Canadian Atlantic Fisheries
Scientific Advisory Committee

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CAFSAC Research Document 89/37

CSCPCA Document de recherche 89/37

Assessment of the Nain Stock Unit Arctic Charr Population in 1988

by

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Abstract

Reported landings of Arctic charr from the Nain assessment unit totaled 38 t in 1988, about 81% of the total allowable catch. This catch represented 52% of the total catch of Arctic charr from the Nain Fishing Region in 1988. Landings were 17% lower than in 1987, although effort was 15% higher than in the previous year. Trends in the length-frequency distributions and mean weights at age over time suggest that a selective removal of a particular stock component, characterized by large fish, may have occurred as a result of commercial exploitation similar to that observed in other stock units. Simulated length-frequency distributions were constructed to illustrate the effects of recruitment failure on the subsequent size characteristics of the exploited stock. Owing to the need to evaluate the appropriateness of the multiplicative model to standardize catch rates for inshore and offshore fishing areas of the Nain unit, calibration of sequential population analyses and the provision of new advice were deferred.

Résumé

Les débarquements déclarés d'omble chevalier provenant de l'unité d'évaluation de la baie Nain ont atteint 38 t en 1988, soit environ 81 % du total des prises admissibles et 52 % des prises totales d'omble chevalier dans la région de pêche de la baie Nain en 1988. Les débarquements étaient inférieurs de 17 % à ceux de 1987, quoique l'effort ait été supérieur de 15 % à celui de l'année antérieure. Les tendances dans la distribution des longueurs et les poids moyens selon l'âge donnent à entendre qu'une exploitation commerciale comparable à celle que l'on a observée dans les autres unités de stock a pu aboutir à un retrait sélectif d'une partie donnée du stock, en l'occurrence des gros poissons. On a simulé des distributions de longueur pour illustrer les effets de l'absence de recrutement sur les caractéristiques de taille subéquentes du stock exploité. Etant donné qu'il est nécessaire d'évaluer la justesse du modèle multiplicatif utilisé pour normaliser les taux de prises dans les secteurs de pêche côtière et hauturière de la baie Nain, on a remis à plus tard l'étalonnage des analyses séquentielles de population et la formulation de nouveaux avis.

1. Introduction

The Nain stock unit (Fig. 1) consists of an inshore zone made up of Anaktalik Bay, Nain Bay, Tikkoatokak Bay, and Webb Bay subareas, and an offshore island zone consisting of the Dog Island and Black Island subareas (Dempson and Kristofferson 1987). It was first assessed as a single unit in 1985 (Dempson and LeDrew 1986). Prior to this, individual assessments were conducted separately on Arctic charr populations from Nain-Tikkoatokak Bay and Anaktalik Bay. Annual landings from the Nain unit have ranged from 34 to 76 t (mean = 53 t, 1974-88) and from 1977 to 1988 have represented 38% of the commercial production from the Nain Fishing Region. In 1988, 52% of the commercial catch came from the Nain stock unit. The recommended total allowable catch (TAC) for 1988 was 47 t. This was partially divided into specific inshore quotas of: Anaktalik Bay - 5.2 t; Nain-Tikkoatokak Bay - 15.5 t; Webb Bay - 8.4 t.

This paper summarizes results of the 1988 fishery and provides a graphical summary of the length distributions of commercial catches from both inshore and offshore zones since 1980 and 1982 respectively. No reference level catches were projected for 1989 pending a review of the appropriateness of deriving a standardized catch rate series.

2. Trends in catch and effort data

Catch and effort data for the Nain stock unit are summarized in Table 1 for 1974-88. The highest catch of 76 t occurred in 1977, the lowest catch of 34 t was in 1975. The TAC listed in Table 1 for 1979-83 applied only to the specific subareas of Anaktalik Bay and Nain-Tikkoatokak Bay. In 1984 and 1985, an offshore component was included in the TAC. The quota area catch in Table 1 summarizes landings for those subareas specifically under quota restrictions only, prior to the derivation of the assessment units in 1986. In 1986, 1987, and 1988, the TAC applies to the entire stock unit.

Landings in 1988 totaled 38 t, about 81% of the TAC but 17% below the 1987 catch. Effort was up by 15% over the previous year, but catch per unit effort (CUE) decreased by 27% and was similar to levels recorded from 1983 to 1985. Effort in general has dropped by approximately 34% from the average levels recorded in 1978-80.

Again in 1988, over 60% of the catch from the Nain stock unit occurred in the offshore zone, continuing the trend previously observed for increased catch and abundance (CUE) of charr in this zone. A summary of the mean dates of catches, following the method of Mundy (1982), are listed in Table 2. Based on either catch or catch per unit effort, the mean dates in 1988 were late in comparison with earlier years, but comparable to recent trends. It was previously shown that years with earlier timing statistics generally coincided with higher landings of Arctic charr (Dempson 1988). Recall that during the operation of the Fraser River and Ikarut River fish counting fences, upstream migrants could begin entering the river as early as the second week of July. Larger charr have a tendency to enter the river first (Dempson and Kristofferson 1987). Differences in the catch and abundance (CUE) of fish in specific subareas probably reflect a combined influence of changes in the distribution of fishing effort, variable movement patterns of fish, variability in the time and duration of fishing effort, as well as actual changes in stock abundance.

3. <u>Size distribution of commercial landings</u>

Figures 2, 3 and 4 illustrate the length-frequency distributions of commercial catches from the inshore and offshore zones, as well as combined, for the Nain stock unit. Last year (Dempson 1988) it was shown that there were significant differences in the size distributions over time, with a trend to a smaller mean and modal size of fish in the catch. It was also noted that there were differences between zones, as well as a tendency for the mean length of the catch to decrease as the fishing season progressed (Table 3). As discussed in previous assessments (Dempson and LeDrew 1987), there has also been a decrease in the mean weight of fish over time as summarized for specific time periods in Table 4. Previous studies (Kristofferson and Sopuck 1983; Boivin 1987) have suggested that intensively harvested Arctic charr stocks are characterized by decreases in the size and age structure of the population, as well as a decline in the catch per unit of effort, characteristics commonly associated with fish stocks in general (Laevastu and Favorite 1988).

In an attempt to rationalize the extent to which changes in the length-frequency distribution of the commercial catch in northern Labrador may be observed from the effects of commercial exploitation, a series of simulated distributions were compiled. The 1987 catch and population numbers from the Nain stock unit were used to initialize the series. Length-frequency distributions at each age were generated from the Nain stock unit commercial sampling data from 1977 to 1987 and applied to the simulated catch-at-age data. Recruitment estimates for the simulations were randomly selected and ranged from 40 to 70 thousand fish. Similarly, fishing mortality was also randomly generated from series between 0.38 to 0.70 (within the range observed for the Nain stock unit). Because stock and recruitment relationships have not been identified for this population, the effects of a 'catastrophic' event were essentially examined. That is, in the fourth year of the simulation (year 1 for graphical illustrations), recruitment was set at only 500 fish. This was carried out for one through five consecutive years with virtually no recruitment. The simulations were run for a total of 20 years. Figures 5 to 9 illustrate the length-frequency distributions of the resulting catches for a nine-year period following the simulated recruitment failure. The same random recruitment and fishing mortality values were used in each simulation. Thus only the number of years of recruitment failure changed.

