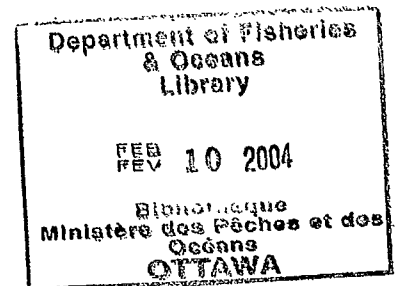


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E. Magnin, and A.-M. Clément



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**GROWTH AND FEEDING HABITS OF ROUND WHITEFISH --PROSOPIUM CYLINDRACEUM
(PALLAS) — IN THE JAMES BAY AREA**

Étienne Magnin and Anne-Marie Clément
Biological Sciences Department, University of Montreal
Box 6128, Montreal H3C 3J7

Abstract

Ages were determined by examination of scales from 598 specimens of Prosopium cylindraceum: 93 from the lower part of the Grande Rivière de la Baleine, 367 from the middle and lower reaches of La Grande Rivière and 138 from the upper parts of these two rivers and the adjacent Caniapiscau River. Growth in fork length and weight is very slow in the Canapiscau area, a little faster in La Grande Rivière and fastest in the Grande Rivière de la Baleine. At age 10, the respective fork lengths and weights in these areas are 275 mm (206 g), 325 mm (355 g) and 344 mm (421 g). Round whitefish from the La Grande Rivière estuary fed mainly on insect larvae, principally those of Trichoptera and Diptera (Chironomidae).

Introduction

The round whitefish, Prosopium cylindraceum (Pallas), is very common throughout Eastern Canada from the Great Lakes Basin (except Lake Erie) and New Brunswick in the south as far north as Ungava Bay, with the exception of a few rivers in the southern James Bay area (Scott and Crossman, 1974; Magnin, 1977). Its growth has been studied in the Great Lakes (Bailey, 1963; Mraz, 1964), a New Hampshire lake (Normandeau, 1969) and the rivers of Ungava (Mackay and Power, 1968; Jessop, 1972). We thought it would be interesting to study the growth of this fish within the watersheds of the Grande Rivière de la Baleine, La Grande Rivière and the Caniapiscau, where round whitefish are abundant (Magnin, 1977) and play an important role in the feeding of lake trout (Magnin et al., 1978). To this we have added a study of feeding habits, which to our knowledge have been the subject of very

little study for round whitefish in Eastern Canada.

Equipment and Methods

From 1973 to 1977, a total of 935 specimens were collected in the James Bay area, including 503 from the lower La Grande Rivière, 337 from the Caniapiscou basin and 95 from the Grande Rivière de la Baleine watershed (Fig. 1). Specimens taken from the headwaters of La Grande Rivière and the Grande Rivière de la Baleine were included with those of the Caniapiscou because of the similarity of these three habitats (altitude, water quality). All specimens from the Grande Rivière de la Baleine and 79% of those from la Grande Rivière were taken with gill nets, whereas most of the Caniapiscou specimens (69%) were caught with seines. This explains the discrepancies in fork length frequency distributions between specimens measured in the three different areas (Fig. 2).

Like most authors studying round whitefish, we have used fork length to determine the size of the fish. However, we have also estimated the functional regression equation (Rocker, 1973) that expresses total length (LT) as a function of fork length (LF);

$$LT = -0,451 + 1,087 LF (r = 0,9998).$$

For any conversions from standard length to fork length, we used the formula established par Carlander (1969).

Age was determined on the basis of both scales and otoliths on 69 specimens. On 46 of these (67%), no difference was found. There was a one-year difference on 18 specimens (26%), a two-year difference on two (3%) and a three-year difference on three (4%). Moreover, age was not found to be consistently greater on either the otoliths or the scales. In a study of round whitefish in the Ungava area, Jessop (1972) observed that 97% of scale and otolith readings concurred, and that scale and otolith age discrepancies appeared only on fish over eight years old. In addition, we found that otolith age readings

would be more difficult on a large number of specimens. As a result, we decided to use only scales. We were able to determine the location of the first annulus on the scales by examining young specimens in the 0 age group. We will see that the results obtained by this method are confirmed by the bar charts of fork length frequencies.

