Assessment of the Voisey Stock Unit Arctic Charr Population in 1988

by

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Abstract

Reported landings of Arctic charr from the Voisey assessment unit totaled 14 t in 1988, about 83% of the total allowable catch. This catch represented 19% of the total catch of Arctic charr from the Nain Fishing Region in 1988. Landings were 34% lower than in 1987 when the total allowable catch was exceeded by 25%. Effort decreased by 49% relative to the previous year, while catch per unit effort increased by 29%. Trends in length-frequency distributions and mean weights at age suggest that a selective removal of a particular stock component characterized by large fish may have occurred. Sequential population analyses were carried out on catch-at-age data from 1977 to 1988 and suggested a reference level catch of 12.5 to 15.4 t.

Résumé

Les débarquements déclarés d'omble chevalier provenant de l'unité d'évaluation de la baie Voisey ont atteint 14 t en 1988, soit environ 83 % du total des prises admissibles et 19 % des prises totales d'omble chevalier dans la région de la baie Nain en 1988. Les débarquements étaient inférieurs de 34 % à ceux de 1987, année où ils dépassaient de 25 % le total des prises admissibles, et l'effort était inférieur de 49 % à celui de l'année antérieure, tandis que les prises par unité d'effort augmentaient de 29 %. Les tendances dans la distribution des longueurs et les poids moyens selon l'âge donnent à entendre qu'un retrait sélectif d'une partie donnée du stock, en l'occurrence des gros poissons, a pu se produire. On a effectué des analyses de séquentielles de population à partir des données sur les prises selon l'âge de 1977 à 1988. Elles permettent de situer entre 12,5 et 15,4 t le niveau de référence des prises.

1. Introduction

Arctic charr catch statistics from the Voisey stock unit, made up of Voisey Bay and Antons subareas (Fig. 1), have been available since 1974. It was first assessed as a single unit in 1985. Annual landings have ranged from 4 to 41 t (mean = 21 t, 1974-88), and from 1977 to 1988 have represented 16% of the commercial production from the Nain Fishing Region. In 1988, 19% of the commercial catch came from the Voisey stock unit. The recommended total allowable catch (TAC) in 1988 was 17 t.

This paper summarizes results of the 1988 fishery and provides a forecast of the reference level catch for 1989.

2. Trends in catch and effort

Catch and effort data for the Voisey stock unit are summarized in Table 1 for 1974-88. The highest catch of 41 t occurred in 1979, the lowest of 4 t was in 1975. The TACs listed in Table 1 for 1979-84 applied only to the Voisey Bay subarea. The quota area catch in Table 1 lists the catch specifically from the Voisey Bay for those years. Since 1985, the TAC has applied to the entire stock unit.

Landings in 1988 totaled 14 t, about 83% of the TAC but 34% lower than the 1987 catch which exceeded the recommended TAC by 25%. Effort decreased by 49% with catch per unit effort (CUE) up by 29%.

3. Length distribution of commercial landings

Figure 2 illustrates the length-frequency distribution of commercial catches from the Voisey stock unit from 1980 to 1988. Similar to the Nain unit, there has been a shift from a modal size of 52 and 54 cm in 1980 and 1981 to the 50 cm interval during the past six years. In general, length-frequency distributions have not changed dramatically over these years. As explained in the Nain unit assessment, with the use of 114 and 127 mm mesh gill nets in conjunction with the large overlap in size at age in these Arctic charr populations, major changes in the length distributions resulting from over exploitation of the stock would probably not be expected unless severe recruitment overfishing has occurred. Any consistent changes that do occur would have to be evaluated in relation to trends in catch rates, biomass estimates (if available) and age distribution.

4.1 Sequential population analyses (SPA)

Catch at age data are available since 1977 and are summarized in Table 2. Catch at age data, along with the estimated standard error and coefficient of variation (C.V.) for the 1988 data are shown in Table 3. Those ages that contributed to the majority of the catch (ages 7 - 10, 84.4% of the total) had coefficients of variation less than 15%. Data were derived from annual commercial sampling programs carried out at the Nain fish plant. Mean age of the catch has ranged from 8.2 years in 1979 to 9.1 years in 1981, with no

apparent increasing or decreasing trend. In 1988, three age-classes, represented by 7-, 8-, and 9-year-old fish made up 67% of the catch. A summary of the percent at age in the catch is provided in Table 4.

