Assessment of the Voisey stock unit Arctic charr population in 1990

by

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Abstract

Reported landings of Arctic charr from the Voisey assessment unit totaled 20 t in 1990, an increase of 81% over 1989 and was similar to the long-term mean catch for this stock unit. A large increase in effort was largely responsible for the increased catch. The Voisey unit has contributed 16% of the commercial catch of Arctic charr from the Nain fishing region over the period 1977-90. Catch at age data from the 1990 fishery indicated that the 1981 and 1982 year-classes were the most abundant representing 53% of the catch in numbers of fish. Standardized catch rates, derived using a multiplicative model, were used in an age disaggregated formulation of ADAPT to estimate fishing mortality and stock size in 1990. The assessment indicated that fully recruited fishing mortality (age 9+ fish) was about 0.47 and that the estimated population size was about 74,500 fish. The projected reference level catch for 1991 ($F_{0.1}$ = 0.4) was similar to the current TAC for the Voisey unit of 17 t.

Résumé

Les débarquements déclarés d'omble chevalier provenant de l'unité d'évaluation de la baie Voisey ont atteint 20 t en 1990, résultat qui représentait une augmentation de 81 % par rapport à 1989 et qui était comparable à la moyenne des prises à long terme dans cette unité. L'accroissement des prises était imputable en grande partie à une intensification marquée de l'effort. Les prises commerciales d'omble chevalier en provenance de l'unité de la baie Voisey ont représenté 16 % des prises commerciales totales d'omble chevalier de la baie Nain de 1977 à 1990. Les données sur les prises selon l'âge en 1990 révèlent que les classes d'âge de 1981 et 1982 étaient les plus abondantes dans la pêche, représentant 53 % du nombre de poissons. On a eu recours à un modèle multiplicatif pour établir des taux de prises normalisés et on a appliqué ces taux de prises à une formule de la méthode ADAPT décomposée par âge afin d'estimer la mortalité due à la pêche et la grosseur des stocks en 1990. Selon cette estimation, la mortalité due à la pêche dans les stocks pleinement recrutés (poissons de 9 ans et plus) était d'environ 0,47 et la population se chiffrait à environ 74 500 poissons. La projection du niveau de référence des prises de 1991 ($F_{0.1}$ = 0,4) est comparable au TPA actuel (17 t) fixé pour l'unité de la baie Voisey.

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 (Dempson and LeDrew 1986). Annual landings have ranged from 4 to 41 t (mean = 21 t, 1974-90), and from 1977 to 1990 have contributed 16% of the commercial catch of charr from the Nain fishing region. In 1990, 23% of the commercial charr catch was taken in the Voisey unit. The recommended Total Allowable Catch (TAC) in 1990 was maintained at 17 t; the same value since 1987. This paper summarizes information from the 1990 fishery and presents the results of the standardization of catch rates for the Voisey assessment unit. Estimates of stock size and fishing mortality are derived using an age disaggregated formulation of the adaptive framework (ADAPT) (Gavaris 1988).

2. Trends in catch and effort data - conventional series

Catch and effort data for the Voisey stock unit are summarized in Table 1 for the period 1974-90. The highest catch of 41 t occurred in 1979, the lowest catch of 4 t was in 1975. The TACs listed in Table 1 for 1979 to 1984 applied only to the Voisey Bay subarea. The quota area catch in Table 1 summarizes the landings for from Voisey Bay for those years. Since 1985, the TAC has applied to the entire stock unit.

Landings in 1990 totaled 19.9 t; an increase of 81% over 1989 and was similar to the long term mean catch for this fishery. Effort increased considerably in 1990 while catch per unit effort (CUE) was 16% below 1989 but still high in relation to past years (Table 1).

3. Catch and average weights at age

Catch at age data are available since 1977 and are summarized in Table 2. Catch at age, along with the estimated standard error and coefficient of variation for the 1990 data are provided in Table 3. The 1981 and 1982 year classes (year of hatching) represented by 8 and 9 year old fish in 1990 were the most abundant representing 53% of the catch (Table 2). The 1980 year class (age 10 fish) was also relatively strong contributing 17% of the total catch. Mean age of the catch in 1990 was 9.3 years and has ranged from 8.2 in 1979 to 9.3 in 1990. A summary of the percent at age in the catch is provided in Table 4.

Weights at age were derived from length-weight relationships obtained from sampling the commercial fishery as explained in past years (Dempson 1990). Gutted head-on weights were converted to whole weight using the conversion factor 1.22 (Dempson 1984). A comparison of recorded total landings with the cross product total (sum of the matrix of estimated numbers at age x matrix of weights at age) agrees quite well with the discrepancy between the two of about 0.3% for 1990. Weight at age data are given in Table 5.

4. Standardization of catch rates

A multiplicative model (Gavaris 1980) was used to account for differences in catch rates between year and week. The regression of ln catch rate for the period 1977 to 1990 was initially fitted using SAS REG procedures (SAS 1985) to avail of the various diagnostics available. Diagnostics included leverage estimates (diagonal elements of the hat matrix) and influence statistics using the DFFITS calculation (Freund and Littell 1986; Myers 1986). Cumulative probability plots of residuals were used in assessing normality of residuals. Standardized catch rates standardized to week 31 and year 1977, were obtained using the STANDAR (APL) version of the multiplicative analysis program.

The regression of ln catch rate of charr for the 1977-90 period in this combined model explained 42% of the variation (Table 6). Normal probability plots confirmed the general normality of the data (Fig. 2). Observations with high leverage were identified in 1982 and 1984 (Fig. 2) but had little influence as indicated by the well balanced DIFFITS values. Both year and week classification variables were significant (Table 6). A comparison of the standardized and unstandardized catch rates for the Voisey stock unit is provided in Fig. 3. Standardized catch rates, their corresponding standard error, and estimated effort are provided in Table 7.

