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Canadian Atlantic Fisheries Scientific Advisory Committee

CAFSAC Research Document 86/24

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Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 86/24

Sequential Population Analysis of the Nain Assessment Unit Arctic Charr Population

by

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Abstract

Tag recapture information indicated that the Nain assessment unit consists of the following subareas: Anaktalik Bay, Nain Bay, Tikkoatokak Bay and Webb Bay for the inshore zone, and Dog Island and Black Island for the offshore zone. Annual landings from this assessment unit have ranged from 34 to 76 t (mean = 56 t) and from 1977-1985 have represented 36% of the total commercial production from the Nain Fishing Region. The total allowable catch in 1985 for the Anaktalik Bay and Tikkoatokak Bay subareas, including an offshore component was 30.5 t. Landings for the Nain assessment unit in 1985 totaled 41 t and were 6% higher than the previous year. A sequential population analysis was carried out on catch at age data from 1977-85 and indicated a fishing mortality of 0.45 in 1985. A projection of the TAC in 1986 fishing at $F_{0.1}$ (= 0.40) indicates a yield of 44 t.

Résumé

Si l'on se fonde sur les données provenant des étiquettes récupérées, l'unité d'évaluation de Nain couvre les sous-zones suivantes : les baies Anaktalik, Nain, Tikkoatokak et Webb, pour la zone côtière, et les îles Dog et Black, pour la zone hauturière. Pour cette unité, les débarquements annuels se sont situés entre 34 et 76 t (moyenne de 56 t), représentant 36 % de la production commerciale totale dans la région de Nain de 1977 à 1985. En 1985, le total des prises admissibles pour les sous-zones des baies Anaktalik et de Tikkoatokak, y compris un segment de la zone hauturière, était de 30,5 t. Les débarquements pour l'unité d'évaluation de Nain se sont élevés à 41 t en 1985, soit 6 % de plus que l'année précédente. Une analyse séquentielle de population effectuée sur les prises par catégorie d'âge de 1977 à 1985 révèle une mortalité due à la pêche de 0.45 en 1985. Une projection du TPA pour 1986, à raison de $F_{0,1}$ = 0,40, établit le rendement à 44 t.

Introduction

In previous years individual assessments were conducted separately on Arctic charr populations from Nain-Tikkoatokak and Anaktalik Bay. Quotas were applied to both these areas beginning in 1979. With increasing catches in the offshore areas of Dog Island and Black Island, an attempt was made to apportion these catches back into the respective inshore fishing areas in order to account for total losses from the population (Dempson and LeDrew 1985).

Analyses of information on tag recaptures at sea indicates that charr from these areas should be considered as one stock complex consisting of the following subareas: Anaktalik Bay, Nain Bay, Tikkoatokak Bay and Webb Bay for the inshore zone, and Dog Island and Black Island for the offshore component (Fig. 1). Annual landings from this assessment unit have ranged from 34 to 76 t (mean = 56 t) and from 1977-1985 have represented 36% of the total commercial production from the entire Nain Fishing Region. The TAC in 1985 for the Anaktalik and Tikkoatokak-Nain subareas, including the offshore component, was 30.5 t.

This paper summarizes results of the 1985 fishery and provides a forecast of available harvest in 1986.

Stock Assessment

Catch and effort data

Catch and effort data for the Nain assessment unit are summarized in Table 1 for 1974-85. The highest catch of 76 t occurred in 1977, the lowest of 34 t was in 1975. Landings in 1985 totaled 41 t and were 6% higher than the previous year. Effort increased by 3% while catch per unit effort was also about 3% higher than in 1984. By grouping subareas in this way it can be seen (Table 1) that the TAC has been exceeded in all but one year. Total landings from 1979 to 1985 of 395 t have exceeded the total of the TACs (323 t) by 22%. It should be remembered, however, that the TAC did not apply to all subareas within the Nain assessment unit over this period.