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 past assessments. For the stock projections, mean weight at age for the period 1987-88 was used. Table 5 summarizes the mean weight at age data for specific time periods.

An estimate of total mortality (Z) was calculated using the Paloheimo method (Ricker 1975) and the average value for the last four years was 0.81, although the data varied considerably. An estimate derived from a catch curve using catch per unit of effort at age data from 1986 to 1988 was 0.83 and refers to an average mortality during the period of time the fish were recruited into the fishery. Natural mortality was assumed to be 0.2.

An initial SPA was run using partial recruitment values and terminal fishing mortality (F_T = 0.7) from last year's assessment (Dempson 1988). An iterative procedure was used to obtain estimates of fishing mortality for the oldest age group (F_B) (Rivard 1982). Following this, partial recruitment rates were calculated using the the historical averaging method from the matrix of fishing mortality rates generated by the SPA using years 1982-86. These values were then applied to the value for terminal F and the procedure repeated until the partial recruitment values stabilized. Final partial recruitment rates and the selectivity coefficients are shown in Tables 5 and 6 respectively.

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 1.08 kg.

4.2 Calibration

A series of SPAs were run using a range of terminal fishing mortality rates from 0.3 to 0.7. In each run, fishing mortality rates for the oldest age group were re-evaluated using the iterative procedure. Regressions of F (weighted mean F for fully-recruited fish) on the index of fishing effort and average exploitable biomass on catch per unit effort were used in the calibration process to determine an appropriate value for F_T in 1988. Data from 1977 to 1988 were used in the analyses.

Regressions of F on effort had the highest correlation coefficient at F_T = 0.45. The residual for the 1988 point was also the smallest at F_T = 0.45, while the sum of residuals for the last three years (1986-88) or the sum of squares of residuals for the last three years were smallest when F_T = 0.55 and 0.5 respectively (Table 7). The intercept value increased with an increasing value of F_T used, but was not significantly different from zero for any terminal F.

Regressions of average exploitable biomass on CUE had the highest correlation when F_T = 0.5. With respect to the residual for the last year (1988), it was lowest when F_T = 0.35, while the sum of the residuals for the last three years, or the sum of squares of residuals for the last three years, was smallest when F_T = 0.5 and 0.4 respectively. The intercept value was closest to zero when F_T = 0.5 (Table 7). In summary, the regression analyses suggested terminal fishing mortality could range from 0.35 to 0.55.

Figure 3 illustrates the trend in population biomass from 1977 to 1988 based on several values for terminal F. All cases show a substantial decrease in biomass from the latter 1970s to the early 1980s. There is little evidence, at estimated current values for terminal fishing mortality (F_T ~ 0.45), that the population biomass is increasing despite the high catch rates experienced this year. Table 8 summarizes the estimated population numbers, biomass, and fishing mortality for the SPA run with F_T = 0.45.

4.3 Catch projections

Projections of reference level catches for 1989 were run with F_T varying from 0.45 to 0.55. Recruitment for the projections was estimated from the geometric mean population numbers for age 6-year-old fish for years 1977-86. Weights at age were based on the 1987-88 data. Results of the projections are summarized in Table 9. The 'reference level catch' in 1989 ranges from 12.5 t, with F_T = 0.55, to 15.4 t with FT = 0.45. The latter value is about 9% lower than the TAC of 17 t in 1988. It should be noted that the high catches in the 1977-81 period (average = 29 $t \cdot y^{-1}$) probably had a significant impact on reducing the total stock biomass in subsequent years. The likelihood of increased spawning escapements in recent years, when catches have been lower, will hopefully aid in rebuilding the stock to earlier levels. However, without information on spawning escapements from any index rivers, we do not know in fact what actual spawning escapements are, nor if they are increasing. Assuming that they have been, the impacts will not be apparent in the fishery for a number of years, as fish only begin to be recruited to the commercial fishery at age 6.

