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Stock Assessment of Tikkoatokak Bay Arctic Charr

by

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Abstract

Catches of Arctic charr in Tikkoatokak Bay increased steadily from 1974 to 1978 when 55 t were removed. Since 1979 this stock has been under quota management with a TAC of 28.5 t in 1981. Stock projections for 1982 were calculated from cohort analyses although only five years of data were available. Population numbers generated from terminal fishing mortalities of 0.4-0.6 indicated an $F_{0.1}$ yield in 1982 between 21.3 and 34.9 t.

Résumé

Les prises d'omble chevalier ont augmenté régulièrement dans la baie Tikkoatokak de 1974 à 1978, année où l'on captura 55 t. Depuis 1979, ce stock est soumis à un contingent, le TPA de 1981 ayant été fixé à 28,5 t. Bien que les données disponibles ne couvrent que 5 ans, nous avons fait des projections pour 1982 à l'aide d'analyses de cohortes. Les effectifs de population déduits d'une mortalité par pêche de dernière année de 0,4 - 0,6 indiquent un rendement à $F_{0,1}$ de 21,3 à 34,9 t en 1982.

Introduction

Catch statistics for the northern Labrador Arctic charr fishery have been available from individual fishing areas since 1974. The largest catches of charr from 1975 to 1980 were from Tikkoatokak Bay (Fig. 1). Landings in this area increased steadily from 1974-78 and in excess of 200 t of charr have been removed during the past five years. This stock has been under quota management since 1979. The total allowable catch (TAC) for 1979 and 1980 was 39.5 t. The TAC in 1981 was 28.5 t (Dempson 1981).

This document updates the 1980 stock assessment utilizing data from the commercial fisheries from 1977-81 and information derived from the Fraser River charr population from 1975-79.

Stock determination

Biological and morphological studies indicated that Tikkoatokak Bay Arctic charr can be defined as one stock complex distinctly different from charr populations to the south in Anaktalik and Voisey Bay and from those to the north in the Okak and Hebron regions (Dempson 1982). Tagging investigations have shown that there is minimal interchange between inner bays from other areas although annual movement into offshore feeding areas does occur but in varying proportions. Nain Bay (Fraser River) charr contribute substantially to the Tikkoatokak Bay fishery and are considered, therefore, as part of the same stock complex (Fig. 2 and 3).

Tagging studies

Beginning in 1979 Arctic charr have been tagged during the period of their spring seaward migration in Nain and/or Tikkoatokak Bay in order to provide information on within season movement and relative exploitation (μ= R/M, Ricker 1975). The weighted mean within season exploitation over two years on Nain Bay charr was $\mu = 51/228 = 0.22$ (95% C.L. = 0.17 - 0.29). Similarly the weighted mean within season rate of exploitation on Tikkoatokak Bay Arctic charr was $\mu = 41/106 = 0.39$ (95% C.L. = 0.28 - 0.52). For Tikkoatokak Bay charr caught only in Tikkoatokak Bay and in no other area, the rate of exploitation reduces to: $\mu = 36/106 = 0.34$ (95% C.L. = 0.24 - 0.47).

Stock Assessment

Catch and effort data

Catch and effort data for Tikkoatokak Bay are summarized in Table 1 for 1974-81. The highest catch occurred in 1978 when in excess of 55 t were removed. A quota of 39.5 t was in effect for 1979 and 1980. A further reduction of the quota in 1981 to 28.5 t has effectively reduced the high catch of 1978 by approximately 50%. Catch per unit effort increased in 1981 to 351 kg/man-week but it has generally remained steady for the past four years. Average C/E from 1978 to 1981 was 350 kg/man-week.

Substantial changes have occurred in the weight composition of the landings. The proportion of charr over 2.3 kg (gutted head-on weight) has declined from an average of 19.1% from 1976-78 to 10.3% in 1980 and only 4.8% in 1981. Length distribution of landings, however has remained virtually constant during the past three years (Fig. 4).

Numbers at age were available from the commercial fishery since 1977 and are summarized in Table 2. Data were derived from age length keys and length frequencies and extrapolated to the total catch.

Weights at age were calculated from commercial samples and converted from gutted head-on to whole condition using the conversion factor 1.24 (Coady and Best 1976) (Table 3).

Partial recruitment rates were derived in two ways. First partial recruitment values were calculated from a matrix of fishing mortality rates generated from a cohort analysis (Rivard 1980) run on the 1977-81 data. F values were averaged at age for the years 1977-79 only. Values are listed in Table 3. In addition, partial recruitment values were calculated using Fraser River counting fence data as an index of the population. The percent at age in the Tikkoatokak Bay catch (1980-81) was compared to the percent at age from the Fraser River fence data (1975-79) (Table 4). The ratio of these percentages provides a measure of selectivity with the highest value assigned the value of 1.0 for fully recruited fish.

Yield per recruit was calculated by the method of Thompson and Bell (Ricker 1975) using partial recruitment values and mean weight at age. Natural mortality was assumed constant at 0.2. $F_{\dot{0}.1}$ calculated from partial recruitment rates derived from cohort analysis was 0.425. $F_{\dot{0}.1}$ calculated from partial recruitment rates derived from Fraser River fence data was 0.466.

Total mortality ($\bar{Z}$) was calculated using the Paloheimo method where catch per unit effort at age data are required (Table 2). Average $\bar{Z}$ calculated was 0.59. Mean $\bar{Z}$ during the past two seasons was 0.48. A separate estimate of fishing mortality was also derived from tag recaptures of Tikkoatokak Bay charr. Assuming a Type I fishery:

$$\mu = 1\text{-}e^{-F} \qquad \text{(Ricker 1975).}$$

Rate of fishing mortality was 0.49 or 0.41 for those Tikkoatokak Bay Arctic charr caught only within Tikkoatokak Bay.