A catch rate index at age was derived using the catch at age along with the estimated effort obtained from the standardization of commercial catch rates (Table 8).

5. Estimation of stock size

The standardized commercial catch rate index was used in an age disaggregated formulation of the adaptive framework (Gavaris 1988) to estimate population size in 1990. The ADAPT process is based on established methods for nonlinear parameter estimation. The minimization procedure is applied to determine a set of parameter values such that the predicted catch at age and abundance indices by age group are closest to the observed values (further details provided in CAFSAC 1988, p. 32).

Initially an intercept model was attempted but would not converge. The accepted formulation for the age disaggregated model is as follows:

Parameters:

- Year-class estimates

  $N_{i,1990}$ $\quad i = 7$ to 12

- Calibration coefficients for commercial catch rates (C/E)

  K_i $\quad i = 7$ to 12

Structure:

- Natural mortality assumed to be 0.2;
- Error in catch at age assumed negligible;
- Fishing mortality (F) for age groups 13-14 set equal to the weighted F for age groups 9-12;
- Model did not include an intercept.

Input:

Ci,t	i = 6 to 12,	t = 1977-90
C/Ei,t	i = 7 to 12,	t = 1977-90

Objective function:

- Minimize:

$$\sum_i \sum_t \{obs(\ln C/Ei,t) - pred(\ln C/Ei,t)\}^2$$

Summary:

- Number of observations = 84
- Number of parameters = 12

Results

Age disaggregated commercial catch rate

Parameter estimates for ages 7-12 abundance and slopes were significant (Table 9). Coefficient of variation (CV) ranged from 0.21 to 0.39 for the abundance estimates and were 0.11 for the slopes. The mean square residual was 0.155. Correlations between estimated parameters were generally low (Table 10). Residuals for ages 7-12 did not appear to display any particular trends (Table 9). A summary of estimated population numbers and fishing mortality are given in Table 11. Fishing mortality in 1990 was about 0.47 on age 9+ fish. Using a geometric mean from 1981 to 1988 for age 6 population numbers provides an estimated total population of about 74,500 fish in 1990; slightly higher but comparable with recent years (Fig. 4).

6. Catch projections

Projections of reference level catches for 1991 were run based on parameters derived from the above ADAPT run. Parameters used for the projections age given in Table 12. Weights are averages of 1988-90 data. Natural mortality was assumed to be 0.2 and $F_{0.1}$ was 0.4. Partial recruitment values were derived from fishing mortalities averaged over the period 1986-90 for the projections based on the age disaggregated ADAPT run. An estimate of recruitment for the projection was based on the geometric mean population numbers for age 6 fish (1981-88).

The age disaggregated projection results indicate a 1991 population of about 74,000 fish and a 1991 reference level catch at $F_{0.1}$ of 16.1 t.

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Table 1. Catch (kg) and effort (person-weeks fished) statistics for the Voisey assessment units from 1974 to 1990. Quota area catch (QAC) refers to the landings from those subareas specifically under TAC regulation only, prior to the derivation of assessment units in 1985.

Year	TAC[1]	QAC	Catch	Effort	CUE	% Offshore	Unit as % of Nain Region Total
1974			29180			31	24
1975			3727			94	8
1976			14652	57	257	21	11
1977			24108	75	321	9	13
1978			36991	102	363	11	17
1979	22500	21880	40590	116	350	47	23
1980	22500	11557	19694	82	240	42	12
1981	16100	16325	23810	90	265	33	10
1982	16100	2688	13309	60	222	45	7
1983	16100	2953	25593	80	320	89	17
1984	16100	8133	20873	101	207	62	17
1985	23400		15648	57	275	91	15
1986	23400		16655	82	203	82	17
1987	17000		21242	101	210	41	22
1988	17000		14037	52	270	60	19
1989	17000		11019	32	344	100	13
1990	17000		19895	69	288	64	23

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

Table 2. Estimated catch at age from the commercial Arctic charr fishery in the Voisey stock unit, 1977-90.

CATCH AT AGE

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
6	318	619	475	154	68	316	1045	291	1	44	8
7	2085	4374	4914	803	915	755	2947	2891	1917	851	1312
8	4030	5372	7928	3386	2571	1566	3410	3254	3066	3230	2813
9	2086	2330	3382	4140	4803	2346	3449	2238	3242	3888	4420
10	1237	1236	1163	1424	2359	1226	1611	1392	433	1400	2029
11	600	1141	634	500	941	657	1084	753	324	686	966
12	389	380	212	238	406	65	827	414	233	244	280
13	212	380	159	159	41	13	147	355	64	149	38
14	108	334	55	28	19	27	45	83	55	123	57
6+	11065	16166	18922	10832	12123	6971	14565	11671	9335	10615	11923
7+	10747	15547	18447	10678	12055	6655	13520	11380	9334	10571	11915
8+	8662	11173	13533	9875	11140	5900	10573	8489	7417	9720	10603

AGE	1988	1989	1990
6	140	68	17
7	1638	911	1110
8	2319	1445	2865
9	1465	1520	2945
10	1440	1135	1827
11	771	702	1083
12	289	245	588
13	28	107	440
14	43	181	83
6+	8133	6314	10958
7+	7993	6246	10941
8+	6355	5335	9831

Table 3. Summary of the catch at age in 1990 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	17	10.3	60.4
7	1110	189.0	17.0
8	2865	290.5	10.1
9	2945	294.4	10.0
10	1827	241.7	13.2
11	1083	188.0	17.4
12	588	141.3	24.0
13	440	127.7	29.0
14	83	45.4	54.6

Table. 4 Summary of the percent at age in the commercial catch of Arctic charr from the Voisey stock unit, 1977-90.

