦ ᓄᑖᒍᓂᖏᓐᓄᑦ, ᓄᐃᑦᓯᒍᑦᓴᐅᖃᔭᖕᖏᑐᑦ ᓱᓕ ᐋᕐᕿᑕᐅᒪᒍᑎᑦᓴᖏᓐᓂᒃ ᐃᖃᓗᐃᑦ ᑲᑎᒪᔩᑦ ᖃᐅᔮᓴᕐᑕᐅᔫᑦ. ᑐᖕᖓᕕᕆᑦᓯᕆᑦ ᐆᒪᔪᐃᑦ ᖃᓄᐃᓕᖓᓂᖏᓐᓂᒃ ᓇᓗᓀᕐᓯᐅᑎᐅᓯᒪᔪᑦ 2016-ᒥ, ᐃᑉᐱᕆᔭᐅᕆᐊᓪᓚᓗᑎᒃ ᑖᒃᑯᐊ ᐱᐅᓂᕐᓴᐅᔪᕆᔭᐅᓂᕐᑐᑦ. MFFP-ᐸ ᐆᒪᔪᓕᕆᔨᖏᑦ ᐊᑐᐃᓐᓇᐅᖏᓐᓈᑐᑦ ᐊᐱᕐᓲᑎᑦᓴᓂᒃ ᑭᐅᒍᓐᓇᓯᑎᒃ ᑖᒃᑯᐊ ᑐᓴᕐᑎᓯᐅᑏᑦ ᐱᑦᔪᑎᕆᓗᕆᑦ. ᐊᐅᐸᓗᒃ ᓄᓇᓕᖓ ᐃᖏᕐᕋᓯᑎᑦᓯᒍᒪᔪᖅ ᐃᑉᐱᒍᓱᓐᓂᒧᑦ ᐱᓇᓱᓚᕐᒥᒃ ᐊᑐᐃᓐᓇᕈᕐᑎᑕᐅᓯᒪᔪᒥᒃ ᐊᒻᒪᓗ ᐊᐅᓚᑕᐅᓂᖃᕐᓯᓂ ᐃᓚᐅᔪᕐᑯᑎᒥᓄᑦ (ᐆᑦᑑᑏᑦ, ᓄᓇᓖᑦ ᐊᖑᕕᓛᐱᖏᑦ), ᐅᖀᕐᖃᐹᓇᑐᑦ MFFP-ᐸ Direction de la gestion de la faune du Nord-du-Québec ᑭᒻᒐᑐᕐᑎᖏᓐᓂᒃ ᐃᓱᒪᕆᔭᖏᓐᓂᒃ ᐅᖃᐅᑎᔭᐅᕙᔭᕋᒥᒃ ᐊᒻᒪᓗ ᐊᔾᔨᕆᐊᑭᑎᖏᓐᓂᒃ. ᐅᖀᕕᐅᒍᓐᓇᑐᑦ ᓄᐃᑕᑎᑕᐅᕝᕙᑦ ᑖᒃᑯᓄᖓ ᑐᓴᕐᑎᓯᐅᑎᓄᑦ ᐊᑖᓃᑦᓯᑎᒃ.

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Appendix I

Table 10. Total average maximum length (in mm) of lake trout by age and by catch site near Aupaluk, Nunavik, in 2016. Sample size (*n*) and range [minimum-maximum] are also shown. The longest sampled lake trout is shown in boldface.