Trends in the catch series can be more clearly seen by separating inshore and offshore zones. Landings in the inshore zone have decreased from a total of 200 t for 1977-79 to 81 t for 1983-85. Landings from the offshore zone have changed from 21 t to 52 t over the two time periods (Fig. 1). Differences in abundance between zones and among years were tested by a Kruskal-Wallis one-way analysis of variance (Sokal and Rohlf 1969) using data from all weeks for years 1977 to 1985. Results indicated a highly significant difference between inshore and offshore zones ($X^2 = 85.0$, df = 1, $P < 0.0001$) but no difference in abundance for the two zones combined over time ($X^2 = 2.3$, df = 8, $P = 0.97$) (Fig. 2). When analyzed separately, there were significant differences among years for both the inshore ($X^2 = 17.6$, df = 8, $P = 0.02$) and the offshore zone ($X^2 = 16.7$, df = 8, $P = 0.03$).

Another factor examined was timing of catches in the commercial fishery. Cumulative weekly proportion of catch and catch per unit effort were compiled for the three time periods 1977-79, 1980-82, and 1983-85 (Fig. 3). Based on either catch or CUE, these data suggest that charr were more abundant at sea later in the summer during the last several years in comparison with the two previous time periods. This appears to be related to the increased abundance of charr in the offshore fishing zone during the past several years.

Numbers at age were available since 1977 and are summarized in Table 2. Data were derived from annual commercial sampling programs. Where possible, numbers at age were estimated for each inshore subarea individually then added together while numbers at age were estimated for the two offshore subareas combined then added to the inshore total. If necessary, numbers were then adjusted to reflect the total estimated number of fish caught for the entire assessment unit as estimated in the commercial landings summary for all subareas combined. Mean age has varied from 8.5 to 9.8 years with a slight drop during the past several years.

Weights at age were calculated from commercial samples (1974, 1977-78 for yield per recruit analysis, and 1983-85 for stock projections) and were converted from gutted head-on to whole weight using the conversion factor 1.22 (Dempson 1984) (Table 3).

Total mortality (Z) was calculated using the Paloheimo method (Ricker 1975) and the average value from all years (1977-78 to 1984-85) was 0.57. Average Z of 0.64 for the past three years (1982-83 to 1984-85) was reasonably constant. Assuming a natural mortality rate as in past assessments of 0.2 yields an estimate of fishing mortality of 0.44. An estimate of total mortality was also derived from a catch curve using catch per unit effort at age data from 1983-85. This indicated a Z of 0.70.

As in past years, an estimate of fishing mortality was derived from:

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

where μ was estimated from tag recaptures. Previously no estimate was incorporated for natural mortality, tagging mortality, tag loss or non-reporting of tags. In order to estimate a more representative value for fishing mortality, the total number of tag recaptures were divided by total number of tags applied less 10%. Therefore:

$$\mu = 116/363 = 0.320.$$

Rate of fishing mortality was calculated to be 0.39 (95% C.L. = 0.31 - 0.48).

An initial cohort analysis was run using partial recruitment values and terminal fishing mortality (F_T) from the 1985 assessment (Dempson and LeDrew 1985) (F_T = 0.40). An iterative procedure was used to obtain estimates of fishing mortality for the oldest age group (F_B). The iteration process stops when the input and output values of F_B differ by 0.005 or less (Rivard 1982). Following this the cohort analysis procedure was rerun using the newly derived values for F_B.

Partial recruitment rates were calculated using the historical averaging method from the matrix of fishing mortality rates generated from the last SPA (sequential population analysis) and are presented in Table 3.

Yield per recruit was calculated by the method of Thompson and Bell (Ricker 1975) using partial recruitment rates and mean weight at age. $F_{0.1}$ was 0.38 at a yield per recruit of 0.91 kg. For the projection, $F_{0.1}$ was rounded to 0.4.

Cohort analyses were performed using a range of terminal fishing mortality rates from 0.2 to 0.7 using the newly derived estimates of partial recruitment. In each run, fishing mortality rates for the oldest age group (F_B) were re-evaluated using the iterative procedure. Regressions of F on effort and population biomass of age 10^+ fish on catch per unit effort of age 10^+ fish were used in tuning the analysis to key in on an appropriate value for F_T in 1985.

