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Assessment of the Tikkoatokak - Nain Bay Arctic charr stock in 1983 and projections for 1984

by

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Abstract

Owing to increased catches of Arctic charr in the offshore fishing areas of Dog Island and Black Island, a method was developed to account for the additional exploitation of the Tikkoatokak-Nain Bay Arctic charr stock in this region. A cohort analysis was performed on the adjusted catch at age data using information from 1977 to 1983. A stock projection using population numbers generated from a terminal fishing mortality in 1983 of 0.3 indicated an $F_{0.1}$ yield in 1984 of 34 t.

Résumé

En raison de l'augmentation des prises d'omble chevalier dans les pêcheries au large des îles Dog et Black, une méthode a été mise au point pour prendre en compte l'exploitation supplémentaire de la population d'omble chevalier des baies Tikkoatokak et Nain dans cette région. Une analyse des cohortes a été effectuée sur les données rajustées des prises par âge, à l'aide d'informations recueillies de 1977 à 1983. Une projection de stock faisant appel à des chiffres de population tirés d'une mortalité par pêche de dernière année de 0,3 en 1983 révélait un rendement à $F_{0,1}$ de 34 t en 1984.

Introduction

The 1983 commercial fishing season marked the tenth year in which catch statistics have been available from individual fishing areas for the northern Labrador Arctic charr fishery. From 1975-80 Tikkoatokak Bay (Fig. 1) had been one of the most important charr producing areas with average annual catches of 39 t. Quota management of the Arctic charr stock in this bay began in 1979. From 1979-81 the quota in this area was obtained but landings in 1982 were 19% below the allocated quota of 35 t (Dempson and LeDrew, 1983). The expansion of the northern Labrador charr fishery north of the Napartok Bay area in 1981 and 1982 effectively redistributed fishing effort away from the local Nain area and was largely responsible for the quota not being obtained in 1982.

For the 1983 commercial fishing season the quota for Tikkoatokak Bay was maintained at 35 t. This paper examines the results of the 1983 fishery and provides an outlook for 1984.

Tagging studies

Again in 1983 Arctic charr were tagged during the period of their outward spring migration (May 25-30) in Nain Bay and Tikkoatokak Bay. These data were used to derive an estimate of within season exploitation rate and fishing mortality.

Stock assessment

Catch and effort data

Catch and effort data for the Tikkoatokak Bay Arctic charr fishery are summarized in Table 1 for 1974-83. During this ten year period, the highest catch of 55 t occurred in 1978 and the lowest catch of 10 t in 1974. Landings in 1983 totalled 16 t and were 43% lower than in 1982. Catch per unit effort declined by 34% suggesting a lower abundance of charr within Tikkoatokak Bay itself during 1983. From 1974 to 1982 catch per unit effort has remained relatively constant at 367 kg per man-week (C.V. = 7.4%).

Catches of Arctic charr in the offshore areas of Dog Island and Black Island have been increasing over the past several years while the catches from the three major inshore areas of Tikkoatokak Bay, Anaktalik Bay and Voisey Bay have been declining. The average percentage of offshore catch to inshore catch has increased from 10% for 1974-79 to 44% for 1980-83. Expressing this in another way indicates that for every charr caught offshore from 1974-79, 10.3 were caught inshore. For the period 1980-83 for every charr caught offshore, only 2.3 were caught inshore and this dropped to 1.2 for 1983 fishery.

Tagging studies have shown that the offshore area is largely composed of a composite of stocks from the inner bay areas (Dempson, 1982a). However, assessments of these latter stocks have not considered the exploitation of their fish in the offshore region. Similarly, while the Nain Bay stock has been considered as part of the same stock complex as Tikkoatokak Bay (Dempson, 1982a) it has generally been omitted from any of the analyses for the Tikkoatokak area.

In an attempt to rectify this problem and provide a more reasonable account for the total exploitation on the Tikkoatokak-Nain stock as well as Voisey Bay and Anaktalik Bay stocks, catches from the offshore region have been apportioned back into the inshore area catches.