From a functional regression (Ricker, 1973), we calculated the equation that yields the logarithm of the fork length (LF) vs the radius (R) of the scale enlarged 20 times:

$$\log LF = 1.065 + 0.747 \log r \quad (r = 0.987)$$

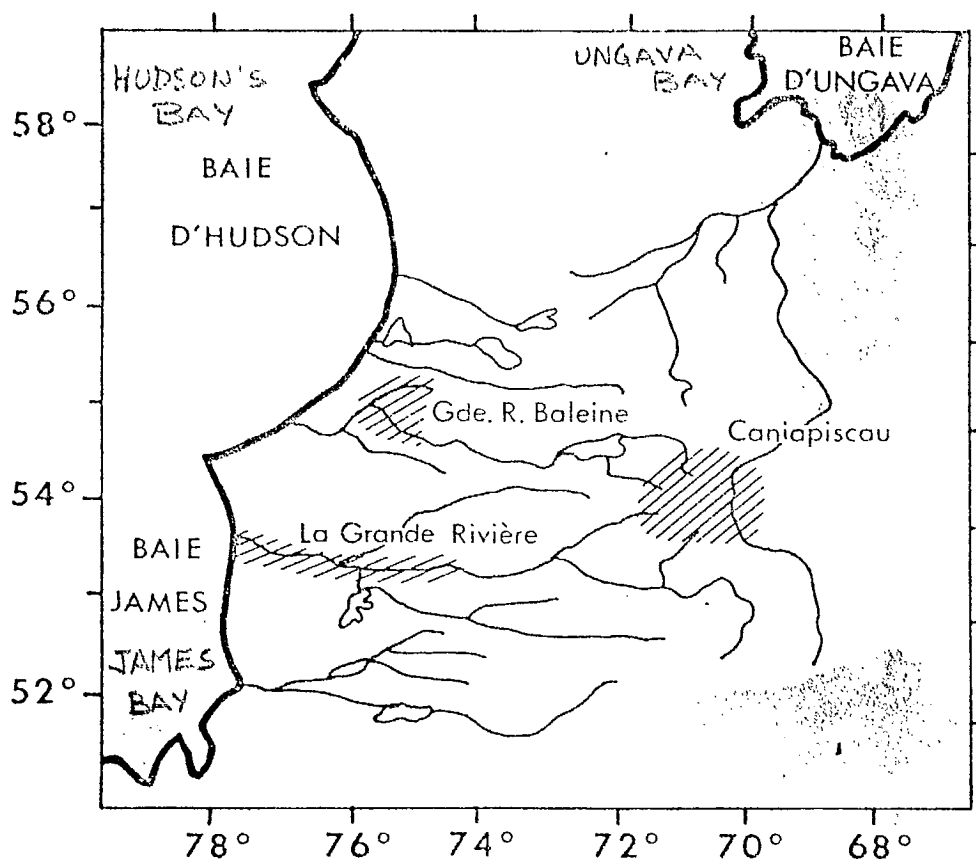


Figure 1. Map showing the three main areas where the round whitefish were caught.