Age	Red Dog Lake	Voltz Lake	Brûlé Lake
1+	102 (2) [95–108]		
2+	145 (8) [130–176]	137 (8) [123–157]	127 (1)
3+	188 (20) [145–217]	208 (9) [165–238]	165 (7) [141–191]
4+	237 (3) [221–263]	203 (2) [173–233]	226 (1)
5+	283 (4) [221–417]	335 (3) [292–375]	240 (7) [199–274]
6+	345 (3) [304–366]		296 (1)
7+	415 (7) [383–496]	447 (11) [403–521]	312 (2) [271–353]
8+	467 (4) [405–526]	528 (1)	
9+	473 (9) [429–538]	539 (12) [482–621]	397 (6) [324–526]
10+	548 (5) [515–583]	541 (11) [485–592]	432 (6) [355–523]
11+	533 (4) [492–557]	536 (7) [490–565]	508 (6) [465–552]
12+	573 (2) [550–596]	560 (11) [508–608]	512 (6) [440–573]
13+	595 (7) [555–654]	614 (3) [511–715]	549 (1)
14+	631 (3) [585–681]		509 (4) [451–570]
15+	579 (4) [570–600]		
16+	619 (2) [610–628]	661 (1)	538 (1)
17+	604 (6) [542–680]	601 (3) [550–638]	543 (3) [534–554]
18+	621 (3) [609–643]		
19+	605 (2) [590–620]	536 (1)	606 (3) [574–634]
20+	602 (3) [571–650]		
21+	601 (4) [583–616]	565 (1)	637 (1)
22+	624 (1)	578 (1)	597 (3) [589–603]
23+	629 (7) [594–704]	623 (5) [591–654]	556 (2) [547–564]
24+	601 (2) [584–618]	638 (2) [559–717]	611 (3) [560–658]
25+	602 (3) [592–608]	643 (1)	
26+	661 (2) [613–708]	648 (3) [599–688]	589 (2) [555–616]
27+		548 (2) [541–555]	579 (1)
28+	631 (2) [590–672]	592 (2) [584–599]	
29+	636 (4) [603–701]	568 (2) [560–576]	582 (1)
30+	632 (1)		561 (1)
31+		591 (1)	
32+	615 (1)	610 (1)	
33+	630 (1)	636 (1)	557 (1)
34+	630 (1)	650 (3) [565–722]	
35+			677 (2) [654–700]
36+	695 (1)	**796** (1)	
37+			
38+		592 (1)	
39+		625 (1)	
40+	662 (1)		
41+	650 (1)		
42+	692 (1)	641 (1)	601 (1)
43+	653 (1)		
44+	649 (1)		
45+	670 (1)		
46+			
47+			
48+		612 (1)	
49+	643 (1)	644 (1)	
50+	640 (1)		

Three lake trout were also caught in the gill nets used in Red Dog River. They were 7, 11 and 26 years old and their total maximum length was 337, 525 and 665 mm, respectively. A 5-year-old lake trout caught in a tributary of Red Dog River had a total maximum length of 265 mm.

Appendix II

Table 11. Average mass (g) of lake trout by age and by catch site near Aupaluk, Nunavik, in 2016. Sample size (*n*) and range [minimum-maximum] are also shown. The heaviest sampled lake trout is shown in boldface.

Age	Red Dog Lake	Voltz Lake	Brûlé Lake
1+	9.3 (2) [8.0–10.5]		
2+	27.4 (8) [19.2–43.4]	20.6 (8) [17.3–29.1]	15.6 (1)
3+	61.2 (20) [27.6–85.9]	73.7 (9) [33.3–104]	36.6 (7) [22.3–57.5]
4+	112 (3) [86.0–149]	69.1 (2) [42.4–95.8]	84.1 (1)
5+	295 (4) [89.3–751]	350 (3) [235–506]	108.3 (7) [56.7–149]
6+	362 (3) [230–432]		193.6 (1)
7+	667 (7) [501–1 210]	903 (11) [548–1 405]	227 (2) [144–454]
8+	932 (4) [595–1 312]	1 407 (1)	
9+	1 074 (9) [741–1 609]	1 657 (11) [1 066–2 666]	567 (6) [247–1 372]
10+	1 643 (5) [1 421–2 045]	1 641 (11) [978–2 105]	729 (6) [342–2 308]
11+	1 421 (4) [946–1 704]	1 528 (7) [1 129–1 792]	1 178 (6) [889–1 548]
12+	1 789 (2) [1 751–1 825]	1 824 (11) [1 486–2 184]	1 215 (6) [617–1 670]
13+	2 023 (7) [1 786–2 620]	2 384 (3) [1 453–3 341]	1 500 (1)
14+	2 312 (3) [1 612–3 039]		1 247 (4) [744–1 806]
15+	1 591 (4) [1 010–1 818]		
16+	1 683 (2) [1 483–1 883]	3 295 (1)	1 342 (1)
17+	1 990 (6) [1 174–2 963]	2 141 (3) [1 434–2 810]	1 363 (3) [1 280–1 512]
18+	2 027 (3) [1 885–2 191]		
19+	1 909 (2) [1 834–1 981]	1 423 (1)	1 868 (3) [1 701–2 047]
20+	2 263 (3) [1 969–2 625]		
21+	2 158 (4) [1 717–2 578]	2 821 (1)	2 396 (1)
22+	2 678 (1)		1 772 (3) [1 654–1 909]
23+	2 423 (7) [2 007–2 952]	2 340 (4) [1 766–2 833]	1 251 (2) [1 115–1 387]
24+	2 382 (2) [2 139–2 625]	2 655 (2) [1 690–3 620]	2 047 (3) [1 806–2 175]
25+	2 332 (3) [2 239–2 503]	2 676 (1)	
26+	2 385 (2) [2 374–2 396]	2 950 (3) [2 306–3 433]	1 786 (2) [1 401–2 170]
27+		1 801 (2) [1 345–2 257]	1 491 (1)
28+	2,679 (2) [2 278–3,081]	1 969 (2) [1 749–2 188]	
29+	2 453 (4) [1 886–2,986]	1 927 (2) [1 795–2 058]	2 143 (1)
30+	2 332 (1)		1 628 (1)
31+		1 687 (1)	
32+	1 905 (1)	2 640 (1)	
33+	2 495 (1)	2 039 (1)	1 270 (1)
34+	2 109 (1)	2 527 (3) [1 930–3 144]	
35+			2 262 (2) [1 885–2 639]
36+	3 223 (1)	**6 702** (1)	
37+			
38+		1 369 (1)	
39+		1 909 (1)	
40+	2 604 (1)		
41+	2 357 (1)		
42+	2 384 (1)	2 530 (1)	1 856 (1)
43+	2 708 (1)		
44+	2 533 (1)		
45+	2 333 (1)		
46+			
47+			
48+		2 115 (1)	
49+	2 400 (1)	2 074 (1)	
50+	2 281 (1)		