Regressions of F on effort produced the highest correlations at $F_T = 0.3$ and 0.35 (Table 4). The best predicted values for F_T in 1985 were obtained with a cohort run of $F_T = 0.55$ although regressions were not statistically significant beyond 0.45 (Table 4). Regressions of biomass on catch per unit effort had the highest correlations at $F_T = 0.4$ and 0.45 with the best predicted value when $F_T = 0.45$ (Table 4). Average fishing mortality from the Paloheimo method for the past several years was 0.44 and from tagging results 0.4. Thus the best estimate of terminal F in 1985 was estimated to be 0.45. Table 5 summarizes population numbers and fishing mortality matrix for the cohort analysis run with $F_T = 0.45$.

A projection was run using 1985 population numbers from a cohort analysis run at $F_T = 0.45$. Recruitment was estimated from the geometric mean of age six population numbers for the years 1977-83. Weights at age for the projection were based on 1983-85 data. The projected TAC for the Nain assessment unit in 1986 is 44 t (Table 6). This is approximately 7% higher than landings in 1985 but 27% lower than the average during the past 10 years.

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Table 1. Summary of catch and effort statistics for the Nain assessment unit 1974-85. Quotas and landings are in kg round weight, effort is expressed as man-weeks fished.

	Quota	Landings	Effort	CUE
1974		37,745		
1975		33,830		
1976		53,313	196	272
1977		76,255	291	262
1978		73,763	314	235
1979	61,000	66,844	336	199
1980	61,000	75,055	390	192
1981	37,160	65,632	278	236
1982	43,660	56,317	235	240
1983	46,000	51,202	289	177
1984	43,200	38,900	244	159
1985	30,500	41,158	252	163

TABLE 2. ESTIMATED CATCH AT AGE FOR ARCTIC CHARR FROM THE NAIN STOCK UNIT, 1977-85.

	1977	1978	1979	1980	1981	1982	1983	1984	1985
6	2003	371	430	113	145	145	210	83	174
7	9250	6703	4306	1023	1557	641	1689	2009	2862
8	12453	13122	11568	11930	6570	4425	4797	3850	7277
9	7630	7984	9593	16725	15180	7746	6732	5692	4510
10	5052	4406	4208	8541	9784	8624	5389	5085	3706
11	2454	2367	2168	3543	3286	5020	5285	2362	2133
12	988	1688	1573	946	673	2604	3378	1539	1324
13	358	312	418	764	232	412	865	575	828
14	180	272	312	349	80	259	306	142	442
15	1	118	34	39	57	47	1	29	214
16	1	97	14	2	10	17	1	1	30
17	1	1	1	16	1	25	15	1	41
TOTAL	40371	37441	34625	43992	37575	29965	28668	21368	23541
MEAN AGE	8.5	8.8	8.9	9.2	9.3	9.8	9.8	9.4	9.2

Table 3. Summary of weight (kg-round) at age data, partial recruitment rates and calculated $F_{0.1}$ for the Nain assessment unit Arctic charr populations.

Age	Weight 1974, 1977-78	Weight 1983-85	Partial Recruitment
6	1.01	1.22	0.017
7	1.52	1.50	0.147
8	1.82	1.80	0.480
9	2.16	2.05	0.730
10	2.51	2.15	1.00
11	2.64	2.10	1.00
12	2.70	2.08	1.00
13	3.25	2.13	1.00
14	3.00	2.11	1.00
15	3.17	2.23	1.00
16	3.17	1.69	1.00
17	3.17	1.97	1.00

$F_{0.1}$ = 0.38 at a Y/R of 0.91 kg.

Table 4. Results of regressions of F on effort and population biomass on catch per unit effort for various terminal fishing mortalities.

Regression	Parameter	F_T 0.20	0.30	0.40	0.45	0.50	0.55
F (weighted age 10^+ on effort) 1977-84	r	0.78	0.81	0.78	0.75	0.70	0.64
	residual (absolute value)	-0.20	-0.16	-0.11	-0.08	-0.04	0.01
10^+ biomass on CUE of 10^+ fish 1977-84	r	0.83	0.91	0.93	0.93	0.92	0.91
	residual (t) (absolute value)	44	18	5	1	-2	-5

Table 5. Summary of population numbers and fishing mortality matrix for the cohort analysis run at F_T = 0.45 on the catch at age data for the Nain stock unit Arctic charr population.