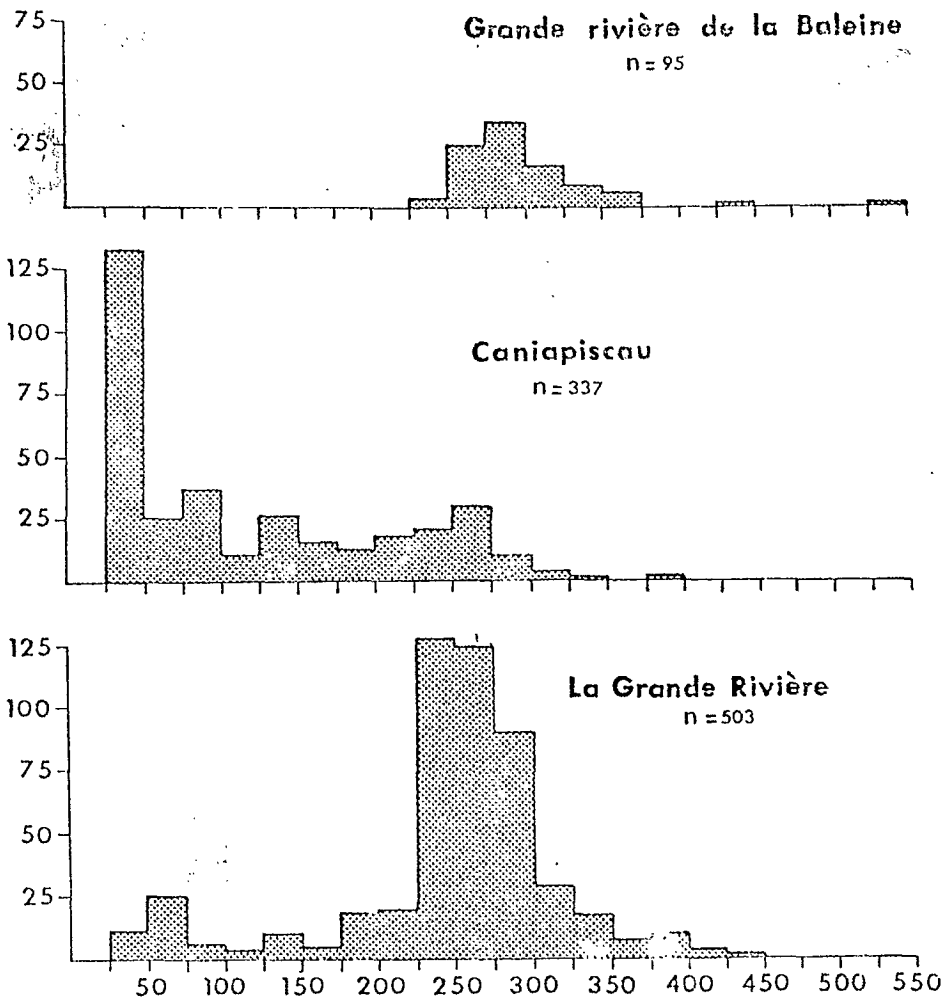


Figure 2. Bar charts of fork length frequency of round whitefish in the three areas under study.

This equation based on 756 paired values is actually allometric, with a confidence interval between 0.730 for the 0.747 curve, given a probability threshold of 0.05 (Ricker, 1975). It allowed us to calculate the length of the specimens at the time of formation of the various annuli. By taking the sum of the mean annual growth values, we obtained lengths which enabled us to establish von Bertalanffy equations.

The relations giving the logarithm of weight vs the logarithm of length were calculated for round whitefish from La Grande Rivière (456 specimens), the Grande Rivière de la Baleine (93 specimens) and the Caniapiscou (42 specimens), after checks to see that there was no statistical difference between males and females. These three equations were then tested by covariate analysis to see if they were statistically different. They also enabled us to derive the weight of round whitefish at the time of formation of the various annuli from the lengths calculated using the von Bertalanffy equation.

Feeding habits could only be studied on 89 specimens from the lower La Grande Rivière basin. These were caught between August and October, and most (70%) were taken between September 14th and 30th. They were generally between 200 and 300 mm long, with only a few larger specimens. Prey were identified according to family for the two main groups (Trichoptera and Diptera), and by Order for all others. Interpretation of stomach contents was carried out by two methods: the frequency occurrence method and the point method proposed by Hynes (1950).