As illustrated in the figures, almost complete recruitment failure for several successive years is needed to observe substantial changes in the length-frequency distribution of the catches. This is because of the large amount of overlap in size at age in these charr populations and the selectivity of the gillnet fishery. With only two years of recruitment failure, the modal size changes little, although there is a noticeable change in the overall distribution. Other nonselective stock abundance indices, such as results from fish counting fence operations, should provide a more appropriate means to monitor stock conditions and changes in the biological characteristics of the exploited populations. Table 5 summarizes the change in mean length, weight, and age from these simulations, along with the total catch biomass. The latter changes dramatically, as expected, and while changes in mean age are more apparent than, say, length or weight, almost complete recruitment failure for a series of years is required in order for this to be clear. Initially, with several successive years of recruitment failure, mean size (length and weight) and age increase as the subsequent catch is based on the existing older age-classes in the population rather than on new recruits. Mean size and age then decrease as the catch is then targeted on younger age-classes while the weak older age-classes work through the fishery.

The exercise illustrates that in this type of fishery substantial changes in the size (length-frequency) distribution similar to that observed in the Arctic charr fishery in the Sylvia Grinnell River (Kristofferson and Sopuck 1983) and, to a lesser degree, age composition probably, would not be expected to occur as a result of high exploitation unless it resulted in severe recruitment overfishing for a number of successive years. Major changes in total catch will occur, as observed in the Nain Fishing Region, but an index of effort is required to determine if catch has declined solely because of a reduction in effort as opposed to a decrease in total stock biomass. However, the small but progressive reduction observed in the modal size of fish caught in the Nain Stock Unit fishery suggest that high exploitation has selectively removed the larger fish from the population. The observed effects on the total population are masked to a degree by the selective gillnet fishery.

4.1 CHARACTERISTICS OF THE 1988 FISHERY

Catch at age data are available since 1977 and are summarized in Table 6. Catch at age data, along with the estimated standard error and coefficient of variation for 1988 data, are shown in Table 7. Those ages that contribute to the majority of the catch (ages 7 - 10, 87.7% of the total) appear to be estimated reasonably with the coefficient of variation less than 7.5%. Data were derived from annual commercial sampling programs carried out at the Nain fish plant. Mean age increased from 8.46 years to 9.8 years from 1977 to 1982 and has declined since then to 8.65 years in 1988. In 1988, three year-classes, represented by 7-, 8-, and 9-year old fish, made up 73% of the catch. A summary of the percent at age in the catch is provided in Table 8. The 1980 year-class (year of hatching), represented by age 7 fish in 1987, was strongly represented by 8-year-olds in 1988.

Weights at age were derived from commercial samples obtained from 1977 to 1988. Gutted head-on weights were converted to whole weight using the conversion factor 1.22 (Dempson 1984). For the yield-per-recruit analysis, mean weight at age for the period 1977-79 was used, similar to previous assessments.

An estimate of total mortality (Z) was calculated using the Paloheimo method (Ricker 1975), and the average value for the last four years was 0.63, although data varied considerably. An estimate of total mortality was also derived from a catch curve using catch per unit effort at age data from 1986 to 1988. This yield a Z of 0.61. Assuming a natural mortality rate of 0.2 suggests a rate of fishing mortality of about 0.41-0.43. No estimates of mortality from within-season tagging were available.

Yield per recruit was calculated by the method of Thompson and Bell (Rivard 1982) using partial recruitment rates and mean weight at age. $F_{0.1}$ was 0.40 at a yield per recruit of 0.89 kg.

4.2 Standardization of catch rates

A brief attempt was made at applying the multiplicative model (Gavaris 1980) to derive a standardized catch rate series for the Nain Stock Unit. As observed in 1986 (Dempson and LeDrew 1986), significant differences existed in catch rates between inshore and offshore island fishing zones, as well as a significant week effect. In recent years an increasing trend for higher charr landings in the offshore zone has been coincident with a later date in the mean catch. Given these variable influences, a further evaluation of the multiplicative model should be undertaken to evaluate the appropriateness of a modified standardized catch rate series. This would be particularly important for the Nain and Okak stock units where there are geographically distinct fishing zones located in inshore bays and offshore island subareas, and where sequential population analyses for all three stock units are calibrated using commercial catch rate indices. Thus calibration of sequential population analyses and the provision of new advice for 1989 were deferred.

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Table 1. Summary of catch and effort statistics for the Nain assessment unit, 1974-88. Total allowable catch (TAC) and landings are in kg round weight, effort is expressed as person-weeks fished. Refer to text for information on quotas and quota area catch.

	Inshore			Offshore				Total				
	Catch	Effort	CUE	Catch	Effort	CUE	% Catch offshore	Catch	Effort*	CUE	TAC	Quota area catch
1974	30,822			6,923			18.1	37,745				
1975	31,076			2,754			8.1	33,830				
1976	50,813	146	348	2,500	52	48	4.7	53,313	196	272		
1977	70,908	183	387	5,347	114	47	7.0	76,255	291	262		
1978	70,465	212	332	3,298	106	31	4.5	73,763	314	235		
1979	54,967	189	291	11,877	152	78	17.8	66,844	336	199	61,000	52,832
1980	52,328	183	286	22,727	215	106	30.3	75,055	390	192	61,000	50,176
1981	49,956	157	318	15,676	131	120	23.9	65,632	278	236	37,160	37,223
1982	43,108	119	362	12,509	117	107	22.2	55,617	235	237	43,660	39,119
1983	33,603	147	229	17,599	149	118	34.4	51,202	289	177	51,000	19,102
1984	24,558	131	187	14,342	128	112	36.9	38,900	244	159	43,200	29,063
1985	21,527	125	172	19,631	130	151	47.7	41,158	252	163	30,500	36,019
1986	16,347	91	180	20,748	101	205	55.9	37,095	185	201	43,000	
1987	17,840	71	251	28,032	135	208	61.1	45,872	200	229	47,000	
1988	14,535	90	162	23,759	149	159	62.1	38,295	229	167	47,000	

*Total effort should be equal to or less than the sum of the inshore and offshore effort.

Table 2. Mean date of catch for Arctic charr from the Nain stock unit as estimated from a migratory timing statistic based on catch and catch per unit effort data (CUE) with 95% confidence intervals (CI) for the grand mean from all years.

Year	Catch	CUE
1977	Jul 18	Jul 22
1978	Jul 13	Jul 17
1979	Jul 9	Jul 13
1980	Jul 23	Jul 25
1981	Jul 14	Jul 17
1982	Jul 19	Jul 19
1983	Jul 28	Jul 30
1984	Aug 1	Aug 5
1985	Aug 4	Aug 4
1986	Aug 6	Aug 4
1987	Aug 1	Jul 28
1988	Aug 5	Aug 1
1977-88	Jul 22 (Jul 11-Aug 2)	Jul 26 (Jul 14-Aug 7)

Table 3. Summary of mean length of Arctic charr catches by time period for inshore and offshore fishing zones of the Nain assessment unit.