We consider the following situation. There are three stock areas (Tikkoatokak-Nain, Voisey, and Anaktalik) which we shall label j and there are data from 10 years which are labelled i. There are local fisheries which fish only the local inshore stocks. The catch in each local area is denoted as y_{ij}. There is also an offshore fishery which catches fish from all local stocks. It is known that the total proportion of offshore catch to inshore catch varies from year to year. In order to estimate the amount of the offshore catch that originates from each of the inshore stock areas with the available data on hand, the following assumptions are made:

1. the proportion of the fish offshore that originate from each of the inshore stock areas remains constant;

2. the proportion of offshore catch originating from areas other than the three inshore stock areas is assumed to be a constant 20%;

3. catches reflect relative abundance of charr stocks in inshore areas.

Let the offshore catch that originates from area j in year i be Z_{ij}. Under the above assumptions we can write this term as

$$Z_{ij} = a_i \times b_j \times y_{ij} \tag{1}$$

where a_i is an index specifying the relative offshore to inshore catch ratio in year i, and b_j is the ratio of the offshore catch which originates from the inshore j areas.

We can estimate b_j from tagging studies. The total offshore catch in any year is known, we shall call it Z_i. We can estimate a_i and Z_{ij} for all years where

$$a_i = \frac{0.8\ Z_i}{\sum_j b_j \times y_{ij}}, \tag{2}$$

recalling the assumption that 20% of the catch in the offshore area originates from areas other than the three major inner bays.

The new adjusted catch from any stock in any year (C_{ij}), therefore, is:

$$C_{ij} = Z_{ij} + y_{ij}. \tag{3}$$

In an ideal situation 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, $b_1 = 0.0625$, $b_2 = 0.4286$, and $b_3 = 0.4554$ 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 four years.

Table 2 summarizes the catch data for the adjusted Tikkoatokak-Nain stock. Tagging data from both Nain Bay and Tikkoatokak Bay were used in deriving an estimate of b_j for this stock area. From the adjusted catches in Table 2 it can be seen that the quota for Tikkoatokak has been reached or exceeded every year except 1983. These quotas, however, were derived for the Tikkoatokak Bay area alone and were not based on adjustments for offshore area catches.

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.

Weights at age were calculated from commercial samples (1974, 1977-78 for yield per recruit analysis, and 1982-83 for stock projections) and were converted from gutted head-on to whole weight using the conversion factor 1.24 (Coady and Best, 1976) (Table 4).

Partial recruitment rates were calculated using Fraser River counting fence data as an index of the population. The percent at age in the Tikkoatokak Bay 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 1982-83 was 0.52. Assuming a natural mortality rate of 0.2 would yield fishing mortality rate of 0.32.

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 returns by R/M (111/426);

$$\mu = 0.26 \text{ (95\% C.L. = 0.22 - 0.31).}$$

Rate of fishing mortality was 0.30 (95% C.L. = 0.25 - 0.37).

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 at a yield per recruit of 0.84 kg.

Cohort analyses were performed using a range of terminal fishing mortality rates (F_T) from 0.3 to 0.6. Regressions of F on effort (Table 6) and population biomass of 9+ fish on catch per unit effort of 9+ fish, which were calculated in order to determine the most appropriate value for F_T, produced the highest r^2 values at an F_T of 0.3.

A projection was run using 1983 population numbers from cohort analysis with $F_T = 0.3$. Recruitment estimate for the projection was calculated from the geometric mean of age six population numbers for the years 1977-81. Weight at age for the projection were based on 1982-83 data.

The result of the projection is shown in Table 7. Fishing at $F_{0.1}$ indicates a catch of 34 t round weight is available in 1984.

Discussion

Previous assessments have not considered the exploitation of the Tikkoatokak-Nain Bay charr stock in the offshore island areas of Dog Island and Black Island. Ideally, estimates of the proportion of offshore catch that originates from each inshore stock should be obtained annually. This would require a large annual tagging program. Nevertheless, the constant proportions used in this assessment to allocate offshore catches both into the inner bays are the best values available at the present time and they are useful in providing a more complete account of losses due to fishing in both offshore and inshore areas.