Results

For each age group, we had done separate calculations for the mean fork length of males and females. Since a Student "t" test then revealed no significant difference in length in any of the age groups, we lumped males and females together for all three river basins (Table I). If we take into account that the fish had gone through part of their annual growth cycle when caught, we note first of all that the lengths calculated from the annual rings on the scales are consistent with the real lengths measured upon capture. On the size frequency bar chart for Caniapiscou round whitefish, we find that the first three modes fall within the 25-50 mm, 75-100 mm and 125-150 mm size categories. According to Table I, these three modes are in keeping with the mean lengths calculated back for age groups I (68 mm), II (114 mm) and III (154 mm). This validates the age readings

taken from the scales.

We can now compare the growth of round whitefish in the three river basins. First of all, we see that round whitefish in the Caniapiscau grow more slowly than those in the other two watersheds. The best growth rate seems to be in the Grande Rivière de la Baleine, particularly from age five upward. To reach a length of 300 mm, it takes seven years for the round whitefish in the Grande Rivière de la Baleine and eight years for those in the lower La Grande Rivière. In the Caniapiscau, they are still only 275 mm long after 10 years.

The von Bertalanffy equations provide quite a good description of the fork length growths of round whitefish in the three watersheds:

$$LF = 403.38 [1 - e^{-0.1948(t+0.0087)}]$$

in the Grande Rivière de la Baleine,

$$LF = 370.03 [1 - e^{-0.2110(t+0.0051)}]$$

in the lower La Grande Rivière and

$$LF = 368.65 [1 - e^{-0.2225(t+0.1019)}]$$

in the Caniapiscau. In these three habitats, the following respective lengths would be attained: 71, 71 and 67 mm at one year; 251, 241 and 209 mm at five years; 346, 325 and 276 mm at 10 years.

TABLE I

Growth in fork length (LF in mm) and weight (M in g) of round whitefish
in the James Bay Region - N = number of specimens

Age Group	Grande Rivière de la Baleine					La Grande Rivière									
	Measured values		Calculated values			Measured values		Calculated values			Measured values		Calculated values		
	N	LF	N	LF	M	N	LF	N	LF	M	N	LF	N	LF	M
1	-	-	93	70	2	19	97	367	67	3	48	87	138	68	2
2	-	-	93	128	17	8	149	348	126	19	28	131	90	114	11
3	-	-	93	179	49	33	214	340	177	51	16	157	62	154	29
4	5	267	93	220	94	68	243	307	216	93	19	197	46	185	53
5	32	276	88	251	148	89	255	239	242	140	10	228	27	210	81
6	22	288	56	277	206	61	268	150	263	190	11	246	17	229	110
7	16	316	34	300	265	33	291	80	283	237	1	260	6	246	138
8	9	326	18	317	322	26	304	56	299	281	4	288	5	259	163
9	3	334	9	333	374	15	316	30	314	321	-	-	1	267	186
10	-	-	6	344	421	11	316	15	325	355	1	220	1	275	206
11	4	350	6	358	463	3	370	4	338	385	-	-	-	-	-
12	2	351	2	369	499	1	390	1	357	411	-	-	-	-	-

GROWTH IN WEIGHT

The equations from which the logarithm of weight M is obtained as a function of the logarithm of fork length are as follows:

$$\log M = -5.6472 + 3.2581 \log LF$$

for round whitefish in the Grande Rivière de la Baleine ($r = 0.965$),

$$\log M = -5.2692 + 3.1130 \log LF$$

for those in the lower La Grande Rivière ($r = 0.992$),

$$\log M = -5.9460 + 3.3840 \log LF$$

for those in the Caniapiscou ($r = 0.984$).

The second equation is significantly different from the other two, which are substantially the same. Furthermore, given equal length, round whitefish in La Grande Rivière weigh more than those in the other two regions when they are small, but less when they grow larger.

Table I shows the weight of round whitefish at the time of formation of the various annuli, according to these equations. Firstly, we see that growth by weight is slower in the Caniapiscou than in the other two basins. In the lower La Grande Rivière, growth by weight is greater than in the Grande Rivière de la Baleine up to the age of five years, at which point the reverse occurs.