Stock projections were performed using a range of terminal fishing mortality rates (F_T) from 0.4 to 0.6 with both sets of partial recruitment data. Although only five years of information were available, regressions of F on effort produced r^2 values of 0.83, 0.80 and 0.66 for terminal F values of 0.4, 0.5 and 0.6 using partial recruitment values derived from cohort analyses (Table 5). Similarly, r^2 values from the regressions of F on effort using partial recruitment rates from counting fence data were 0.95, 0.89 and 0.81 for terminal F's of 0.4, 0.5 and 0.6 respectively (Table 5). Recruitment estimates for the projections were calculated from the geometric mean of the age six population numbers for the years 1977-79.

Results of the projections are shown in Tables 6 and 7. Fishing at $F_{\hat{0}.1}$ indicates a catch of 15.2 - 24.8 t is available in 1982 using partial recruitment values for cohort analysis. Similarly, using counting fence recruitment rates the projected catch for 1982 is 21.3 - 34.9 t.

Discussion

Relative estimates of within season exploitation, as derived from tag recaptures, suggests a high rate of fishing in Tikkoatokak Bay. Adult stock size has undoubtedly decreased since the mid to latter 1970's, but despite the apparent high exploitation, catch per unit effort has remained quite high and constant. Similarly, size composition of landings in terms of length distribution has changed little during the past three years but there has been a decrease in the number of charr less than 50 cm and greater than 60 cm in comparison with 1977-78. Variation in mean length from 1979-81 was 0.9 cm and from 1977-81 it was 2.9 cm. There has also been a noticeable decline in the proportion of heavier fish in the catches.

This decline in stock size, coupled with an initial change in size structure but later consistency, has been observed in other exploited charr populations (Johnson 1980). Johnson (pers. commun.) suggests charr populations respond to exploitation through a community interaction which "results in a uniformity in the population, irrespective of age, so that instead of getting a population of charr of various sizes, of increasing age, we get a population of very uniform size but non-uniform age." Figure 5 illustrates the length distribution of the Fraser River adult population from 1975-79. Again there has been a decrease in the number of charr in larger length groups in comparison with 1975, but a fairly constant distribution in 1977 and 1979. Mean length has varied by only 1.3 cm for 1975 to 1979, however weight of charr at size also appears to have declined (Table 8). When age groups are superimposed on length strata a large overlap, and non-uniform distribution of age at size results (Fig. 6). Charr of any age exploited by the commercial fishery in Tikkoatokak Bay can virtually be found in any length group greater than 40 cm.

It is suggested that a surplus of pre-recruit juveniles was built up in the Nain-Tikkoatokak system during years of low exploitation (pre-1976). Owing to variations in growth rate and age at first seaward migration, many of these juveniles are still being recruited into the fishery and maintaining the high catch rates of 8-10 year old fish. If catch had not been reduced from the 1978 level, recruitment overfishing would have undoubtedly occurred. The present quota of 28.5 t represents a substantial decline from catches and TAC's from 1977-80 and should have a corresponding effect of increasing escapement into these systems.

The present assessment was conducted using partial recruitment rates derived from two sources. Since relatively few years of data are available it is felt that the PR's generated from the non-selective counting fence data are more accurate. In addition, regressions of F on effort were correspondingly higher using partial recruitment rates generated by this method. Projections for 1982 indicate that an $F_{\hat{0}.1}$ catch of between 21.2 - 34.9 t is available for 1982. Average total mortality obtained from the Paloheimo method was approximately 0.6 (F = 0.4) which would give a TAC of 34.9 t. Estimated fishing mortality derived from recaptures of Tikkoatokak Bay charr caught within the same area

(F = 0.41) would also yield a similar TAC. Based upon the long term projection of $F_{0.1}$ at 0.6 a yield of 0.827 kg (age 6 population of 41,179), a TAC of 35 t is recommended for 1982.

References

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Table 1. Summary of catch (kg round), effort, and size composition statistics from Tikkoatokak Bay, 1974-1981. Size composition expressed as percentage of landings greater than 2.3 kg (gutted head on weight).

SUMMARY OF CATCH, EFFORT, AND SIZE COMPOSITION

YEAR	1974	1975	1976	1977	1978	1979	1980	1981
TIKKOATOKAK BAY								
QUOTAS						39500	39500	28500
CATCH (KG)	9960	27698	31568	39477	55047	37912	42127	28063
EFFORT (MAN-WEEKS)	28	76	81	94	147	108	130	80
C/E (KG)	356	364	390	420	374	351	324	351
%/% > 2.3KG			19.0	20.0	18.0	14.0	10.0	5.0

Table 2. Estimated numbers at age and catch per unit effort at age for Tikkoatokak Bay Arctic charr, 1977-81.