The $F_{0.1}$ value in this assessment (0.39) was lower than the previous years assessment (0.53) as a result of using a more standard procedure for the calculation of yield per recruit. This included using a longer age range (6-15 years) and previous mean weight at age data (1974, 1977-78). By convention, historical age ranges and weight data should be used in the calculation of yield per recruit (YRP). The effect of using a higher age range reduces the value of $F_{0.1}$ and theoretically allows the stock to rebuild to its former condition. Since an average of less than 1% of the catch since 1977 has been made up of fish 14 years older, the YPR was run only to age 15. Historical data from the commercial fishery during the early 1950's did not have any fish beyond age 13 in the catches for the Nain area (Andrews and Lear, 1956). This would indicate that during the past decade the more intense fishery in the region has not reduced the age span of the population.

Paloheimo z's are subject to variability in effort data influencing catch per unit effort at age estimates. In addition, environmental conditions influencing the catchability of the fish would also impact on the catch per unit effort estimates. The average z during the past several years was 0.52. Assuming a rate of natural mortality of 0.2 yields a rate of fishing mortality of about 0.3 which was similar to the value derived from tag recaptures. A projection for 1984 with $F_T = 0.3$ catches is 34 t. This, however, is the projected available catch for both offshore and inshore regions and is slightly below the long-term projected yield of 36 t (with $F_T = 0.4$ rather than 0.3) for a total offshore and inshore catch (recruits of 42,995 x YPR at $F_{0.1}$ of 0.840 kg).

We can use equations 1 and 3 to apportion the projected available catch of 34 t into offshore and inner bay areas. Combining (1) and (3) and solving for y_{ij} we have:

$$y_{ij} = \frac{C_{ij}}{(\bar{a}_i \times b_j) + 1} \qquad (4)$$

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 3 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 1984 and have arbitrarily chosen an average value for 1979-83 ($\bar{a}$ = 0.7983). With a 1983 terminal fishing mortality estimated at 0.3, the approximated inshore and offshore catches for 1984 would be 25176 kg and 9152 kg respectively. The range in the catch ratio (a_i), however, could result in a catch distribution of 20-29 t inshore and 5-14 t offshore. Assuming that a fishery will take place in Nain Bay, then the projected inshore available catch would have to be apportioned into Tikkoatokak Bay and Nain Bay accordingly.

The time series of data is still relatively short and, therefore, subject to errors particularly in the derivation of terminal fishing mortalities. Continued commercial sampling over the next several years will aid in both the interpretation and reliability of the analyses.

Examination of the length-frequency distribution of Tikkoatokak Bay catches over a period of 8 years indicates that the bulk of the catch has remained within the 48-56 cm length class (Fig. 2). There is no major shift in the size distribution resulting from commecial exploitation. The mean length of 52.5 cm has a coefficient of variation over 8 years of less than 2%.

Sex ratio data (Table 8) indicates that there is a differential sex ratio in favour of females during the month of July and first week of August in the inshore commercial fishing areas. During the month of August the sex ratio changes more to an equal contribution of both sexes. Data from Fraser River (Dempson, 1982b) also indicated that female charr were more abundant than males during the initial part of their upstream migration which began as early as the middle of July. In contrast, sex ratios in the offshore area suggest that there is more of an offshore movement by males than females. Delayed opening of the fishery in the inshore areas may reduce the differential exploitation on the female component allowng increased numbers to escape.

References

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TABLE 1. ARCTIC CHARR CATCH STATISTICS FOR TIKKOATOKAK BAY,1974-1983 ;
SUMMARY OF CATCH, EFFORT,AND SIZE COMPOSITION

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

Table 2. Summary of adjusted catch data for the Tikkoatokak-Nain Bay stock area, 1974-83.

	Year									
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Quota kg						39500	39500	28500	35000	35000
Catch kg	12708	29719	33125	42400	57113	44582	57311	37688	35561	29665

Table 3a. Estimated numbers at age for Tikkoatokak Bay Arctic charr, 1977-83. 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
6	1493	217	308	0	89	108	93
7	6776	4133	3008	671	697	427	778
8	7293	10441	8870	9960	3804	2920	2483
9	4250	6525	6479	12542	9042	5027	3488
10	2183	3698	2237	6397	5813	6080	3034
11	804	2030	926	2520	1718	2882	2968
12	402	1450	926	479	228	1344	1893
13	115	217	155	347	85	116	478
14	58	217	155	115	11	68	170
15		73			40		
16		73					
17				15			
Total	23374	29074	23064	33046	21529	18972	15384

Table 3b. Estimated numbers at age and catch per unit effort at age for Tikkoatokak Bay Arctic charr, 1977-83.