SUMMARY OF PERCENT AT AGE FOR THE VOISEY STOCK UNIT

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
6	2.9	3.8	2.5	1.4	0.6	4.5	7.2	2.5	0.0	0.4	0.1	1.7
7	18.8	27.1	26.0	7.4	7.5	10.8	20.2	24.8	20.5	8.0	11.0	20.1
8	36.4	33.2	41.9	31.3	21.2	22.5	23.4	27.9	32.8	30.4	23.6	28.5
9	18.9	14.4	17.9	38.2	39.6	33.7	23.7	19.2	34.7	36.6	37.1	18.0
10	11.2	7.6	6.1	13.1	19.5	17.6	11.1	11.9	4.6	13.2	17.0	17.7
11	5.4	7.1	3.4	4.6	7.8	9.4	7.4	6.5	3.5	6.5	8.1	9.5
12	3.5	2.4	1.1	2.2	3.3	0.9	5.7	3.5	2.5	2.3	2.3	3.6
13	1.3	2.4	0.8	1.5	0.3	0.2	1.0	3.0	0.7	1.4	0.3	0.3
14	1.0	2.1	0.3	0.3	0.2	0.4	0.3	0.7	0.6	1.2	0.5	0.5

	1989	1990
6	1.1	0.2
7	14.4	10.1
8	22.9	26.1
9	24.1	26.9
10	18.0	16.7
11	11.1	9.9
12	3.9	5.4
13	1.7	4.0
14	2.9	0.8

Table 5. Average weight at age (kg - round) from the commercial Arctic charr fishery, Voisey stock unit, 1977-90.

AVERAGE WEIGHT AT AGE

AGE	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
6	1.53	1.53	1.53	1.03	0.93	1.20	1.33	1.25	1.05	1.07	1.03	1.23
7	1.77	1.77	1.77	1.24	1.26	1.46	1.54	1.53	1.39	1.21	1.41	1.50
8	2.07	2.07	2.07	1.60	1.77	1.70	1.64	1.71	1.63	1.44	1.73	1.69
9	2.60	2.60	2.60	1.89	2.04	2.02	1.89	1.93	1.77	1.64	1.80	1.78
10	2.78	2.78	2.78	2.19	2.17	2.20	2.04	2.06	1.98	1.72	1.95	1.89
11	2.94	2.94	2.94	2.42	2.30	2.49	2.18	2.14	1.99	1.90	2.02	1.98
12	3.24	3.24	3.24	2.49	2.37	2.83	2.10	2.32	2.18	1.90	1.92	1.88
13	2.60	2.60	2.60	2.70	3.36	2.83	2.20	1.91	2.26	1.97	2.31	2.23
14	2.76	2.76	2.76	3.73	2.76	3.42	2.55	1.82	2.26	1.45	1.58	1.45

AGE	1989	1990
6	1.27	1.12
7	1.43	1.48
8	1.68	1.70
9	1.79	1.83
10	1.95	1.94
11	2.06	2.01
12	1.90	1.98
13	2.04	1.90
14	1.90	2.29

Table 6. Results of the analysis of variance of log transformed catch rate for the Voisey stock unit, 1977-90.

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: CUE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	23	10.94167267	0.47572490	2.98	0.0001	0.421919	7.2297
ERROR	94	14.99143045	0.15948330		ROOT MSE		CUE MEAN
CORRECTED TOTAL	117	25.93310312			0.39935361		5.52377932

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
YY	13	5.66161246	2.73	0.0026	13	4.44027667	2.14	0.0183
WK	10	5.28006021	3.31	0.0010	10	5.28006021	3.31	0.0010

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	5.70203090	0.17550939	32.488	0.0001
YY78	1	0.20064275	0.19468876	1.031	0.3054
YY79	1	0.24812324	0.19519879	1.271	0.2068
YY80	1	-0.0138623	0.20100695	-0.069	0.9452
YY81	1	-0.0227221	0.19098024	-0.119	0.9055
YY82	1	-0.424784	0.19814782	-2.144	0.0346
YY83	1	0.35900703	0.20874383	1.720	0.0888
YY84	1	-0.16227	0.19242559	-0.843	0.4012
YY85	1	0.10622989	0.19468876	0.546	0.5866
YY86	1	-0.206084	0.19098024	-1.079	0.2833
YY87	1	-0.139443	0.21968487	-0.635	0.5271
YY88	1	-0.0293762	0.19098024	-0.154	0.8781
YY89	1	0.19700728	0.21697769	0.908	0.3662
YY90	1	0.09067019	0.20731573	0.437	0.6629
WK25	1	0.074852	0.21823591	0.343	0.7324
WK26	1	-0.375435	0.16564096	-2.267	0.0257
WK27	1	-0.270802	0.15767870	-1.717	0.0892
WK28	1	-0.244585	0.15762709	-1.552	0.1241
WK29	1	-0.122524	0.15430697	-0.794	0.4292
WK30	1	0.004296194	0.15430697	0.028	0.9778
WK32	1	0.0485409	0.15663937	0.310	0.7573
WK33	1	-0.211097	0.16466062	-1.282	0.2030
WK34	1	-0.720986	0.17530961	-4.113	0.0001
WK35	1	-0.546324	0.31638722	-1.727	0.0875

Table 7. Commercial catch rate index for the Voisey stock unit, 1977-90.

Year	Standardized catch rate	Standard error	Effort
1977	320	56	75
1978	391	66	95
1979	410	70	99
1980	315	55	62
1981	313	52	76
1982	209	36	64
1983	457	83	56
1984	272	45	77
1985	356	60	44
1986	261	43	64
1987	276	56	77
1988	311	51	45
1989	388	74	28
1990	349	64	57

Table 8. Catch rate index for the Voisey stock unit, 1977-90.