The following von Bertalanffy equations:

$$M = 695.60 [1 - e^{-0.1948(t-0.0087)}]^{3.2581}$$

$$M = 531.22 [1 - e^{-0.2110(t+0.0051)}]^{3.1130}$$

$$M = 300.79 [1 - e^{-0.2225(t+0.1019)}]^{3.3840}$$

allow for a relatively good description of growth by weight in the three habitats of the Grande Rivière de la Baleine, La Grande Rivière and the Caniapiscau. In each of these habitats, the respective weights would be 2, 3 and 2 g at one year; 148, 140 and 81 g at five years; 241, 355 and 206 g at 10 years.

FEEDING HABITS

The last two columns of Table II show that 94% round whitefish stomachs in the Fort Georges area contain insect larvae, 30% contain mollusks and only 8% contain fish, and that the proportions by volume of these three principal prey categories are respectively 93%, 6% and 4%. Insect larvae therefore play a prime role in the round whitefish diet, with Trichoptera larvae (63% by volume) and Chironomidae larvae (17% by volume) making up the major part.

Table II also shows that the feeding habits of the round whitefish vary according to the location. At station FG025, Lepidostomatidae, Leptoceridae and Chironomidae larvae are found more often than not in the stomach contents, and these organisms represent 24%, 20% and 24% respectively of the total volume of prey. At FG060, Phryganeidae are found in a large number of stomachs (43%) and in the largest quantities (40% of total prey), whereas the Chironomidae, which are present in 52% of all stomachs, represent only 3% of the total volume of prey. The latter recur as important elements in a group of several other stations (58% occurrence and 17% by volume). It should be noted that amphipods play a substantial part in the round whitefish diet at these stations (approx. 15% occurrence and volume).

Discussion

GROWTH IN LENGTH

The relatively slow growth of the round whitefish in the Caniapiscau compared with the growth of those in the other two zones

is easily explained. The lakes and rivers in this area are located far inland at an altitude of about 500 metres. In summer, the water temperature is generally 3-4°C lower than in the lower reaches of La Grande Rivière. The water usually freezes sooner in the fall and thaws later in the spring, with an ice-free period of only 100 to 120 days as opposed to 150 days on the lower La Grande Rivière (Magnin, 1977).

On the other hand, it is difficult to explain why the round whitefish of the Grande Rivière de la Baleine grow faster than those of La Grande Rivière, which is farther south. One explanation might be interspecies competition between the round whitefish and the common whitefish (Coregonus clupeaformis). According to Sandercock (1964), these two species do indeed occupy the same food niche, and the presence of common whitefish would limit the growth of round whitefish living in the same habitat. In the James Bay region, these two species are generally found together, but according to catch data from 1973 and 1977, the proportion of round whitefish to common whitefish is 10 to 3 in the Grande Rivière de la Baleine, and only 3 to 10 in the lower reaches of La Grande Rivière.