Age	1977	1978	1979	1980	1981	1982	1983
6	1365	209	257	0	67	86	51
7	6197	3973	2508	489	522	339	425
8	6670	10037	7395	7260	2850	2321	1356
9	3887	6273	5402	9143	6774	3996	1905
10	1996	3555	1865	4663	4355	4833	1657
11	735	1951	772	1837	1287	2291	1621
12	368	1394	772	349	171	1068	1034
13	105	209	129	253	64	92	261
14	53	209	129	84	8	54	93
15		70			30		
16		70					
17				11			
Total	21376	27950	19229	24089	16128	15080	8403
Effort	94	147	108	130	80	75	65

Paloheimo total mortality rates

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

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

Average z = 0.52
1979-80 to 1982-83

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

	Weight (kg-round)		
Age	1974, 1977-78	1982-83	Partial recruitment rate
6	0.85	1.44	0.04
7	1.31	1.45	0.18
8	1.66	1.80	0.66
9	1.95	2.08	0.99
10	2.17	1.99	1.00
11	2.35	2.04	1.00
12	2.53	2.15	1.00
13	3.27	2.02	1.00
14	2.85	2.10	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: Tikkoatokak (A) 1978-81	Percent at age: Fraser River (B) 1975-79	Ratio A/B	Partial recruitment
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. Regressions of average F on effort for terminal fishing mortalities of 0.3-0.6, 1977-82. Natural mortality is 0.2.

Year	Effort (man-weeks)	F_T 0.3	0.4	0.5	0.6
1977	94	0.367	0.368	0.368	0.368
1978	147	0.980	0.983	0.986	0.987
1979	108	0.569	0.575	0.578	0.581
1980	130	0.791	0.842	0.875	0.899
1981	80	0.340	0.391	0.429	0.459
1982	75	0.346	0.423	0.488	0.544
1983	65	0.300	0.400	0.500	0.600
r^2 (1977-82)		0.962	0.914	0.853	0.788

Table 7. Projection of available catch for the Tikkoatokak-Nain Bay Arctic charr stock in 1984 from cohort analysis run with $F_T = 0.3$.

POPULATION NUMBERS

	1983	1984
6	49591	49591
7	17586	40518
8	15063	13696
9	14903	10097
10	12851	9066
11	12572	7794
12	8018	7625
13	2025	4863
14	283	1228
6+	132892	144479
7+	83301	94888
8+	65715	54370
9+	50652	40674

POPULATION BIOMASS (AVERAGE)

	1983	1984
6	64658.38	64237.59
7	22562.06	51482.50
8	22346.85	19784.37
9	24427.23	15892.23
10	20124.65	13628.37
11	20182.54	12010.97
12	13565.69	12383.99
13	3219.04	7428.39
14	338.67	1948.42
6+	191425.10	198788.82
7+	126766.73	134551.23
8+	104204.67	83068.73
9+	81857.82	63284.36

CATCH BIOMASS

	1983	1984
6	134	1002
7	1128	3614
8	4469	5092
9	7255	6136
10	6038	5315
11	6055	4684
12	4070	4830
13	966	2894
14	357	768
6+	30471	34328
7+	30337	33325
8+	29209	25711
9+	24740	24619

Table 8. Summary of sex ratio information from Arctic charr caught in the commercial fishery from inshore and offshore areas.

	% Female Inshore*		% Female offshore
Week	1982	1983	1983
June 25-July 1	60	70	-
July 2-8	65	50	28
9-15	68	58	46
16-22	66	62	36
23-29	66	66	29
July 30-Aug. 5	61	59	-
Aug. 6- 12	57	63	-
13-19	-	47	-
20-26	47	41	37
Aug. 27-Sept. 2	46	21	-
Total	63	59	38
N	3720	6990	661

* 1983 data from Tikkoatokak Bay and Webb Bay.
1982 data from Tikkoatokak Bay only.

