Analysis of the Okak Assessment Unit Arctic Charr Population in 1986

by

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Abstract

The Okak assessment unit, made up of Okak Bay and the Cutthroat subareas, was first assessed as a homogeneous unit at the end of the 1985 fishery. Annual landings have ranged from 5 to 76 t (mean 38 t) and from 1977 to 1986 have represented 26% of the total commercial catch of Arctic charr from the Nain Fishing Region. Total allowable catch in 1986 was 42 t. Landings in 1986 were 39 t or 69% of the recommended TAC. Effort decreased by 17% while catch per unit effort was up by 5%. A sequential population analysis was carried out on catch at age data from 1977 to 1986 and suggested a reference level catch in 1987 of 38-50 t.

Résumé

L'unité d'évaluation d'Okak, constituée de la baie d'Okak et des sous-zones de Cutthroat, a été évaluée pour la première fois comme unité homogène à la fin de la saison de pêche de 1985. Les débarquements annuels ont varié de 5 à 76 t (moyenne = 38 t) et, de 1977 à 1986, ils ont constitué 26 % de la pêche commerciale totale de l'omble chevalier pour la zone de pêche de Nain. En 1986, le TPA a été de 42 t, et les débarquements ont été de 39 t, ou 69 % du TPA recommandé. L'effort a diminué de 17 %, tandis que les prises par unité d'effort ont augmenté de 5 %. Une analyse séquentielle de population a été réalisée à partir des données sur les prises par âge de 1977 à 1986 et cette analyse indique un taux de prise de référence de 38-50 t pour 1987.

Introduction

Okak Bay is located approximately 125 km north of the village of Nain, Labrador (Fig. 1). This bay is a major area for the commercial production of Arctic charr along the northern Labrador coast. Catches of Arctic charr are delivered to the fish plant in Nain via a collector boat system. Results of tagging studies indicated that Okak Bay and the offshore area of Cutthroat were a single unit (Dempson et al. 1986). This was first assessed as such after the 1985 fishery. Catch statistics for the Okak assessment unit have been available since 1974 (Table 1). Annual landings have ranged from 5 to 76 t (mean = 38 t) and from 1977 to 1986 have represented 26% of the total commercial catch of Arctic charr from the Nain Fishing Region. Quotas were first applied to Okak Bay itself in 1981, while a TAC of 42 t was recommended for the Okak assessment unit for 1986. This paper summarizes the results of the 1986 fishery and provides a forecast of available harvest or 'reference level' catch for 1987 based upon the results of a sequential population analysis.

Stock Assessment

Catch and effort data are summarized in Table 1 for 1974-86. Landings in 1986 totaled 29 t and were 13% lower than in the previous year. This was approximately 69% of the TAC. Effort decreased by 17% while catch per unit effort (CUE) was up by 5%. The quota area catch column in Table 1 refers to the subarea specifically under quota restriction only (Okak Bay) prior to the formation of the assessment unit in 1986.

Numbers at age were available since 1977 and are summarized in Table 2. Data were derived from annual commercial sampling programs. Mean age of the catch has varied from 9.1 to 12.1 years with a slight decrease during the past several years. From 1977 to 1986, 52% of the catch has been made up to 9- to 11-year-old fish while fish aged 12 and above have represented 21% of the catch.

Weights at age were calculated from commercial samples obtained from 1977 to 1986. Gutted head-on was 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. For stock projections mean weight at age for the period 1984-86 was used (Table 3).

Mean weight at age for the Okak assessment unit has also decreased over time. For 7- to 10-year-old Arctic charr the average percentage decrease in weight is 5% (0.08 kg) (average 1977-79 to 1984-86). For 11- to 14-year-old fish the percentage decline in weight is 13% (0.30 kg). Similar to the other stock units, there has been a decline in the proportion of 'large' charr in the commercial catch (fish greater than 2.3 kg gutted head-on weight) over this period of time. Since this trend occurs in three assessment units it is not believed to be a sampling problem as opposed to a selective removal of larger fish by the commercial fishery.

Total mortality (Z) was calculated using the Paloheimo method (Ricker 1975) and the average value for all years (excluding 1983-84) was 0.65. Assuming a natural mortality rate of 0.2 yields an estimate of fishing mortality of 0.45. As in past years there was a considerable amount of variation in the estimates and a catch curve was also used to provide an estimate of Z. Using catch per unit effort at age data from 1984 to 1986 (ages 11-16) a Z of 0.63 was obtained.

An independent estimate of exploitation and fishing mortality, as derived from tag recaptures, was obtained for the first time for this assessment unit where:

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

Assuming a value of 10% for an estimate of tagging mortality, tag loss and non-reporting of tags results in a value of μ of

$$\mu = \frac{39}{98} = 0.398.$$

Tag loss is believed to be minimal given the short period of time between tagging in the spring and the duration of fishery (two to three months). Nonreporting of tags is also believed to be minimal. Fisheries and Oceans staff have been present at the Nain Fish Plant for the duration of the fishery each year since 1977. This has ensured a good cooperation with fishermen regarding reporting of tags, and prompt reward payment for their return.