Three lake trout were also caught in the gill nets used in the Red Dog River. They were 7, 11 and 26 years of age. Their weight was 303, 1 286 and 2 723 g, respectively. A 5-year-old lake trout was caught in a tributary of the Red Dog River and weighed 174 g.

Appendix III

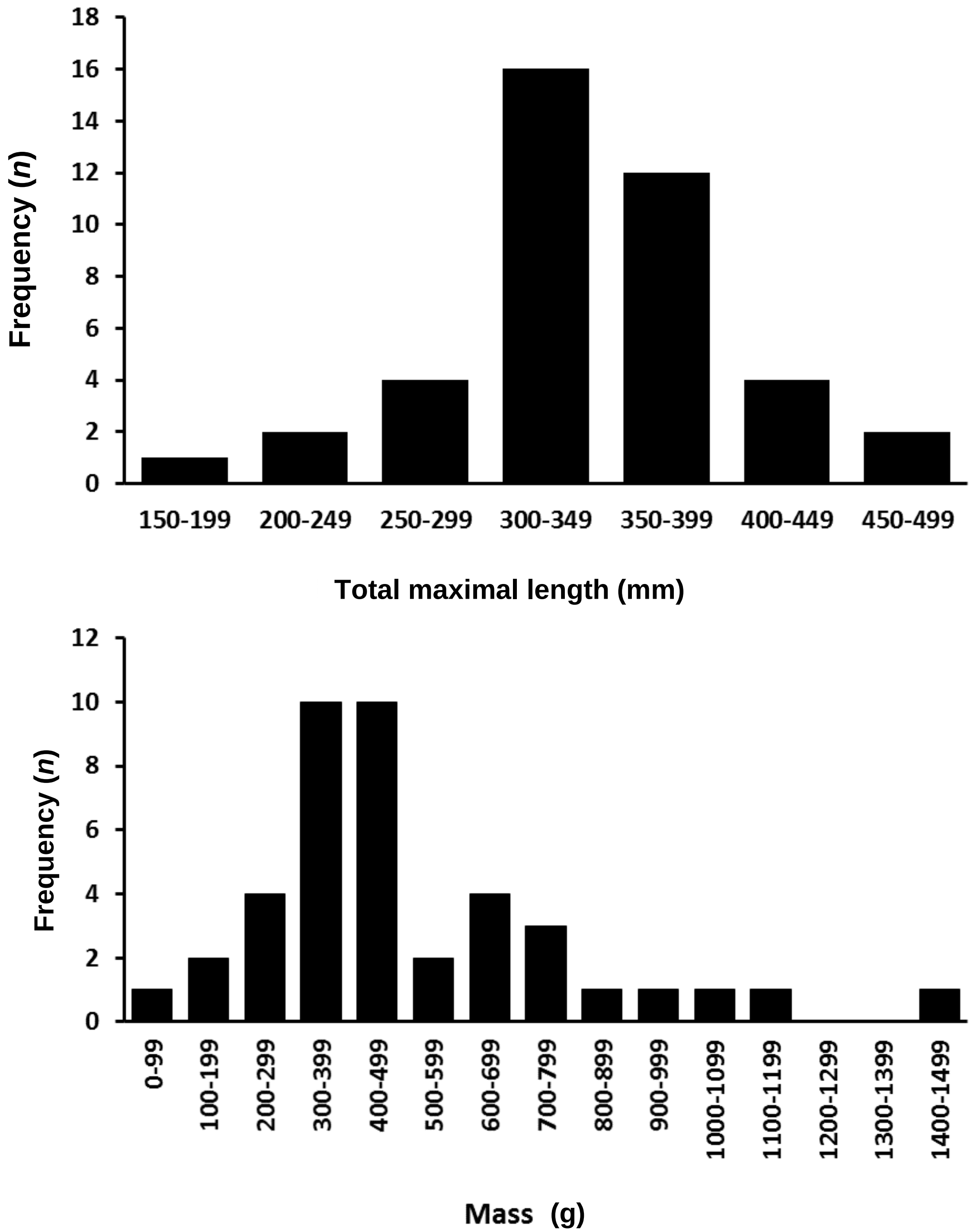

Figure 14. Frequency distribution of total maximum length and mass (in 50 mm or 100 g classes, respectively) for brook trout sampled in Red Dog River.

Appendix IV

Table 12. Percentage of individual fish with mature gonads by sex, among sampled lake trout, by age or by total maximum length (50 mm classes).

Age	Percentage of mature females	Percentage of mature males	Total maximum length class	Percentage of mature females	Percentage of mature males
1+	0.00 (1)	0.00 (1)	50-99	0.00 (1)	
2+	0.00 (6)	0.00 (11)	100-149	0.00 (5)	0.00 (13)
3+	0.00 (11)	0.00 (25)	150-199	0.00 (9)	0.00 (18)
4+	0.00 (1)	0.00 (3)	200-249	0.00 (7)	0.00 (12)
5+	0.00 (5)	0.14 (7)	250-299	0.00 (3)	0.17 (6)
6+	0.00 (2)	0.00 (2)	300-349	0.00 (1)	0.00 (4)
7+	0.00 (7)	0.08 (12)	350-399	0.00 (6)	0.00 (7)
8+	0.00 (2)	0.33 (3)	400-449	0.00 (9)	0.00 (9)
9+	0.13 (15)	0.36 (11)	450-499	0.13 (16)	0.17 (6)