Fishing mortality rates experienced by some of the northern Labrador Arctic charr stocks (F's of 0.4 to 0.7 or annual rates of 33 to 50%) appear rather high when compared with, for example, some of the cod populations. However, in comparison with values often assumed for our Atlantic salmon stocks, they tend to be much lower. Occasionally an exploitation of 85% on large salmon and 55% on small salmon has been used (Pippy 1982). These annual values would relate to instantaneous rates of about 0.8 to 1.9. Salmon have a different reproductive strategy than charr, and a much lower turnover time, and could undoubtedly support higher levels of exploitation. Optimal rates have not been derived for salmon. As additional information on year-classes in the fishery become available, the capacity of Arctic charr populations to tolerate and respond to various levels of exploitation, and the effects of exploitation on population characteristics will slowly become more apparent.

References

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Table 1. Summary of catch and effort statistics for the Voisey assessment unit, 1974-88. Total allowable catches (TAC) and landings are in kg-round weight, effort is expressed as person-weeks fished.

Year	TAC[1]	Quota[2] area catch	Landings	Effort	CUE
1974			29,180		
1975			3,727		
1976			14,652	57	257
1977			24,108	75	321
1978			36,991	102	363
1979	22,500	21,880	40,590	116	350
1980	22,500	11,557	19,694	82	240
1981	16,100	16,325	23,810	90	265
1982	16,100	2,688	13,309	60	222
1983	16,100	2,953	25,593	80	320
1984	16,100	8,113	20,873	101	207
1985	23,400		15,648	57	275
1986	20,000		16,655	82	203
1987	17,000		21,242	101	210
1988	17,000		14,037	52	270

[1]TAC applied to the Voisey Bay subarea only from 1979 to 1984.

[2]Quota area catch refers to the landings for that subarea specifically under TAC regulation prior to the derivation of assessment units in 1985.

Table 2. Estimated catch at age of Arctic charr from the Voisey Stock Unit, 1977 - 1988.

CATCH AT AGE

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
6	318	619	475	132	75	255	1694	253	1	41	8	139
7	2085	4374	4914	666	983	770	2641	2306	1922	797	1312	1638
8	4030	5372	7928	3349	2607	1628	2853	3352	3070	3025	2812	2319
9	2086	2330	3382	4086	4780	2297	3797	2374	3245	3644	4420	1465
10	1237	1236	1163	1341	2350	1140	1647	1577	434	1313	2030	1444
11	600	1141	634	521	941	595	1101	806	321	645	965	772
12	389	380	212	260	406	62	737	401	236	229	280	286
13	212	380	159	166	43	12	63	377	66	140	38	29
14	108	334	55	64	19	20	8	136	86	111	62	45
6+	11065	16166	18922	10585	12204	6779	14541	11582	9381	9945	11927	8137
7+	10747	15547	18447	10453	12129	6524	12847	11329	9380	9904	11919	7998
8+	8662	11173	13533	9787	11146	5754	10206	9023	7458	9107	10607	6360
9+	4632	5801	5605	6438	8539	4126	7353	5671	4388	6082	7795	4041

Table 3. Summary of the catch at age in 1988 with an estimate of the standard error and coefficient of variation (C.V.) for the Voisey stock unit.

Age	Catch at age	Standard error	C.V. (%)
6	139	23.15	16.6
7	1638	205.8	12.6
8	2319	248.8	10.7
9	1465	200.3	13.7
10	1444	205.7	14.3
11	772	154.2	20.0
12	286	97.5	34.1
13	29	25.1	86.4
14	45	42.3	98.5

Table 4. Summary of the percent at age in the catch of Arctic charr from the Voisey Stock Unit, 1977 - 1988.