VOSIEY STOCK UNIT CATCH RATE AT AGE INDEX

	77	78	79	80	81	82	83	84	85	86	87	88
6	4.2	6.5	4.8	2.5	0.9	4.9	18.7	3.8	0.0	0.7	0.1	3.1
7	27.8	46.0	49.6	13.0	12.0	11.8	52.6	37.5	43.6	13.3	17.0	36.4
8	53.7	56.5	80.1	54.6	33.8	24.5	60.9	42.3	69.7	50.5	36.5	51.5
9	27.8	24.5	34.2	66.8	63.2	36.7	61.6	29.1	73.7	60.7	57.4	32.6
10	16.5	13.0	11.7	23.0	31.0	19.2	28.8	18.1	9.8	21.9	26.4	32.0
11	8.0	12.0	6.4	8.1	12.4	10.3	19.4	9.8	7.4	10.7	12.5	17.1
12	5.2	4.0	2.1	3.8	5.3	1.0	14.8	5.4	5.3	3.8	3.6	6.4
13	2.8	4.0	1.6	2.6	0.5	0.2	2.6	4.6	1.5	2.3	0.5	0.6
14	1.4	3.5	0.6	0.5	0.2	0.4	0.8	1.1	1.2	1.9	0.7	1.0

	89	90
6	2.4	0.3
7	32.5	19.5
8	51.6	50.3
9	54.3	51.7
10	40.5	32.1
11	25.1	19.0
12	8.8	10.3
13	3.8	7.7
14	6.5	1.5

Table 9. Parameter estimates and residuals from ADAPT for the Voisey stock unit, ages 7-12, 1977-90.

ESTIMATED PARAMETERS AND STANDARD ERRORS
APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET..... 0.020004
MEAN SQUARE RESIDUALS 0.154727

AGE	PARAMETER	ESTIMATE	STD. ERR.	T-STATISTIC	C.V.
7	ABUNDANCE	1.45677E4	5.69570E3	2.55766E0	0.39
8	ABUNDANCE	1.60699E4	4.41895E3	3.63659E0	0.27
9	ABUNDANCE	1.01556E4	2.20579E3	4.60408E0	0.22
10	ABUNDANCE	4.60484E3	9.78320E2	4.70688E0	0.21
11	ABUNDANCE	2.58951E3	5.61967E2	4.60794E0	0.22
12	ABUNDANCE	1.84214E3	4.39686E2	4.18967E0	0.24
7	SLOPE	1.54863E-3	1.76628E-4	8.76773E0	0.11
8	SLOPE	4.41132E-3	4.90086E-4	9.00112E0	0.11
9	SLOPE	7.66581E-3	8.51260E-4	9.00526E0	0.11
10	SLOPE	7.48297E-3	8.40394E-4	8.90412E0	0.11
11	SLOPE	8.81807E-3	9.97927E-4	8.83639E0	0.11
12	SLOPE	7.78621E-3	8.79909E-4	8.84888E0	0.11

LOG RESIDUALS FOR ABUNDANCE INDEX

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
7	-0.042	0.067	0.425	-0.467	-0.452	-0.611	0.695	0.149	0.334	-0.435
8	0.359	0.108	0.089	-0.084	-0.184	-0.464	0.392	-0.136	0.096	-0.204
9	-0.128	-0.268	-0.217	0.034	0.176	-0.097	0.564	-0.302	0.485	-0.057
10	-0.177	-0.095	-0.208	0.188	0.023	-0.271	0.419	0.318	-0.875	0.004
11	-0.177	0.328	-0.045	0.025	0.335	-0.608	0.276	0.034	0.043	-0.518
12	-0.194	0.142	-0.213	0.602	0.876	-1.322	0.634	-0.089	0.324	0.215

	1987	1988	1989	1990
7	-0.186	0.375	0.148	0.000
8	-0.083	0.251	-0.011	-0.129
9	-0.030	-0.263	0.210	-0.109
10	-0.206	0.072	0.481	0.327
11	0.083	-0.208	0.194	0.238
12	-0.997	0.343	-0.316	-0.003

SUM OF INDEX 1 RESIDUALS : 0.0001579968 MEAN RESIDUAL : 0.0000018809

Table 10. Paramater correlation matrix for the Voisey stock unit ADAPT run calibrated using ages 7-12, 1977-90.

PARAMETER CORRELATION MATRIX

	1	2	3	4	5	6	7	8	9	10
1	1.000	0.056	0.047	0.035	0.027	0.022	-0.278	-0.026	-0.020	-0.019
2	0.056	1.000	0.068	0.052	0.041	0.033	-0.202	-0.221	-0.030	-0.028
3	0.047	0.068	1.000	0.023	0.048	0.068	-0.167	-0.181	-0.226	-0.081
4	0.035	0.052	0.023	1.000	0.058	0.074	-0.125	-0.144	-0.180	-0.267
5	0.027	0.041	0.048	0.058	1.000	0.094	-0.098	-0.113	-0.144	-0.192
6	0.022	0.033	0.068	0.074	0.094	1.000	-0.079	-0.089	-0.122	-0.168
7	-0.278	-0.202	-0.167	-0.125	-0.098	-0.079	1.000	0.094	0.074	0.067
8	-0.026	-0.221	-0.181	-0.144	-0.113	-0.089	0.094	1.000	0.082	0.076
9	-0.020	-0.030	-0.226	-0.180	-0.144	-0.122	0.074	0.082	1.000	0.097
10	-0.019	-0.028	-0.081	-0.267	-0.192	-0.168	0.067	0.076	0.097	1.000
11	-0.018	-0.027	-0.119	-0.115	-0.288	-0.222	0.066	0.075	0.096	0.111
12	-0.019	-0.028	-0.161	-0.149	-0.134	-0.301	0.068	0.077	0.099	0.107

	11	12
1	-0.018	-0.019
2	-0.027	-0.028
3	-0.119	-0.161
4	-0.115	-0.149
5	-0.288	-0.134
6	-0.222	-0.301
7	0.066	0.068
8	0.075	0.077
9	0.096	0.099
10	0.111	0.107
11	1.000	0.118
12	0.118	1.000

Table 11. Estimated population numbers and fishing mortality from ADAPT for the Voisey stock unit, calibrated using ages 7-12, 1977-90.