POPULATION NUMBERS

	1977	1978	1979	1980	1981	1982	1983	1984	1985
6	124748	109344	61922	53109	45323	40952	64380	60412	24090
7	83870	100323	89187	50309	43379	36976	33398	52520	49386
8	43207	60297	76072	69124	40264	34107	29693	25815	41182
9	21510	24107	37494	51815	45799	27020	23921	19970	17652
10	13258	10707	1[illegible]513	22017	27289	23762	15113	13493	11200
11	6639	6283	4779	6437	10298	13490	11651	7498	6446
12	2223	3215	3003	1951	2065	5458	6502	4757	4001
13	826	926	1105	1035	741	1081	2112	2267	2502
14	419	352	476	527	156	397	513	947	1336
15	134	180	42	107	115	55	91	143	647
16	3	109	41	4	53	43	3	73	91
17	1	1	1	21	1	34	20	1	59
6+	296839	315845	286636	256456	215484	183376	187397	187898	158593
7+	172091	206502	224714	203348	170161	142424	123017	127485	134503
8+	88221	106179	135527	153039	126782	105448	89619	74965	85116
9+	45013	45882	59455	83915	86519	71341	59926	49150	43935

FISHING MORTALITY

	1977	1978	1979	1980	1981	1982	1983	1984	1985
6	0.018	0.004	0.008	0.002	0.004	0.004	0.004	0.002	0.008
7	0.130	0.077	0.055	0.023	0.040	0.019	0.058	0.043	0.066
8	0.383	0.275	0.184	0.212	0.199	0.155	0.197	0.180	0.216
9	0.498	0.456	0.332	0.441	0.456	0.381	0.373	0.378	0.329
10	0.547	0.607	0.465	0.560	0.505	0.513	0.501	0.539	0.450
11	0.525	0.538	0.696	0.937	0.435	0.530	0.696	0.428	0.450
12	0.676	0.868	0.865	0.768	0.447	0.749	0.854	0.442	0.450
13	0.652	0.466	0.541	1.692	0.424	0.547	0.602	0.329	0.450
14	0.644	1.918	1.289	1.318	0.835	1.276	1.078	0.181	0.450
15	0.008	1.285	2.176	0.513	0.789	2.765	0.012	0.254	0.450
16	0.524	4.193	0.476	0.824	0.236	0.576	0.489	0.015	0.450
17	0.553	0.635	0.578	0.671	0.483	0.551	0.630	0.460	0.450
10+	0.555	0.664	0.595	0.697	0.484	0.558	0.641	0.464	0.450

Table 6. Projection of available catch for the Nain stock unit for 1986-87 from a cohort analysis run with $F_T = 0.45$.

POPULATION NUMBERS

	1985	1986	1987
6	65835	65835	65835
7	49386	53744	53536
8	41182	37851	41489
9	17652	27167	25576
10	11200	10400	16610
11	6446	5847	5708
12	4001	3365	3209
13	2502	2089	1847
14	1336	1306	1146
15	647	698	717
16	91	338	383
17	59	48	185
6+	200337	208687	216241

POPULATION BIOMASS

	1985	1986	1987
6	72693.90	72557.82	72557.82
7	65044.93	71028.82	70753.77
8	60642.07	56364.96	61782.03
9	28101.41	43987.62	41412.05
10	17706.35	16814.93	26854.30
11	9953.57	9233.18	9013.62
12	6119.22	5263.33	5019.02
13	3918.55	3345.37	2958.01
14	2072.90	2072.30	1818.74
15	1061.03	1169.68	1201.98
16	113.19	429.34	486.49
17	58.29	70.52	274.67
6+	267485.40	282337.87	294132.50

CATCH BIOMASS

	1985	1986	1987
6	212	493	493
7	4293	4176	4160
8	13099	10822	11862
9	9246	12844	12092
10	7968	6726	10742
11	4479	3693	3605
12	2754	2105	2008
13	1764	1338	1183
14	933	829	727
15	477	468	481
16	51	172	195
17	81	28	110
6+	45355	43696	47659