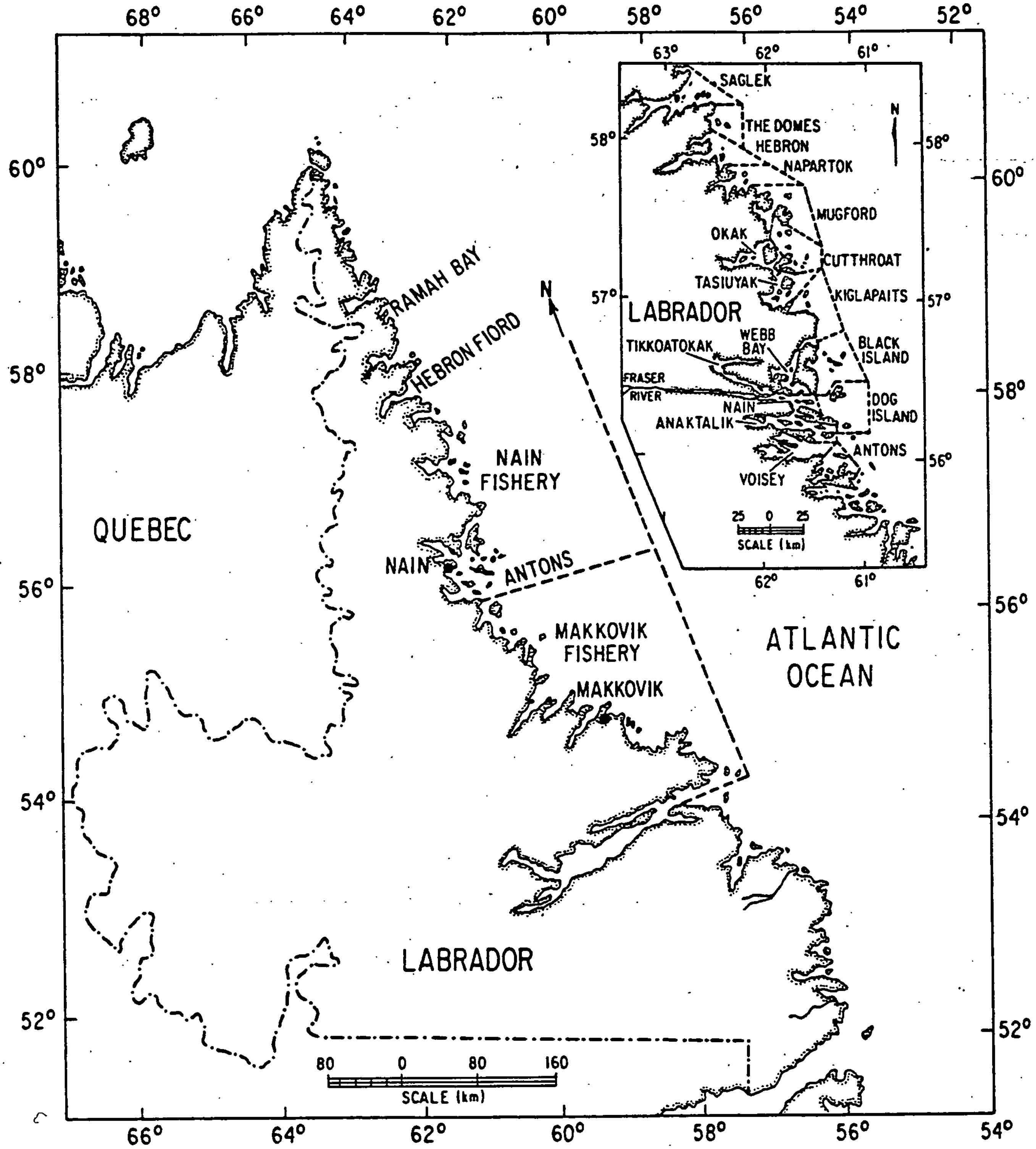

Fig. 1. Location of the Nain and Makkovik Arctic charr commercial fishing regions in northern Labrador. Insert illustrates the fishing area breakdown within the Nain fishing region.

