Assessment of the Tikkoatokak - Nain Bay
Arctic Charr Stock - 1984

by

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Abstract

The Tikkoatokak Bay Arctic charr fishery has been under quota management since 1979. In 1983 a method was developed to account for the additional exploitation of this stock in the offshore fishing region. This method was again used in the assessment of the 1984 fishery. The total allowable catch (TAC) for the Tikkoatokak - Nain Bay stock in 1984 was 35 t of which 26 t could be taken within the regulated inshore fishing area. Landings for the total stock were only 17 t in 1984. A cohort analysis was performed on the adjusted catch-at-age data using information from 1977 to 1984. A stock projection using population numbers generated from a terminal fishing mortality in 1984 of 0.4 indicated an $F_{0.1}$ yield in 1985 of 17 t.

Résumé

La pêche à l'omble chevalier dans la baie Tikkoatokak fait l'objet d'une gestion par contingents depuis 1979. En 1983, on a mis au point une méthode pour tenir compte de l'exploitation additionnelle de ce stock par les pêcheurs qui oeuvrent au large. Cette méthode a été utilisée de nouveau pour évaluer la pêche de 1984. Le total des prises admissibles (TPA) pour le stock des baies Tikkoatokak et Nain a été de 35 t en 1984, dont 26 t pouvaient être prélevés dans la zone de pêche réglementée sur la côte. Les débarquements pour le stock entier n'ont été que de 17 t en 1984. Une analyse par cohortes a été réalisée à partir de données ajustées des prises par âge pour la période de 1977 à 1984. Une projection des stocks faisant appel à des chiffres de population obtenus à partir d'une mortalité par pêche pour la dernière année (1984) de 0,4 indique pour 1985 un rendement à $F_{0,1}$ de 17 t.

Introduction

Catch statistics from individual fishing areas for the northern Labrador Arctic charr fishery have been available since 1974. From 1975 to 1982 Tikkoatokak Bay (Fig. 1) had been one of the most important charr fishing areas with annual commercial landings averaging 36 t y^{-1}. For the period 1975-80, more than 20% of the commercial charr catch within the Nain fishing region came from Tikkoatokak Bay. Quota management of the charr stock in this area began in 1979.

Beginning with the assessment of the 1983 fishery, catches in the offshore areas of Dog Island and Black Island were apportioned back into inshore fishing areas of Voisey Bay, Anaktalik Bay, and Tikkoatokak Bay (Dempson et al. 1984). In addition, Nain Bay was grouped with Tikkoatokak Bay as it has been considered as part of the same stock complex, but generally omitted from any of the previous analyses (Dempson et al. 1984).

For the 1984 commercial fishing season, the quota for the Tikkoatokak - Nain Bay stock was 35 t, of which 26 t could be taken within the regulated inshore fishing area. This paper examines the results of the 1984 fishery and provides an outlook for 1985.

Stock assessment

Catch and effort data

Catch and effort data for the Tikkoatokak Bay Arctic charr fishery are summarized in Table 1 for 1974-84. The highest catch of 55 t occurred in 1978, the lowest catch of 8.6 t in 1984. Landings in 1984 were 47% lower than in 1983. Effort in 1984 was 34% lower than the previous year. A decline in catch per unit effort to 200 kg/man-week was 20% lower than in 1983, suggesting a lower abundance of charr within Tikkoatokak Bay itself during 1984.

In a previous assessment, a method was developed to account for additional losses of the Tikkoatokak - Nain Bay charr stock (as well as Voisey Bay and Anaktalik Bay) in the offshore fishing areas of Dog Island and Black Island (Dempson et al. 1984). This method was again applied to the 1984 fishery. The offshore catch that originates from area j in year i is Z_{ij}, and,

$$Z_{ij} = a_i \times b_j \times y_{ij} \qquad (1)$$

where a_i is an index specifying the relative offshore to inshore catch ratio in year i; b_j, which is estimated from tagging studies, is the ratio of the offshore catch which originates from the inshore j areas; and y_{ij} is the catch in each inshore area (Voisey Bay, Anaktalik Bay, and Tikkoatokak - Nain Bay).