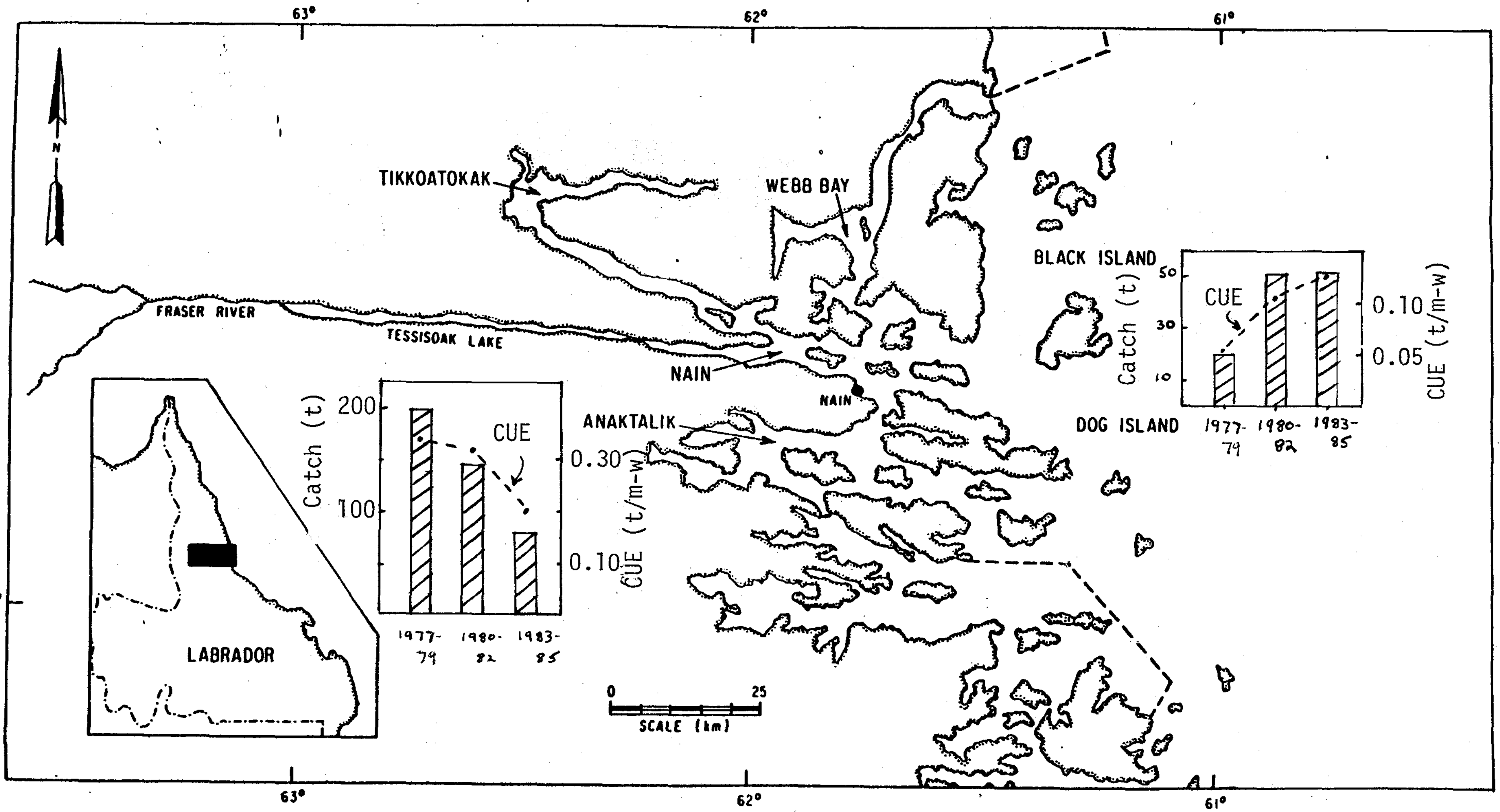

Fig. 1. Location of subareas within the Nain stock unit. Graphs illustrate change in catch and CUE for inshore and offshore zones for the periods 1977-79, 1980-82, 1983-85.