SUMMARY OF PERCENT AT AGE FOR THE VOISEY STOCK UNIT 2/ 2/89

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
6	2.9	3.8	2.5	1.2	0.6	3.8	11.6	2.2	0.0	0.4	0.1	1.7
7	18.8	27.1	26.0	6.3	8.1	11.4	18.2	19.9	20.5	8.0	11.0	20.1
8	36.4	33.2	41.9	31.6	21.4	24.0	19.6	28.9	32.7	30.4	23.6	28.5
9	18.9	14.4	17.9	38.6	39.2	33.9	26.1	20.5	34.6	36.6	37.1	18.0
10	11.2	7.6	6.1	12.7	19.3	16.8	11.3	13.6	4.6	13.2	17.0	17.7
11	5.4	7.1	3.4	4.9	7.7	8.8	7.6	7.0	3.4	6.5	8.1	9.5
12	3.5	2.4	1.1	2.5	3.3	0.9	5.1	3.5	2.5	2.3	2.3	3.5
13	1.9	2.4	0.8	1.6	0.4	0.2	0.4	3.3	0.7	1.4	0.3	0.4
14	1.0	2.1	0.3	0.6	0.2	0.3	0.1	1.2	0.9	1.1	0.5	0.6

Table 5. Summary of weight (kg round) at age data for specific time periods, partial recruitment rates and calculated $F_{0.1}$ for the Arctic charr population in the Voisey assessment unit.

Age	Weight				Partial recruitment
	1977-79	1980-83	1984-86	1987-88	
6	1.53	1.18	1.05	1.09	0.03
7	1.77	1.41	1.29	1.27	0.18
8	2.07	1.67	1.68	1.69	0.46
9	2.60	2.17	1.99	1.91	1.0
10	2.78	2.37	2.26	2.23	1.0
11	2.94	2.63	2.35	2.25	1.0
12	3.24	2.54	2.53	2.16	1.0
13	3.33	2.91	2.28	2.45	1.0
14	3.50	3.36	2.22	2.45	1.0
15	3.46				
16	3.46				

$F_{0.1}$ = 0.40 at a Y/R of 1.08 kg.

Table 6. Selectivity coefficients for the Voisey Stock Unit.

SELECTIVITY COEFFICIENTS

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
6	0.02	0.03	0.04	0.01	0.01	0.03	0.09	0.01	0.00	0.00	0.00	0.03
7	0.23	0.22	0.36	0.09	0.10	0.18	0.21	0.15	0.21	0.16	0.13	0.18
8	0.97	0.67	0.72	0.48	0.38	0.45	0.55	0.36	0.49	0.45	0.71	0.46
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 7. Results of regressions (1977-88) of F on effort and average exploitable biomass on catch per unit effort for various terminal fishing mortality rates (F_T) for the Voisey assessment unit.

Regression	Parameter	Terminal F 0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.70
F (weighted mean for fully-recruited fish) on effort									
	r	0.72	0.74	0.75	0.75	0.74	0.72	0.69	0.60
	intercept	0.06	0.09	0.12	0.15	0.18	0.21	0.24	0.30
	residual - 1988	-0.09	-0.06	-0.03	0.00	0.04	0.07	0.10	0.17
	Σ residuals (1986-88)	-0.40	-0.31	-0.22	-0.14	-0.07	0.00	0.07	0.19
	Σ (residuals)² 1986-88	0.06	0.04	0.02	0.01	0.01	0.01	0.02	0.04
Average exploitable biomass on catch per unit effort									
	r	0.63	0.72	0.76	0.78	0.78	0.78	0.77	0.76
	intercept (t)	12.8	8.2	4.8	2.1	-0.1	-1.8	-3.3	-5.6
	residual (t) 1988	6.7	1.1	-3.2	-6.5	-9.2	-11.4	-13.2	-16.0
	Σ residuals (t) 1986-88	23.4	15.0	8.8	3.9	0.0	-3.2	-5.9	-10.0
	Σ (residuals)² (t) 1986-88	187	99	82	99	131	169	209	288

Table 8. Summary of estimated population numbers (a), fishing mortality (b), and population biomass (c) for the Voisey Stock Unit with terminal fishing mortality of 0.45 in 1988.