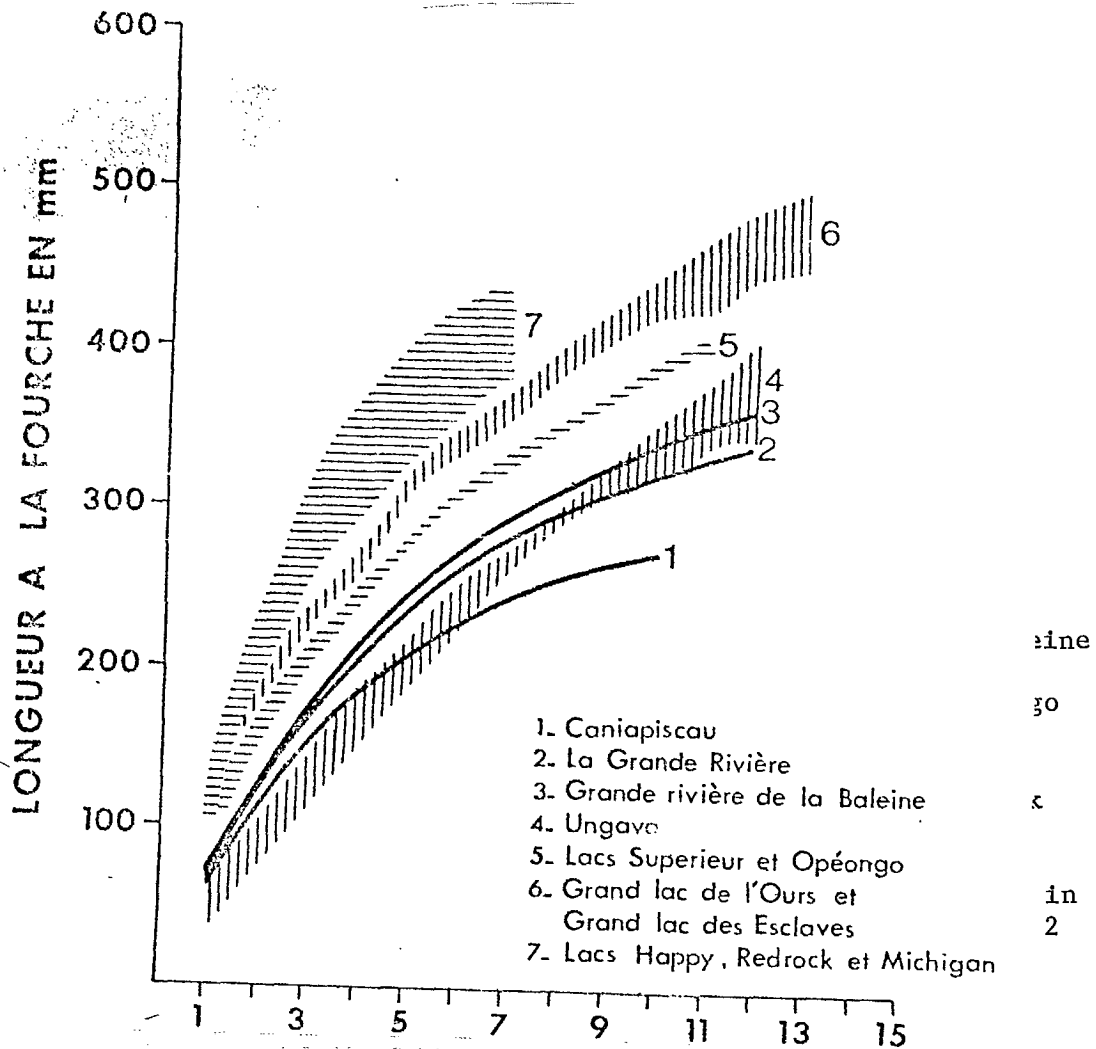
TABLE II

Occurrence (O) and Point (P) percentages attributed to prey found
in the stomach contents of round whitefish caught near Fort Georges (FG)

	Station FG025		Station FG060		Other FG		Total	
	O	P	O	P	O	P	O	P
Trichoptera								
Lepidostomatidae	72	24	39	15	37	23	56	21
Leptoceridae	53	20	39	13	21	1	43	15
Phryganeidae	13	4	43	40	5	1	19	14
Hydropsychidae	11	1	22	5	21	9	16	4
Brachycentridae			26	7			7	2
Psychomiidae	9	3			5	+	6	2
Hydroptilidae	9	+	4	+	5	+	7	+
Molannidae	2	+	4	+	11	8	4	2
Limnephilidae	4	1	4	1			3	1
Glossosomatidae					5	3	1	+
Others	15	2	9	2	11	3	12	2
Total Trichoptera	83	56	96	83	68	49	83	63
Diptera								
Cironomidae	68	24	52	3	58	17	62	17
Dolichopodidae	2	1					1	+
Ceratopogonidae	2	+					1	+
Total Diptera	68	25	52	3	58	17	62	17
Ephemeroptera	15	2	17	1	5	+	13	1
Plecoptera			4	+	5	6	2	1
Hemiptera	4	+	4	+			3	+
Neuroptera			4	2			1	+
Coleoptera			4	1			1	+
Total Insects	96	84	96	88	89	72	94	83
Mollusca								
Gastropoda	26	5	26	3			20	3
Lamellibranchia	11	3	9	2	16	4	11	3
Total Mollusca	36	8	30	5	16	4	30	6
Amphipoda	2	+			16	14	4	3
Fish								
Cottus sp.	4	3	4	3	5	6	4	3
Others	2	+	4	1	5	1	3	+
Total Fish	6	3	9	4	11	7	8	4
Phytoplankton	4	+			5	+	3	+
Debris	32	5	17	3	5	3	22	4
Number of stomach boluses	47		23		19		89	