	Fork length (cm)	
Time period	Inshore zone	Offshore zone
1 - Jun 15-Jul 14	53.4	53.4
2 - Jul 15-Jul 31	53.0	51.7
3 - Aug 1-Aug 15	51.1	50.8
4 - Aug 16-end	49.8	49.5

Table 4. Summary of weight (kg-round) at age data for various time periods, partial recruitment rates, and calculated $F_{0.1}$ for the Nain stock unit Arctic charr population.

Age	Weight 1977-79	1980-83	1984-86	1987-88	Partial recruitment
6	1.05	1.13	1.03	1.00	0.01
7	1.52	1.41	1.26	1.23	0.13
8	1.83	1.62	1.59	1.55	0.42
9	2.12	1.91	1.85	1.73	0.73
10	2.45	2.01	1.98	1.81	1.0
11	2.59	2.01	2.02	1.89	1.0
12	2.63	2.08	2.08	1.88	1.0
13	2.74	2.16	2.13	1.92	1.0
14	3.13	2.09	2.04	1.94	1.0
15	3.05	2.18	2.04	2.00	1.0
16	3.05	2.10	2.04	2.00	1.0
17	3.05	2.10	2.04	2.00	1.0

$F_{0.1}$ = 0.397 at a Y/R of 0.895 kg

Table 5. Summary of change in mean age, weight, length, and catch biomass resulting from various simulations with 1, 2, 3, or 5 consecutive years of recruitment failure. Year 0 refers to the initial base year.

	Type															
	1				2				3				5			
Year	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
0	9.1	1.6	51.6	48	9.1	1.6	51.6	48	9.1	1.6	51.6	48	9.1	1.6	51.6	48
1	9.3	1.7	52.2	46	9.3	1.7	52.2	46	9.3	1.7	52.2	46	9.3	1.7	52.2	46
2	9.5	1.7	52.7	33	9.6	1.7	52.8	33	9.6	1.7	52.8	33	9.6	1.7	52.8	33
3	9.7	1.7	52.8	48	10.1	1.8	53.6	44	10.1	1.8	53.7	44	10.1	1.8	53.7	44
4	9.4	1.7	51.9	36	10.1	1.7	52.7	25	10.8	1.8	54.0	22	10.9	1.8	54.3	22
5	9.1	1.7	51.7	28	9.2	1.6	51.1	18	10.1	1.7	51.6	11	11.8	1.9	54.4	8
6	9.1	1.6	51.8	31	8.8	1.6	51.1	24	8.7	1.5	50.2	15	11.8	1.8	53.4	4
7	9.0	1.6	51.8	35	8.8	1.6	51.5	31	8.5	1.6	50.8	24	8.7	1.4	48.8	6
8	9.0	1.6	51.8	31	8.9	1.6	51.7	30	8.7	1.6	51.4	27	8.0	1.5	49.4	12
9	9.2	1.7	52.1	34	9.1	1.7	52.0	33	9.0	1.7	51.9	31	8.4	1.6	51.0	21
10	9.3	1.7	52.4	35	9.3	1.7	52.3	35	9.2	1.7	52.2	34	8.8	1.6	51.9	28
11	9.4	1.7	52.2	41	9.3	1.7	52.2	40	9.3	1.7	52.2	40	9.0	1.7	52.0	36
12	9.2	1.7	51.9	34	9.2	1.7	51.9	34	9.2	1.7	51.9	34	9.0	1.6	51.7	32
13	9.1	1.7	51.9	55	9.1	1.7	51.9	55	9.1	1.7	51.8	55	9.0	1.6	51.8	54
14	9.1	1.7	52.1	50	9.1	1.7	52.1	50	9.1	1.7	52.1	50	9.1	1.7	52.0	50
15	9.3	1.7	52.3	31	9.3	1.7	52.3	31	9.3	1.7	52.3	31	9.2	1.7	52.2	31

Type refers to number of consecutive years of recruitment failure.
a - mean age in years
b - mean weight in kilograms
c - mean length in centimeters
d - catch biomass in tonnes

Table 6. Estimated catch at age of Arctic charr from the Main Stock Unit, 1977 - 1988.

CATCH AT AGE

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
6	2003	371	430	113	145	145	210	83	174	209	482	203
7	9250	6703	4306	1023	1557	641	1689	2009	2862	4128	5464	6299
8	12453	13122	11568	11930	6570	4425	4797	3850	7277	7712	6295	7178
9	7630	7984	9593	16725	15180	7746	6732	5692	4510	5861	7549	4697
10	5052	4406	4208	8541	9784	8624	5389	5085	3706	2856	4498	3615
11	2454	2367	2168	3543	3286	5020	5285	2362	2133	1287	2013	1635
12	988	1688	1573	946	673	2604	3378	1539	1324	627	1376	653
13	358	312	418	764	232	412	865	575	828	239	896	325
14	180	272	312	349	80	259	306	142	442	198	307	136
15	1	118	34	39	57	47	1	29	214	203	358	52
16	1	97	14	2	10	17	1	1	30	51	181	20
17	1	1	1	16	1	25	15	1	41	1	100	41
6+	40371	37441	34625	43991	37575	29965	28668	21368	23541	23372	29519	24854
7+	38368	37070	34195	43878	37430	29820	28458	21285	23367	23163	29037	24651

Table 7. Summary of catch-at-age data for the Nain stock unit in 1988 with standard error and coefficient of variation (C.V.).

Age	Catch at age	Standard error	C.V. (%)
6	203	49.5	24.4
7	6299	312.0	5.0
8	7178	336.4	4.7
9	4697	282.9	6.0
10	3615	256.2	7.1
11	1635	175.4	10.4
12	653	114.3	17.5
13	325	80.6	24.8
14	136	54.0	39.7
15	52	30.8	59.1
16	20	20.2	100.8
17	41	28.4	69.4

Table 8. Summary of the percent at age in the catch of Arctic charr from the Nain Stock Unit, 1977 - 1988.

SUMMARY OF PERCENT AT AGE FOR THE NAIN STOCK UNIT

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
6	5.0	1.0	1.2	0.3	0.4	0.5	0.7	0.4	0.7	0.9	1.6	0.8
7	22.9	17.9	12.4	2.3	4.1	2.1	5.9	9.4	12.2	17.7	18.5	25.3
8	30.8	35.0	33.4	27.1	17.5	14.8	16.7	18.0	30.9	33.0	21.3	28.9
9	18.9	21.3	27.7	38.0	40.4	25.9	23.5	26.6	19.2	25.1	25.6	18.9
10	12.5	11.8	12.2	19.4	26.0	28.8	18.8	23.8	15.7	12.2	15.2	14.5
11	6.1	6.3	6.3	8.1	8.7	16.8	18.4	11.1	9.1	5.5	6.8	6.6
12	2.4	4.5	4.5	2.2	1.8	8.7	11.8	7.2	5.6	2.7	4.7	2.6
13	0.9	0.8	1.2	1.7	0.6	1.4	3.0	2.7	3.5	1.0	3.0	1.3
14	0.4	0.7	0.9	0.8	0.2	0.9	1.1	0.7	1.9	0.8	1.0	0.5
15	0.0	0.3	0.1	0.1	0.2	0.2	0.0	0.1	0.9	0.9	1.2	0.2
16	0.0	0.3	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.2	0.6	0.1
17	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.2	0.0	0.3	0.2