(a) POPULATION NUMBERS

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
6	40114	31103	18716	17979	14995	24906	28720	26474	13780	21769	26907	11435
7	21246	32555	24905	14893	14600	12209	20161	21981	21446	11282	17786	22023
8	11634	15508	22696	15944	11591	11064	9299	14116	15910	15820	8515	13375
9	5730	5878	7836	11408	10023	7131	7586	5032	8525	10248	10215	4427
10	3645	2804	2705	3356	5643	3881	3760	2775	1972	4043	5093	4364
11	1597	1865	1177	1162	1534	2494	2146	1588	845	1222	2122	2333
12	1049	764	494	390	480	404	1504	761	571	401	416	864
13	756	507	282	213	84	26	275	564	260	254	121	88
14	152	427	71	87	24	30	10	168	121	153	81	65
6+	85923	91412	78882	65432	58975	62146	73460	73460	63430	65192	71258	58973
7+	45809	60309	60167	47454	43980	37240	44740	46985	49649	43423	44351	47539
8+	24563	27754	35262	32560	29380	25031	24579	25005	28203	32141	26565	25516
9+	12929	12246	12566	16616	17789	13967	15280	10888	12293	16321	18049	12141

(b) FISHING MORTALITY

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
6	0.009	0.022	0.028	0.008	0.006	0.011	0.067	0.011	0.000	0.002	0.000	0.014
7	0.115	0.161	0.246	0.051	0.077	0.072	0.156	0.123	0.104	0.081	0.085	0.086
8	0.483	0.483	0.488	0.264	0.286	0.177	0.414	0.304	0.240	0.237	0.454	0.211
9	0.515	0.576	0.648	0.504	0.749	0.440	0.806	0.737	0.546	0.499	0.650	0.450
10	0.470	0.668	0.645	0.583	0.617	0.392	0.662	0.989	0.279	0.445	0.581	0.450
11	0.537	1.128	0.904	0.684	1.133	0.306	0.837	0.823	0.544	0.876	0.698	0.450
12	0.527	0.797	0.643	1.332	2.731	0.186	0.780	0.873	0.610	0.996	1.359	0.450
13	0.371	1.762	0.976	1.981	0.829	0.729	0.292	1.342	0.329	0.940	0.425	0.450
14	0.496	0.716	0.675	0.555	0.755	0.394	0.758	0.845	0.495	0.525	0.646	0.450
9+	0.497	0.749	0.679	0.571	0.794	0.396	0.763	0.856	0.501	0.533	0.651	0.450

Table 8. continued.

(c) MEAN POPULATION BIOMASS (KG)

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
6	55391	42670	25600	19153	15994	26491	29736	25066	13114	20696	26578	11223
7	32261	48374	35563	18574	17978	15070	23913	24229	23853	12686	19654	24331
8	17453	23265	33969	21302	15333	15390	11604	18625	21625	21527	10563	18530
9	10646	10629	13736	17773	14048	11429	10381	6500	11956	14672	13140	6218
10	7384	5212	5076	5515	9140	6941	5972	3668	3541	6735	7884	7156
11	3322	3034	2096	2029	2228	5147	3514	2337	1400	1758	3151	3860
12	2416	1568	1082	507	394	852	2434	1181	990	592	456	1373
13	1919	740	552	252	153	49	632	656	461	345	221	158
14	382	980	166	205	52	76	22	232	193	242	134	117
6+	131173	136471	117841	85310	75321	81446	88208	82492	77132	79254	81781	72965
7+	75782	93801	92242	66158	59327	54955	58471	57427	64019	58558	55203	61742
8+	43520	45427	56678	47584	41349	39885	34559	33198	40166	45872	35549	37412
9+	26068	22162	22709	26282	26016	24495	22955	14572	18541	24345	24986	18882

Table 9. Summary of projected reference level catch (t) for 1989 and 1990 with F_T in 1988 varying from 0.45 to 0.55 for the Voisey stock unit.