Age	1977	1978	1979	1980	1981
6	1,365	209	257	0	67
7	6,197	3,973	2,508	489	522
8	6670	10,037	7,395	7,260	2,850
9	3,887	6,273	5,402	9,143	6,774
10	1,996	3,555	1,865	4,663	4,355
11	735	1,951	772	1,837	1,287
12	368	1,394	772	349	171
13	105	209	129	253	64
14	53	209	129	84	8
15		70			30
16		70			
17				11	
Total	21,376	27,950	19,229	24,089	16,128
Effort	94	147	108	130	80
		CATCH PER UNIT EFFORT AT AGE			
6	13.5	1.4	2.4	-	0.8
7	65.9	27.0	23.2	3.8	6.5
8	71.0	68.3	68.5	55.8	35.6
9	41.4	42.7	50.0	70.3	84.7
10	21.2	24.2	17.3	34.3	54.4
11	7.8	13.3	7.1	14.1	16.1
12	3.9	9.5	7.1	2.7	2.1
13	1.1	1.4	1.2	1.2	0.8
14	0.6	1.4	1.2	0.6	0.1
15		0.5			0.4

$$\frac{\Sigma\ 10\text{-}14}{\Sigma\ 9\text{-}13} = \frac{49.8}{75.4} = \frac{33.9}{91.1} = \frac{52.9}{82.7} = \frac{73.5}{122.6}$$

$$Z = 0.41 = 0.99 = 0.45 = 0.51$$

Average $Z = 0.59$

Table 3. Summary of weight at age and partial recruitment rates as derived from fishing mortality values generated from cohort analysis.

Age	Weight (kg-round)	Partial Recruitment
6	0.91	0.04
7	1.32	0.20
8	1.61	0.64
9	1.94	1.00
10	2.14	1.00
11	2.27	1.00
12	2.57	1.00
13	2.81	1.00
14	2.62	1.00

Table 4. Partial recruitment values derived from comparisons of percent at age in the commercial catch from Tikkoatokak Bay with percent at age from the Fraser River counting fence.

Age	Percent at age: Tikkoatokak (A) 1980-81	Percent at age: Fraser River (B) 1975-79	Ratio A/B	Partial Recruitment
6	0.2	.2	0.02	0.01
7	2.6	23.9	0.11	0.05
8	23.9	27.8	0.86	0.36
9	40.0	17.7	2.26	0.95
10	23.2	9.7	2.39	1.00
11	7.8	5.1	1.53	1.00
12	1.2	5.1	0.24	1.00
13	0.8	0.6	1.33	1.00
14	0.3	0.9	0.33	1.00

Table 5. Regressions of average F (ages 9-14) on effort.

Year	Effort (man-weeks)	F_T[1] 0.40	F_T[1] 0.50	F_T[1] 0.60	F_T[2] 0.40	F_T[2] 0.50	F_T[2] 0.60
1977	94	0.420	0.424	0.427	0.374	0.378	0.381
1978	147	0.891	0.909	0.922	1.078	1.101	1.118
1979	108	0.475	0.505	0.526	0.649	0.673	0.691
1980	130	0.575	0.659	0.730	0.821	0.926	1.013
1981	80	0.400	0.500	0.600	0.400	0.500	0.600
r^2 (1977-80)		0.87	0.96	0.99	0.97	0.98	0.95
r^2 (1977-81)		0.83	0.80	0.66	0.95	0.89	0.81

[1]Using partial recruitment rates derived from cohort analysis.

[2]Using partial recruitment rates derived from counting fence comparisons with commercial catch data.

Table 6. Projection to 1982 from cohort analyses run at (A) F=0.4, (B) F=0.5, and (C) F=0.6 with partial recruitment values generated from cohort analyses and $F_{0.1}$=0.425.

A.

	POPULATION NUMBERS		CATCH NUMBERS		CATCH BIOMASS	
	1981	1982	1981	1982	1981	1982
6	7428	43813	67	670	61	609
7	7481	6021	522	445	689	588
8	13675	5654	2850	1226	4589	1974
9	22521	8633	6774	2728	13142	5293
10	14478	12360	4355	3906	9320	8359
11	4279	7946	1287	2511	2921	5700
12	568	2348	171	742	439	1907
13	213	312	64	98	180	277
14	57	117	38	37	100	97
6+	70700	87203	16128	12363	31440	24803
7+	63272	43390	16061	11694	31379	24194
8+	55791	37369	15539	11249	30690	23606
9+	42116	31715	12689	10023	26102	21632

B.

	POPULATION NUMBERS		CATCH NUMBERS		CATCH BIOMASS	
	1981	1982	1981	1982	1981	1982
6	3732	38649	67	591	61	537
7	6042	2995	522	222	689	292
8	11422	4476	2850	970	4589	1562
9	18839	6791	6774	2146	13142	4163
10	12114	9355	4355	2956	9320	6327
11	3579	6016	1287	1901	2921	4316
12	476	1777	171	562	439	1443
13	178	237	64	75	180	210
14	53	88	38	28	100	73
6+	56435	70385	16128	9451	31440	18925
7+	52703	31736	16061	8860	31379	18388
8+	46661	28741	15539	8639	30690	18095
9+	35239	24265	12689	7668	26102	16533

C.

	POPULATION NUMBERS		CATCH NUMBERS		CATCH BIOMASS	
	1981	1982	1981	1982	1981	1982
6	3732	35142	67	537	61	489
7	5083	2995	522	222	689	292
8	9884	3691	2850	800	4589	1288
9	16402	5534	6774	1749	13142	3393
10	10545	7370	4355	2329	9320	4984
11	3116	4738	1287	1497	2921	3399
12	414	1400	171	442	439	1137
13	155	186	64	59	180	165
14	51	70	38	22	100	58
6+	49382	61126	16128	7657	31440	15206
7+	45650	25984	16061	7120	31379	14717
8+	40567	22989	15539	6899	30690	14425
9+	30683	19298	12689	6099	26102	13136

Table 7. Projection to 1982 from cohort analyses run at (A) F=0.4, (B) F=0.5, and (C) F=0.6 with partial recruitment values generated from comparisons of commercial catches with counting fence data

A.