Rate of fishing mortality was calculated to be 0.51 (95% C.L. = 0.34 - 0.79). The number of tags applied was only about one-quarter of the number applied in the Nain assessment unit.

An initial cohort analysis was run using partial recruitment values and terminal fishing mortality (F_T) from last year's assessment (Dempson and LeDrew 1986) ($F_T = 0.45$). An iterative procedure was used to obtain estimates of fishing mortality for the oldest age group (F_B) (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 a matrix of fishing mortality rates generated from the last sequential population analysis (SPA) 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 0.43 at a yield per recruit of 0.74 kg. This $F_{0.1}$ value was rounded to 0.4 for conformity with other assessment units.

Cohort analyses were performed using a range of terminal fishing mortality rates from 0.2 to 0.6 using the newly-derived estimates of partial recruitment. 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 effort and population biomass on catch per unit effort of fully-recruited fish were used in tuning the analysis to determine an appropriate value for F_T in 1986. Data from 1977 to 1986 (excluding 1984) were included in the regression analysis.

Regressions of F on effort showed a decrease in the correlation coefficient with an increase in F_T (Table 4). The distance of the last point (1986) to the regression line was lowest when F_T = 0.4-0.5. The intercept value was lowest when F_T = 0.35 and the residuals for the last two years were smallest when F_T was 0.35 or less.

The regressions of population biomass on CUE had the highest correlation at F_T = 0.25. Residuals were also lowest when F_T = 0.25.

In summary, regression analyses suggested a value of F_T from 0.25 to 0.45 while the Paloheimo, catch curve, and tagging results suggested an average value of around 0.45. Dropping the lowest and highest values indicated F_T may range between 0.3 and 0.4.

Stock projections were run for a series of terminal fishing mortalities ranging from 0.30 to 0.40. Recruitment for the projections was estimated from the geometric mean of population numbers for age 6- and 7-year-old charr. Weights at age were based on 1984-86 data. Table 5 summarizes the population numbers and fishing mortality matrix for the cohort analysis run with F_T = 0.40.

Results of the projections are summarized in Table 6. The 'reference level' catch in 1987 ranges from 38 to 50 t with the highest value occurring with F_T = 0.30. The 1986 TAC was 42 t while the average catch during the past five years has been 33 t. Given that effort decreased in 1986 and that there has not been any consistent change in age structure of the population, it is suggested that the 1986 'reference level' catch of 42 t remain in effect for 1987.

References

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Table 1. Summary of catch and effort statistics for the Okak assessment unit, 1974-86. Quotas and landings are in kg-round weight, effort is expressed as man-weeks fished.

Year	Quota	Quota area catch	Landings	Effort	CUE
1974			46,891		
1975			5,057		
1976			25,338	148	171
1977			42,392	243	174
1978			76,024	352	216
1979			43,261	283	153
1980			49,035	253	194
1981	27,300	11,049	47,541	202	235
1982	27,300	9,031	34,171	186	184
1983	21,000	30,732	48,978	286	171
1984	27,000	13,864	18,146	94	193
1985	27,000	24,746	33,261	208	160
1986	42,000		28,896	172	168

TABLE 2. ESTIMATED CATCH AT AGE FOR ARCTIC CHARR FROM THE OKAK STOCK UNIT, 1977-86.

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
6	84	205	1	130	39	93	475	251	17	41
7	139	2465	1989	638	526	713	1762	1371	2675	2056
8	417	8163	7462	5631	2135	2760	4471	2336	4948	6333
9	1084	5494	4997	9175	7166	4167	5787	2151	5385	5197
10	2667	5594	3299	6487	7615	3848	5601	1850	2740	3291
11	3388	3747	1954	2863	4673	3622	5169	2211	2936	1261
12	5417	3953	878	1382	1330	1542	4075	1472	987	875
13	2278	2773	761	407	1044	444	1643	1180	740	562
14	1694	514	527	350	459	342	658	587	768	148
15	1472	1027	410	262	359	183	307	219	103	170
16	832	308	351	90	44	57	107	127	75	8
17	139	411	234	129	145	38	11	12	50	1
18	139	103	95	33	48	15	43	1	6	72
19	139	117	138	61	132	1	63	35	56	1
TOTAL	19889	34874	23096	27638	25715	17827	30172	13803	21486	20014
MEAN AGE	12.1	10.1	9.6	9.6	10.2	9.9	10.1	10.1	9.5	9.1

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

Age	Weight		Partial recruitment
	1977-79	1984-86	
6	1.21	1.14	0.005
7	1.48	1.31	0.067
8	1.66	1.60	0.317
9	1.85	1.78	0.553
10	1.98	1.98	0.772
11	2.02	1.87	1.0
12	2.36	2.06	1.0
13	2.30	1.93	1.0
14	2.38	2.00	1.0
15	2.48	1.92	1.0
16	2.30	1.96	1.0
17	2.30	1.96	1.0
18	2.30	1.96	1.0
19	2.30	1.96	1.0

$F_{0.1}$ = 0.43 at a Y/R of 0.74 kg.