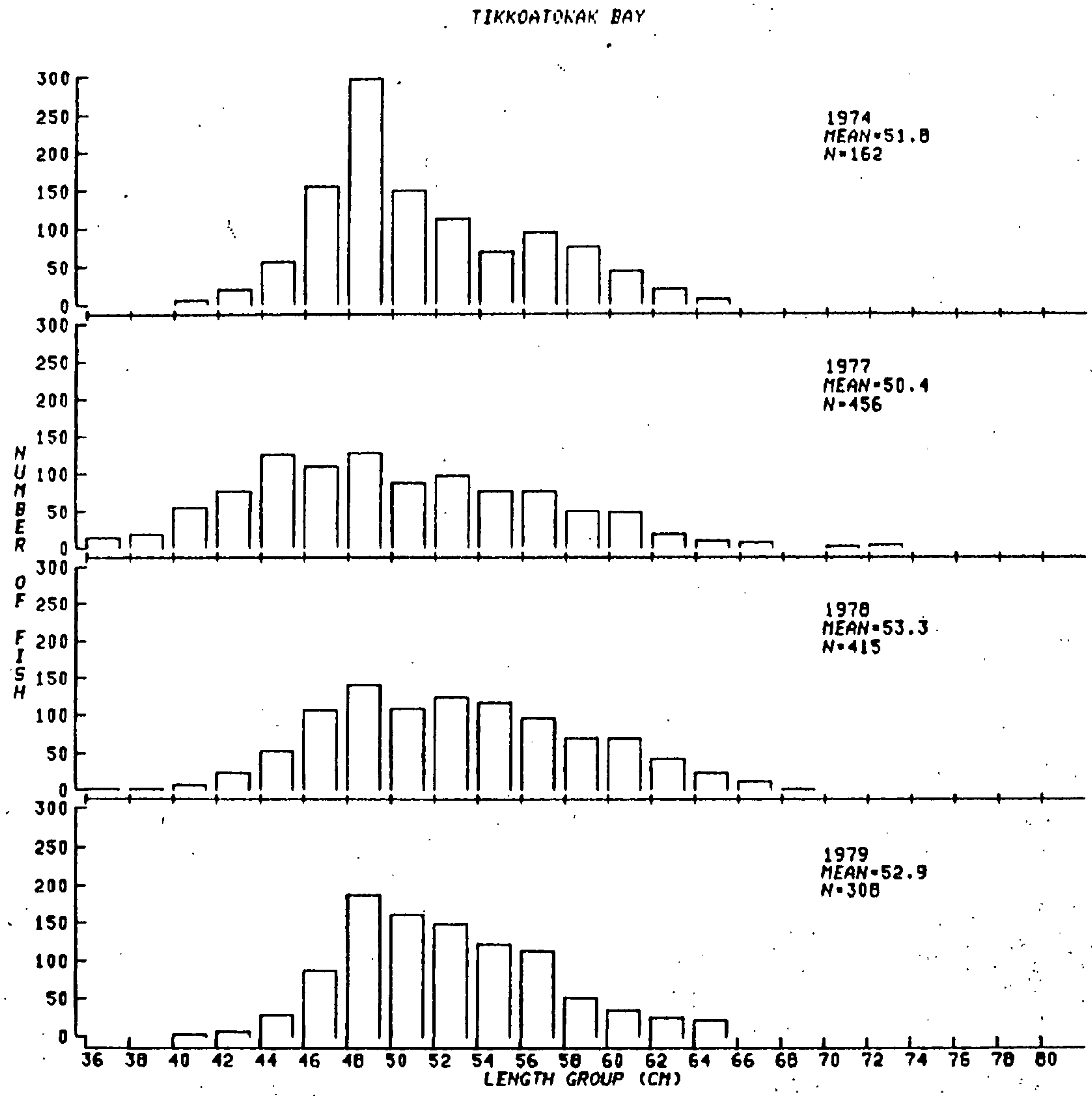

Fig. 2. Length frequency distribution (numbers per 1000) of Arctic charr catches in Tikkoatokak Bay, 1974, 1977–83.