10+	0.36 (14)	0.50 (8)	500-549	0.60 (25)	0.75 (20)
11+	0.55 (11)	0.57 (7)	550-599	0.52 (33)	1.00 (36)
12+	0.30 (10)	1.00 (9)	600-649	0.50 (24)	0.84 (31)
13+	0.25 (8)	0.67 (3)	650-699	0.38 (8)	0.80 (10)
14+	0.00 (4)	0.33 (3)	700-749	0.33 (6)	0.00 (1)
15+	0.67 (3)	1.00 (1)	750-799	0.50 (2)	
16+	0.67 (3)	1.00 (1)			
17+	0.33 (6)	0.67 (6)			
18+		0.67 (3)			
19+	0.50 (2)	0.75 (4)			
20+	1.00 (2)	1.00 (1)			
21+	0.33 (3)	1.00 (3)			
22+	0.00 (1)	1.00 (3)			
23+	0.83 (6)	1.00 (7)			
24+	1.00 (2)	1.00 (5)			
25+	1.00 (3)	1.00 (1)			
26+	1.00 (2)	1.00 (6)			
27+	1.00 (1)	1.00 (2)			
28+	0.00 (2)	1.00 (2)			
29+	1.00 (3)	0.75 (4)			
30+	0.00 (1)	1.00 (1)			
31+		1.00 (1)			
32+	1.00 (1)	1.00 (1)			
33+	1.00 (1)	1.00 (2)			
34+	0.00 (3)	1.00 (1)			
35+	1.00 (1)	1.00 (1)			
36+	1.00 (2)				
37+					
38+		1.00 (1)			
39+		1.00 (1)			
40+	1.00 (1)				
41+		1.00 (1)			
42+	0.00 (1)	0.00 (1)			
43+		1.00 (1)			
44+		1.00 (1)			
45+		1.00 (1)			
46+					
47+					
48+		1.00 (1)			
49+		1.00 (2)			
50+	1.00 (1)				

The fish shown in Table 12 were caught in Voltz Lake, Brûlé Lake and Red Dog Lake, as well as in Red Dog River. The data presented here are from all the sites together.