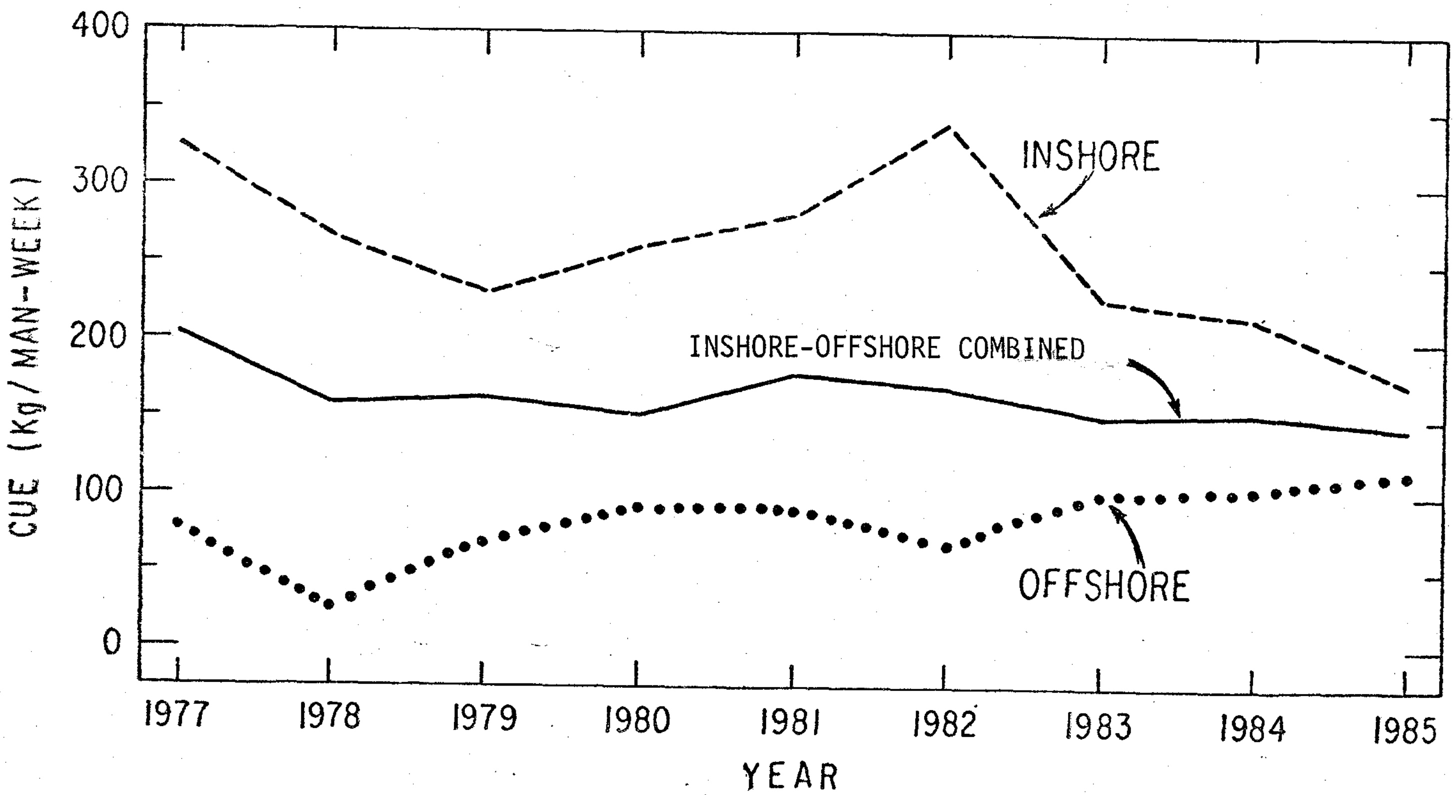

Fig. 2. Difference in abundance of Arctic charr (CUE) between inshore and offshore zones of the Nain stock unit from 1977-1985.