Ideally, the proportion b_j would be estimated each year. These data do not exist and would require annual tagging in each of the inshore areas contributing to the offshore fishery. In this paper, therefore, $b_1 = 0.0769$, $b_2 = 0.5714$, and $b_3 = 0.3422$ where 1, 2, and 3 refer to Voisey Bay, Anaktalik Bay, and Tikkoatokak - Nain Bay respectively. These values were calculated

from the ratio of offshore to inshore tag recaptures totalled over the past five years and were used to update the 1984 catch data.

The new adjusted catch (C) for any stock (j) in 1984, therefore, is:

$$C_j = Z_j + y_j. \tag{2}$$

Table 2 summarizes the catch data for the adjusted Tikkoatokak - Nain Bay stock. From the adjusted catches in Table 2 it can be seen that the quota set for the original Tikkoatokak Bay stock has been reached or exceeded from 1979 to 1982. In 1983 the adjusted catch was 14% lower than the quota while in 1984 the adjusted catch was 52% below the recommended TAC.

Numbers at age were available since 1977 and are summarized in Table 3a for the adjusted catch and 3b for the non-adjusted catch. Data were derived from annual commercial sampling programs. Length-frequency distributions from commercial samples show a rather stable size configuration in catches over the past four years (1980-84) (Fig. 2).

Weights at age were calculated from commercial samples (1974, 1977-78 for yield per recruit analysis, and 1982-84 for stock projections) and were converted from gutted head-on to whole weight using the conversion factor 1.22 (Dempson 1984) for 1982-84 data and 1.24 (Coady and Best 1976) for previous years (Table 4).

Partial recruitment rates were the same as those used in a previous assessment (Dempson et al. 1984). Values were derived using the Fraser River counting fence data as an index of the population. The percent at age in the commercial catch (1978-81) was compared to the percent at age from the Fraser River fence data (1975-79) (Table 5). The ratio of these percentages provides a measure of selectivity with the highest value assigned the value of 1.0 for fully recruited fish.

Total mortality (z) was calculated using the Paloheimo method (Ricker 1975) using inshore catch and effort data only (Table 3b). Average z from 1979-80 to 1983-84 was 0.57. Assuming a natural mortality rate of 0.2 yields an estimate of fishing mortality of 0.37.

Assuming a Type I fishery (Ricker 1975) where losses due to natural mortality are occurring during a time of year other than the fishing season, an estimate of fishing mortality can be derived from:

$$\mu = 1 - e^{-F}$$

where μ was estimated from tag recaptures by R/M (Ricker 1975) (101/392);

$$\mu = 0.26 \ (95\% \ C.L. = 0.21 - 0.31).$$

Rate of fishing mortality was calculated to be 0.30 (95% C.L. = 0.24 - 0.37). This value is a minimum estimate since no account has been made for natural mortality, tagging mortality, and non-reporting of tags during the fishery.

Estimates of F derived from tagging studies in 1982 and 1983 were 0.32 and 0.30 respectively.

Yield per recruit was calculated by the method of Thompson and Bell (Ricker 1975) using partial recruitment rates and mean weight at age (weight data from 1974, 1977-78, ages 6-15). $F_{0.1}$ was 0.39 (rounded 0.4) at a yield per recruit of 0.84 kg.

Cohort analyses were performed using a range of terminal fishing mortality rates (F_T) from 0.2 to 0.5. Regressions of F on effort and population biomass of 9+ fish on catch per unit effort of 9+ fish were used to tune the analysis and determine the appropriate value for F_T. Effort values used were from the inshore area only and were assumed to be an index of total effort. Regression of F on effort produced the best correlation at F_T = 0.2, although correlations were generally low and not statistically significant (Table 6). Regressions of biomass on catch per unit effort were much higher and were significant for F_T of 0.2 - 0.3. The best correlation was obtained with F_T = 0.20 and the best predicted value for 9+ biomass in 1984 was derived from the run with F_T = 0.30. Average fishing mortalities from the Paloheimo method and from tagging results were 0.37 and 0.30 respectively. Terminal F in 1984 was estimated to be 0.4 on the basis of the tagging information (minimum estimate) and a consideration of the Paloheimo total mortality (average over past several years). Fishing mortality values from cohort results also appear to have been underestimated in past years.