Appendix V

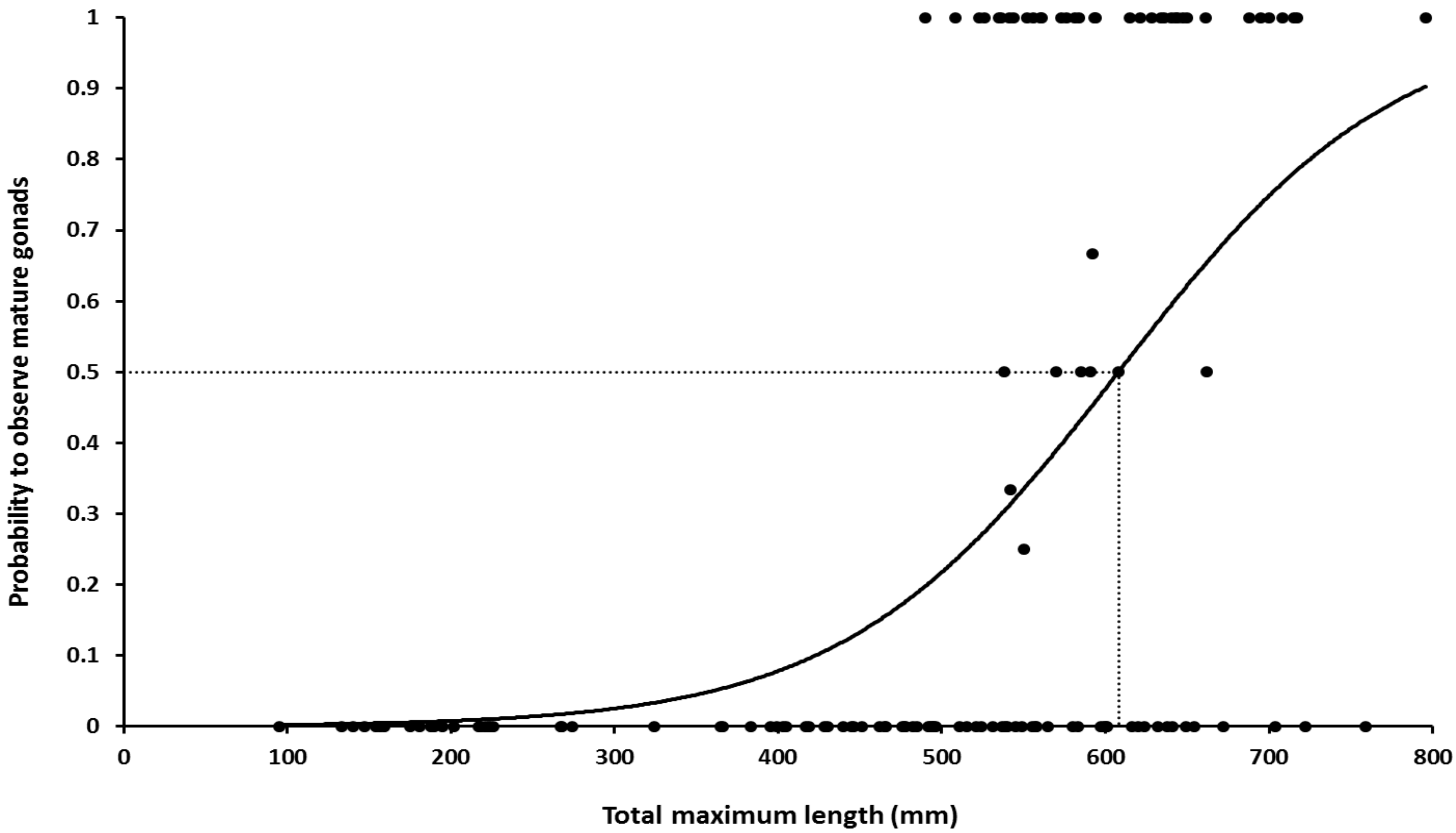

Figure 15. Probability of finding mature gonads in female lake trout sampled in Voltz Lake, Brûlé Lake and Red Dog Lake (combined) according to total maximum length; the dotted line shows the size above which 50 % of females are likely to have mature gonads.