POPULATION NUMBERS

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
6	40949	32476	19078	17295	19537	25310	31371	28848	18485	18838
7	21884	33239	26029	15190	14020	15934	20436	24739	23356	15134
8	11885	16031	23256	16864	11710	10651	12363	14065	17639	17387
9	5853	6084	8264	11867	10744	7261	7303	7036	8571	11667
10	3670	2905	2873	3706	5970	4450	3822	2859	3736	4084
11	1574	1885	1260	1300	1746	2753	2534	1672	1081	2667
12	1134	746	511	458	612	578	1659	1094	687	592
13	1112	577	267	227	159	134	414	610	521	352
14	315	719	128	74	42	93	98	206	179	369
6+	88376	94660	81665	66980	64539	67164	80000	81129	74254	71089

	1987	1988	1989	1990
6	22958	25231	17813	1344
7	15383	18789	20531	14522
8	11620	11408	13901	15985
9	11313	6969	7242	10074
10	6034	5263	4380	4554
11	2077	3104	3006	2559
12	1563	826	1844	1826
13	264	1026	415	1288
14	153	182	815	243
6+	71366	72798	69946	52394

FISHING MORTALITY

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
6	0.009	0.021	0.028	0.010	0.004	0.014	0.038	0.011	0.000	0.003	0.000
7	0.111	0.157	0.234	0.060	0.075	0.054	0.174	0.138	0.095	0.064	0.099
8	0.470	0.463	0.473	0.251	0.278	0.177	0.364	0.295	0.213	0.230	0.311
9	0.501	0.550	0.602	0.487	0.681	0.442	0.738	0.433	0.541	0.459	0.565
10	0.466	0.635	0.593	0.553	0.574	0.363	0.627	0.773	0.137	0.476	0.465
11	0.547	1.105	0.812	0.554	0.906	0.306	0.640	0.689	0.402	0.334	0.722
12	0.477	0.829	0.613	0.855	1.322	0.133	0.800	0.542	0.470	0.608	0.221
13	0.237	1.303	1.076	1.495	0.334	0.114	0.498	1.029	0.146	0.631	0.173
14	0.471	0.707	0.632	0.530	0.689	0.381	0.699	0.580	0.412	0.455	0.522

	1988	1989	1990
6	0.006	0.004	0.014
7	0.101	0.050	0.088
8	0.254	0.122	0.219
9	0.264	0.264	0.386
10	0.360	0.337	0.577
11	0.321	0.299	0.620
12	0.489	0.159	0.435
13	0.031	0.335	0.468
14	0.301	0.280	0.468

Table 12. Parameters used as input for catch projections of Voisey stock unit Arctic charr.

Age	Mean weight (kg.)	Age disaggregated	
		Population numbers 1990	PR
6	1.21	23412	0.01
7	1.47	14522	0.19
8	1.69	15985	0.52
9	1.80	10074	0.83
10	1.93	4554	1.00
11	2.02	2559	1.00
12	1.92	1826	1.00
13	2.06	1288	1.00
14	1.88	243	1.00