A projection was run using 1984 population numbers from a cohort analysis run at F_T = 0.4. Recruitment estimate for the projection was calculated from the geometric mean of age six population numbers for the years 1977-82. Weights at age for the projection were based on 1982-84 data. The projected $F_{0.1}$ catch in 1985 is 17 t (Table 7). Projections were also extended to 1986 and 1987. The $F_{0.1}$ catch in 1986 would be 20.4 t and 24.2 t in 1987.

The projected available catch of 17 t in 1985 can be apportioned into offshore and inner bay components using equations (1) and (2). Combining (1) and (2) and solving for y_{ij} we have:

$$y_{ij} = \frac{C_{ij}}{(\bar{a}_i \times b_j) + 1} \tag{3}$$

where C_{ij} is now the projected available catch for both areas and y_{ij} is the catch for the inner bay area. Solving equation (2) for Z_{ij} gives the amount of the projected catch of the Tikkoatokak - Nain Bay stock in the offshore area. We do not know the value of a_i in 1985 and, similar to last year, have chosen an average value for the past five years (1980-84, $\bar{a}$ = 1.0804). With a 1984 terminal fishing mortality estimated at 0.4, the inshore and offshore catches for 1985 would be 12,503 kg and 4,622 kg respectively. The inshore catch (12,503 kg) includes Nain Bay. The reduced quota for this stock reflects the decline in catch per unit of effort during the past several years and the decline in recruitment of age 6- and 7-year-old charr in comparison with the latter 1970s.

References

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YEAR		1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
TIKKOATOKAK BAY												
QUOTAS							39500	39500	28500	35000	35000	26000
CATCH (KG)		9960	27695	31568	39483	55061	37919	42131	28066	28283	16211	8618
EFFORT (MAN-WEEKS)		28	76	81	94	147	108	130	80	75	65	43
C/E (KG)		356	364	390	420	374	351	324	351	377	249	200
0/0 > 2.3KG				19.0	20.0	18.0	14.0	10.0	5.0	7.0	8.2	5.1

Table 2. Summary of adjusted catch data for the Tikkoatokak - Nain Bay stock area, 1974-84.

	Year										
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Quota kg						39,500	39,500	28,500	35,000	35,000	35,000
Catch kg	25,169	29,719	36,244	50,864	57,113	44,582	57,311	43,138	35,646	30,197	16,961

Table 3a. Estimated catch at age for Tikkoatokak - Nain Bay stock of Arctic charr, 1977-84. Numbers have been adjusted to account for losses of Tikkoatokak charr in the offshore fishing areas of Dog Island and Black Island.

Age	1977	1978	1979	1980	1981	1982	1983	1984
6	1,799	217	308	0	104	108	95	19
7	8,163	4,133	3,008	671	814	428	794	812
8	8,786	10,441	8,870	9,960	4,441	2,929	2,535	1,569
9	5,120	6,525	6,479	12,542	10,555	5,042	3,560	2,552
10	2,630	3,698	2,237	6,397	6,786	6,098	3,097	2,412
11	969	2,030	926	2,520	2,006	2,891	3,030	1,044
12	484	1,450	926	479	266	1,348	1,932	582
13	139	217	155	347	99	116	488	123
14	70	217	155	115	13	68	173	25
15		73			47			
16		73						
17				15				
Total	28,160	29,074	23,064	33,046	25,131	19,028	15,704	9,138

Table 3b. Estimated catch at age and catch per unit effort at age for Tikkoatokak Bay Arctic charr, 1977-84.

Age	1977	1978	1979	1980	1981	1982	1983	1984
6	1,365	209	257	0	67	86	51	9
7	6,197	3,973	2,508	489	522	339	425	389
8	6,670	10,037	7,395	7,260	2,850	2,321	1,356	752
9	3,887	6,273	5,402	9,143	6,774	3,996	1,905	1,223
10	1,996	3,555	1,865	4,663	4,355	4,833	1,657	1,156
11	735	1,951	772	1,837	1,287	2,291	1,621	500
12	368	1,394	772	349	171	1,068	1,034	279
13	105	209	129	253	64	92	261	59
14	53	209	129	84	8	54	93	12
15		70			30			
16		70						
17				11				
Total	21,376	27,950	19,229	24,089	16,128	15,080	8,403	4,379
Effort	94	147	108	130	80	75	65	43

Paloheimo total mortality rates

1979-80	1980-81	1981-82	1982-83	1983-84
= 0.40	= 0.52	= 0.35	= 0.82	= 0.76

$$z = \ln \frac{\sum_{10}^{14} C/E_i + 1}{\sum_{9}^{13} C/E_i}$$

Average z = 0.57
1979-80 to 1983-84

Table 4. Summary of weight at age and partial recruitment rates for Tikkoatokak Bay Arctic charr.