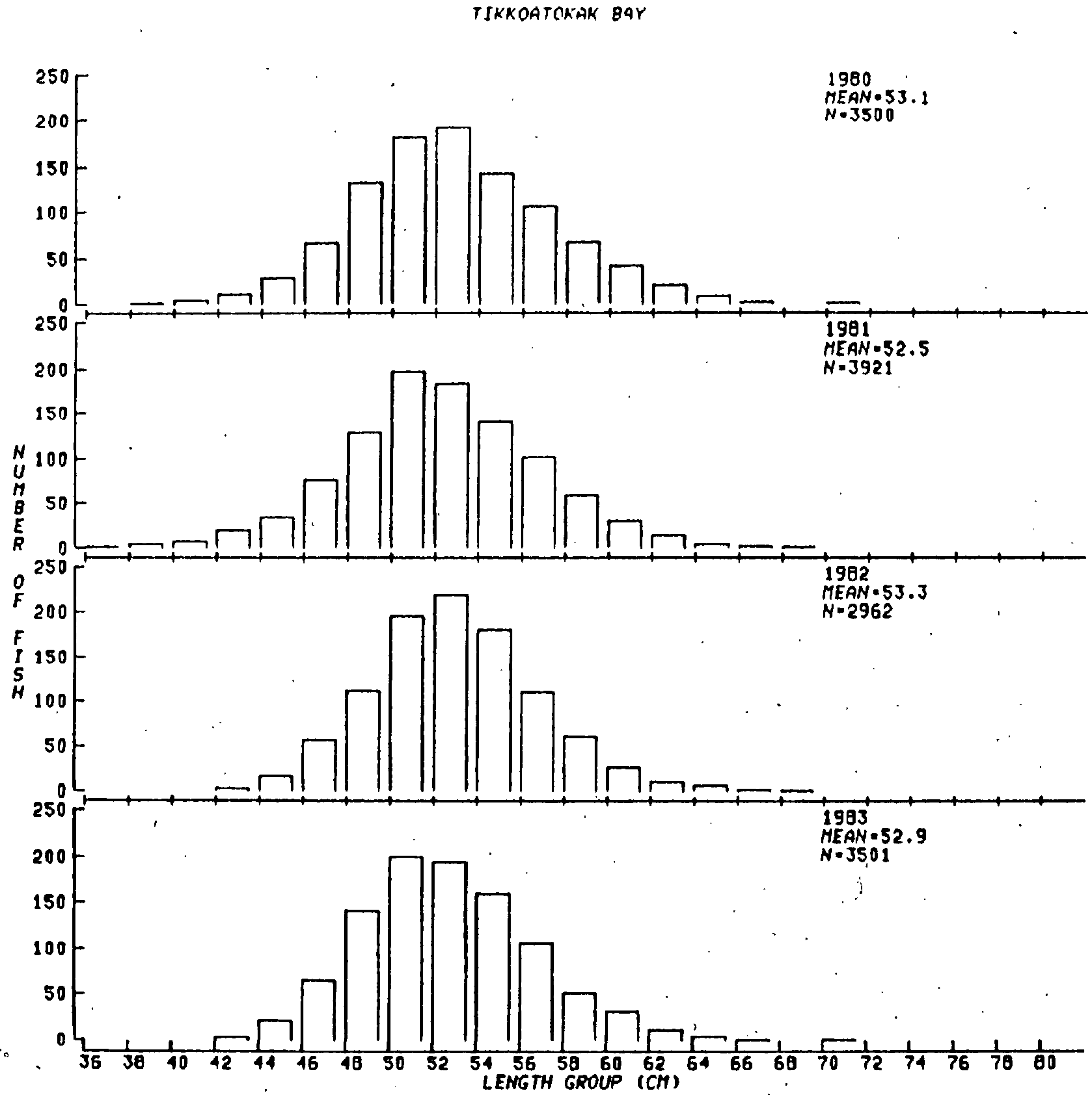
TIKKOATOKAK BAY
1980
MEAN=53.1
N=3500
1981
MEAN=52.5
N=3921
1982
MEAN=53.3
N=2962
1983
MEAN=52.9
N=3501
NUMBER OF FISH
0
50
100
150
200
250
36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74 76 78 80
LENGTH GROUP (CM)

Fig. 2. Cont'd.