POPULATION NUMBERS

	1981	1982
6	18517	53062
7	29076	15100
8	24014	23334
9	23493	17092
10	14478	13154
11	4279	7946
12	568	2348
13	213	312
14	57	117
6+	114695	132465
7+	96178	79403
8+	67102	64303
9+	43088	40969

CATCH NUMBERS

	1981	1982
6	67	224
7	522	315
8	2850	3275
9	6774	5582
10	4355	4475
11	1287	2703
12	171	799
13	64	106
14	38	40
6+	16128	17520
7+	16061	17296
8+	15539	16981
9+	12689	13705

CATCH BIOMASS

	1981	1982
6	61	203
7	689	416
8	4589	5273
9	13142	10829
10	9320	9577
11	2921	6136
12	439	2053
13	180	298
14	100	104
6+	31440	34891
7+	31379	34688
8+	30690	34272
9+	26102	28998

B.

POPULATION NUMBERS

	1981	1982
6	7428	45833
7	19478	6021
8	19032	15476
9	19450	13015
10	12111	9854
11	3579	6014
12	476	1777
13	178	237
14	53	88
6+	81785	98315
7+	74357	52482
8+	54879	46461
9+	35847	30985

CATCH NUMBERS

	1981	1982
6	67	193
7	522	126
8	2850	2172
9	6774	4251
10	4355	3352
11	1287	2046
12	171	605
13	64	80
14	38	30
6+	16128	12856
7+	16061	12662
8+	15539	12537
9+	12689	10364

CATCH BIOMASS

	1981	1982
6	61	176
7	689	166
8	4589	3498
9	13142	8246
10	9320	7174
11	2921	4645
12	439	1554
13	180	226
14	100	79
6+	31440	25763
7+	31379	25587
8+	30690	25421
9+	26102	21924

C.

POPULATION NUMBERS

	1981	1982
6	7428	41179
7	19478	6021
8	15865	15476
9	17041	10424
10	10545	7890
11	3116	4738
12	414	1400
13	155	186
14	51	70
6+	74093	87384
7+	66665	46205
8+	47187	40184
9+	31322	24708

CATCH BIOMASS

	1981	1982
6	61	158
7	689	166
8	4589	3498
9	13142	6604
10	9320	5745
11	2921	3659
12	439	1224
13	180	178
14	100	62
6+	31440	21294
7+	31379	21136
8+	30690	20970
9+	26102	17473

CATCH NUMBERS

	1981	1982
6	67	174
7	522	126
8	2850	2172
9	6774	3404
10	4355	2684
11	1287	1612
12	171	476
13	64	63
14	38	24
6+	16128	10736
7+	16061	10562
8+	15539	10437
9+	12689	8264

Table 8. Mean length (cm) and weight (kg) by week of upstream migrant Arctic charr in the Fraser River, Labrador, 1975-1979.

Date	Fork Length										Whole Weight									
	1975		1976		1977		1979		1975-1979		1975		1976		1977		1979		1975-1979	
	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean
July 15-21			24	52.9			15	49.4	39	51.6			24	2.41			15	1.30	39	1.98
22-28	143	51.8					121	50.3	264	51.1							121	1.45	121	1.45
29-4	361	49.7	226	48.9	66	46.3	429	47.1	1082	48.3	420	1.95	226	2.01	64	1.65	157	1.38	867	1.84
Aug. 5-11	1030	47.9	426	47.1	444	46.5	773	46.7	2673	47.2	1029	1.58	426	1.80	444	1.41	502	1.29	2401	1.53
12-18	318	44.9	199	43.2	587	44.9	712	45.4	1816	44.9	314	1.36	198	1.40	489	1.29	603	1.30	1604	1.32
19-25	541	45.1	513	44.2	165	42.1	756	42.1	1975	43.5	537	1.31	513	1.56	165	1.06	733	1.08	1948	1.27
26-1	290	42.7	253	42.9	357	44.2	537	41.2	1437	42.5	289	1.07	253	1.44	357	1.26	520	1.06	1419	1.18
Sept. 2-8	264	34.5			39	41.0			303	35.3	206	0.78			39	0.84			245	0.79
9-15					18	40.9			18	40.9					18	0.84			18	0.84
16-22					231	41.9			231	41.9					231	0.87			231	0.87
Total	2947	45.8	1641	45.4	1907	44.5	3343	44.7	9838	45.1	2795	1.45	1640	1.66	1807	1.24	2651	1.20	8893	1.37