Age	Weight (kg-round)		Partial recruitment rate
	1974, 1977-78	1982-84	
6	0.85	1.25	0.04
7	1.31	1.38	0.18
8	1.66	1.74	0.66
9	1.95	2.07	0.99
10	2.17	2.02	1.00
11	2.35	2.00	1.00
12	2.53	2.12	1.00
13	3.27	2.14	1.00
14	2.85	2.17	1.00
15	2.58		1.00

Table 5. 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 | | Ratio A/B | Partial recruitment |
	Tikkoatokak (A) 1978-81	Fraser River (B) 1975-79		
6	0.6	9.1	0.07	0.04
7	8.0	24.9	0.32	0.18
8	31.0	26.8	1.16	0.66
9	32.4	18.4	1.76	0.99
10	17.0	9.6	1.77	1.00
11	6.7	5.2	1.29	1.00
12	2.9	4.6	0.63	1.00
13	0.8	0.5	1.60	1.00
14	0.5	0.7	0.71	1.00
15	0.1	0.6	0.17	1.00

Table 6. Results of regressions of F on effort and population biomass on catch per unit effort for terminal fishing mortalities (F$_T$) of 0.2 - 0.5.

Regression	Parameter	F$_T$					
		0.20	0.25	0.30	0.35	0.40	0.50
F (weighted age 10+ on effort)							
1977-82	r	0.59	0.54	0.50	0.46	0.43	0.39
1977-83	r	0.57	0.43	0.30	0.19	0.10	0.04
9+ biomass on CPUE of 9+ fish							
1977-83	r	0.91	0.84	0.76	0.68	0.61	0.50
	residual from predicted 1984 age 9+ biomass and 1984 cohort 9+ biomass	-17,294	-4,896	+3,294	+9,197	+13,585	+19,760

Table 7. Projection of available catch for the Tikkoatokak - Nain Bay Arctic charr stock for 1985-87 from a cohort analysis run with F_T = 0.4.

POPULATION NUMBERS   1/ 3/85

	1984	1985	1986	1987
6	34354	34354	34354	34354
7	12001	28110	27680	27680
8	7428	9813	21415	21000
9	8556	4670	6170	13465
10	8019	4714	2573	3400
11	3471	4401	2607	1412
12	1935	1905	2415	1420
13	409	1062	1045	1326
14	37	224	583	574
6+	77009	89254	98024	114719
7+	42735	54900	64470	78365
8+	29854	26790	36790	42605
9+	22426	16977	15374	21597

POPULATION BIOMASS (AVERAGE)   1/ 3/85

	1984	1985	1986	1987
6	38909.29	38621.35	38621.35	38621.35
7	15563.33	33963.02	33444.35	33444.35
8	10340.74	13661.66	29813.10	29357.00
9	13340.89	7203.07	9622.07	20997.72
10	12241.23	7196.86	3928.42	5198.06
11	5220.30	6610.88	3898.92	2124.16
12	3804.81	3836.90	3858.47	2263.58
13	650.21	1708.90	1682.41	2133.12
14	41.44	366.31	951.86	936.27
6+	99400.25	112456.23	125804.14	135868.26
7+	60490.95	73834.88	87182.78	96446.91
8+	44927.62	39871.66	53738.44	63082.57
9+	34586.88	26210.21	23925.34	33644.77