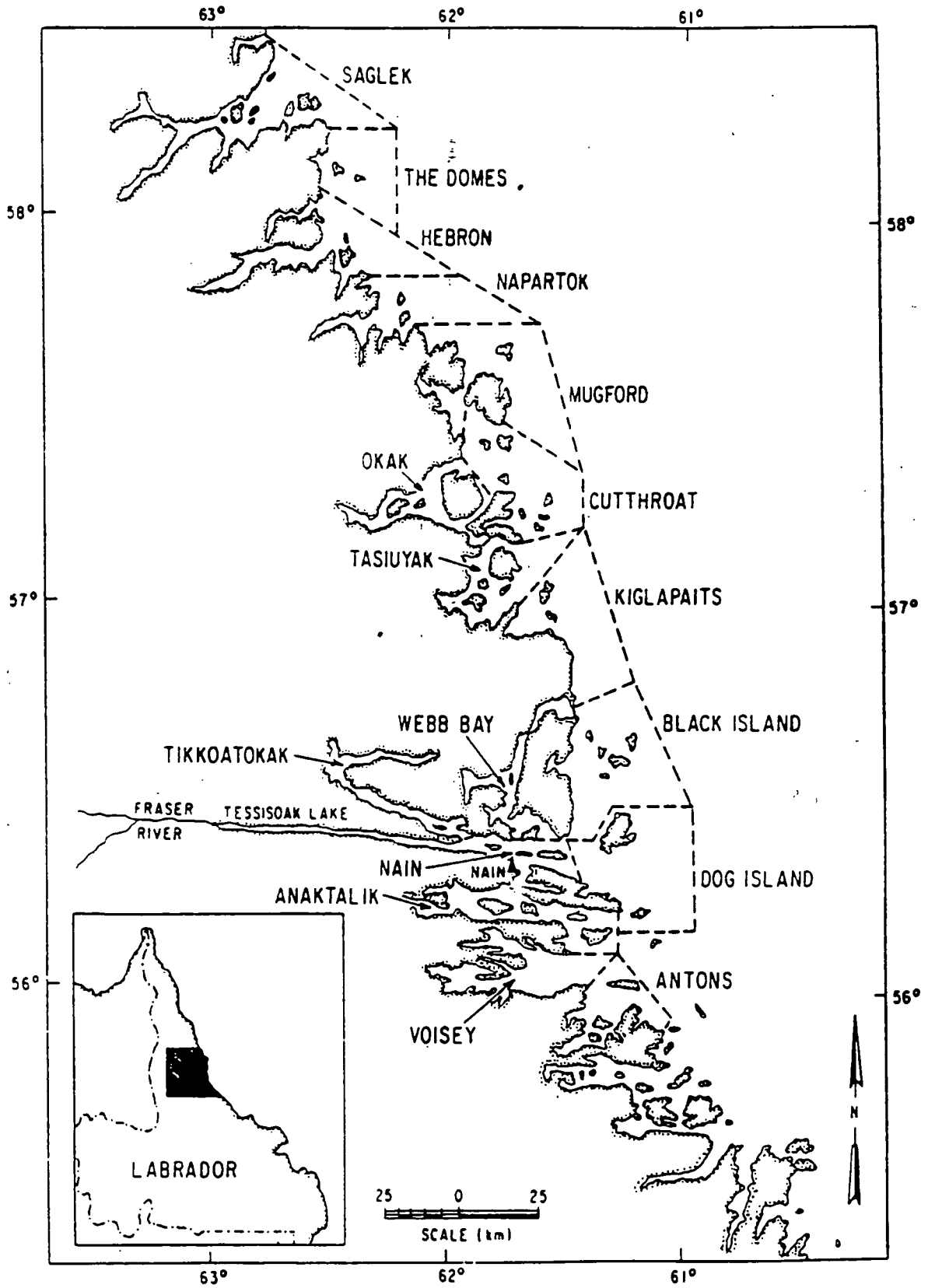
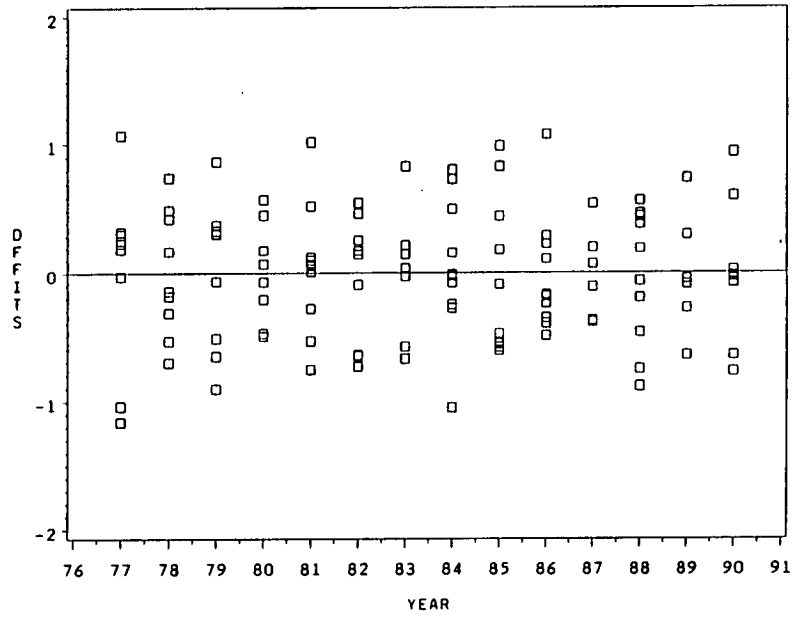
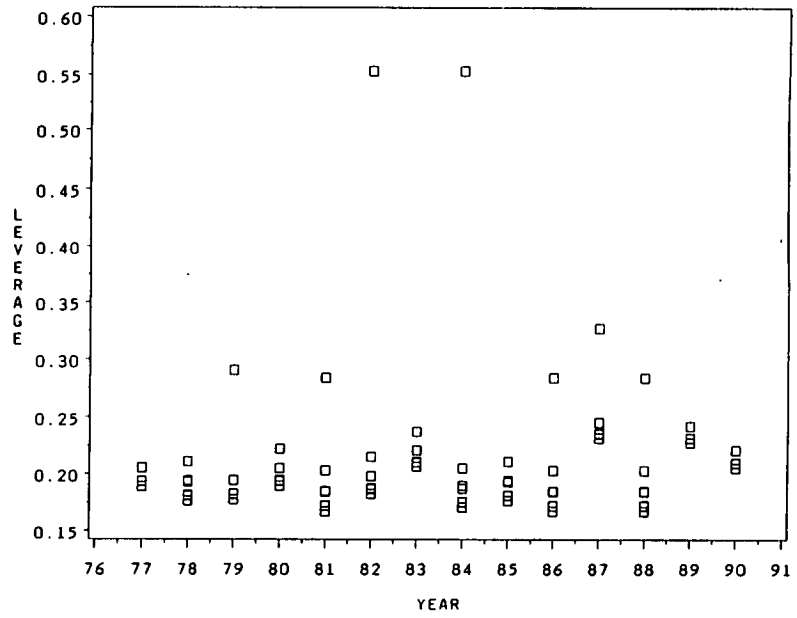
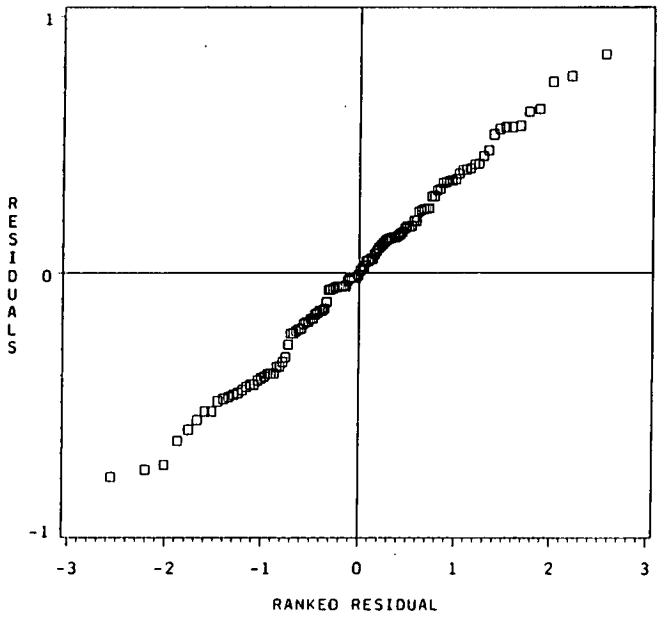


Fig. 1. Geographical separation of the Nain Fishing Region subareas.