Appendix VI

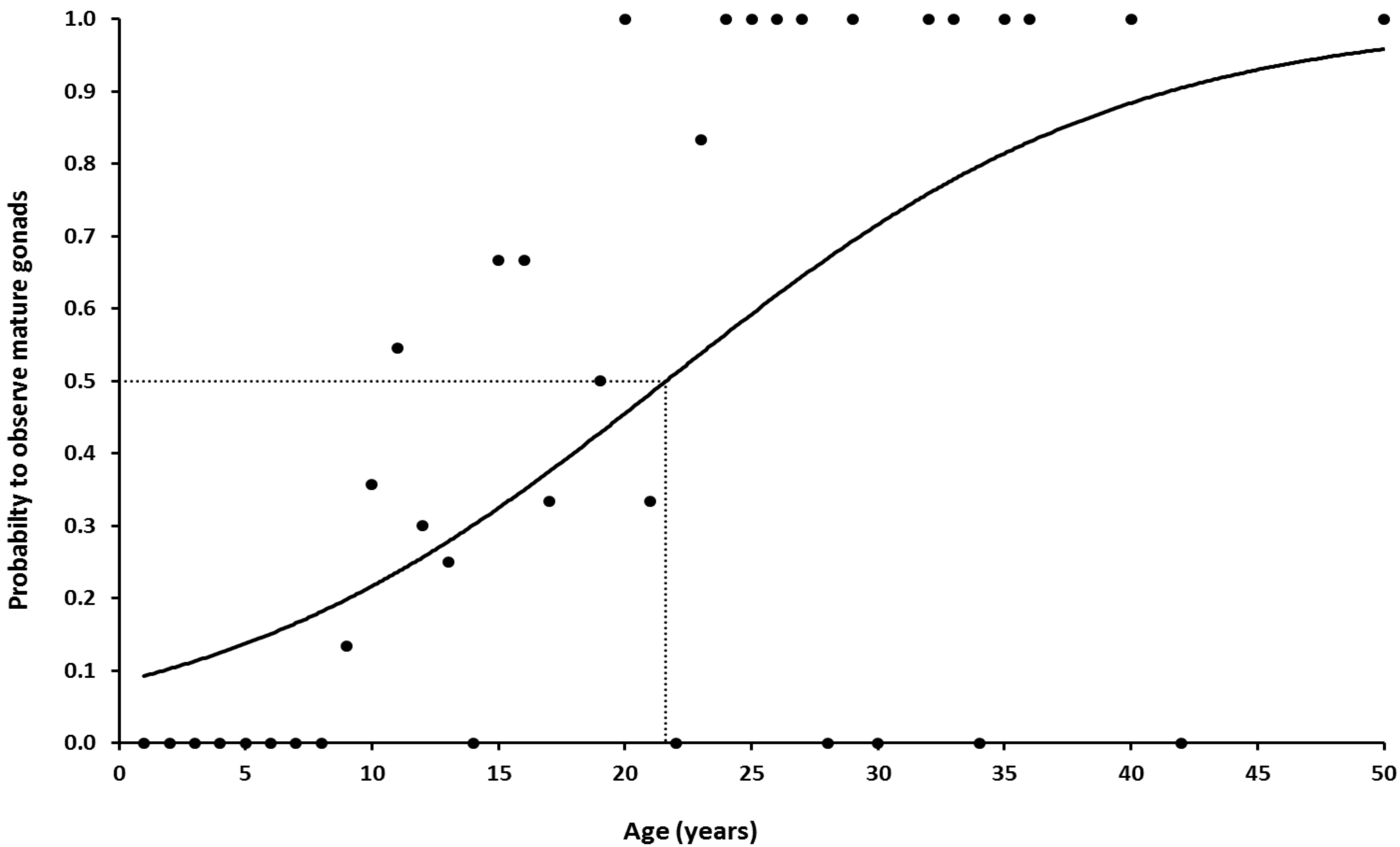

Figure 16. Probability of finding mature gonads in female lake trout sampled in Voltz Lake, Brûlé Lake and Red Dog Lake (combined) according to age; the dotted line indicates the age above which 50 % of females are likely to have mature gonads.