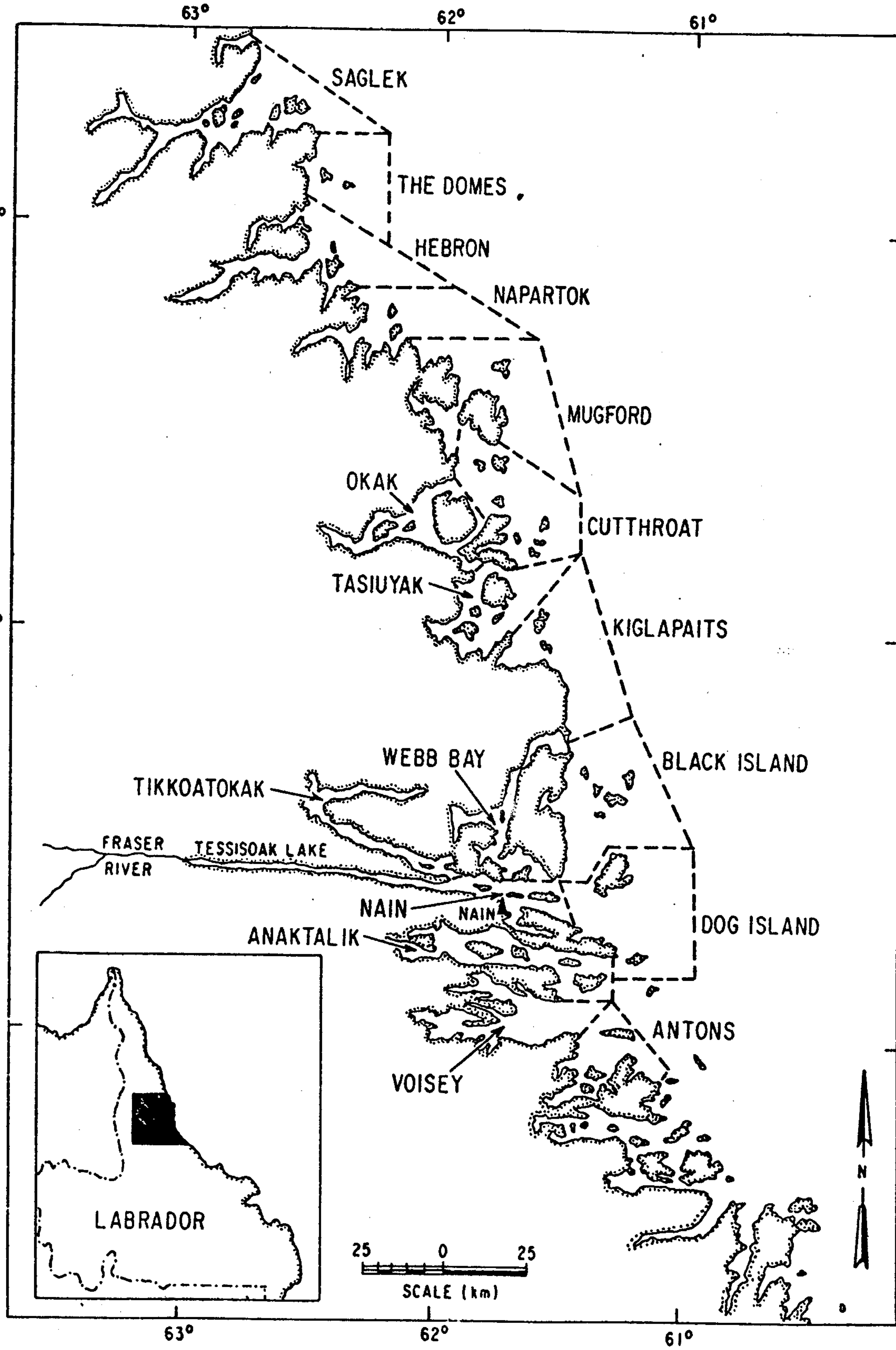

Figure 1. Geographical separation of the Nain Fishing Region subareas.

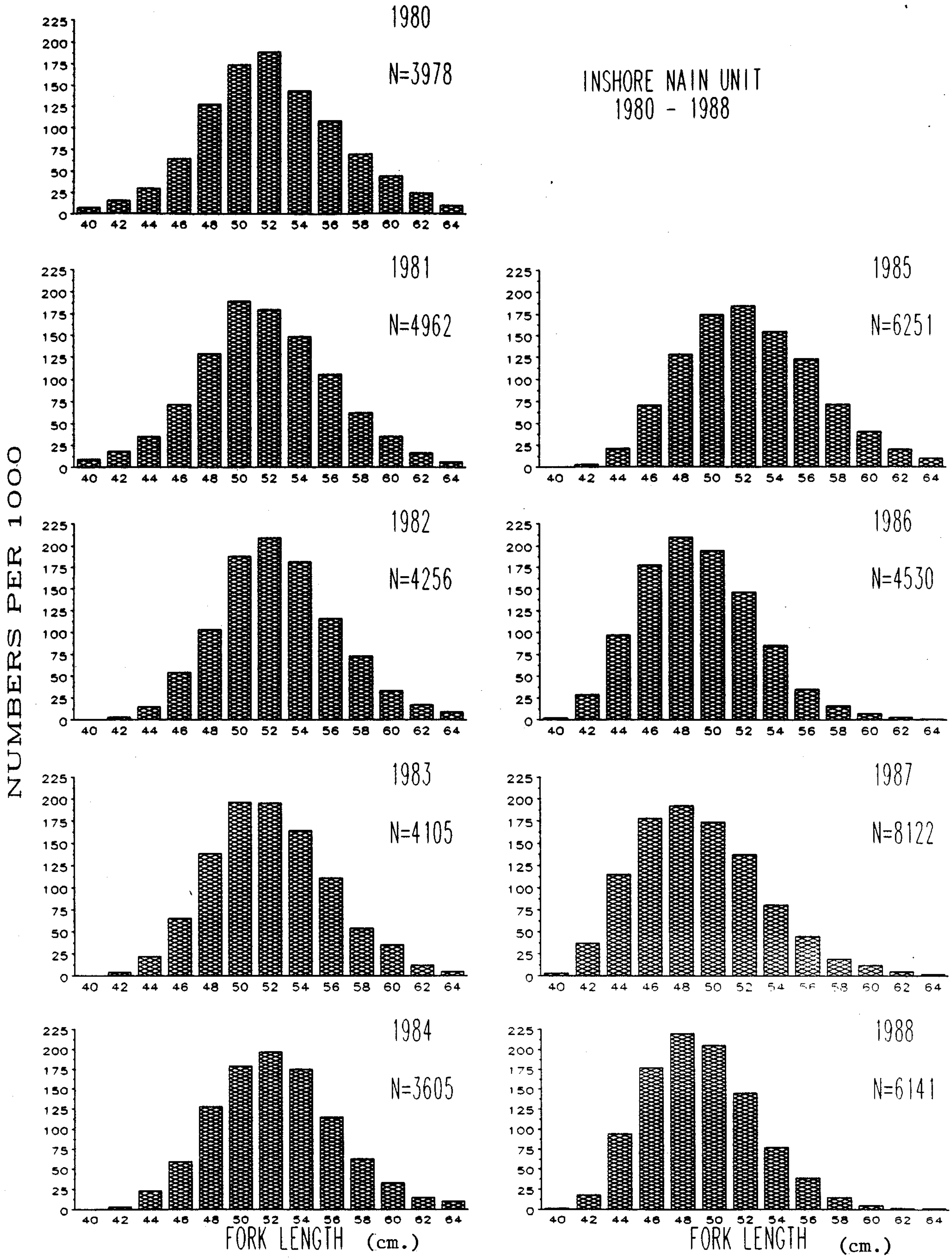

Fig. 2. Length-frequency distributions of Arctic charr catches from the inshore component of the Nain Stock Unit, 1980 - 1988.