	F_T in 1988		
	0.45	0.5	0.55
1989	15.4	13.8	12.5
1990	17.4	16.0	14.8

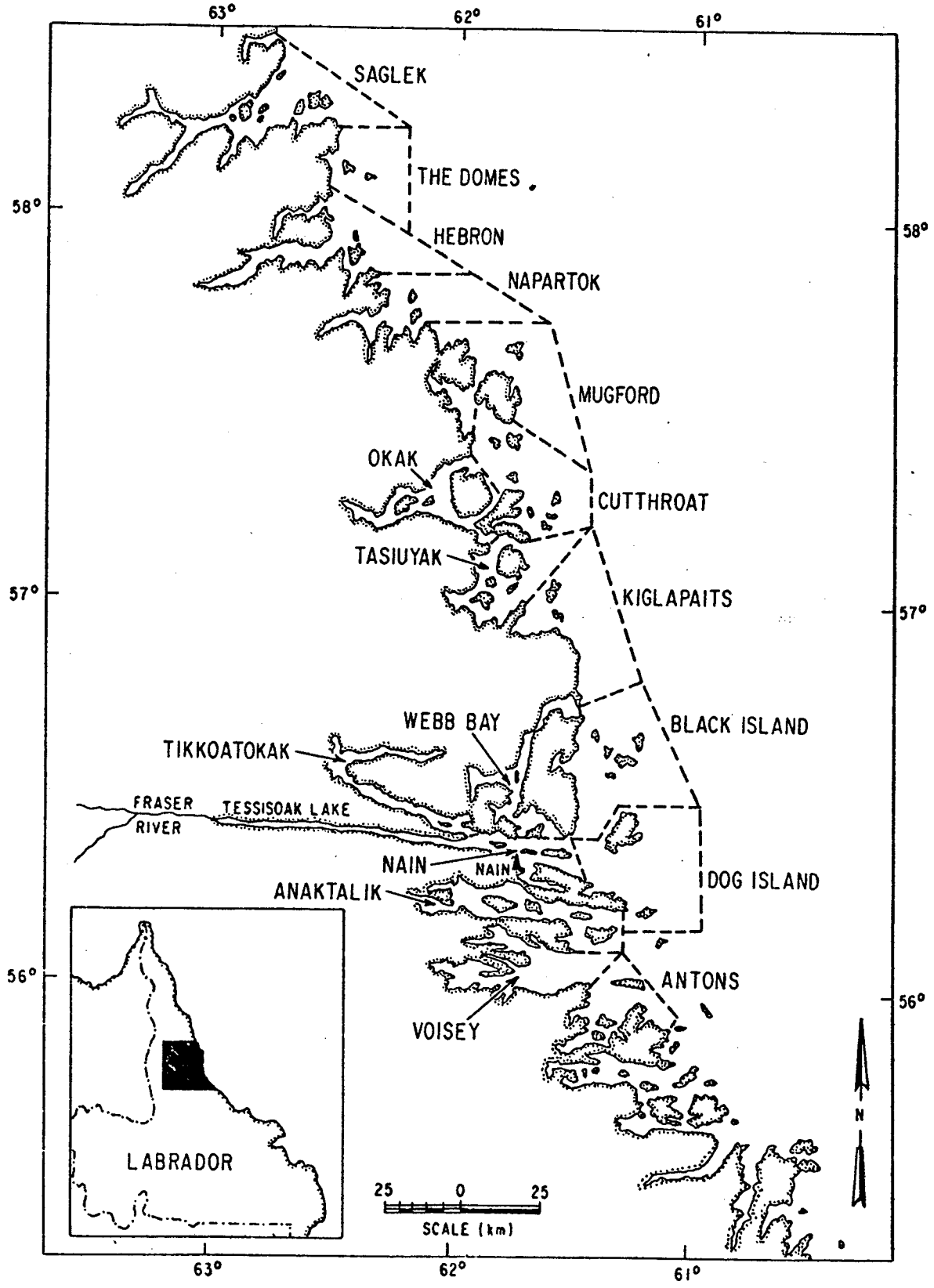

Figure 1. Geographical separation of the Nain Fishing Region subareas.