Appendix VII

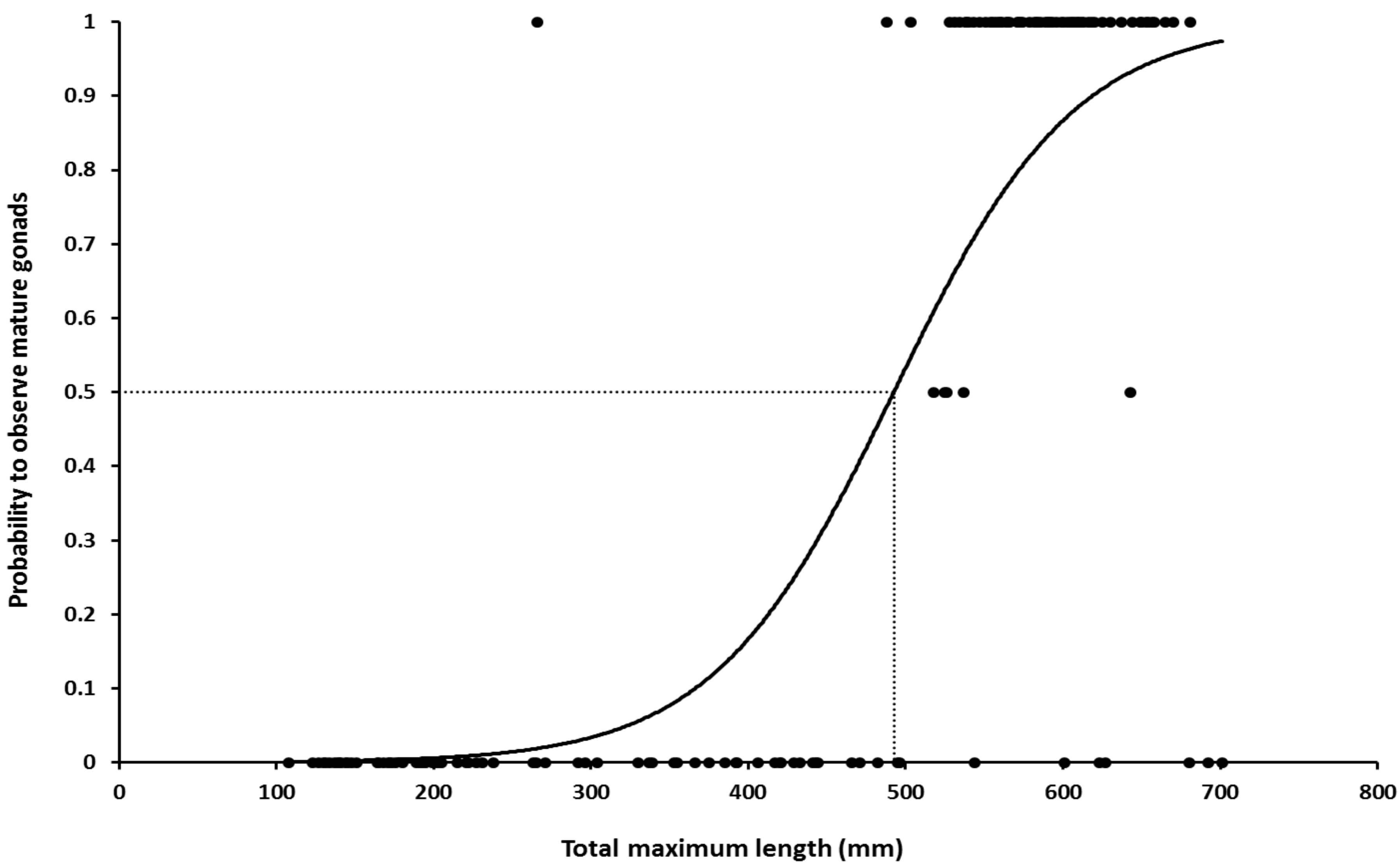

Figure 17. Probability of finding mature gonads in male lake trout sampled in Voltz Lake, Brûlé Lake and Red Dog Lake (combined) according to total maximum length; the dotted line shows the size above which 50% of males are likely to have mature gonads.