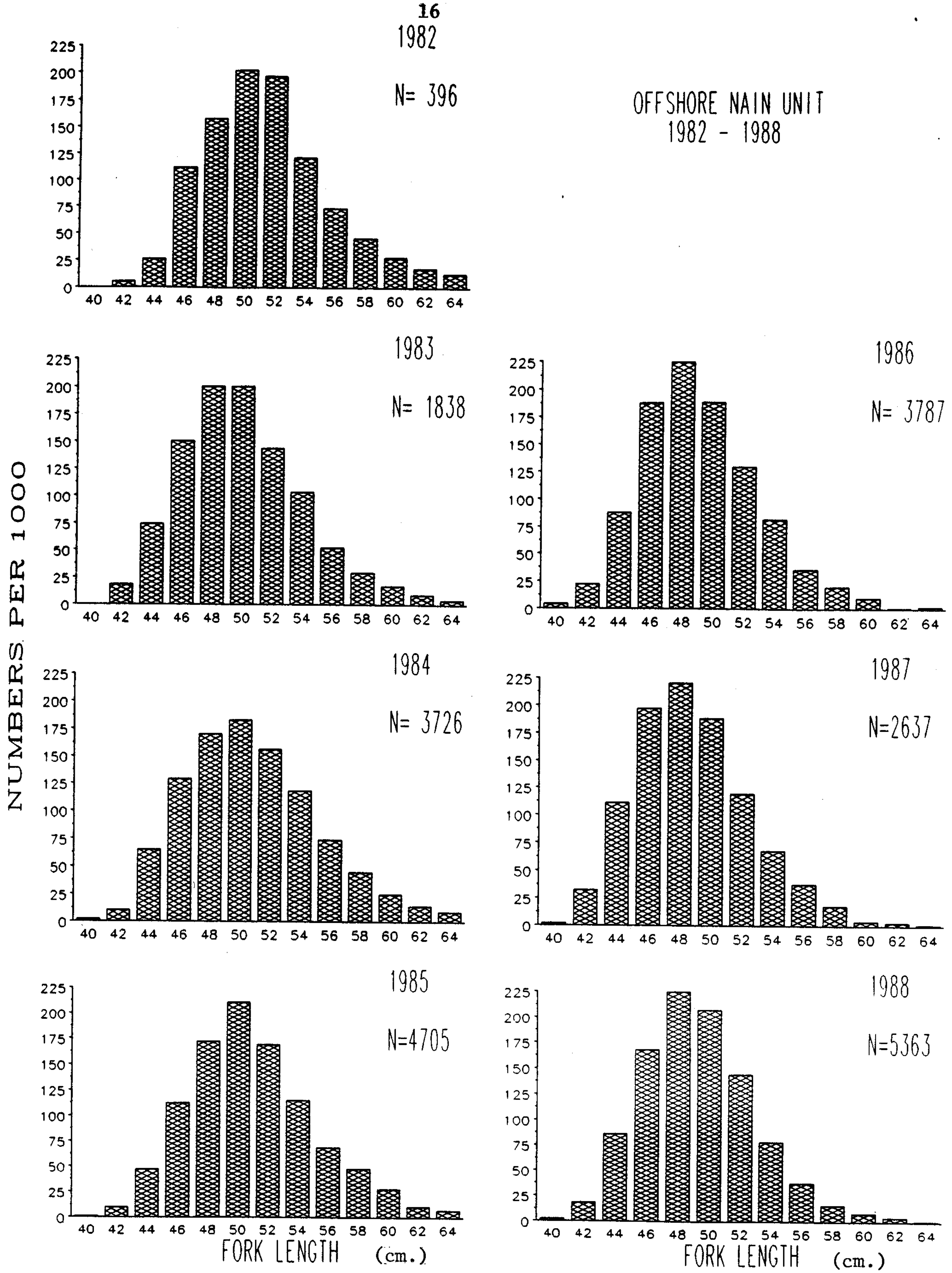

Fig. 3. Length-frequency distributions of Arctic charr catches from the offshore component of the Nain Stock Unit, 1982 - 1988.