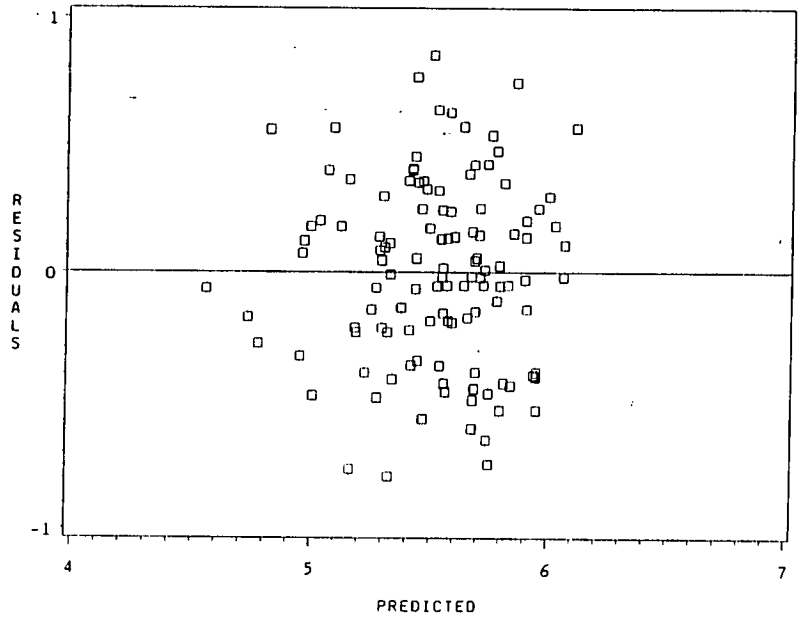


Fig. 2. Residual plots and influence diagnostics for the Voisey stock unit, 1977-90.

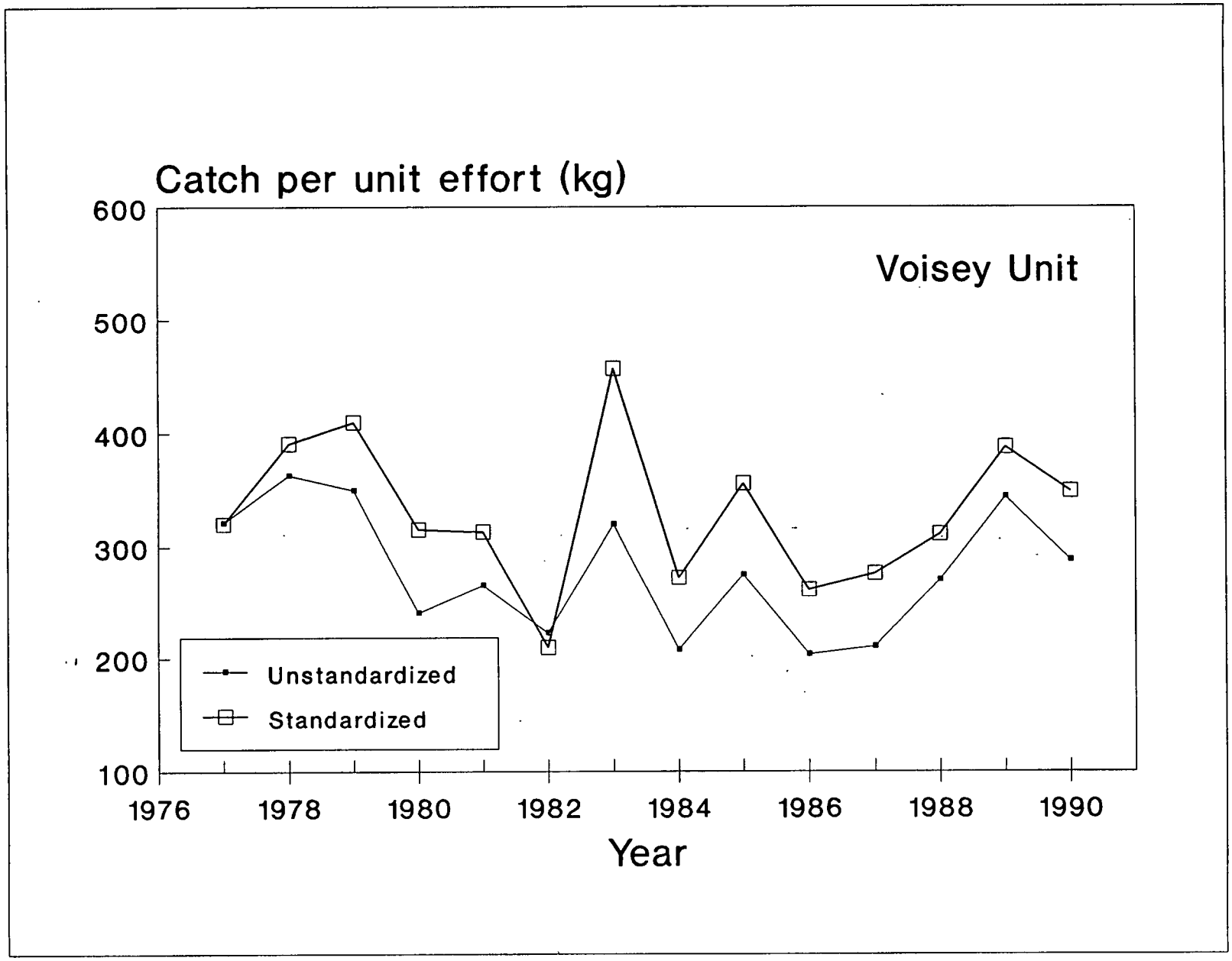
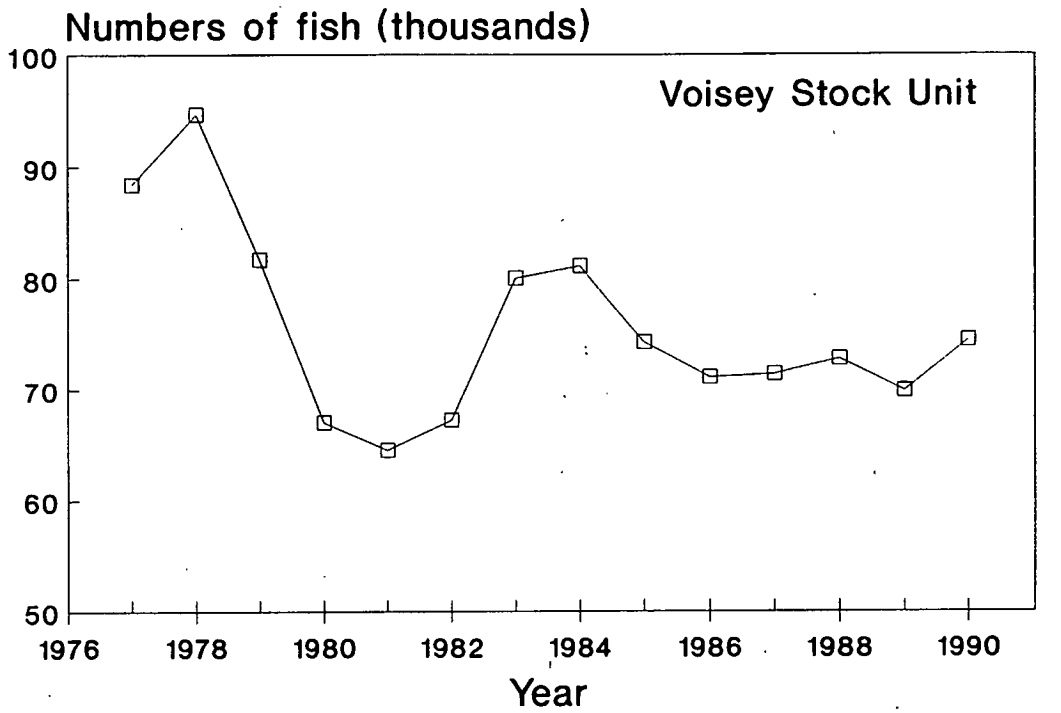