Appendix VIII

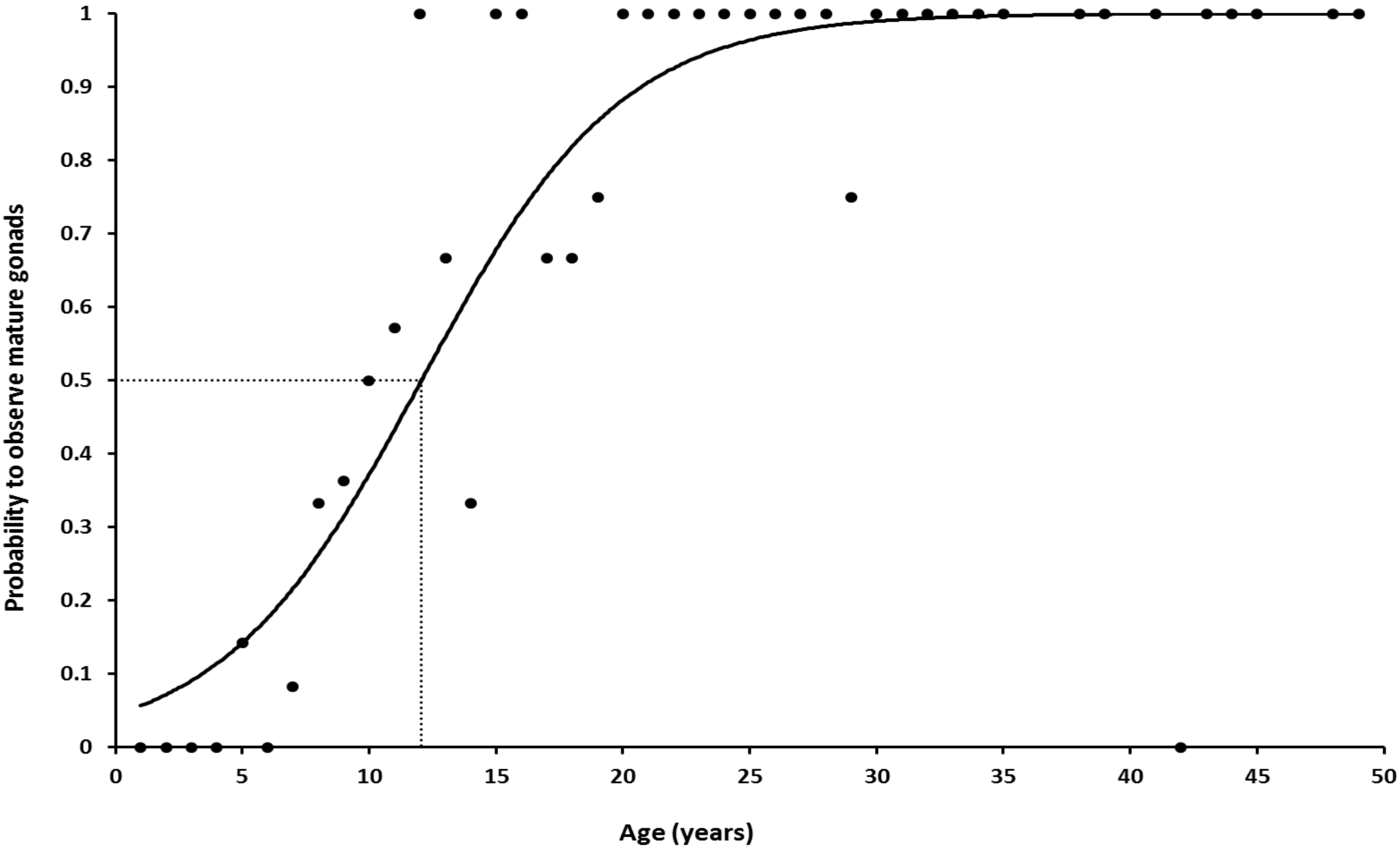

Figure 18. **Probability of finding mature gonads in male lake trout sampled in Voltz Lake, Brûlé Lake and Red Dog Lake (combined) according to age; the dotted line indicates the age above which 50 % of males are likely to have mature gonads.**

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