In other North-American habitats (Fig. 3), there are also cases of growth rates that fail to follow the rule of latitude alone. Growth is relatively slow in the Leaf, Koksoak and Georges rivers that flow into Ungava Bay (Gray, 1965; Mackay and Power, 1968; Jessop and Power, 1973), being similar to the growth rate of round whitefish in the James Bay area.

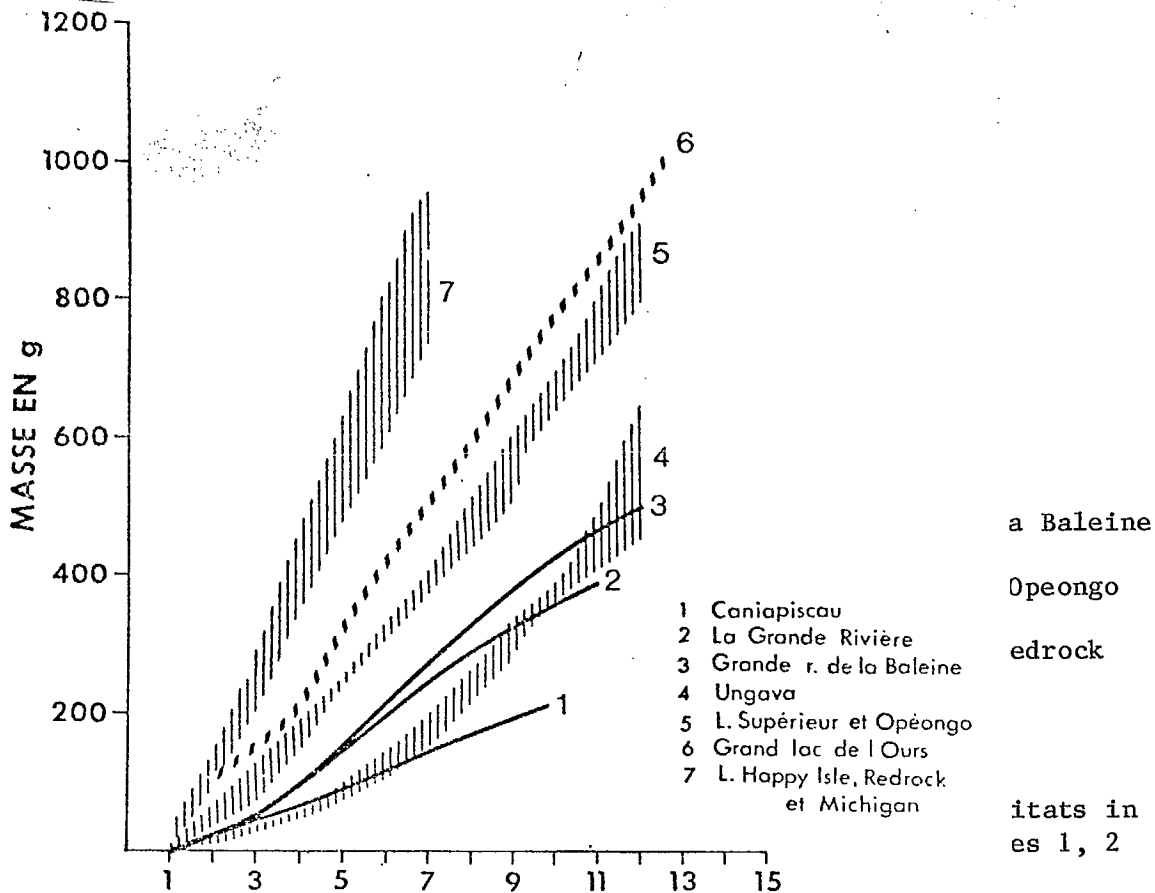
On the other hand, the round whitefish of Great Bear Lake (Falk and Dahle, 1974) and Great Slave Lake (Rawson, 1951), both in the Northwest Territories, have a much higher growth rate than those in the James Bay region or even in waters farther south such as Lake Superior (Bailey, 1963) and Lake Opeongo (Sandercock, 1964). The highest growth rate for round whitefish was observed in Lake Michigan (Mraz, 1964); Armstrong et al., 1977) and in Happy Isle and Redrock lakes in Algonquin Park (Sandercock, 1964).