Fig. 3. Comparison of standardized and unstandardized commercial catch rates for the Voisey stock unit, 1977-90.



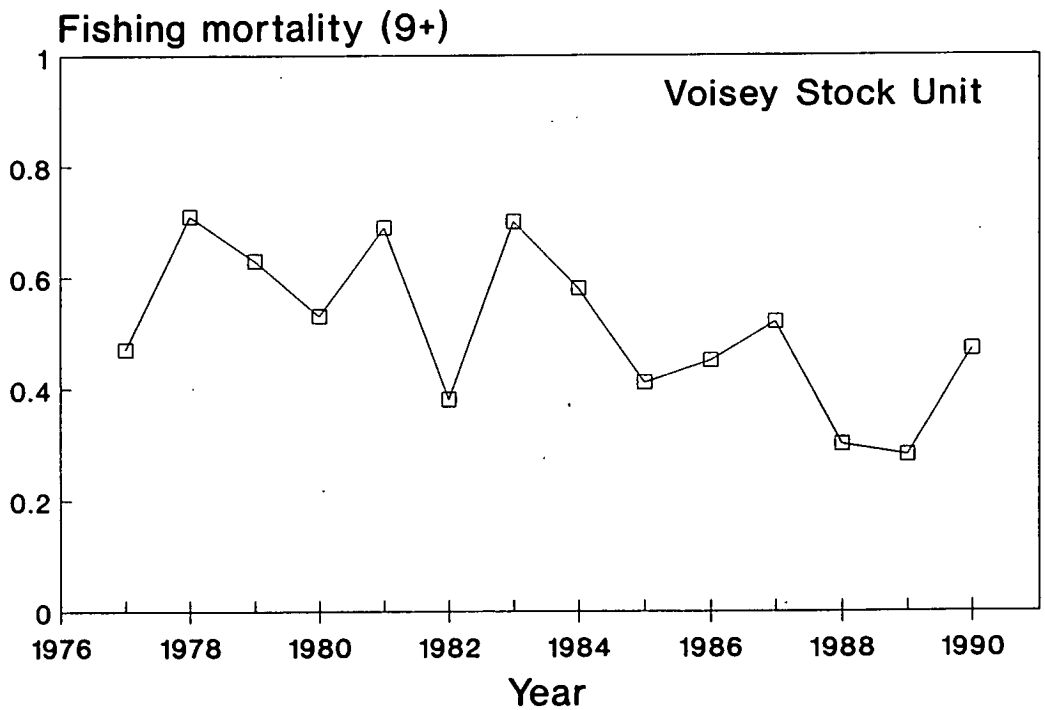


Fig. 4. Estimated population numbers and fishing mortality from the Voisey stock unit Arctic charr population, 1977-90.