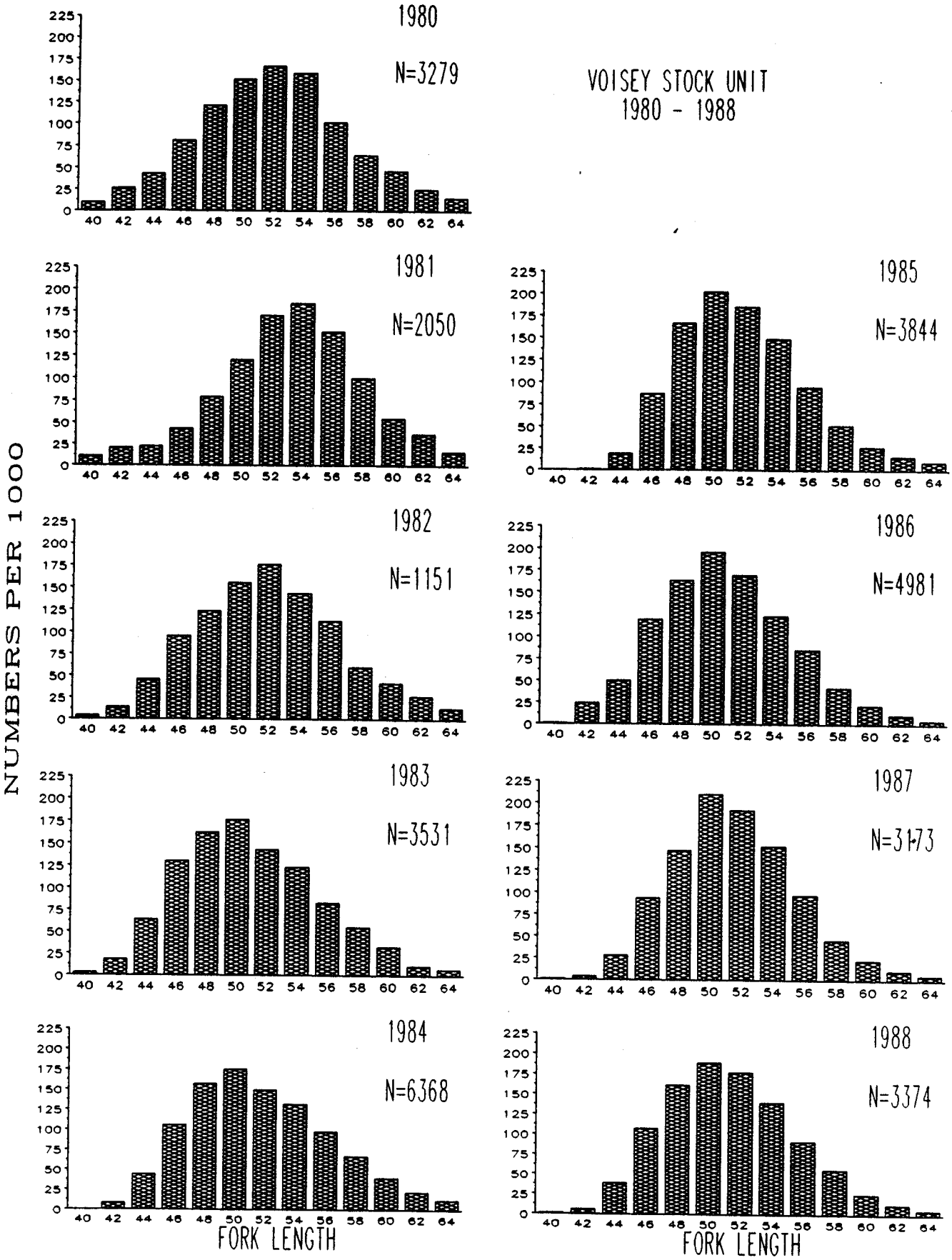

Fig. 2. Length-frequency distributions of the catch of Arctic charr from the Voisey Stock Unit, 1980 - 1988.