GROWTH BY WEIGHT

In Table III, we see that for a given length, round whitefish may vary greatly in weight depending on their habitat. They weigh the least in Lake Michigan, but this is where the best growth in length is found. On the other hand, the greatest weights are found in Great Bear Lake and in the lakes of Algonquin Park. Thus a 300-mm round whitefish weighs 240 to 260 g in Lake Michigan, 265 to 290 g in the lakes and rivers of northern Quebec, 300 g in Great Bear Lake and 320 to 347 g in the lakes of Algonquin Park.

In many habitats, however, weight follows length quite consistently (Fig. 4). It is lowest in the lakes and rivers of the James Bay and Ungava regions (Mackay and Power, 1968; Jessop and Power, 1973), higher in lakes Superior and Opeongo (Bailey, 1963; Sandercock, 1964) and in Great Bear Lake (Falk and Dahle, 1974) and much greater in lakes Happy Isle, Redrock and Michigan (Sandercock, 1964; Mraz, 1964; Armstrong et al., 1977).



FEEDING HABITS

Trichoptera and Chironomidae larvae are also a very important part of the round whitefish diet in Great Bear Lake (Kennedy, 1949), Great Slave Lake (Rawson, 1951) and Black Lake in northern Saskatchewan (Johnson, 1971). In Lake Michigan, however, gastropod mollusks are the main element in their diet (Armstrong et al., 1977). All of these observations therefore combine with our own to indicate that round whitefish are bottom feeders that adapt to the foods available in the habitat.

TABLE III

Weight of round whitefish for various lengths as derived from weight-length ratios given by various authors: Mraz (1964) and Armstrong (1977) in Lake Michigan (A and B); Jessop and Power (1973) in the Leaf River; Mackay and Power (1968) in the Georges River and Koksoak river; Falk (1974) in Great Bear Lake; Sandercock (1964) in Happy Isle, Redrock and Opeongo lakes.

LF in mm	Total Weight in g											
	Lake Michigan		James Bay			Leaf River	Georges River	Koksoak River	Great Bear Lake	Happy Isle Lake	Opeongo Lake	Redrock Lake
	A	B	B	LG	CA							
100	6	6	7	9	7	8	17	15	11	15	10	9
200	63	63	71	78	69	74	67	65	89	101	87	87
250	131	138	146	157	147	153	134	136	172	188	174	183
300	239	261	265	276	273	279	269	289	297	321	319	347
350	397	447	438	447	460	464	540	611	478	492	516	580
400	617	712	677	677	723	720	1083	1292	701	712	781	903

Conclusion

Latitude is not the only explanation for the low growth rate, in length and in weight, of round whitefish in the James Bay region. Indeed, the rate is higher in Great Bear Lake and Great Slave Lake, which are both at higher latitudes. Within the James Bay region itself, growth is greater in the lower Grande Rivière de la Baleine than in the lower reaches of the more southerly La Grande Rivière. It could be that the main reason for this lower growth rate is the increased competition with the common whitefish, Coregonus clupeaformis, in the latter basin. On the other hand, the very low growth rate of round whitefish in the Caniapiscau area appears to be attributable to the higher altitude.

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