CATCH BIOMASS   1/ 3/85

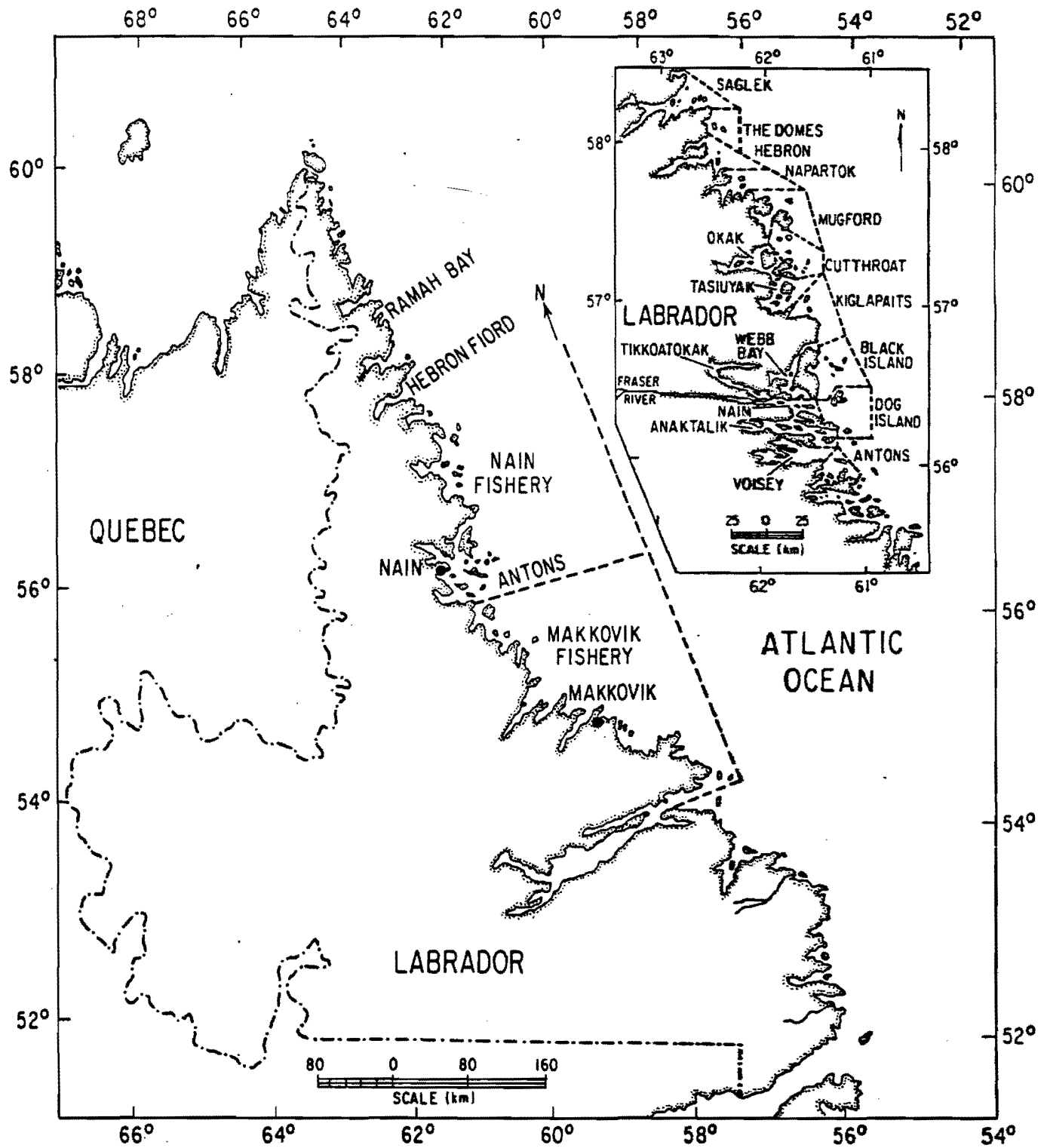|	1984	1985	1986	1987
6	24	610	610	610
7	1121	2445	2400	2400
8	2730	3607	7871	7750
9	5203	2804	3810	8315
10	4096	2870	1571	2076
11	2100	2648	1556	850
12	1234	1215	1540	905
13	263	684	673	853
14	54	147	300	378
6+	17693	17126	20420	24150
7+	17669	16507	19810	23532
8+	16548	14062	17402	21124
9+	13818	10455	9632	13374