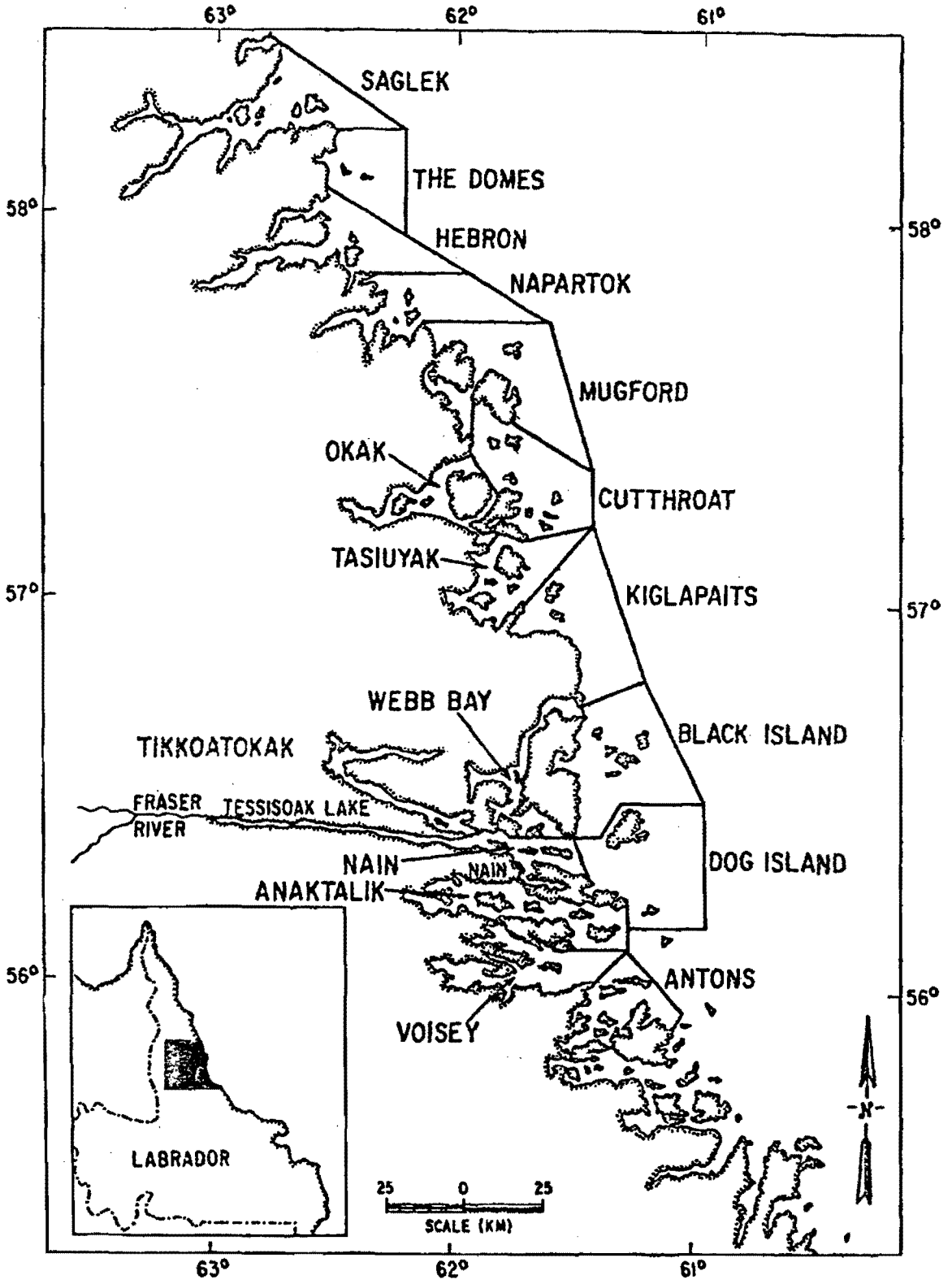

Fig. 1. Coastal breakdown of Nain commercial fishing areas.