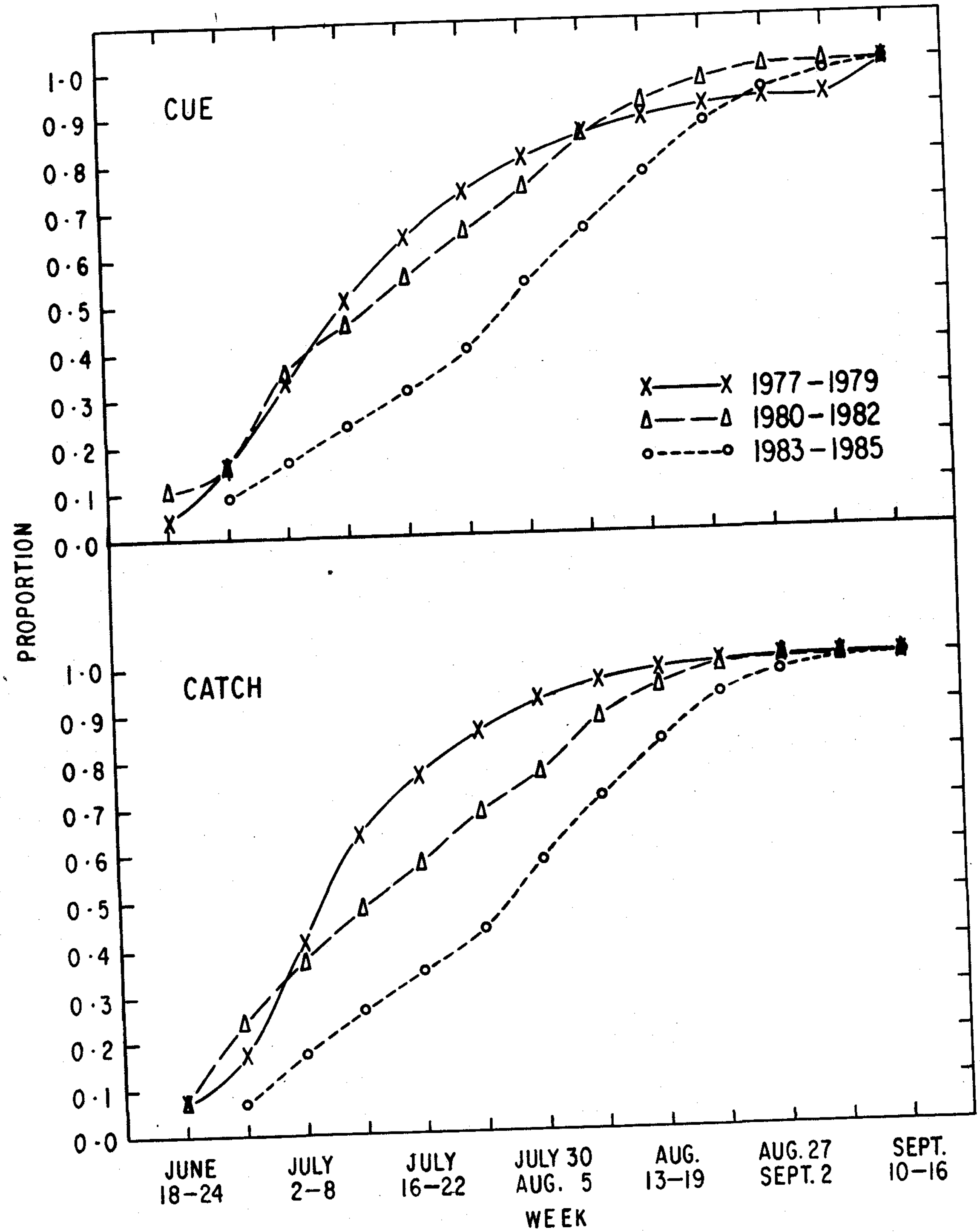

Fig. 3. Cummulative proportion of catch per unit effort and catch as a function of time for Arctic charr caught in the Nain stock unit of northern Labrador over three time periods 1977-79, 1980-82 and 1983-85.