Fig. 1. Location of the Nain and Makkovik Arctic charr commercial fishing regions in northern Labrador. Insert illustrates the fishing area breakdown within the Nain fishing region.
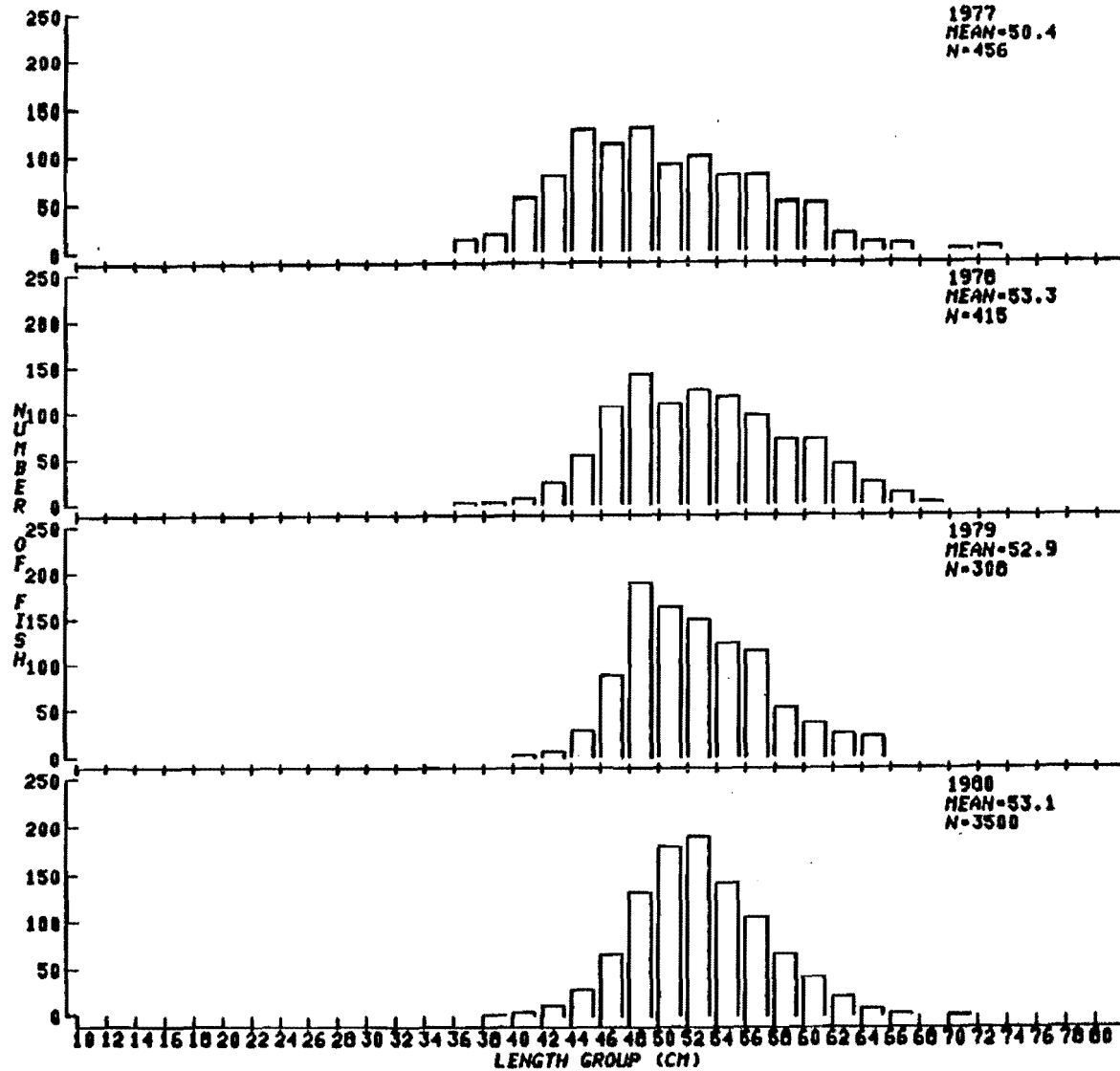
TIKKOATOKAK BAY 1977 - 1980

1977
MEAN=50.4
N=456

1978
MEAN=53.3
N=415

1979
MEAN=52.9
N=308

1980
MEAN=53.1
N=3580

NUMBER OF FISH

LENGTH GROUP (CM)