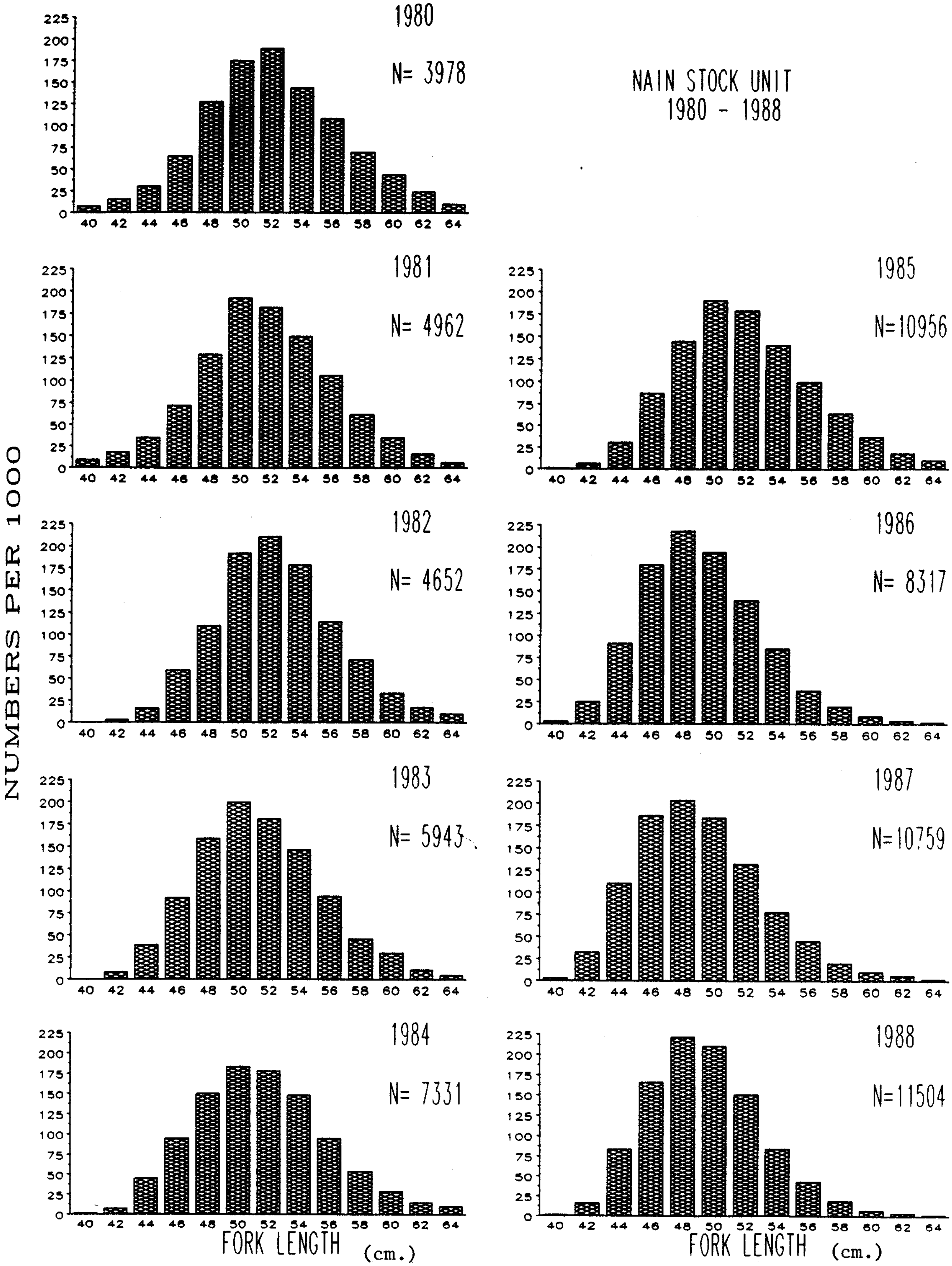

Fig. 4 Length-frequency distributions of the catch of Arctic charr from the Nain Stock Unit, 1980 - 1988.

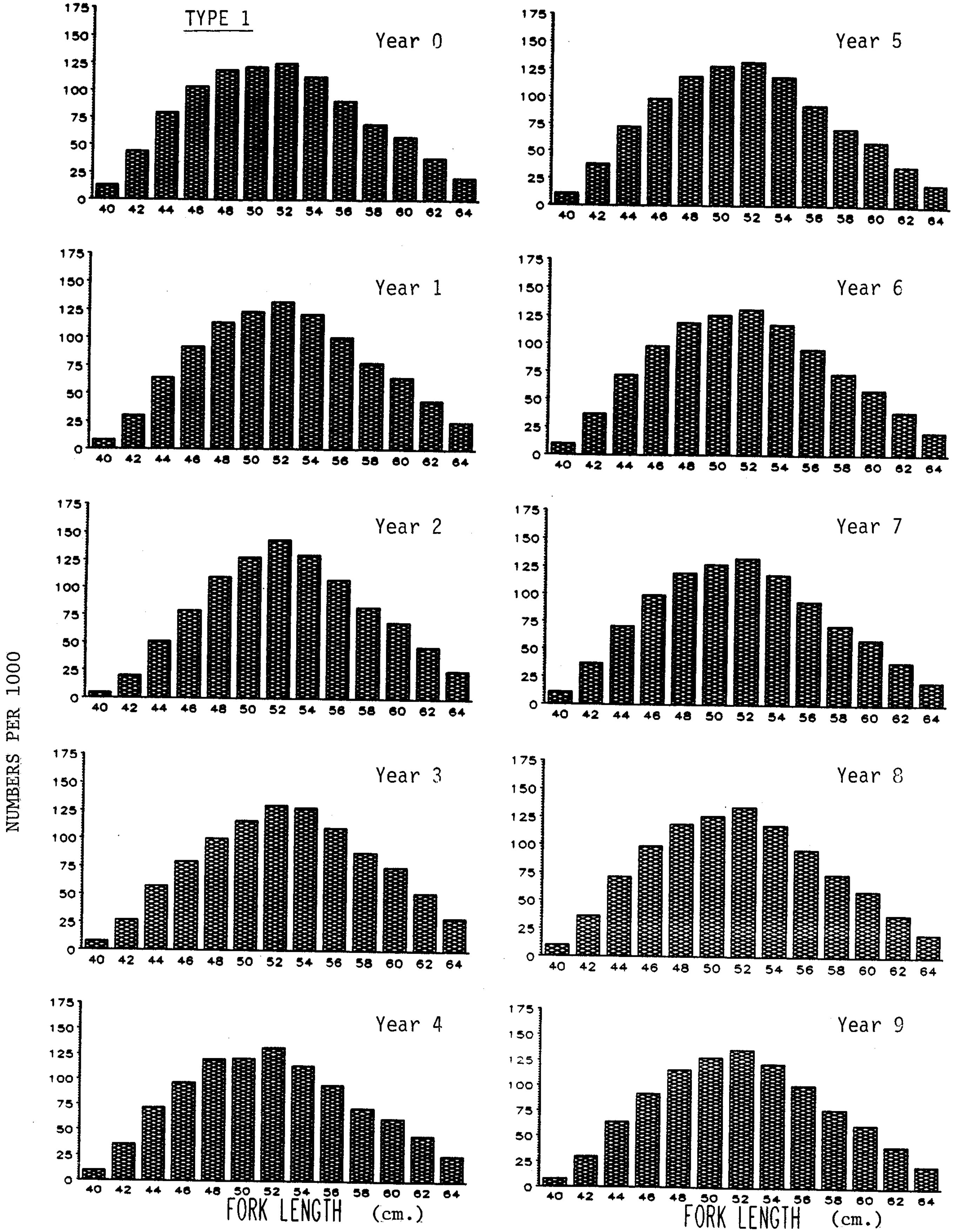

Fig. 5. Length-frequency distributions of simulated catches of Arctic charr where recruitment failure occurs in year 1 (type 1). Year 0 refers to the initial base year.