Table 4. Results of regressions of F on effort and population biomass on catch per unit effort for various terminal fishing mortality rates (F_T) for the Okak assessment unit.

Regression	Parameter	Terminal F 0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.6
F (weighted mean for fully-recruited fish) on effort						NS			
	r	0.78	0.78	0.73	0.69	0.64	0.59	0.53	0.41
	residual - 1986	-0.10	-0.06	-0.06	-0.04	-0.02	0.01	0.03	0.08
	normalized	-0.19	-0.12	-0.11	-0.07	-0.03	0.01	0.05	0.14
	intercept	-0.18	-0.16	-0.06	0.01	0.06	0.12	0.17	0.28
	normalized	-0.37	-0.32	-0.10	0.01	0.11	0.21	0.30	0.46
	Σ residuals (1985-86)	-0.10	-0.10	0.02	0.07	0.13	0.18	0.23	0.32
	Σ (residuals)^2 (1985-86)	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.06
Population biomass (fully-recruited fish) on CUE									
	r	0.88	0.91	0.90	0.90	0.89	0.89	0.88	0.88
	residual (t) - 1986	4	1	-1	-3	-4	-5	-6	-7
	normalized	0.11	0.02	-0.04	-0.09	-0.13	-0.16	-0.19	-0.23
	intercept (t)	17	13	11	9	7	6	5	4
	normalized	0.48	0.39	0.32	0.27	0.23	0.20	0.18	0.14
	Σ residuals (1985-86)	3	-3	-6	-9	-11	-13	-14	-16
	Σ (residuals)^2 (1985-86)	18	12	27	46	64	82	97	123

Table 5. Summary of the population numbers and fishing mortality matrix for the cohort analysis run with F_T = 0.40 on the catch at age data for the Okak assessment unit Arctic charr population.

POPULATION NUMBERS

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
6	91674	62774	44390	40086	30844	47422	63033	91105	103982	22640
7	57985	74980	51209	36343	32702	25217	38742	51177	74363	85118
8	27513	47348	59158	40127	29178	26298	20001	30125	40660	58463
9	21766	22149	31379	41683	27758	21957	19034	12330	22550	28812
10	12439	16840	13163	21170	25825	16242	14206	10347	8149	13590
11	12507	7771	8726	7792	11463	14253	9816	6563	6798	4192
12	11699	7174	2972	5376	3789	5156	8392	3360	3373	2909
13	4730	4677	2297	1639	3151	1898	2826	3184	1419	1868
14	4219	1811	1320	1192	974	1635	1153	827	1539	492
15	2892	1922	1018	604	659	382	1029	348	146	565
16	1794	1036	644	462	257	215	147	565	87	27
17	604	716	569	210	297	171	124	24	348	3
18	332	368	214	254	55	112	106	92	8	239
19	187	146	208	90	178	2	78	47	74	1
6+	250342	249712	217269	197027	167130	160962	178688	210094	263495	218920
7+	158668	186939	172878	156941	136286	113540	115655	118989	159514	196280
8+	100683	111958	121669	120598	103584	88322	76914	67812	85151	111163
9+	73170	64610	62511	80471	74406	62024	56912	37688	44491	52700

FISHING MORTALITY

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
6	0.001	0.004	0.000	0.004	0.001	0.002	0.008	0.003	0.000	0.002
7	0.003	0.037	0.044	0.020	0.018	0.032	0.052	0.030	0.041	0.027
8	0.017	0.211	0.150	0.169	0.084	0.123	0.284	0.090	0.144	0.127
9	0.057	0.320	0.194	0.279	0.336	0.235	0.409	0.214	0.306	0.221
10	0.270	0.457	0.324	0.413	0.394	0.304	0.572	0.220	0.465	0.309
11	0.356	0.761	0.284	0.521	0.599	0.330	0.872	0.466	0.649	0.400
12	0.717	0.939	0.395	0.334	0.491	0.401	0.769	0.662	0.391	0.400
13	0.760	1.065	0.456	0.321	0.456	0.299	1.028	0.527	0.859	0.400
14	0.586	0.376	0.582	0.392	0.736	0.263	0.997	1.533	0.802	0.400
15	0.827	0.893	0.589	0.653	0.921	0.755	0.400	1.188	1.505	0.400
16	0.719	0.398	0.922	0.242	0.209	0.347	1.633	0.286	3.064	0.400
17	0.294	1.006	0.606	1.139	0.775	0.282	0.103	0.830	0.173	0.400
18	0.622	0.370	0.673	0.155	3.347	0.160	0.598	0.012	1.560	0.400
19	0.576	0.814	0.392	0.427	0.569	0.342	0.827	0.560	0.610	0.400
11+	0.592	0.836	0.403	0.435	0.579	0.344	0.839	0.590	0.637	0.400

Table 6. Summary of projected reference level catch (t) for 1987 and 1988 with F_T in 1986 varying from 0.35 to 0.45.