Fig. 2. Length-frequency distributions (numbers per 1000) of Arctic charr landings from Tikkoatokak Bay, 1977-84.
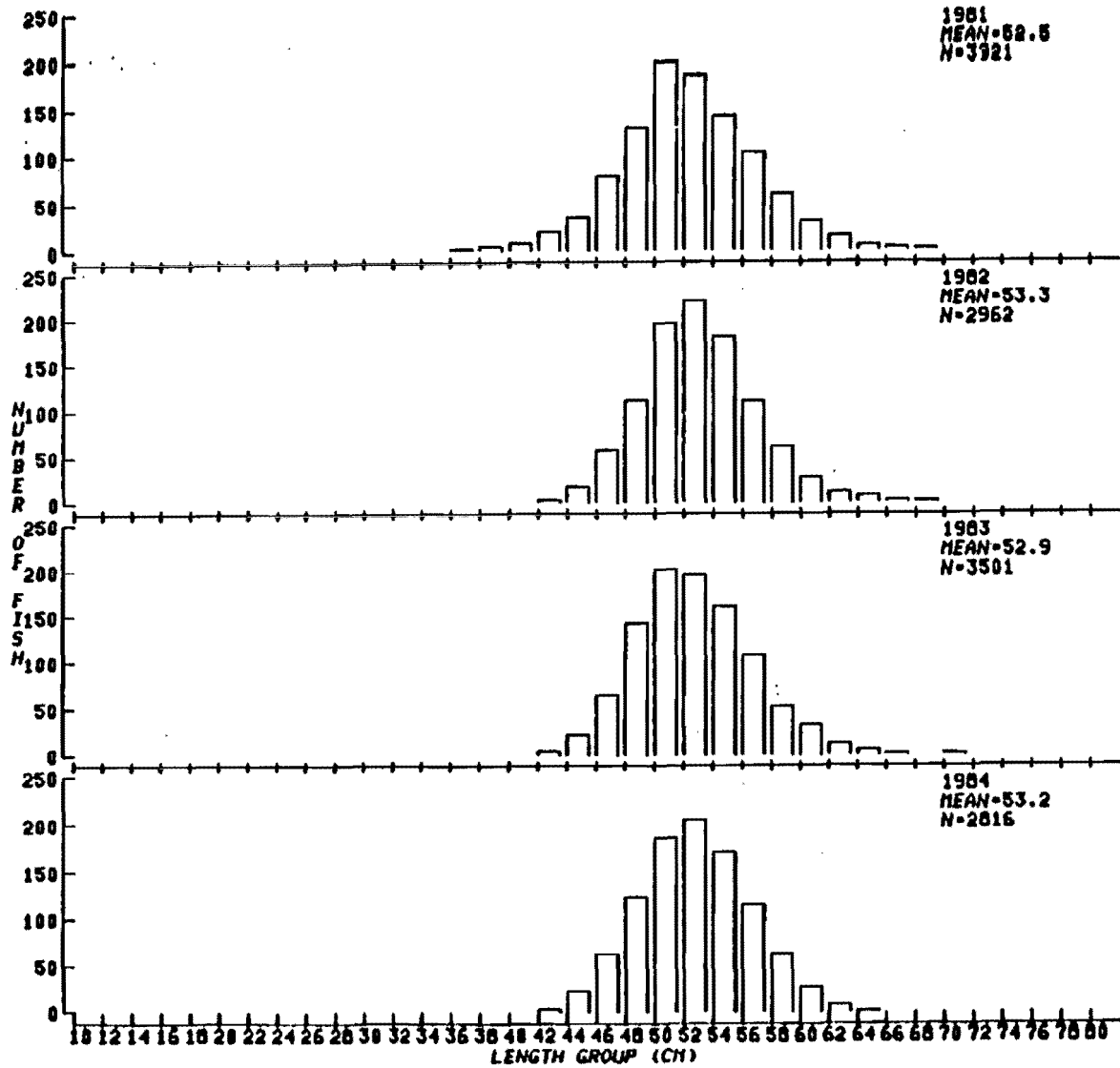
TIKKOATOKAK BAY 1981 - 1984

Fig. 2 (cont'd)