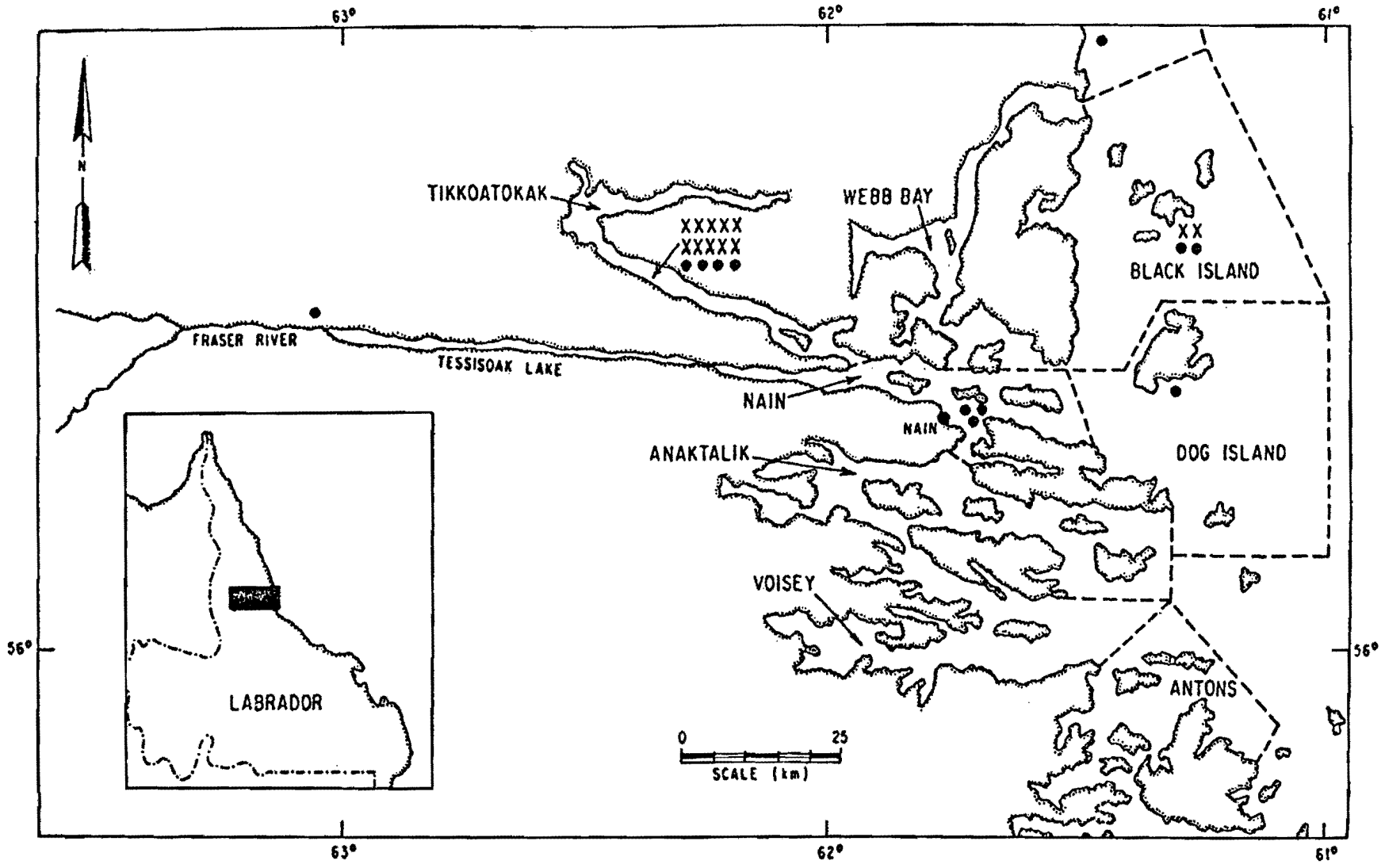

Fig. 2. Recaptures of Arctic charr tagged in Tikkoatokak Bay during 1979 and 1980. Each (X) represents five tag recaptures and each (●) corresponds to one tag return.

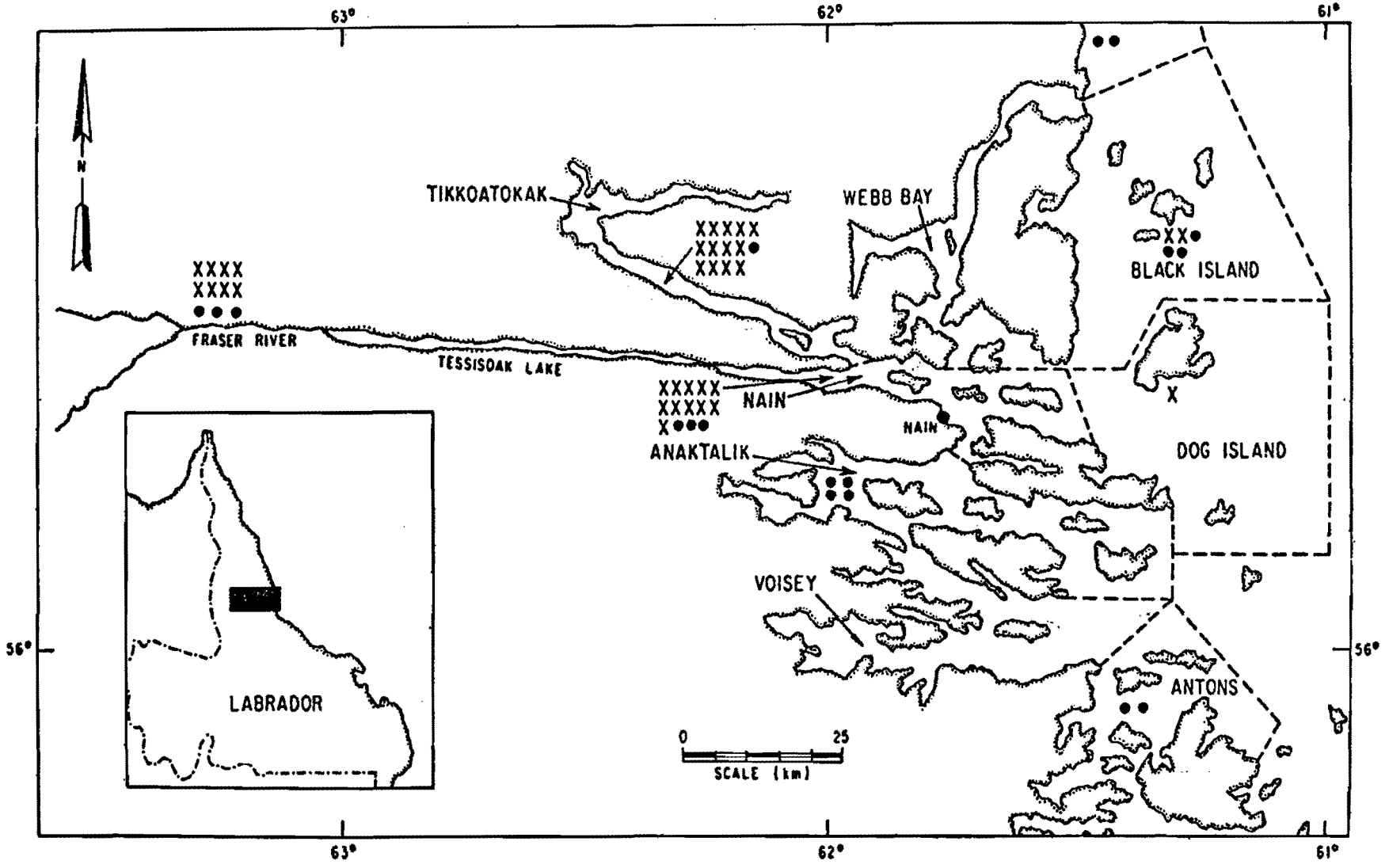

Fig. 3. Recaptures of Arctic charr tagged at the Fraser River from 1975-1979. Each (X) represents five tag recaptures and each (●) corresponds to one tag return.