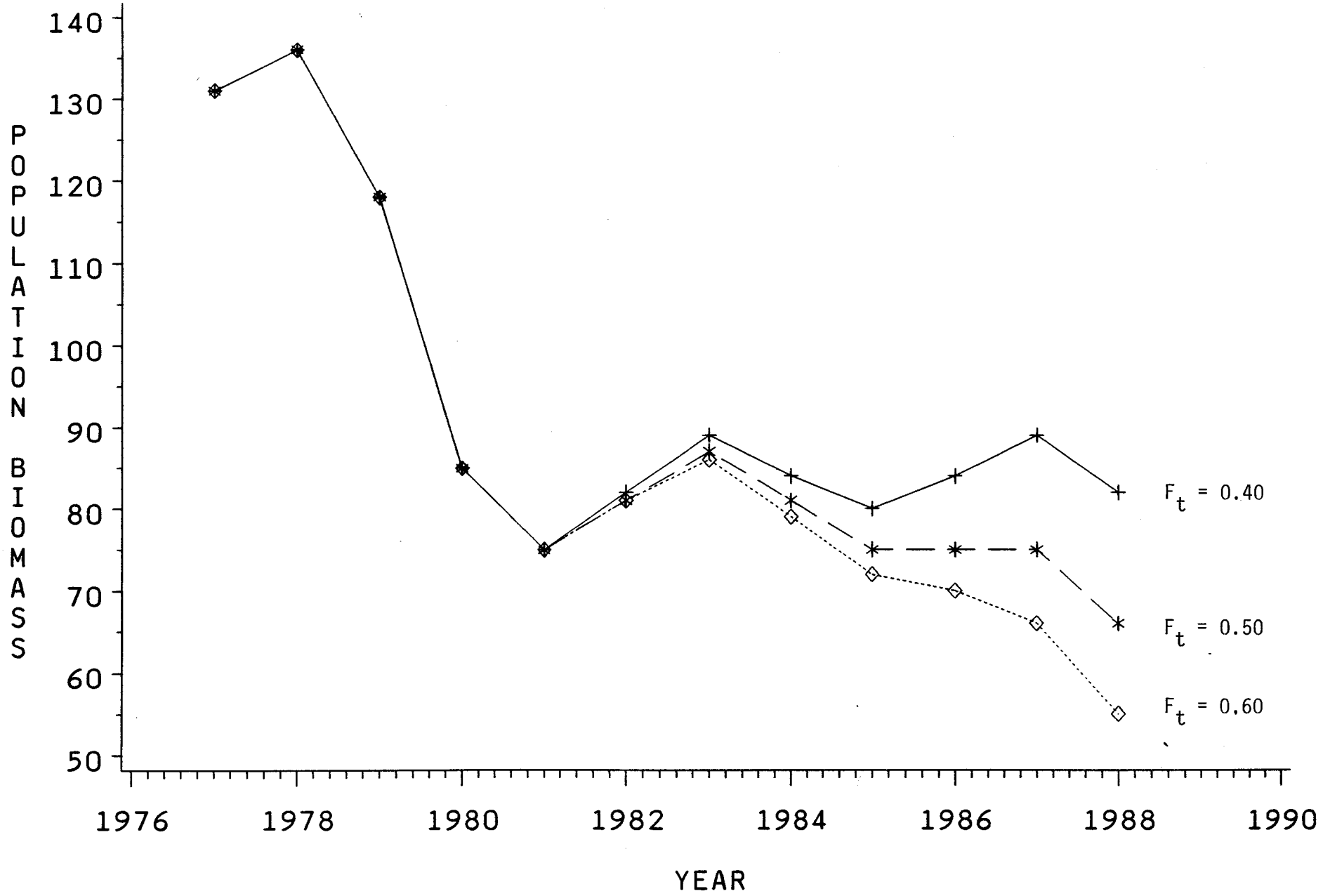

FIG. 3 TREND IN AVERAGE POPULATION BIOMASS FOR VARIOUS LEVELS OF TERMINAL FISHING MORTALITY – VOISEY UNIT