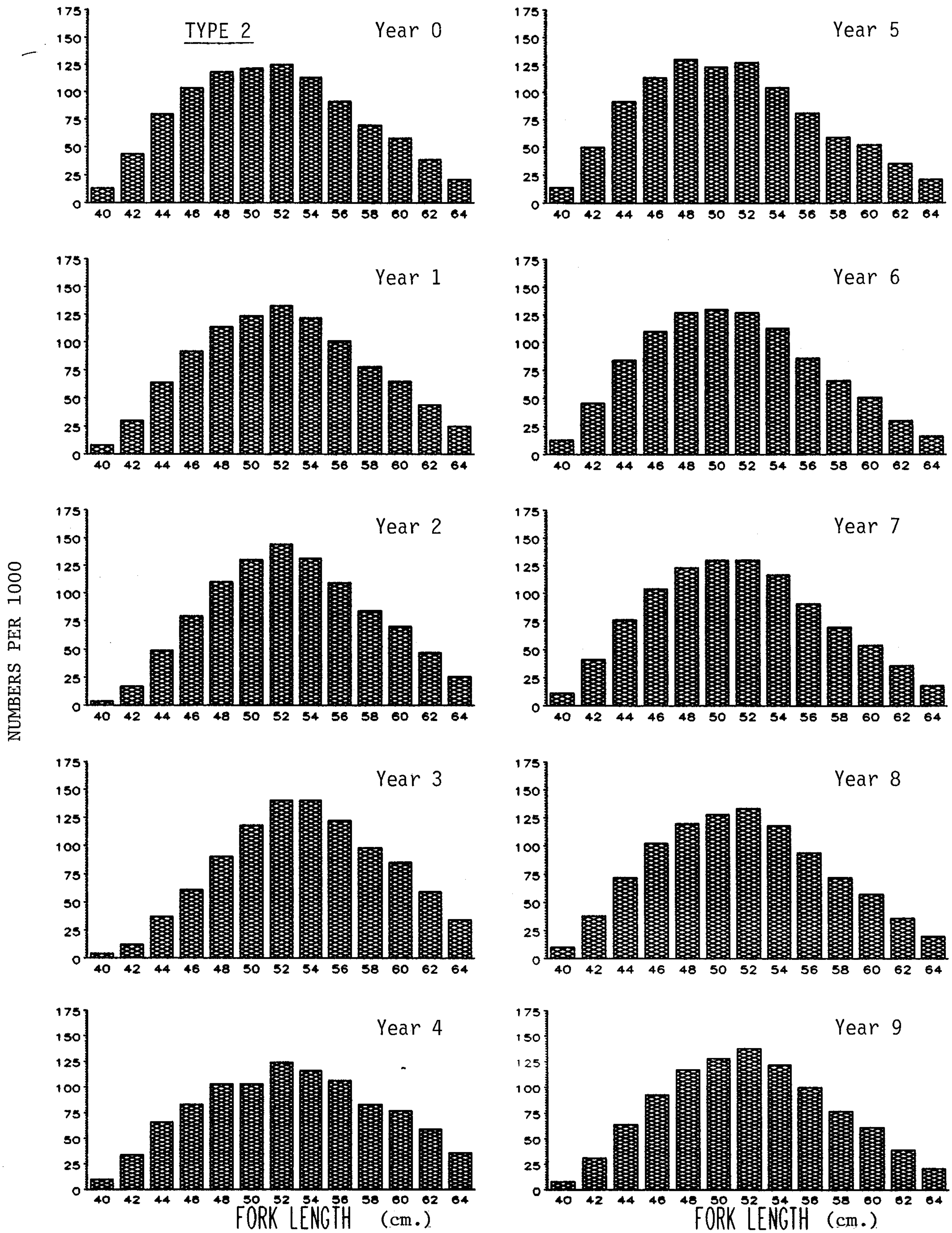

Fig. 6. Length-frequency distributions of simulated catches of Arctic charr where recruitment failure occurs in year 1 and 2 (type 2). Year 0 refers to the initial base year.

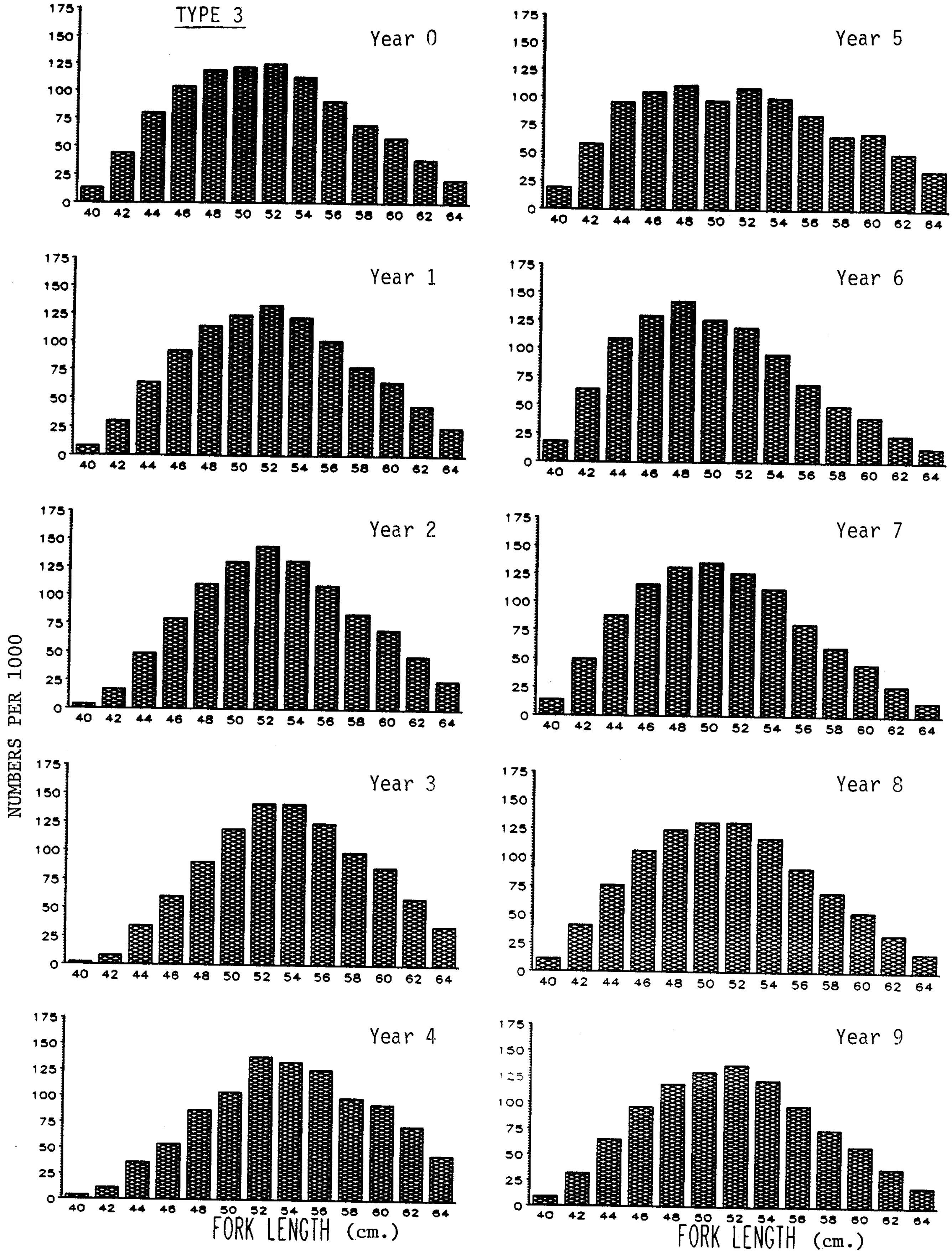

Fig. 7. Length-frequency distributions of simulated catches of Arctic charr where recruitment failure occurs in years 1-3 (type 3). Year 0 refers to the initial base year.