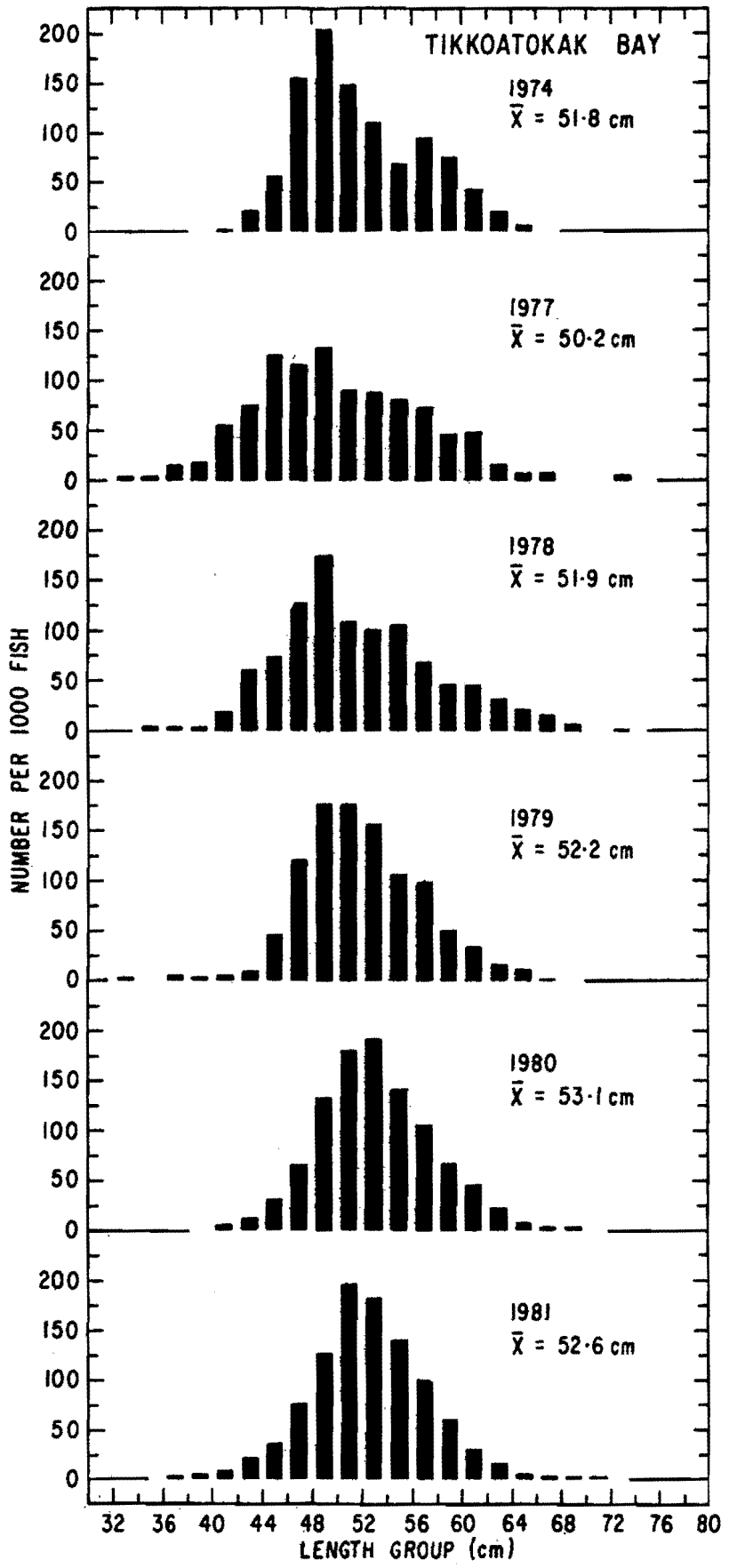

Fig. 4. Length-frequency distribution of Arctic charr landings from Tikkoatokak Bay, 1974-1981.