Reference level catch	F_T in 1986		
	0.35	0.40	0.45
1987	43.1	38.0	34.0
1988	44.3	39.8	36.3

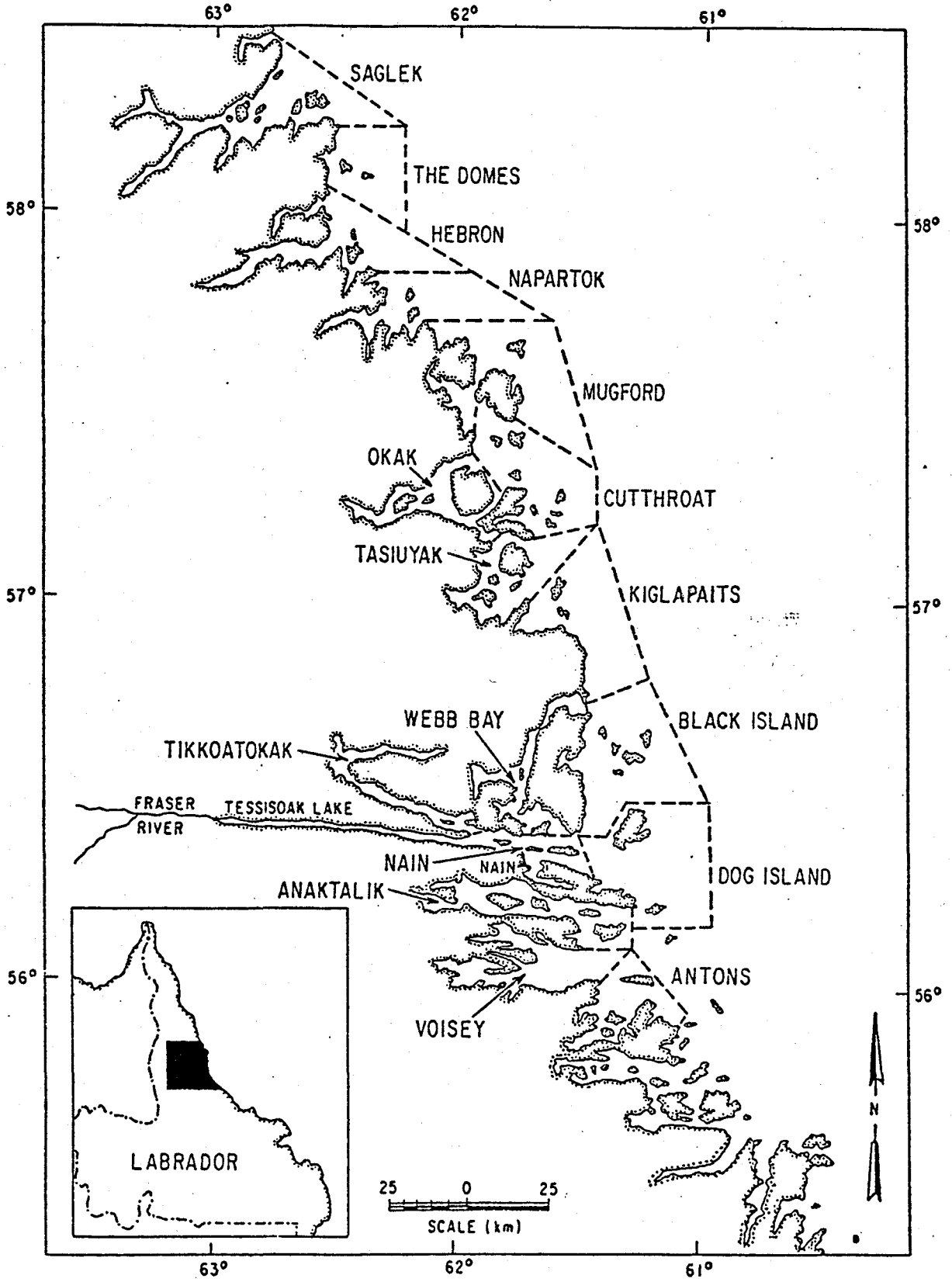

Fig. 1. Geographic separation of Nain Fishing Region subareas.