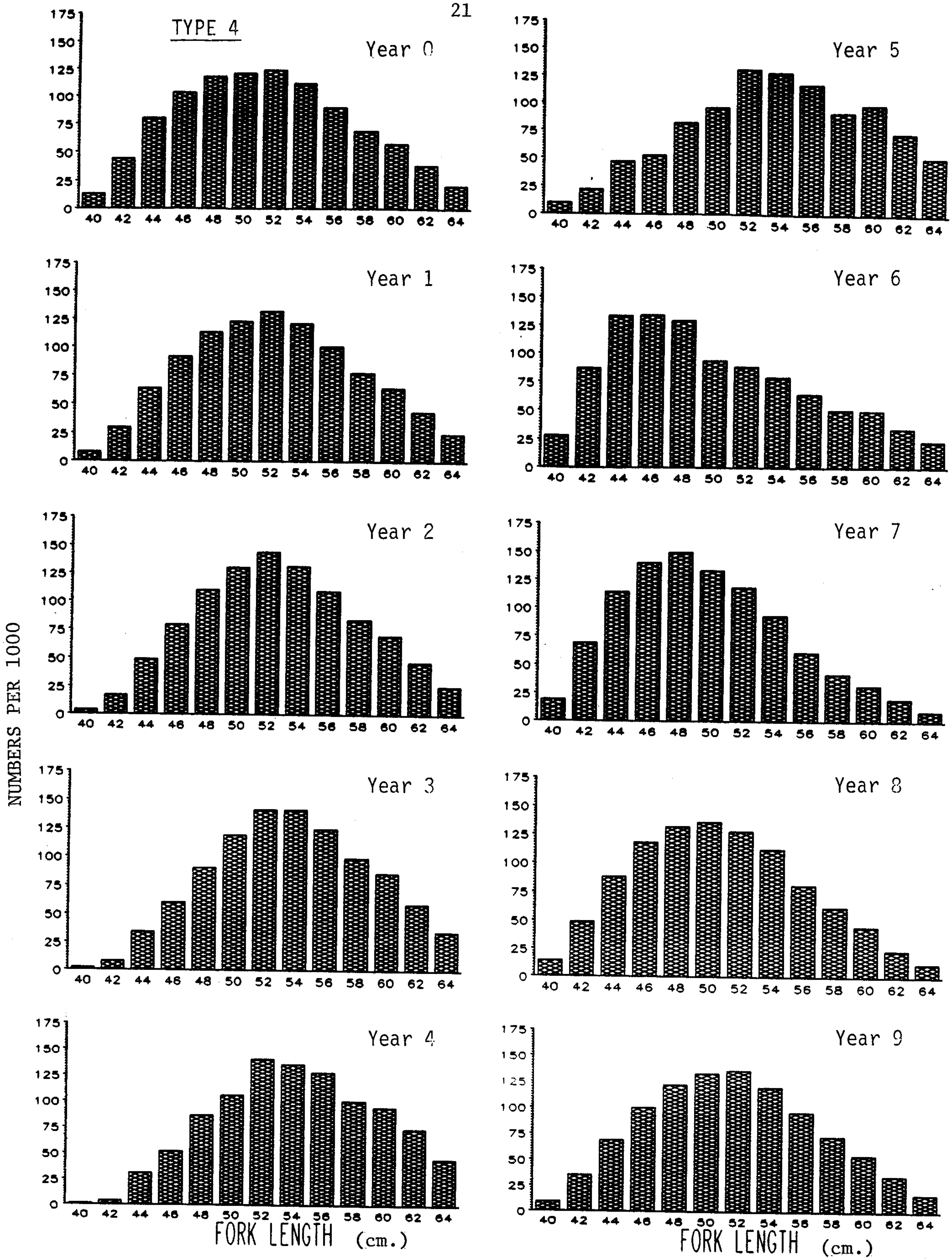

Fig. 8. Length-frequency distributions of simulated catches of Arctic charr where recruitment failure occurs in years 1-4 (type 4). Year 0 refers to the initial base year.

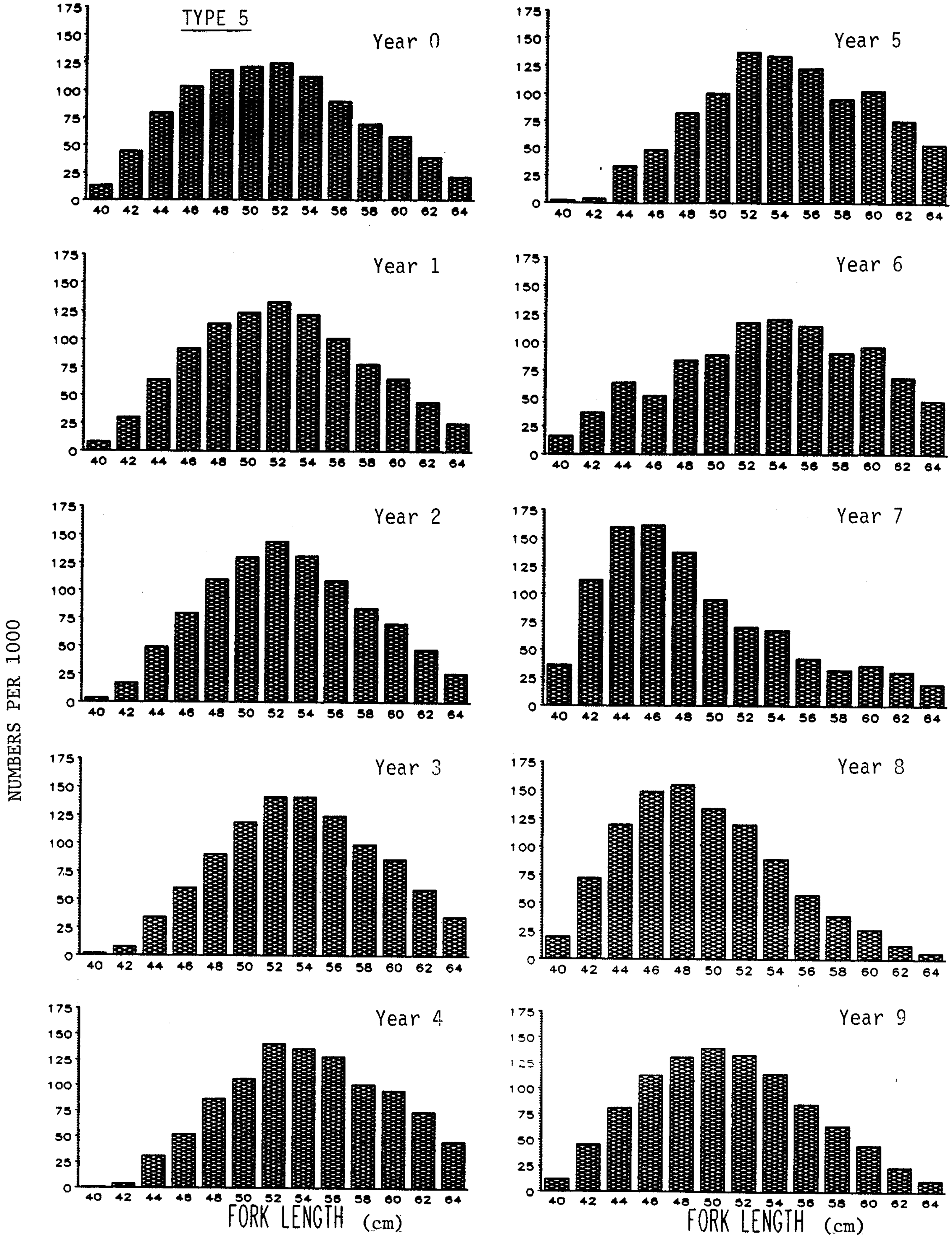

Fig. 9. Length-frequency distributions of simulated catches of Arctic charr where recruitment failure occurs in years 1-5 (type 5). Year 0 refers to the initial base year.