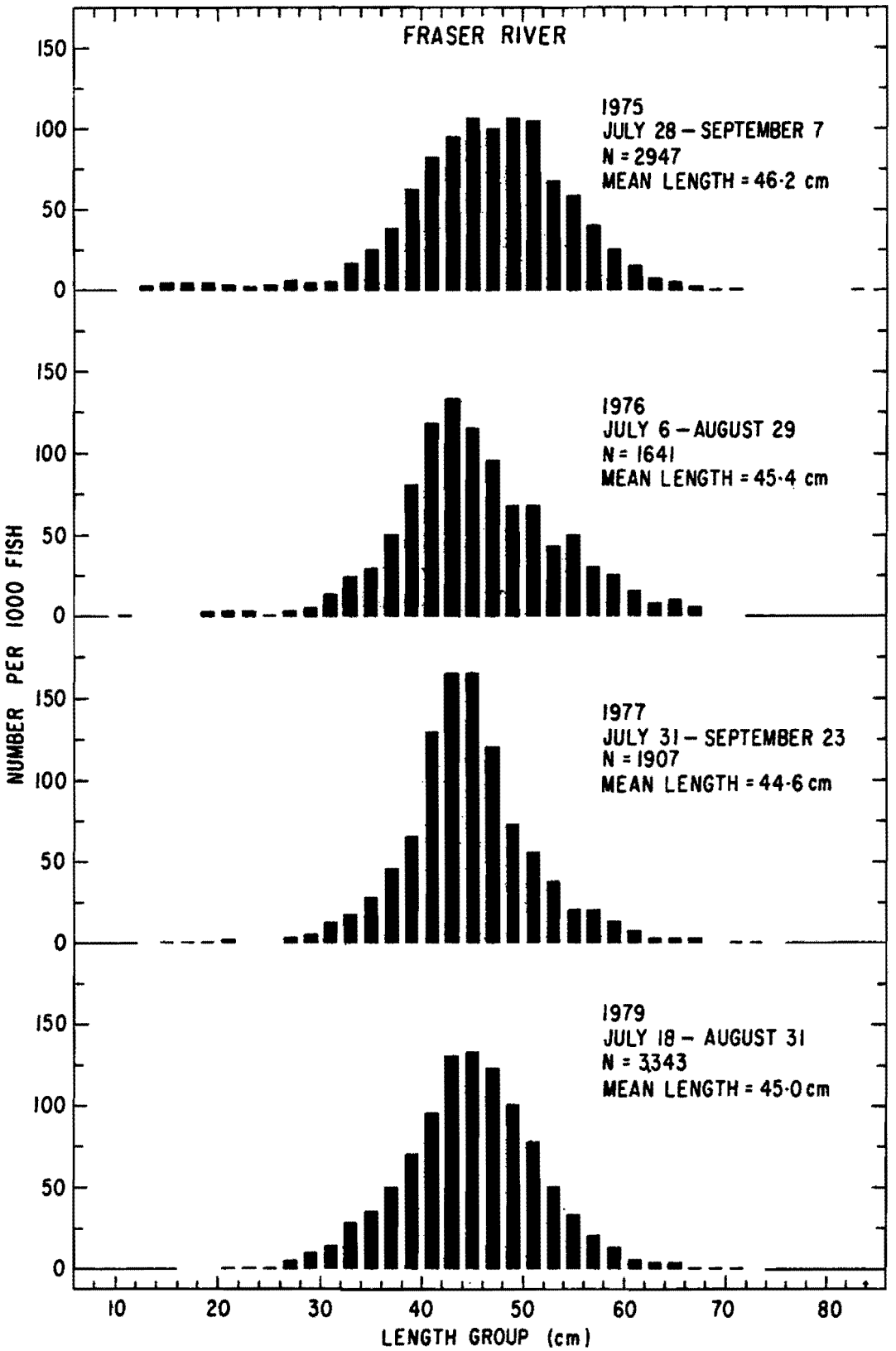

Fig. 5. Length-frequency distribution of upstream migrant Fraser River Arctic charr, 1975-1979. Number (N) refers to number sampled for length.

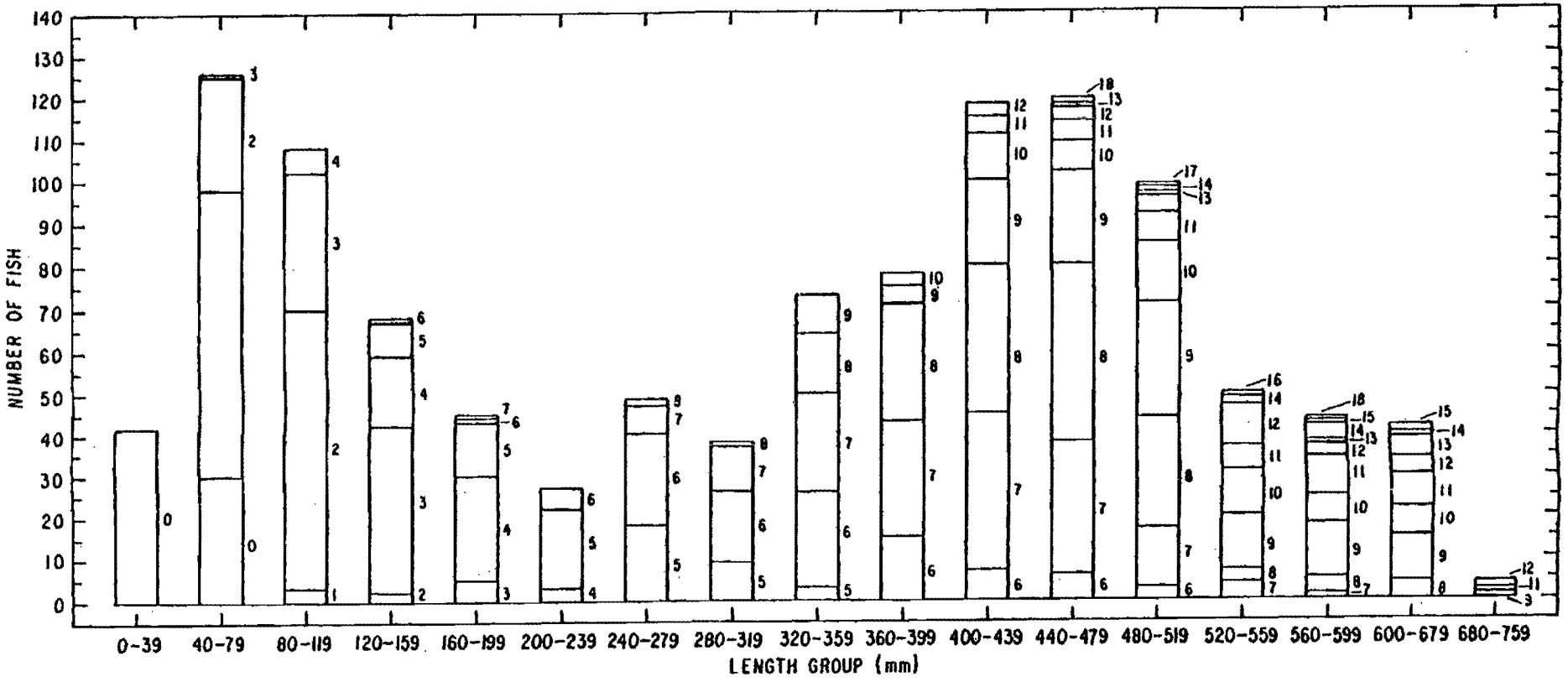

Fig. 6 Distribution of age at length in Fraser River Arctic charr, 1975-1979.